

UNIVERSITY OF CALIFORNIA SAN DIEGO

**Kinematics, Multiplicity, Rotational Dynamics, and Population Properties of
Ultracool Dwarfs Inferred from High-Resolution Near-Infrared Spectroscopy**

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requirements for the degree
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in

Physics

by

Chih-Chun Hsu (許智鈞)

Committee in charge:

Adam J. Burgasser, Chair
Jelena Bradic
Raphael Flauger
George M. Fuller
Christopher R. Gelino
Quinn M. Konopacky

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The dissertation of Chih-Chun Hsu (許智鈞) is approved,
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microfilm and electronically.

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DEDICATION

To my father, Kae-Chau Sheu (許凱超),
mother, Ya-Mien Chen (陳雅綿),
grandma, Chiu-Lan Hsu-Lin (許林秋蘭),
and brother, He-Ling Hsu (許鶴齡),

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VITA

| | |
|-----------|--|
| 2014 | B. S. in Physics, National Tsing Hua University, Hsinchu, Taiwan |
| 2016–2021 | Graduate Teaching Assistant, Department of Physics, University of California San Diego |
| 2020 | Ph. D. candidate in Physics, University of California San Diego |
| 2022 | Graduate Student Researcher, Center for Astrophysics and Space Sciences, University of California San Diego |
| 2022 | Ph. D. in Physics, University of California San Diego |

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ABSTRACT OF THE DISSERTATION

Kinematics, Multiplicity, Rotational Dynamics, and Population Properties of Ultracool Dwarfs Inferred from High-Resolution Near-Infrared Spectroscopy

by

Chih-Chun Hsu (許智鈞)

Doctor of Philosophy in Physics

University of California, San Diego, 2022

Adam J. Burgasser, Chair

Ultracool dwarfs (UCDs) are the lowest-mass stars and brown dwarfs, with mass $< 0.1 M_{\odot}$ effective temperatures $\leq 3,000$ K. Since they are abundant and long-lived, they can be tracers of the Milky Way formation and evolution history. In the past two decades, tens of thousands of UCDs have been discovered with all-sky surveys including the Two Micron All Sky Survey (2MASS), Wide-field Infrared Survey Explorer (*WISE*), and more recently the *Gaia* satellite. It is now possible to statistically and critically assess these objects as a population, by examining local UCD kinematics and angular momentum evolution, probing their formation history and evolution, and testing brown dwarf evolu-

tionary models. However, only a few hundred precise (3 km s^{-1}) radial (RV) and rotation velocities ($v \sin i$) are presently available due to these sources' faintness. I have developed a Markov Chain Monte Carlo forward-modeling technique to extract precise RVs and $v \sin i$ s in the UCD regime and applied it to new and existing high-resolution near-infrared spectroscopic data obtained with the Near-Infrared Spectrometer (NIRSPEC) on the Keck II Telescope and the Apache Point Observatory Galactic Evolution Experiment (APOGEE) from the Sloan Digital Sky Survey (SDSS). These spectrographs cover the near-infrared waveband, which allow me to increase the number of precise RV and $v \sin i$ measurements for low-temperature UCDs, even for relatively low signal-to-noise ratios. I have modeled 219 unique UCDs with measurements taken over 773 epochs. Such a statistically large sample enables assessments of local UCD kinematics and angular momentum evolution, and identifications of substellar binaries. From my analysis, I have resolved a decade-long mystery of local L dwarfs having old kinematics, inconsistent with population simulations incorporating brown dwarf evolutionary models; this can be explained by a high rate of contamination of thick disk L dwarfs in the local sample. I also identified a kinematic break around L4–L6 subtypes, which aligns with the terminus of the stellar Main Sequence. I have identified and confirmed 21 UCD binaries using the RV method, including the first two T dwarf binary systems and one of the shortest period UCD binaries identified to date. UCDs statistically rotate faster from late-M to T types, indicating that their angular momentum is not efficiently lost through magnetized winds as it is for normal stars, consistent with previous studies. For a subset of M and L dwarfs with APOGEE data and measured variability periods, I found that the projected radii generally decline as a function of age, and that the inclination distribution of the ~ 10 Myr Upper Scorpius cluster and field objects are both consistent with random orientation distribution. I provide a comprehensive sample of RVs, $v \sin i$ s, effective temperatures (T_{eff}) and surface gravities ($\log g$) for 349 late-M, L, and T dwarfs based on observations

made in this work.

Chapter 1

Introduction

1.1 Ultracool Dwarfs

Ultracool dwarfs (UCDs) are low-mass ($M < 0.1 M_{\odot}$) stellar and substellar objects with effective temperatures $T_{\text{eff}} \leq 3,000$ K and spectral types M7 or later, encompassing late-M, L, T, and Y dwarf spectral classes (Kirkpatrick et al. 1999; Kirkpatrick 2005; Burgasser et al. 2006b; Cushing et al. 2011). Figure 1.1 (McLean et al. 2003; Kirkpatrick et al. 1995) shows a spectral sequence of UCDs, ranging from M6–T8 in the near-infrared waveband. Distinct from F-, G-, and K-type stars which show mostly hydrogen and other atomic absorption features, UCDs have photospheric temperatures low enough to host abundant molecular species and associated absorption features. The prominent molecular features of late-M and L dwarfs in the near-infrared are H₂O, CO, FeH, and alkali lines such as K I and Na I, and clouds of condensates such as iron or corundum (Al₂O₃) in L dwarfs Allard et al. (2001). As the spectral sequence transitions to the T dwarf regime, CH₄ emerges as the prominent absorption feature of T dwarfs, converted from CO at the L/T transition. Collision-induced absorption (CIA) H₂ also appears in late-L and T dwarf spectra, widely suppressing *K*-band flux (Linsky 1969;

Burgasser et al. 2002). Figure 1.2 illustrates the theoretical thermal evolution of UCDs based on models from Burrows et al. (1997), Chabrier et al. (2000), and Baraffe et al. (2003). The thermal evolution of stellar UCDs (i.e. lowest-mass stars) reflects their slower contraction over ~ 1 Gyr followed by the ignition of core nuclear H fusion reactions in the Main Sequence. The minimum core temperature for H fusion is 3×10^6 K in the Burrows et al. (1997) models. Substellar UCDs, never reach thermal equilibrium, but maintain hydrostatic equilibrium between electron degeneracy pressure and gravity (Kumar 1962, 1963; Hayashi & Nakano 1963). As such, substellar UCDs constantly cool over time. Late-M ($3,000 \text{ K} \gtrsim T_{\text{eff}} \gtrsim 2,500 \text{ K}$) and L dwarfs ($2,500 \text{ K} \gtrsim T_{\text{eff}} \gtrsim 1,400 \text{ K}$) are a mixed population of low-mass stars and brown dwarfs, while T dwarfs ($1,400 \text{ K} \gtrsim T_{\text{eff}} \gtrsim 600 \text{ K}$) and Y dwarfs ($T_{\text{eff}} \lesssim 600 \text{ K}$) are all substellar.

UCDs are abundant in the Galaxy (20–50% of all stars; Bochanski et al. 2007a; Kirkpatrick et al. 2019, 2021; Reyl   et al. 2021) and have lifetimes several orders of magnitude longer than the current age of the Universe (Laughlin et al. 1997). UCDs thus provide a means of investigating the low-mass star formation and chemical enrichment history of the Milky Way and its substructures (Bochanski et al. 2007a; Burgasser 2009). In addition, the long-term cooling brown dwarfs makes them useful tracers of age in various populations. Indeed, brown dwarfs have been used to age-date young clusters (Stauffer et al. 1998; Mart  n et al. 2018) and binaries (Song et al. 2002), and could potentially be used to age-date other Galactic populations such as globular clusters and the Galactic halo (Burgasser 2009; Caiazzo et al. 2017; Gerasimov et al. 2022).

Over the past two decades, thousands of UCDs have been discovered with large-area sky surveys such as the Deep Near Infrared Survey of the Southern Sky (DENIS; Epchtein et al. 1997), the Two Micron All Sky Survey (2MASS; Skrutskie et al. 2006), the Sloan Digital Sky Survey (SDSS; York et al. 2000), the UKIRT Infrared Deep Sky Survey (UKIDSS; Lawrence et al. 2007), *Wide-field Infrared Survey Explorer* (WISE; Cutri & et

al. 2012), the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS; Chambers et al. 2016), Canada-France-Hawaii Telescope Legacy Survey (CFHTLS; Gwyn 2012), the VISTA Hemisphere Survey (VHS; McMahon et al. 2013), and *Gaia* (Gaia Collaboration et al. 2018a, 2021), among others. These surveys have provided photometry and astrometry measurements, including proper motions and parallaxes, useful for studying the statistical properties of UCDs (Faherty et al. 2009). As will be shown in the following sections, the addition of high-resolution spectroscopy facilitates studies of kinematics and age (Section 1.2), multiplicity (Section 1.3), and rotation (Section 1.4).

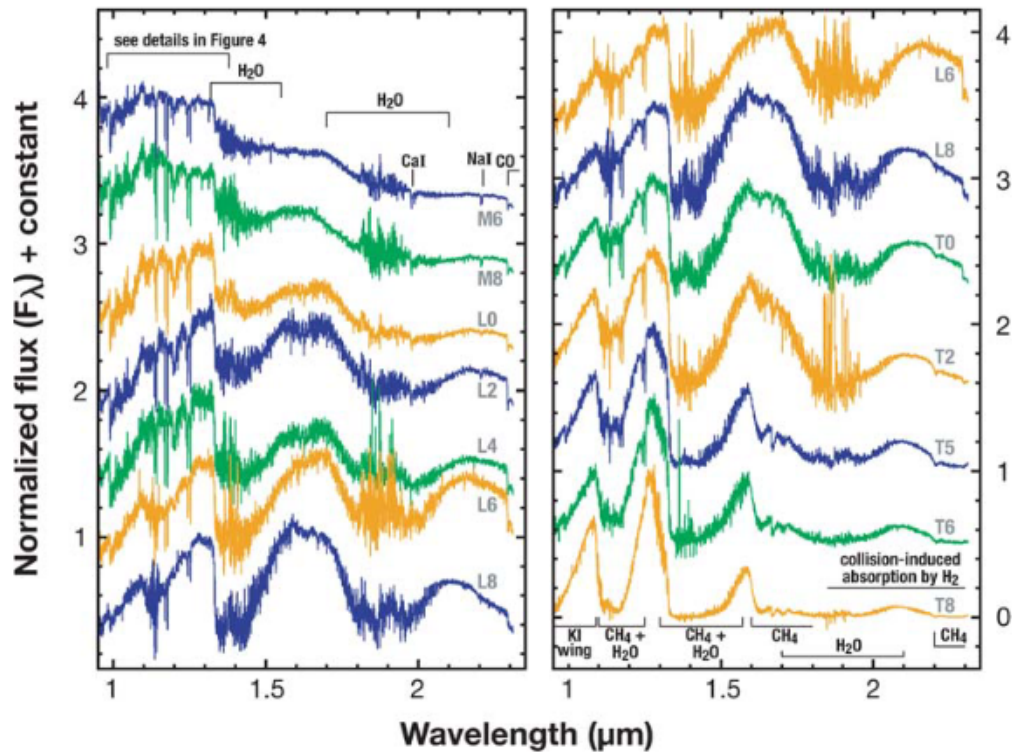


Figure 1.1: Near-infrared spectral sequence of UCDs, ranging from M6 (top left) to T8 (bottom right), over a wavelength range of 0.95–2.3 μm . Prominent atomic and molecular absorption features are labeled. (Figure 3 from Kirkpatrick 2005, data originally from McLean et al. 2003).

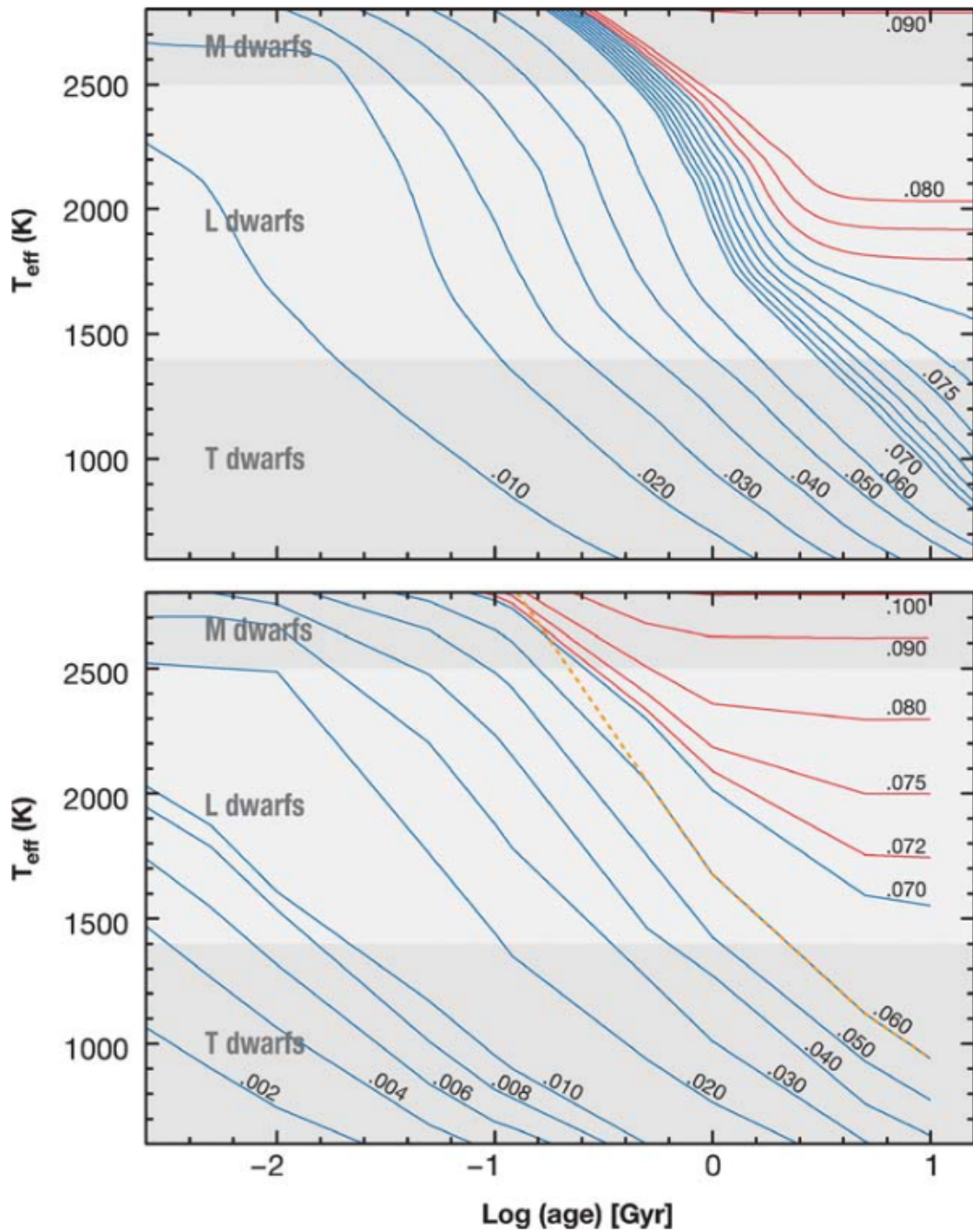


Figure 1.2: Theoretical thermal evolution tracks of ultracool dwarfs. Stars and brown dwarfs are labeled in red and blue lines, representing constant masses in M_{\odot} . The approximate temperature ranges of late-M, L, and T dwarfs are labeled in different grey bands. *Top:* Models from Burrows et al. (1997). *Bottom:* Models from Chabrier et al. (2000) for $T_{\text{eff}} > 1,500$ K and Baraffe et al. (2003) for $T_{\text{eff}} < 1,500$ K. The orange line in the bottom panel shows the 50% depletion of primordial lithium computed by Chabrier et al. (2000). (Figure 10 from Kirkpatrick 2005).

1.2 Kinematics, Age, and Evolution

Stellar kinematics can provide an independent method of measuring the age of Galactic populations. Coarse ages can be inferred through different Galactic populations for thin disk, thick disk, and halo populations (Bensby et al. 2003; Pinfield et al. 2014). For an ensemble of stars, empirical age-velocity dispersion relations can be used to measure their statistical age caused by disk heating mechanisms. Stars form in clusters within the Galactic disk. After their birth, they undergo diffuse dynamical scattering with giant molecular clouds, the Galactic spiral arms, and bar structure, resulting in larger velocity dispersion over time (Wielen 1977; Aumer & Binney 2009). The study of UCD populations must account for the distinct thermal and dynamical evolution of stars and brown dwarfs. UCD population analyses make use of simulations incorporating stellar and substellar evolution to map physical properties (age, mass, composition) to present-day observables (Reid et al. 1999; Burgasser 2004; Kirkpatrick et al. 2019). A consistent prediction of these simulations is that L-type UCDs, a mix of stars and rapidly-cooling brown dwarfs (typical L-type dwarf cooling timescale $\tau \approx 0.5\text{--}1$ Gyr; Burrows et al. 1997; Baraffe et al. 2003), should be on average younger than late M-type UCDs, which are predominantly long-lived stars (Reid et al. 1999; Burgasser 2004; Allen et al. 2005; Ryan et al. 2017). Observations of statistical ages through kinematics have mostly contradicted this prediction. In one of the first 3D kinematic studies of UCDs, combining RVs and tangential velocities, Zapatero Osorio et al. (2007) found that local L and T dwarfs had a lower velocity dispersion than local late-M dwarfs, although the sample included only 21 L and T dwarfs. A 2D proper motion survey of 277 UCDs by Faherty et al. (2009) found local 20 pc L dwarfs to be marginally older than late-M and T dwarfs, while their whole sample of 841 UCDs gave consistent ages. Schmidt et al. (2010) identified both young and old L dwarf populations in a 3D kinematic survey of

over 300 sources using low-resolution spectroscopy. The diagnostic power of these early studies was limited by incomplete samples and relatively low-precision measurements ($\sigma_{\text{RV}} \gtrsim 5\text{--}10 \text{ km s}^{-1}$).

Subsequent volume-limited 3D kinematic surveys of late-M and L dwarfs using high-resolution spectra and improved astrometry have consistently found the local L dwarf population to be significantly more dispersed, and hence older, than the late-M dwarfs, in disagreement with simulation predictions (Reiners & Basri 2009a; Seifahrt et al. 2010; Blake et al. 2010; Burgasser et al. 2015a). The most recent study prior to this thesis by Burgasser et al. (2015a) attempted to explain this discrepancy as an evolution of the mass function over time, with a greater abundance of brown dwarfs at earlier ages. While this ansatz was able to correctly predict the relative ages of late-M and L dwarfs, the absolute ages and corresponding mass function were inconsistent with observations. Whether this persistent disagreement between simulated and observed ages of L dwarfs arises from a more complex star and brown dwarf formation history, a problem with brown dwarf evolutionary models, or incompleteness or bias in the local UCD sample, remains uncertain.

The kinematics of local T dwarfs can provide clarity on this issue. These low-temperature, evolved brown dwarfs have cooling ages of several Gyr, and are predicted to be kinematically older than L dwarfs (Burgasser 2004). T dwarfs are also intrinsically fainter than late-M and L dwarfs, limiting the number of sources with suitable high-precision RV measurements. While there are more than 500 T dwarfs currently known, there are fewer than 15 T dwarfs with precise RV ($\sigma_{\text{RV}} \leq 3 \text{ km s}^{-1}$) and rotational velocity ($\sigma_{v \sin i} \leq 5 \text{ km s}^{-1}$) measurements reported in the literature (Zapatero Osorio et al. 2006, 2007; Prato et al. 2015; Gagné et al. 2017, 2018a; Vos et al. 2017, 2018). This sample is insufficient to accurately measure kinematic dispersions and ages, or test population simulations. This lack of data motivated my study to expand the local T dwarf

high-resolution spectroscopic sample using Keck/NIRSPEC data.

1.3 Multiplicity

Multiplicity is the direct outcome of star formation. Identifying and characterizing multiple systems through observations provide measurements of orbital parameters including separations, periods, and eccentricity in different environments and ages, which can be used to refine the Initial Mass Function (IMF) and constrain binary formation theories, as well as long-term dynamical evolution and stability of such systems (Duchêne & Kraus 2013). The multiplicity frequency (MF) generally decreases from higher mass (MF $\geq 80\%$ for stellar mass $M \gtrsim 16 M_{\odot}$; Chini et al. 2012) to the ultracool dwarfs ($22^{+6}_{-4}\%$, Allen 2007; $\approx 20\%$, Burgasser 2007). The distribution of binary mass ratios ($q = M_{\text{secondary}}/M_{\text{primary}}$), often characterized by a power-law distribution ($f(q) = q^{\gamma}$), broadens with mass, meaning that higher-mass stars prefer to form unequal mass binaries ($\gamma = -0.5 \pm 0.2$ for $1.5 M_{\odot} \lesssim M \lesssim 5 M_{\odot}$; Duchêne & Kraus 2013), while UCD binaries are likely to form in equal masses ($\gamma = 4.2 \pm 1.0$; Burgasser et al. 2007). The separation distribution is larger for high-mass stars than lower-mass stars, and its frequency $f(P)$ can be characterized by a power law with period P , $f(P) \propto P^{-1}$ (Öpik 1924), a trend that continues down to early M dwarf primaries (Dhital et al. 2010). In the UCD regime, the typical binary separation is 4–7 AU while limited by instrumental resolutions (Burgasser et al. 2007; Dupuy & Liu 2017). The eccentricity distribution favors higher eccentricities for solar-type stars (all binaries $e > 0.1$; Raghavan et al. 2010) and lower eccentricities for UCDs (most binaries with $e < 0.2$; Dupuy & Liu 2017). The difference may be explained by longer-lived dissipative gas disks for UCDs (Dupuy & Liu 2017). Similar to the multiplicity frequency trend over mass, high-order multiple systems (hierarchical systems) are more likely to be present in higher-mass stars than UCDs (Dhital et al. 2010;

Duchêne & Kraus 2013), although higher-order multiple systems of UCDs are more difficult to identify due to their faintness. To statistically constrain multiplicity properties, careful and complete surveys must be conducted, a challenge for intrinsically faint UCDs.

Most of the UCD binaries discovered to date are resolved binaries (Bardalez Gagliuffi et al. 2019a; Figure 1.3), largely found through high-resolution imaging with the *Hubble Space Telescope* and ground-based, large aperture, adaptive optics instruments (e.g. Konopacky et al. 2010; Dupuy & Liu 2017; Brandt et al. 2019). Imaging observations are useful in providing dynamical masses but have a resolution limit ~ 1 AU (Dupuy & Liu 2017; Bardalez Gagliuffi et al. 2019a). Closer systems need to be identified through other techniques, such as overluminosity, spectral binaries, astrometric variability, and radial velocity variability. Overluminosity on color-magnitude diagrams is an efficient means of identifying unresolved binaries but requiring accurate parallaxes, favoring equal-mass binaries, and can be contaminated by other effects such as metallicity, age, reddening, and background contamination, so follow-up spectroscopic, astrometric, or adaptive optics observations are needed to confirm (Smart et al. 2019). Spectral binaries are identified by the peculiar blended-light spectra of binaries with different components, which can be inferred through binary template fitting with low-resolution spectra (Burgasser et al. 2008, 2010; Bardalez Gagliuffi et al. 2014). Again, contamination by metallicity and other effects requires follow-up imaging, astrometric and/or high-resolution spectroscopic observations to verify such systems. Astrometric variables arise from the orbital motion of the center of light of a system relative to the center of mass, favoring unequal brightness systems at close separations (Sahlmann et al. 2015, 2020, 2021). These systems necessitates very precise astrometry and are blind to equal-brightness/equal-mass systems. Radial velocity (RV) variables are detected from the Doppler shift of the spectra of the primary (single-line binary; SB1) or both components (double-line binary; SB2) and can detect both high- and low-mass companions

(RV variability is the technique used for the detection of the first exoplanet 51 Pegasi b; Mayor & Queloz 1995). This method for UCDs typically requires high-resolution near-infrared spectrometers on large aperture telescopes due to UCDs' intrinsic faintness (Blake et al. 2010; Burgasser et al. 2015b, 2016). However, this method is limited to close binaries while wide binaries can be discovered through imaging with consistent proper motions and astrometry (RV can be still used to verify the comoving nature of wide binaries).

To precisely characterize the orbits of unresolved, close UCD binaries requires high-resolution spectroscopy. The other methods cannot provide precise mass measurements for short period binaries such as 2MASSW J1510478–281817AB system (Figure 1.4). Due to the need for near-infrared high-resolution spectroscopy on large aperture telescopes, only 7 UCD binaries prior to this work have been discovered or verified through the RV method. Relevant systems include the M8.5 + T5 binary 2MASS J03202839–0446358 (Blake et al. 2010), the resolved M9 + T5 binary WISE J072003.20–084651.2 (Burgasser et al. 2015b; Dupuy et al. 2019), and the young M9 + M9 eclipsing binary 2MASSW J1510478–281817 (Triaud et al. 2020; Figure 1.4). It is noted that 2MASS J03202839–0446358 and WISE J072003.20–084651.2 were both identified as spectral binaries. Blake et al. (2010) estimate an RV binary fraction of $2.5^{+8.6}_{-1.6}$ for UCDs (Table 1.1), compared to 3–4% for M dwarfs (Clark et al. 2012) and $24 \pm 4\%$ for higher-mass stars (Moe et al. 2019).

1.4 Rotation

Stellar rotation is another quantity that connects to star formation and evolution (and age), as well as the generation of magnetic fields and stellar activity. There are two primary methods of measuring stellar rotation, including variability rotation periods from

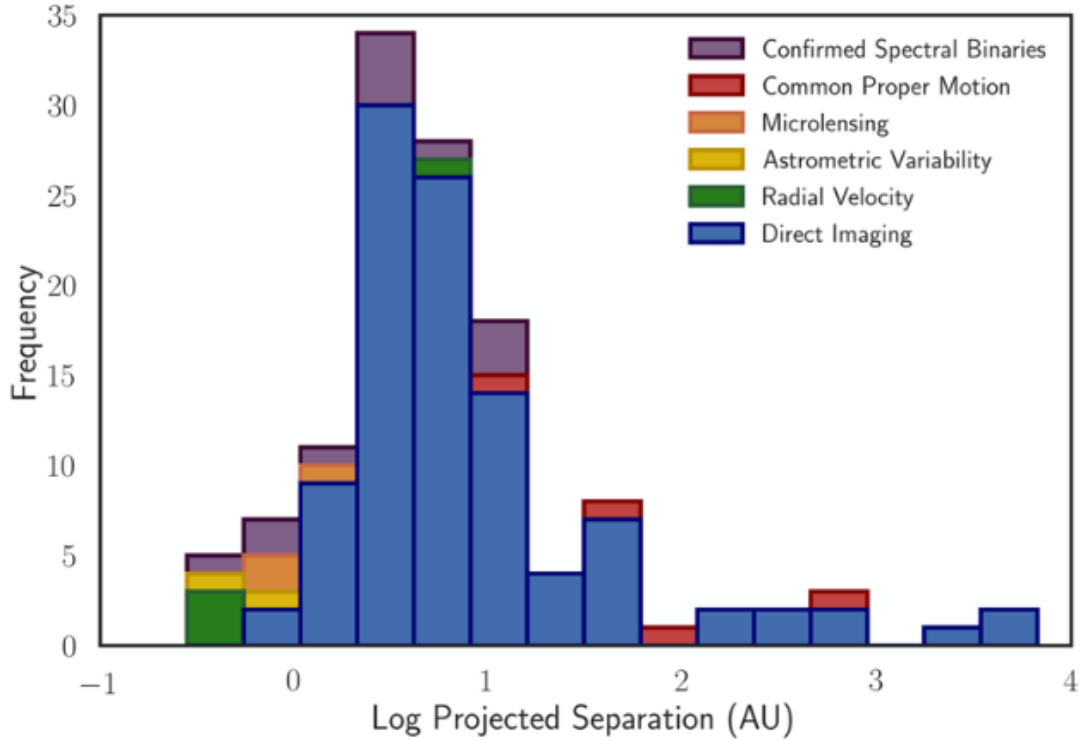


Figure 1.3: Binary detection frequency and projected separation distribution of ultracool binaries discovered up to 2014. The detection techniques are labeled in different colors as shown in the legend. The peak at 2.5 AU corresponds to the imaging resolution limit of the *Hubble Space Telescope* and ground-based adaptive optics instruments. The “Common Proper Motion” binaries are identified and confirmed with *Gaia* proper motion, which are a subset of the “Direct Imaging” binaries. (Figure 1 from Bardalez Gagliuffi et al. 2019a).

light curves and Doppler line broadening from high-resolution spectroscopy. Rotation periods for UCDs have been measured with *Spitzer* (Werner et al. 2004), the *Kepler* and *K2* Mission (Koch et al. 2010; Howell et al. 2014), the *Transiting Exoplanet Survey Satellite* (*TESS*; Ricker et al. 2015), and ground-based facilities such as M_{Earth} (Nutzman & Charbonneau 2008), and SPECULOOS (Sebastian et al. 2021) among others. This method is limited to objects that are varying and periodic. Late-M dwarfs have no clear correlation with period and amplitude and show both short and long periods from 0.1 to >100 days (Irwin et al. 2011; Newton et al. 2016). Metchev et al. (2015) found that photometric variability is common among L dwarfs ($80^{+20}_{-27}\%$) and becomes lower for

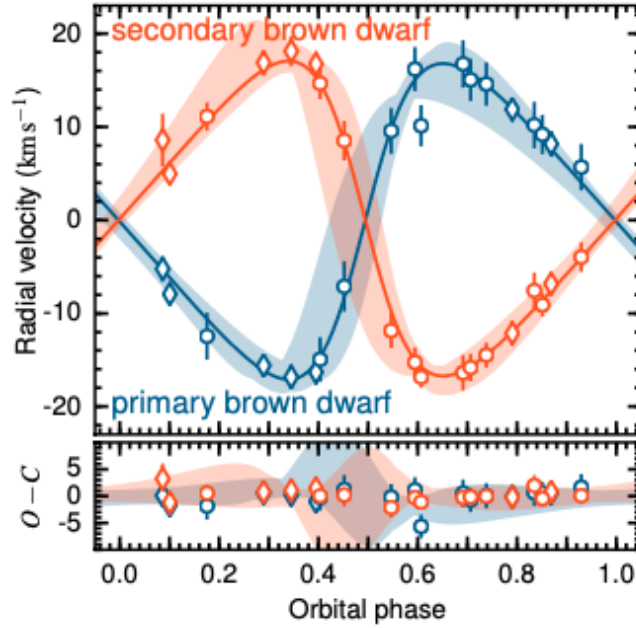


Figure 1.4: Phase-folded RV time series of M9 + M9 eclipsing binary 2MASS J1510478–281817. *Top:* The primary (blue) and secondary (orange) RV measurements (VLT/UVES: circles; Keck/NIRSPEC: diamonds) and the corresponding RV orbital fits (same colors with $2\text{-}\sigma$ uncertainties in shaded regions). *Bottom:* Residuals (data–model) and the corresponding uncertainties for both components with the same colors. (Figure 5b from Triaud et al. 2020).

T dwarfs ($36^{+26}_{-17}\%$). Vos et al. (2022) found young brown dwarfs are more likely to exhibit variability between L2–T4 dwarfs than the field dwarfs. These studies assume observed variability arises from stable starspots or clouds, and that these features align with bulk rotational dynamics. Projected rotational velocity ($v \sin i$) is measured from high-resolution spectroscopy through the Doppler broadening of spectral lines (Gray 1992; Collins & Truax 1995), which does not rely on variability but is limited sources with strong features. Mohanty & Basri (2003) showed that the $v \sin i$ increase from mid-M to L dwarfs. Zapatero Osorio et al. (2006), which is the largest T dwarf $v \sin i$ survey prior to this work, illustrated the trend continue to increase to T dwarfs. Both of the studies used high-resolution spectroscopy. Although the $v \sin i$ method has a lower limit set by the spectral resolution limit, $v \sin i$ s of L and T dwarfs measured in the

Table 1.1: Confirmed UCD RV Binaries

| short name | full name | SpT | Type | Ref |
|------------|--------------------------|-----------|------------------|-----|
| J0320–0446 | 2MASS J03202839–0446358 | M8.5+T5 | SB1 ^b | (2) |
| J0535–0546 | 2MASS J05352184–0546085 | M6.5+M6.5 | SB2 ^a | (1) |
| J0630–1840 | DENIS J063001.4–184014 | M9+L2 | SB1 ^c | (7) |
| J0720–0846 | WISE J072003.20–084651.2 | M9.5+T5 | SB1 ^b | (3) |
| J0805+4812 | SDSS J080531.84+481233.0 | L3.5+T4.5 | SB1 ^b | (4) |
| J1059–2113 | 2MASS J10595138–2113082 | L0+T3.5 | SB1 ^b | (6) |
| J1106+2754 | 2MASS J11061197+2754225 | T0+T4.5 | SB1 ^b | (8) |
| J1510+2818 | 2MASS J15104761–2818234 | M9+M9 | SB2 ^a | (5) |
| J2126+7617 | 2MASS J21265916+7617440 | L7+T3.5 | SB1 ^b | (8) |

Reference: (1) Stassun et al. (2006), (2) Burgasser et al. (2008), (3) Burgasser et al. (2015b), (4) Burgasser et al. (2016), (5) Triaud et al. (2020), (6) Sahlmann et al. (2020), (7) Sahlmann et al. (2021), (8) Hsu et al. (2021)

Note: (a) eclipsing binary, (b) spectral binary, (c) astrometric binary.

literature typically are well above the resolution limit and well below the break up speed ($\sqrt{GM/R} = 155 - 365 \text{ km s}^{-1}$, assuming mass $M = 0.013 - 0.072 M_{\odot}$ and radius $R = 1 R_{\text{Jupiter}}$).

Rotation connected to stellar age over time through the loss of angular momentum through magnetized winds. Normal F-, G-, and K-type stars have a well-characterized connection between age, rotational spin-down, and declined activity encompassed by the Skumanich Law ($\tau^{-0.5}$, where τ is the stellar age; Skumanich 1972), which has been extensively used to age-date the stars through rotation (so-called “gyrochronology”). At their earliest ages, stars first spin up due to contraction and converge into a narrow range of rapid rotation rates until reaching the zero-age Main Sequence (ZAMS) around 600 Myr. As these stars have convective envelopes, they draw dynamos that generate magnetic fields which strength with faster rotation speeds. Differential rotation of solar-type stars twists the magnetic fields and generates stellar flares and winds, leading to the ejection of material that also carries away angular momentum (Barnes 2003, 2007; Irwin et al. 2011). The resulting spin-down reduces magnetic field strength, connecting

age, rotation, and activity. The spin-down trend continues into fully convective M dwarfs although the spin-down timescale become longer for M dwarfs than solar-type stars (West et al. 2008; Irwin et al. 2011). Mohanty & Basri (2003) have shown that M9–L6 dwarfs can be fast rotators with weak magnetic emission (indicated from H α emission observations), which can be explained by their cool and neutral atmospheres becoming decoupled from magnetic fields, and thus breaking the rotation-magnetic activity relation. This has been validated in rotational periods in different cluster ages (Baraffe et al. 2003; Angus et al. 2019), and projected rotational velocity measured with high-resolution spectroscopy (Mohanty & Basri 2003; Irwin et al. 2011; Crossfield 2014). Figure 1.5 illustrates a compilation of period, variability, and $v \sin i$ from Crossfield (2014). Note that periods tend to get shorter and $v \sin i$ tends to increase toward later spectral type, which can be explained with reduced angular momentum loss for cooler UCDs.

Rotation also provides insight into the geometry of a star, including radius and viewing orientations. The combination of rotational period, $v \sin i$, and radius allows stellar inclination to be measured (Vos et al. 2017, 2022). Sources with edge-on inclinations (90 deg) can be prioritized for the search for exoplanet systems (Triaud et al. 2010; Triaud 2018), while pole-on inclinations (0 deg) can be used for studies of magnetic field axis alignments with stellar rotational orientations (Smith et al. 1974; Acuna & Ness 1976). For bright UCDs such as the Luhman 16AB (Luhman 2013; Burgasser et al. 2013), the Doppler imaging technique can be used to infer global cloud properties by measuring variations in the line shape over time (Donati et al. 2006; Crossfield et al. 2014). Zeeman line broadening or splitting in spectra, which originates from the quantum mechanical spin-orbit coupling of electron orbitals with a magnetic field and splits energy level (Zeeman 1897), can be measured through magnetically sensitive lines such as FeH at $\sim 1 \mu\text{m}$ in high signal-to-noise ratio high-resolution spectra (Reiners & Basri 2007, 2009b).

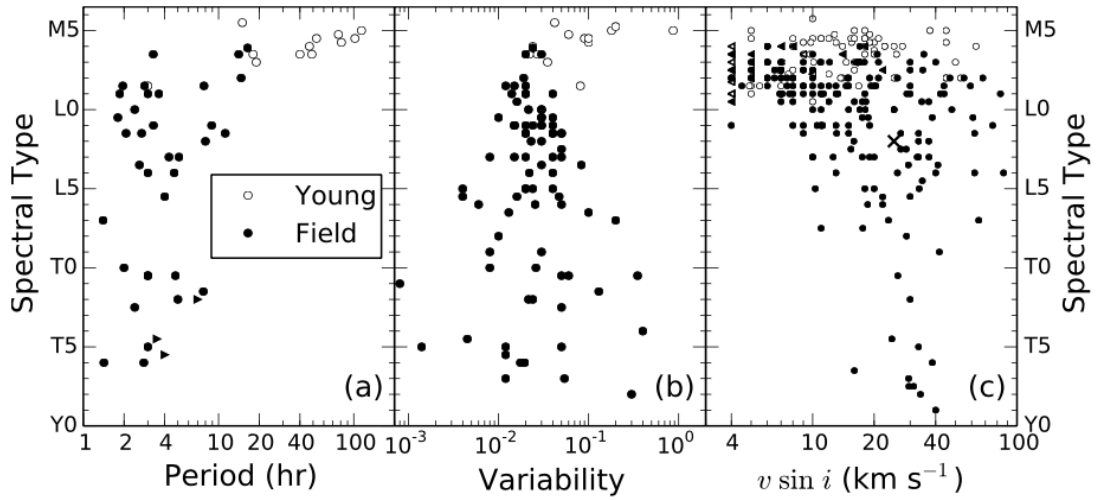


Figure 1.5: Compilation of literature measurements versus spectral type for (a) periods, (b) variability (photometric variability semi-amplitude in any filters), and (c) projected rotational velocity ($v \sin i$). Young (sources associated with known young clusters or young moving groups reported in literature) and field objects are labeled in open and solid dots, respectively. The triangles in (a) and (c) indicate the upper limit on periods and lower limits to $v \sin i$, respectively. The cross symbol indicates the young giant exoplanet Beta Pic b (Snellen et al. 2014). (Figure 1 from Crossfield 2014).

1.5 High-resolution Spectroscopy

High-resolution spectroscopy provides several opportunities for studying UCDs in detail, including precise measurements of RVs, $v \sin i$ s, stellar abundances, and detailed spectral line-profile modeling. Radial velocities are essential for full 3D precise kinematics, which can then be used to determine their Galactic populations (Bensby et al. 2003) and membership in nearby young clusters and moving groups (Gagné et al. 2018c). Kinematic distribution also probes the ages of stellar populations through empirical age-velocity dispersion relations (Wielen 1977; Aumer & Binney 2009) (Section 1.2). Multi-epoch precise radial velocities allow me to identify single-line or double-line low-mass binaries (e.g. Blake et al. 2010; Burgasser et al. 2016; Triaud et al. 2020), crucial in constraining binary parameters including orbital periods, separation, and eccentricity (Section 1.3). Projected rotational velocities ($v \sin i$) for UCDs of known ages map angu-

lar momentum evolution as a function of age and magnetic activity (Zapatero Osorio et al. 2006; Irwin et al. 2011), while individual rotational velocities probe spin/orbit alignment (Rossiter–McLaughlin effect) for exoplanet systems, and can be used to prioritize transit searches (Triaud et al. 2010; Triaud 2018, Section 1.4). High-resolution spectroscopy is also necessary to determine precise abundances, including those of species such as C, O, Na, Mg, Al, Si, K, Ca, Ti, V, Cr, Mn, Fe, and N (Souto et al. 2022) and isotopes (e.g. ^{12}CO and ^{13}CO ; Tsuji 2016; Souto et al. 2017; Crossfield et al. 2019). Finally, high-resolution spectroscopy enables detailed line modeling, influenced by Zeeman splitting (magnetic field strength), limb darkening (atmospheric structure), Doppler variations (magnetic spots and clouds), and pressure broadening (surface gravity; e.g. Reiners & Basri 2006; Shulyak et al. 2010; Crossfield 2014).

Despite these opportunities, the currently published high-resolution spectroscopic sample of UCDs is limited to a few hundred sources, due to their intrinsic faintness and the necessity of observing at near-infrared wavelengths (Blake et al. 2010; Burgasser et al. 2015a). Fortunately, there is a wealth of near-infrared high-resolution spectra that have been taken over the past two decades, particularly with the Near-Infrared Spectrometer (NIRSPEC; McLean et al. 1998, 2000) on the Keck II Telescope and the Apache Point Observatory Galactic Evolution Experiment (APOGEE; Majewski et al. 2017) survey from the Sloan Digital Sky Survey (SDSS).

NIRSPEC is a high-resolution near-infrared spectrometer ($\lambda/\Delta\lambda \sim 25,000$ pre-upgrade, McLean et al. 1998, 2000; $\lambda/\Delta\lambda \sim 35,000$ post-upgrade, Martin et al. 2018), covering the entire J , H , and K -bands. With the large 10 m aperture at Keck, NIRSPEC is ideal for expanding the high-resolution spectroscopic sample of UCDs, with limiting brightness of $J \approx 15.5$ mag and $K \approx 14.5$ mag. Previous high-resolution studies with NIRSPEC include the RV and $v \sin i$ survey of local L and T dwarfs by Zapatero Osorio et al. (2006, 2007), the RV survey of 59 late-M and L dwarfs with ~ 600 measurements by

Blake et al. (2010), the RV and $v \sin i$ survey of 23 late-M dwarfs by Tanner et al. (2012), the RV survey of 25 late-M/L/T dwarfs (Prato et al. 2015), and various individual UCD RV binaries (Burgasser & McElwain 2006; Burgasser et al. 2015b, 2016; Konopacky et al. 2010). Figure 1.6 shows the NIRSPEC spectrum of WISE J072003.20–084651.2 from Burgasser et al. (2015b), which the 2.285 to 2.318 μm region covering the CO ($v=2-0$) bandhead. This spectral order has abundant telluric absorption features that provide a simultaneous absolute reference frame of wavelength scale down to precisions of $\sim 50 \text{ m s}^{-1}$ (Tanner et al. 2012). Full usage of the existing NIRSPEC spectral data has not been achieved, as 400 unique UCDs and $>5,000$ science files of published and unpublished data are available on the Keck Observatory Archive¹ (KOA). Even considering only data with $S/N > 5$, there are >250 unique UCDs with $>2,700$ science files. Precise RVs and $v \sin i$ s can be measured with an accurate modeling technique (see Section 2.2), which can drastically improve the modeling precision for sources measured with other methods (e.g. the cross-correlation method; Zapatero Osorio et al. 2007; Prato et al. 2015).

APOGEE provides high resolution ($\lambda / \Delta\lambda \sim 22,500$, Majewski et al. 2017; Wilson et al. 2019) near-infrared spectra covering the entire H -band, ideal for expanding the high-resolution spectroscopic sample of UCDs. APOGEE has observed more than 730,000 stars in multiple epochs (Abdurro’uf et al. 2022), enabling the discovery of thousands of binary candidates, including $\sim 4,000$ single-lined binaries for giants (Price-Whelan et al. 2018), $>7,000$ double-lined binaries for A stars to mid-M dwarfs (effective temperatures from 8,000 K down to 3,000 K; Kounkel et al. 2021), and 44 double-lined binaries for early- to mid-M dwarfs (Skinner et al. 2018). However, the APOGEE pipeline does not provide robust RVs and $v \sin i$ s for late-M dwarfs, as the APOGEE Stellar Parameter and Chemical Abundances Pipeline (ASPCAP) pipeline (García Pérez et al. 2016) and a recent radial velocity pipeline `Doppler` (Nidever 2021) has difficulty in precise determinations

¹<https://koa.ipac.caltech.edu/>

of these parameters for low-temperature atmospheres. This limitation motivated specific efforts to improve APOGEE measurements of UCDs through the APOGEE M dwarf Ancillary Program (Deshpande et al. 2013; Holtzman et al. 2015). Deshpande et al. (2013) presented RVs and $v \sin i$ measurements of 253 M dwarfs related to this program, using cross-correlation and forward-modeling methods with BT-Settl models (Allard et al. 2012), achieving typical RV and $v \sin i$ uncertainties of 0.18 km s^{-1} and 1.0 km s^{-1} , respectively. Figure 1.7 shows an example spectrum and the best-fit BT-Settl model ($T_{\text{eff}} = 3000 \text{ K}$, $\log g = 5.0 \text{ dex}$, and $[\text{Fe}/\text{H}] = 0.3$) from Deshpande et al. (2013). While the best-fit model provides reasonable match to the data, there are some spectral regions that do not fit well, especially in redder wavelength regions (Figure 1.7 middle and bottom panels). As I will show, I can improve fidelity and accuracy on the same data with up-to-date models.

1.6 Organization of Thesis

In this thesis, I present multi-epoch RV and $v \sin i$ measurements of 37 T dwarfs with Keck/NIRSPEC in Chapter 2, 182 M4–L2 dwarfs with SDSS APOGEE in Chapter 3. Appendix lists diagnostics of minimum $v \sin i$ determination and population simulations in Chapter 2 and binary candidates identified in Chapter 3. The conclusions of the work and future directions are summarized in Chapter 4.

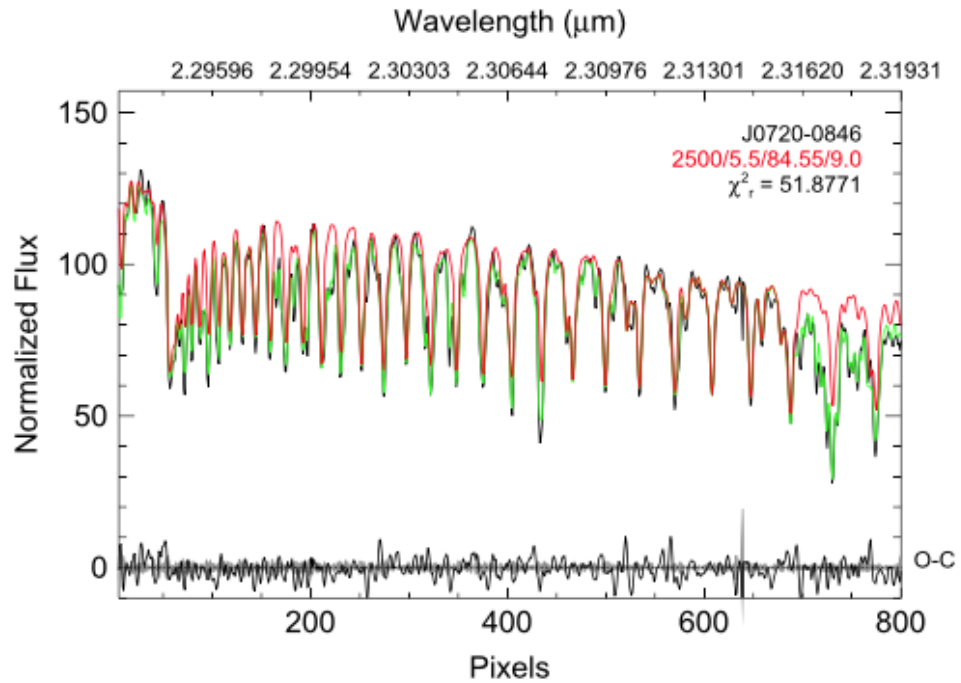


Figure 1.6: NIRSPEC high-resolution spectrum of M9 + T5 Binary WISE J072003.20–084651.2. The data are shown in black, and model with and without the telluric correction are shown in green and red, respectively. The uncertainty is shown in the shaded grey region and the residual (data–model) is shown in black at the bottom of the figure. This spectral order focuses on the CO bandhead $\sim 2.3 \mu\text{m}$ and telluric CH_4 absorption for simultaneous wavelength calibration. (Figure 8 from Burgasser et al. 2015b).

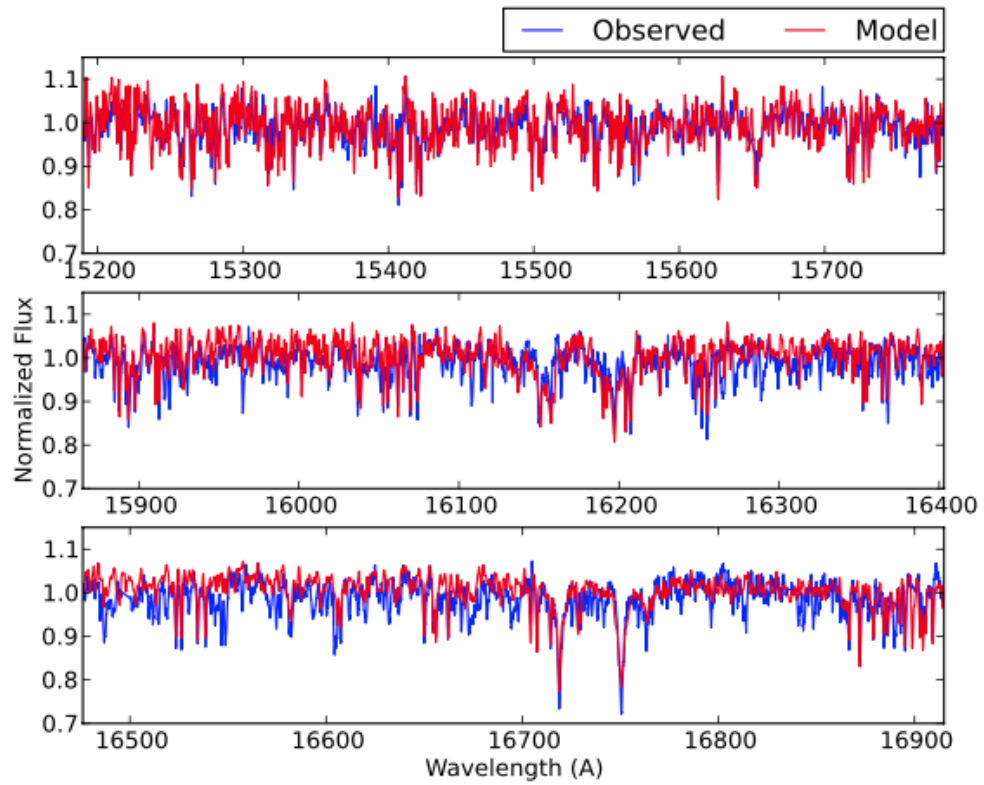


Figure 1.7: APOGEE high-resolution spectrum compared to the best-fit model. The data and BT-Settl model ($T_{\text{eff}} = 3000$ K, $\log g = 5.0$ dex, and $[\text{Fe}/\text{H}] = 0.3$) are shown in blue and red, respectively. (Figure 10 from Deshpande et al. 2013).

Chapter 2

Keck/NIRSPEC

2.1 NIRSPEC T Dwarf Observations

My T dwarf sample was compiled from sources observed with the Keck Near-Infrared Spectrometer (NIRSPEC; McLean et al. 1998, 2000). NIRSPEC is a high-resolution, near-infrared, cross-dispersed spectrograph, mounted on the Keck II telescope, spanning 0.95 to 5.5 μm with a spectral resolution of $\sim 25,000$ (pre-upgrade) and $\sim 35,000$ (post-upgrade) for a slit width of $0''.432$. Table 2.1 lists the 37 T dwarfs in my sample, with photometry from the Two Micron All Sky Survey (2MASS; Skrutskie et al. 2006) and the UKIRT Infrared Deep Sky Survey (UKIDSS; Lawrence et al. 2013); astrometry from 2MASS, the *Wide-field Infrared Survey Explorer* (WISE; Cutri & et al. 2012), the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS; Chambers & et al. 2017) and *Gaia* (Gaia Collaboration et al. 2018b, 2021); and classifications from the literature. My sample encompasses observations taken between 2000 and 2021, including publicly available archival data obtained from the Keck Observatory Archive (KOA)¹. All public data were downloaded directly from KOA, with the exception of

¹<https://koa.ipac.caltech.edu>

data from 2001 June 15 (Zapatero Osorio et al. 2006, 2007) and 2005 July 19 (Prato et al. 2015) which were provided by the PIs of these programs. Fourteen sources were observed after the NIRSPEC upgrade (Martin et al. 2018). Table 2.2 lists the details for each observation, segregated by epoch. Most observations were accompanied by observation of an early type star (typically A0) for telluric absorption correction. In total, I analyzed 290 near-infrared spectra in order *N3* (1.143–1.375 μm) and 101 near-infrared spectra in order *N7* (1.839–2.630 μm).

2.1.1 NIRSPEC Data Reduction

NSDRP Pipeline and Modifications

All of the NIRSPEC data were reduced using a modified version of the NIRSPEC Data Reduction Pipeline (NSDRP; Tran et al. 2016). My modifications were as follows:

1. I loosened the criteria for determining the edges of each dispersion order. NSDRP determines these edges from flat field frames, but the threshold value for edge detection was too strict and cut off some science spectra in certain orders. Note that NSDRP only processes orders that are completely within the image. Orders that are cut off at the top or bottom of the detector are ignored.
2. NSDRP determines the wavelength calibration using only sky emission lines, so I added arc lamp and etalon lamp exposures as additional inputs for wavelength calibration. Arc lamp line identifications were drawn primarily from the National Institute of Standards and Technology (NIST; Kramida et al. 2019), the Atomic Line List (Van Hoof 2018), and Outred (1978). Etalon lamp lines are not tied to an absolute wavelength scale but provide a way to refine the relative wavelength calibration across an order.

3. When spatially rectifying the tilted orders, NSDRP uses the top and bottom of the edges of the flat field dispersions. This is suitable for data with low S/N, such as my science spectra. For data with high S/N, such as my telluric star spectra, I found that this rectification can be offset by 1–2 pixels across the spectral order. For these data, I used the trace of the bright object spectrum, determined by a Gaussian profile fit along each column.
4. I added a $3\text{-}\sigma$ clipping algorithm to find the optimal spectral tilt (spatial y-direction) from the emission line traces.
5. I added new coefficients for the grating equation, determined empirically, for $N3$ (J -band) and $N7$ (K -band) data obtained with the upgraded NIRSPEC instrument.

These modifications have been integrated into an updated version of the NSDRP.²

In addition, I implemented an algorithm to correct for fringing features in the flat field images. Interference from reflections between the echelle gratings and internal optics in NIRSPEC produce fringing patterns, easily visible in high signal-to-noise (S/N) data and flat field images. The interference patterns reduce both my ability to model the spectra and achieve high radial velocity precision. I therefore added a defringing algorithm for the raw flat field files using the wavelet analysis described in Rojo & Harrington (2006) and the *wavelets*³ package described in Torrence & Compo (1998). Briefly, each pixel in the flat field data is substituted for the median-average value of the nearest 10 pixels in the vertical direction, making the horizontal fringe patterns more prominent. A continuum profile is determined from the binned data using a low-order cubic spline. Subtracting this continuum, I fit the difference using a wavelet analysis. The modeled fringe pattern for the flat images was then subtracted from the original flat field frame. This algorithm was only applied to flat field images, so fringing remains in

²<https://github.com/ctheissen/NIRSPEC-Data-Reduction-Pipeline>

³<https://github.com/aaren/wavelets>

the science frames. As my data were typically low S/N, I did not attempt to correct the science frames for fringing, and defer this to a future study.

Telluric Wavelength Calibration

The wavelength calibration from NSDRP is a second-order polynomial fit to the sky, arc, and etalon lamp emission lines in the science and calibration data. I found this default calibration to be insufficient for precise RV measurement. I therefore adopted the wavelength calibration method described in Burgasser et al. (2016), cross-correlating the associated telluric standard star spectrum with a telluric absorption model (Moehler et al. 2014) over discrete wavebands of width 15 Å. This fit was performed after first modeling out the continuum of the A0 V with a second-order polynomial and a Voigt absorption profile for orders containing H I absorption lines⁴. I used a fit to the residual shift to update the wavelength solution, both represented as fourth-order polynomial functions. This process was iterated until the wavelength solution residuals reached a minimum. The calibrated wavelength solution of each telluric standard star spectrum was applied to the corresponding science spectrum with a wavelength offset determined in the forward-modeling (Section 2.2). The typical standard deviation of velocity residuals in the calibrated telluric spectra ranges from 0.1 to 0.6 km s⁻¹, with a median residual of 0.3 km s⁻¹. My baseline N3 order 58 has a median residual of 0.2 km s⁻¹, while my baseline N7 order 33 has a median residual of 0.4 km s⁻¹. I also determined wavelength calibrations for orders 32, 34, 37, and 38 (N7); and 57, 63, 64, 65, and 66 (N3). Orders 35 and 36 (N7), and 59, 60, 61, 62 (N3) do not have sufficient telluric absorption features to apply this method, while orders 55 and 56 have excessively strong telluric absorption and do not provide sufficient signal for my targets.

⁴Order 59 in *J*-band and order 35 in *K*-band are fit with a Voigt profile, multiplied by a second-order polynomial function, using *scipy*'s `special.wofz` function. The Voigt profile parameters are optimized by a least squares fit.

Table 2.1: NIRSPEC T Dwarf Sample

| Source Name | Coordinates (J2000) | SpT | 2MASS <i>J</i> (mag) | <i>J</i> - <i>K</i> (mag) | μ_{α} (mas yr ⁻¹) | μ_{δ} (mas yr ⁻¹) | <i>d</i> (pc) | Published RV (km s ⁻¹) | Published <i>v</i> sin <i>i</i> (km s ⁻¹) | References ^a |
|-------------------------|-------------------------|------------------------|-------------------------|------------------------------|---|---|------------------|---------------------------------------|--|-------------------------|
| J0000+2554 | 00 00 13.54 +25 54 18.0 | T4.5 | 15.06 ± 0.04 | 0.22 ± 0.13 | -19 ± 2 | 127 ± 1 | 14.12 ± 0.38 | ... | ... | (18, 14, 13) |
| J0034+0523 | 00 34 51.58 +05 23 05.1 | T6.5 | 15.140 ± 0.004 | -0.933 ± 0.03 | 674 ± 1 | 178 ± 2 | 8.42 ± 0.19 | ... | ... | (8, 10, 35) |
| J0136+0933 ^b | 01 36 56.56 +09 33 47.3 | T2.5 | 13.46 ± 0.03 | 0.68 ± 0.04 | 1238 ± 1 | -16 ± 0 | 6.12 ± 0.02 | 11.5 ± 0.4 | 50.9 ± 0.8 | (1, 14, 33, 39) |
| J0150+3827 | 01 50 09.97 +38 27 25.9 | T0 | 16.11 ± 0.08 | 1.63 ± 0.1 | 881 ± 1 | -120 ± 1 | 22.42 ± 1.61 | ... | ... | (17, 35) |
| J0213+3648 | 02 13 19.86 +36 48 38.0 | T3 | 15.3 ± 0.5 | 0.5 ± 0.5 | 65 ± 65 | 0 ± 0 | 14.28 ± 0.04 | ... | ... | (12, 32) |
| J0243-2453 | 02 43 13.72 -24 53 29.8 | T6 | 15.38 ± 0.05 | 0.17 ± 0.18 | -288 ± 4 | -208 ± 3 | 10.68 ± 0.41 | ... | ... | (5, 14, 31) |
| J0415-0935 | 04 15 19.54 -09 35 06.7 | T8 | 15.7 ± 0.1 | 0.3 ± 0.2 | 2214 ± 1 | 536 ± 1 | 5.71 ± 0.06 | 49.6 ± 1.2 | 33.5 ± 2.0 | (5, 13, 43) |
| J0559-1404 | 05 59 19.19 -14 04 49.2 | T4.5 | 13.8 ± 0.02 | 0.23 ± 0.06 | 571 ± 1 | -338 ± 1 | 10.5 ± 0.08 | -9.0 ± 3.0 | 20.1 ± 4.8 | (5, 20, 33, 41) |
| J0627-1114 | 06 27 20.08 -11 14 24.1 | T6 | 15.49 ± 0.05 | 0.06 ± 0.19 | -13 ± 1 | -338 ± 1 | 13.37 ± 0.64 | ... | ... | (17, 34) |
| J0629+2418 | 06 29 05.12 +24 18 08.7 | T2sb ^c | 15.89 ± 0.09 | 0.72 ± 0.18 | -35 ± 4 | -368 ± 4 | 26.67 ± 2.35 | ... | ... | (23, 35) |
| J0755+2212 | 07 55 47.95 +22 12 16.9 | T5 | 15.73 ± 0.06 | 0.0 ± 0.2 | -21 ± 1 | -256 ± 1 | 14.84 ± 0.7 | ... | ... | (5, 35) |
| J0819-0335 | 08 19 58.21 -03 35 26.6 | T4 | 14.99 ± 0.04 | 0.41 ± 0.11 | -199 ± 3 | -166 ± 2 | 14.01 ± 0.43 | ... | ... | (17, 29, 35) |
| J0909+6525 | 09 09 00.86 +65 25 27.6 | T1.5+T2.5 ^e | 16.03 ± 0.09 | 0.86 ± 0.17 | -223 ± 1 | -120 ± 1 | 15.65 ± 0.96 | ... | ... | (10, 9, 35) |
| J0937+2931 | 09 37 34.88 +29 31 41.0 | T6 | 14.65 ± 0.04 | -0.62 ± 0.13 | 973 ± 6 | -1298 ± 5 | 6.12 ± 0.07 | -5.0 ± 3.0 | 60 ± 10.0 | (5, 14, 31, 41) |
| J1106+2754 | 11 06 11.92 +27 54 21.6 | T0+T4.5 ^f | 14.82 ± 0.04 | 1.02 ± 0.07 | -271 ± 1 | -452 ± 1 | 20.3 ± 0.5 | ... | ... | (21, 9, 33) |
| J1217-0311 | 12 17 11.10 -03 11 13.2 | T7.5 | 15.86 ± 0.06 | -0.03 ± 0.07 | -1054 ± 2 | 76 ± 2 | 11.01 ± 0.27 | 5.0 ± 1.6 | 31.4 ± 2.1 | (3, 25, 14, 31, 43) |
| J1225-2739 | 12 25 54.32 -27 39 46.7 | T5.5+T8 ^f | 15.26 ± 0.05 | 0.19 ± 0.16 | 385 ± 3 | -628 ± 2 | 13.32 ± 0.44 | ... | ... | (3, 13, 14, 31) |
| J1254-0122 | 12 54 53.90 -01 22 47.3 | T2e | 14.89 ± 0.04 | 1.05 ± 0.06 | -492 ± 4 | 111 ± 3 | 13.48 ± 0.42 | 4.0 ± 3.0 | 27.3 ± 2.5 | (19, 6, 32, 41) |
| J1324+6358 ^e | 13 24 33.86 +63 58 30.7 | T2p | 15.6 ± 0.07 | 1.54 ± 0.09 | -364 ± 2 | -72 ± 2 | 10.03 ± 0.56 | -23.7 ± 0.4 | 11.5 ± 1.0 | (21, 17, 35, 40) |
| J1331-0116 | 13 31 48.95 -01 16 50.1 | T0 | 15.46 ± 0.04 | 1.39 ± 0.08 | -422 ± 6 | -1039 ± 5 | 20.0 ± 2.0 | ... | ... | (15, 26, 37) |
| J1346-0031 | 13 46 46.35 -00 31 50.1 | T6.5 | 16.0 ± 0.1 | 0.23 ± 0.29 | -503 ± 3 | -114 ± 2 | 14.64 ± 0.49 | -23.1 ± 1.5 | < 15 | (3, 9, 14, 31, 43) |
| J1457-2122 | 14 57 14.96 -21 21 47.8 | T8 | 15.32 ± 0.05 | 0.08 ± 0.16 | 1034 ± 2 | -1726 ± 1 | 5.91 ± 0.06 | 28.9 ± 2.4 | 28.6 ± 2.4 | (4, 38, 31, 43) |
| J1503+2525 | 15 03 19.61 +25 25 19.8 | T5.5 | 13.94 ± 0.02 | -0.03 ± 0.06 | 87 ± 1 | 558 ± 1 | 6.42 ± 0.03 | -40.5 ± 2.1 | 32.8 ± 2.0 | (7, 33, 43) |
| J1506+7027 | 15 06 52.44 +70 27 25.1 | T6 | 13.7 ± 0.03 | -0.09 ± 0.07 | -1194 ± 1 | 1042 ± 1 | 5.16 ± 0.02 | ... | ... | (16, 17, 33) |
| J1520+3546 | 15 20 39.75 +35 46 21.0 | T0 | 15.54 ± 0.06 | 1.54 ± 0.08 | 315 ± 2 | -378 ± 2 | 13.59 ± 1.05 | ... | ... | (10, 14, 35) |
| J1553+1532 | 15 53 02.28 +15 32 36.9 | T6.5+T7.5 ^f | 15.83 ± 0.07 | 0.32 ± 0.2 | -386 ± 1 | 166 ± 1 | 13.32 ± 0.16 | -32.9 ± 3.0 | 29.4 ± 2.3 | (5, 13, 43) |
| J1624+0029 | 16 24 14.37 +00 29 15.8 | T6 | 15.49 ± 0.05 | -0.02 ± 0.07 | -373 ± 2 | -9 ± 2 | 11.0 ± 0.15 | -30.7 ± 3.0 | 38.5 ± 2.0 | (27, 5, 14, 31, 43) |
| J1629+0335 | 16 29 18.41 +03 35 37.1 | T2 | 15.29 ± 0.04 | 1.11 ± 0.07 | 234 ± 2 | -144 ± 2 | 12.99 ± 0.67 | ... | ... | (11, 24, 28, 29) |
| J1809-0448 | 18 09 52.56 -04 48 08.1 | T1 | 15.14 ± 0.05 | 1.18 ± 0.08 | -54 ± 2 | -402 ± 5 | 20.33 ± 1.2 | ... | ... | (2, 35) |
| J1928+2356 | 19 28 41.55 +23 56 01.6 | T6 | 14.34 ± 0.06 | 0.25 ± 0.08 | -248 ± 1 | 239 ± 1 | 6.46 ± 0.08 | ... | ... | (24, 35) |
| J1952+7240 ^f | 19 52 46.66 +72 40 00.8 | T4 | 15.09 ± 0.05 | 0.44 ± 0.09 | -294 ± 1 | -355 ± 2 | 12.1 ± 0.3 | ... | ... | (17, 28) |
| J2030+0749 | 20 30 42.33 +07 49 35.8 | T1.5 | 14.22 ± 0.03 | 0.91 ± 0.05 | 664 ± 1 | -112 ± 1 | 9.73 ± 0.08 | ... | ... | (24, 33) |
| J2126+7617 | 21 26 59.14 +76 17 43.3 | T0p ^f | 14.34 ± 0.03 | 1.18 ± 0.05 | 756 ± 1 | 822 ± 1 | 16.35 ± 0.16 | ... | ... | (16, 17, 33) |
| HN Peg B | 21 44 31.33 +14 46 18.9 | T2.5 | 15.86 ± 0.03 | 0.46 ± 0.03 | 231 ± 0 | -113 ± 0 | 18.13 ± 0.01 | ... | ... | (22, 33) |
| J2236+5105 | 22 36 16.86 +51 05 48.7 | T5 | 14.58 ± 0.04 | 0.13 ± 0.1 | 729 ± 2 | 324 ± 2 | 9.97 ± 0.36 | ... | ... | (2, 35) |
| J2254+3123 | 22 54 18.92 +31 23 49.8 | T5 | 15.26 ± 0.05 | 0.36 ± 0.15 | 60 ± 3 | 187 ± 2 | 13.89 ± 0.58 | 14.0 ± 3.0 | 15 ± 5.0 | (5, 28, 36, 41) |
| J2356-1553 | 23 56 54.77 -15 53 11.1 | T6 | 15.82 ± 0.06 | 0.05 ± 0.19 | -423 ± 4 | -616 ± 4 | 13.44 ± 1.05 | 19.0 ± 3.0 | 15 ± 5.0 | (5, 31, 41) |

Table 2.1 (continued)

Table 2.1 (*continued*)

| Source Name | Coordinates (J2000) | SpT | 2MASS J (mag) | $J - K$ (mag) | μ_{α} (mas yr $^{-1}$) | μ_{δ} (mas yr $^{-1}$) | d (pc) | Published RV (km s $^{-1}$) | Published $v \sin i$ (km s $^{-1}$) | References ^a |
|-------------|------------------------|-----|--------------------|------------------|-------------------------------------|-------------------------------------|-------------|---------------------------------|---|-------------------------|
|-------------|------------------------|-----|--------------------|------------------|-------------------------------------|-------------------------------------|-------------|---------------------------------|---|-------------------------|

^a References are in the order of discovery, classification, astrometry, previously published RV and $v \sin i$ measurements.

^b Previously identified as a member of the Carina-Near moving group.

^c Previously identified as a member of the AB Doradus moving group.

^d Distance is estimated using M_V /spectral type relation in Dupuy & Liu (2012).

^e Suspected binary based on blended light spectrum; the component types are estimated to be L7+T5.5 for J0629+2418 (Mace et al. 2013) and T1.5+T2.5 for J0909+6525 (Burgasser et al. 2010).

^f Confirmed binary as reported in Burgasser et al. (2003c, 2006c, 2010); Kirkpatrick et al. (2010); Dupuy & Liu (2012); and this paper

References – Source discovery/classification: (1) Artigau et al. (2006), (2) Best et al. (2013), (3) Burgasser et al. (1999), (4) Burgasser et al. (2000a), (5) Burgasser et al. (2002), (6) Burgasser et al. (2003a), (7) Burgasser et al. (2003b), (8) Burgasser et al. (2004), (9) Burgasser et al. (2010), (10) Chiu et al. (2006), (11) Deacon et al. (2011), (12) Deacon et al. (2017), (13) Dupuy & Liu (2012), (14) Faherty et al. (2009), (15) Hawley et al. (2002), (16) Kirkpatrick et al. (2010), (17) Kirkpatrick et al. (2011), (18) Knapp et al. (2004), (19) Leggett et al. (2000), (20) Liu et al. (2006), (21)Looper et al. (2007), (22) Luhman et al. (2007), (23) Mace et al. (2013), (24) Mace (2014), (25) Metchev et al. (2008), (26) Schneider et al. (2014), (27) Strauss et al. (1999), Source astrometry: (28) Best et al. (2018), (29) Best et al. (2020), (30) Dupuy & Liu (2017), (31) Faherty et al. (2012), (32) Gaia Collaboration et al. (2018b), (33) Gaia Collaboration et al. (2021), (34) Kirkpatrick et al. (2019), (35) Kirkpatrick et al. (2021), (36) Manjavacas et al. (2013), (37) Smart et al. (2018), (38) Weinberger et al. (2016), Source previously published RV and $v \sin i$: (39) Gagné et al. (2017), (40) Gagné et al. (2018a), (41) Prato et al. (2015), (42) Zapatero Osorio et al. (2006), (43) Zapatero Osorio et al. (2007)

Table 2.2: NIRSPEC T Dwarf Observing Log

| Source | Program PI | UT Date | UT Time ^a (hh:mm:ss) | Integration ^b (s) | Airmass ^d | Filter ^d | Slit | Echelle Angle ^e (deg) | Cross-disperser Angle ^e (deg) | Barycentric Correction (km s ⁻¹) |
|-------------------------|-------------|------------|------------------------------------|---------------------------------|----------------------|---------------------|------------|--|--|--|
| J0000+2554 ^c | Burgasser | 2019-10-17 | 08:39:13 | 2 × 1500 | 1.01 | N3 | 0''/432×12 | 62.97 | 34.09 | -6.329 |
| J0034+0523 ^c | Burgasser | 2020-09-03 | 08:39:31 | 2 × 1400 | 1.62 | N3 | 0''/432×12 | 62.98 | 34.09 | 14.315 |
| J0136+0933 | McLean | 2008-12-04 | 04:38:53 | 4 × 600 | 1.21 | N3 | 0''/432×12 | 63.00 | 34.08 | -21.792 |
| ... | Burgasser | 2013-10-16 | 11:42:53 | 2 × 900 | 1.08 | N7 | 0''/432×12 | 62.97 | 35.47 | 0.857 |
| ... | Burgasser | 2016-02-03 | 05:04:31 | 2 × 750 | 1.15 | N7 | 0''/432×12 | 63.03 | 35.46 | -29.081 |
| J0150+3827 ^c | Burgasser | 2020-08-05 | 13:56:36 | 2 × 1500 | 1.10 | N7 | 0''/432×12 | 62.98 | 35.73 | 26.588 |
| J0213+3648 ^c | Burgasser | 2020-09-03 | 10:08:18 | 1 × 750 | 1.54 | N3 | 0''/432×12 | 62.98 | 34.09 | 24.419 |
| J0243-2453 ^c | Burgasser | 2021-01-01 | 05:27:08 | 2 × 1800 | 1.45 | N3 | 0''/432×12 | 62.95 | 34.06 | -22.462 |
| J0415-0935 | Martin | 2005-10-26 | 12:55:37 | 2 × 600 | 1.16 | N3 | 0''/432×12 | 63.00 | 34.08 | 11.18 |
| ... | Wainscoat | 2006-01-18 | 09:01:02 | 2 × 600 | 1.39 | N3 | 0''/432×12 | 63.00 | 34.08 | -22.389 |
| J0559-1404 | Engineering | 2000-10-10 | 13:53:03 | 4 × 600 | 1.27 | N3 | 0''/576×12 | 63.00 | 34.08 | 22.527 |
| ... | McLean | 2001-10-09 | 15:06:35 | 2 × 600 | 1.20 | N3 | 0''/432×12 | 63.00 | 34.08 | 22.564 |
| ... | Rayner | 2001-11-02 | 13:17:34 | 10 × 300 | 1.21 | N3 | 0''/432×12 | 63.00 | 34.08 | 17.938 |
| ... | McLean | 2001-12-29 | 07:49:17 | 2 × 600 | 1.41 | N3 | 0''/432×12 | 63.00 | 34.08 | -3.097 |
| ... | Martin | 2002-11-25 | 13:06:34 | 3 × 600 | 1.25 | N3 | 0''/576×12 | 63.00 | 34.08 | 10.44 |
| ... | Wainscoat | 2004-12-05 | 13:03:11 | 2 × 300 | 1.34 | N3 | 0''/432×12 | 63.00 | 34.08 | 6.31 |
| ... | Martin | 2005-10-26 | 13:37:56 | 3 × 480 | 1.21 | N3 | 0''/432×12 | 63.00 | 34.08 | 19.706 |
| ... | Martin | 2005-10-27 | 12:35:45 | 3 × 480 | 1.29 | N3 | 0''/432×12 | 63.00 | 34.08 | 19.593 |
| ... | Martin | 2005-10-28 | 12:49:07 | 3 × 480 | 1.26 | N3 | 0''/432×12 | 63.00 | 34.08 | 19.326 |
| ... | McLean | 2006-01-11 | 07:48:54 | 26 × 300 | 1.27 | N3 | 0''/432×12 | 63.00 | 34.08 | -8.445 |
| ... | McLean | 2008-03-19 | 05:55:54 | 7 × 600 | 1.30 | N3 | 0''/432×12 | 63.00 | 34.08 | -23.852 |
| ... | Burgasser | 2015-12-29 | 11:17:25 | 2 × 1500 | 1.30 | N7 | 0''/432×12 | 63.02 | 35.48 | -3.265 |
| ... | Burgasser | 2021-01-01 | 07:58:37 | 2 × 1200 | 1.33 | N3 | 0''/432×12 | 62.95 | 34.06 | -4.434 |
| J0627-1114 ^c | Burgasser | 2021-01-01 | 09:08:11 | 2 × 1800 | 1.21 | N3 | 0''/432×12 | 62.95 | 34.06 | -1.101 |
| J0629+2418 | Burgasser | 2012-11-28 | 12:50:54 | 2 × 1500 | 1.00 | N7 | 0''/432×12 | 63.02 | 35.55 | 14.826 |
| J0755+2212 ^c | Burgasser | 2021-01-01 | 10:16:22 | 1 × 1800 | 1.05 | N3 | 0''/432×12 | 62.95 | 34.06 | 8.315 |
| J0819-0335 ^c | Burgasser | 2021-01-01 | 11:36:35 | 2 × 1800 | 1.09 | N3 | 0''/432×12 | 62.95 | 34.06 | 12.859 |
| J0909+6525 | Burgasser | 2010-12-26 | 12:12:07 | 4 × 1200 | 1.45 | N7 | 0''/432×12 | 63.00 | 35.55 | 7.764 |
| J0937+2931 | McLean | 2002-04-23 | 05:15:35 | 4 × 300 | 1.03 | N3 | 0''/432×12 | 63.00 | 34.08 | -27.634 |
| ... | McLean | 2003-03-24 | 08:12:11 | 6 × 600 | 1.02 | N3 | 0''/432×12 | 63.00 | 34.08 | -20.594 |
| ... | Prato | 2003-05-12 | 05:30:39 | 13 × 300 | 1.03 | N3 | 0''/432×12 | 63.00 | 34.08 | -28.564 |
| ... | McLean | 2006-01-10 | 13:10:31 | 24 × 300 | 1.02 | N3 | 0''/432×12 | 63.00 | 34.08 | 13.261 |
| ... | McLean | 2006-05-19 | 07:15:48 | 8 × 300 | 1.35 | N3 | 0''/432×12 | 63.00 | 34.08 | -28.282 |
| J1106+2754 | McLean | 2008-03-19 | 08:19:51 | 12 × 600 | 1.06 | N3 | 0''/432×12 | 63.00 | 34.08 | -10.193 |
| ... | Burgasser | 2010-12-26 | 15:07:25 | 3 × 1000 | 1.01 | N3 | 0''/432×12 | 62.95 | 34.08 | 25.007 |
| ... | Burgasser | 2012-04-02 | 11:07:11 | 3 × 1500 | 1.20 | N7 | 0''/432×12 | 63.00 | 35.52 | -16.475 |
| ... | Burgasser | 2012-11-27 | 13:42:12 | 3 × 1200 | 1.43 | N7 | 0''/432×12 | 63.01 | 35.52 | 28.583 |

Table 2.2 (continued)

Table 2.2 (continued)

| Source | Program PI | UT Date | UT Time ^a (hh:mm:ss) | Integration ^b (s) | Airmass ^c | Filter ^d | Slit | Echelle Angle ^e (deg) | Cross-disperser Angle ^e (deg) | Barycentric Correction (km s ⁻¹) |
|-------------------------|------------|------------|------------------------------------|---------------------------------|----------------------|---------------------|------------|--|--|--|
| ... | Burgasser | 2013-02-05 | 14:15:17 | 3 × 1500 | 1.07 | N7 | 0''/432×12 | 63.03 | 35.46 | 9.608 |
| ... | Burgasser | 2015-01-01 | 15:00:50 | 2 × 1500 | 1.01 | N7 | 0''/432×12 | 63.03 | 35.46 | 23.434 |
| ... | Burgasser | 2016-01-18 | 14:03:05 | 2 × 1500 | 1.01 | N7 | 0''/432×12 | 63.02 | 35.48 | 17.818 |
| ... | Burgasser | 2016-02-16 | 09:47:02 | 3 × 1400 | 1.13 | N7 | 0''/432×12 | 63.03 | 35.48 | 5.18 |
| ... | Burgasser | 2016-04-22 | 08:43:42 | 3 × 1500 | 1.06 | N7 | 0''/432×12 | 62.98 | 35.48 | -22.888 |
| ... | Burgasser | 2016-05-22 | 07:56:10 | 3 × 1500 | 1.22 | N7 | 0''/432×12 | 62.97 | 35.48 | -27.661 |
| ... | Burgasser | 2017-03-22 | 13:00:58 | 2 × 900 | 1.02 | N7 | 0''/432×12 | 63.02 | 35.52 | 9.678 |
| ... | Burgasser | 2017-05-06 | 07:14:02 | 2 × 1200 | 1.01 | N7 | 0''/432×12 | 63.02 | 35.52 | -25.802 |
| ... | Burgasser | 2018-01-01 | 14:47:39 | 2 × 1500 | 1.01 | N7 | 0''/432×12 | 63.01 | 35.48 | 23.406 |
| ... | Burgasser | 2018-06-03 | 06:19:27 | 2 × 1500 | 1.05 | N7 | 0''/432×12 | 63.01 | 35.38 | -27.541 |
| ... | Burgasser | 2021-01-01 | 12:57:30 | 2 × 1500 | 1.11 | N3 | 0''/432×12 | 62.95 | 34.06 | 23.544 |
| ... | Burgasser | 2021-01-01 | 14:20:08 | 2 × 1500 | 1.01 | N7 | 0''/432×12 | 62.95 | 34.06 | 23.394 |
| J1217-0311 | Martin | 2001-06-15 | 06:08:18 | 2 × 900 | 1.11 | N3 | 0''/576×12 | 63.00 | 34.08 | -28.873 |
| ... | Wainscoat | 2006-01-18 | 14:07:41 | 2 × 600 | 1.10 | N3 | 0''/432×12 | 63.00 | 34.08 | 27.977 |
| ... | Wainscoat | 2006-01-19 | 12:40:31 | 3 × 1200 | 1.27 | N3 | 0''/432×12 | 63.00 | 34.08 | 27.929 |
| J1225-2739 | McLean | 2002-04-23 | 08:37:15 | 6 × 300 | 1.48 | N3 | 0''/432×12 | 63.00 | 34.08 | -6.921 |
| J1254-0122 | McLean | 2001-12-31 | 15:13:36 | 3 × 300 | 1.15 | N3 | 0''/432×12 | 63.00 | 34.08 | 30.294 |
| ... | Basri | 2002-05-17 | 06:55:33 | 9 × 300 | 1.09 | N3 | 0''/432×12 | 63.00 | 34.08 | -19.715 |
| ... | Prato | 2003-05-14 | 05:50:51 | 14 × 300 | 1.24 | N3 | 0''/432×12 | 63.00 | 34.08 | -18.322 |
| ... | Wainscoat | 2006-01-19 | 13:55:21 | 9 × 600 | 1.15 | N3 | 0''/432×12 | 63.00 | 34.08 | 29.206 |
| ... | McLean | 2007-05-31 | 06:51:50 | 8 × 600 | 1.15 | N3 | 0''/432×12 | 63.00 | 34.08 | -24.187 |
| ... | Burgasser | 2011-06-10 | 05:46:19 | 2 × 900 | 1.07 | N7 | 0''/432×12 | 63.00 | 35.53 | -26.549 |
| J1324+6358 | Burgasser | 2016-05-22 | 09:03:28 | 2 × 3000 | 1.44 | N7 | 0''/432×12 | 62.97 | 35.48 | -13.606 |
| J1331-0116 | Burgasser | 2011-03-18 | 12:20:39 | 4 × 1200 | 1.07 | N7 | 0''/432×12 | 63.00 | 35.47 | 12.621 |
| ... | Burgasser | 2011-07-06 | 06:32:30 | 2 × 1500 | 1.17 | N7 | 0''/432×12 | 63.00 | 35.53 | -28.921 |
| ... | McLean | 2013-05-24 | 08:27:28 | 4 × 600 | 1.08 | N3 | 0''/432×12 | 63.00 | 34.08 | 11.046 |
| J1346-0031 | Martin | 2001-06-15 | 07:10:43 | 3 × 900 | 1.08 | N3 | 0''/576×12 | 63.00 | 34.08 | -24.832 |
| ... | Wainscoat | 2006-01-18 | 14:55:32 | 3 × 600 | 1.14 | N3 | 0''/432×12 | 63.00 | 34.08 | 29.934 |
| J1457-2122 | Martin | 2001-06-15 | 08:58:36 | 2 × 900 | 1.41 | N3 | 0''/576×12 | 63.00 | 34.08 | -17.283 |
| ... | Wainscoat | 2006-01-18 | 15:37:10 | 2 × 600 | 1.53 | N3 | 0''/432×12 | 63.00 | 34.08 | 28.542 |
| ... | McLean | 2008-03-19 | 11:22:16 | 8 × 600 | 1.61 | N3 | 0''/432×12 | 63.00 | 34.08 | 23.02 |
| J1503+2525 | Wainscoat | 2006-01-19 | 15:54:04 | 2 × 300 | 1.08 | N3 | 0''/432×12 | 63.00 | 34.08 | 23.037 |
| ... | McLean | 2008-03-19 | 13:48:14 | 8 × 600 | 1.01 | N3 | 0''/432×12 | 63.00 | 34.08 | 13.207 |
| J1506+7027 ^c | Burgasser | 2020-09-03 | 05:17:38 | 2 × 1200 | 1.77 | N3 | 0''/432×12 | 62.98 | 34.09 | 2.035 |
| J1520+3546 | Burgasser | 2012-04-02 | 14:19:49 | 2 × 1200 | 1.09 | N7 | 0''/432×12 | 63.00 | 35.52 | 6.498 |
| J1553+1523 | Martin | 2001-06-15 | 09:38:29 | 2 × 900 | 1.03 | N3 | 0''/576×12 | 63.00 | 34.08 | -12.915 |
| J1624+0029 | Martin | 2001-06-15 | 10:22:21 | 2 × 900 | 1.11 | N3 | 0''/576×12 | 63.00 | 34.08 | -9.423 |
| ... | Basri | 2002-05-17 | 12:23:06 | 8 × 300 | 1.12 | N3 | 0''/432×12 | 63.00 | 34.08 | 3.83 |

Table 2.2 (continued)

Table 2.2 (*continued*)

| Source | Program PI | UT Date | UT Time ^a (hh:mm:ss) | Integration ^b (s) | Airmass ^c | Filter ^d | Slit | Echelle Angle ^d (deg) | Cross-disperser Angle ^c (deg) | Barycentric Correction (km s ⁻¹) |
|-------------------------|------------|------------|------------------------------------|---------------------------------|----------------------|---------------------|------------------------|--|--|--|
| ... | McLean | 2005-06-04 | 08:08:51 | 1 × 600 | 1.18 | N3 | 0 ^h :432×12 | 63.00 | 34.08 | -4.155 |
| J1629+0335 | Burgasser | 2011-08-11 | 06:55:17 | 2 × 1500 | 1.11 | N7 | 0 ^h :432×12 | 63.00 | 35.47 | -25.693 |
| ... | Burgasser | 2011-09-07 | 05:15:20 | 2 × 1200 | 1.12 | N7 | 0 ^h :432×12 | 63.00 | 35.46 | -26.499 |
| J1809-0448 ^c | Burgasser | 2020-08-25 | 06:37:23 | 2 × 1500 | 1.10 | N7 | 0 ^h :432×12 | 62.98 | 35.75 | -24.312 |
| J1928+2356 ^c | Burgasser | 2019-09-12 | 08:00:26 | 1 × 1500 | 1.04 | N7 | 0 ^h :432×12 | 63.00 | 35.76 | -16.283 |
| ... | Burgasser | 2019-10-17 | 06:31:42 | 2 × 1200 | 1.2 | N3 | 0 ^h :432×12 | 62.97 | 34.09 | -21.221 |
| J1952+7240 ^c | Burgasser | 2019-10-17 | 07:31:51 | 2 × 1500 | 1.91 | N3 | 0 ^h :432×12 | 62.97 | 34.09 | 1.957 |
| J2030+0749 ^c | Burgasser | 2020-07-10 | 09:55:16 | 2 × 900 | 1.13 | N7 | 0 ^h :432×12 | 63.00 | 35.73 | 10.869 |
| J2126+7617 | Burgasser | 2011-06-10 | 14:59:25 | 2 × 750 | 1.81 | N7 | 0 ^h :432×12 | 63.00 | 35.53 | 3.919 |
| ... | Burgasser | 2011-07-06 | 13:51:48 | 2 × 1200 | 1.83 | N7 | 0 ^h :432×12 | 63.00 | 35.53 | 7.054 |
| ... | Burgasser | 2011-08-11 | 11:38:20 | 2 × 1500 | 1.84 | N7 | 0 ^h :432×12 | 63.00 | 35.47 | 9.141 |
| ... | Burgasser | 2011-09-07 | 10:49:22 | 2 × 1200 | 1.92 | N7 | 0 ^h :432×12 | 63.00 | 35.46 | 8.549 |
| ... | Burgasser | 2013-09-17 | 10:46:37 | 2 × 1500 | 2.00 | N7 | 0 ^h :432×12 | 62.97 | 35.51 | 7.816 |
| ... | Burgasser | 2013-10-16 | 10:34:47 | 2 × 1500 | 2.38 | N7 | 0 ^h :432×12 | 62.97 | 35.47 | 4.528 |
| ... | Burgasser | 2014-09-02 | 09:25:11 | 2 × 1200 | 1.81 | N7 | 0 ^h :288×12 | 63.02 | 35.49 | 8.839 |
| ... | Burgasser | 2020-08-25 | 08:52:17 | 2 × 1500 | 1.82 | N7 | 0 ^h :432×12 | 62.98 | 35.75 | 9.12 |
| ... | Burgasser | 2020-09-03 | 06:46:14 | 2 × 1200 | 1.93 | N3 | 0 ^h :432×12 | 62.98 | 34.09 | 8.838 |
| HN Peg B | Skemer | 2017-06-09 | 11:21:04 | 20 × 13200 | 1.59 | N7 | 0 ^h :432×12 | 63.01 | 36.60 | 25.737 |
| ... | Skemer | 2017-10-08 | 05:36:07 | 10 × 9000 | 1.07 | N7 | 0 ^h :432×24 | 62.93 | 36.55 | -17.657 |
| J2236+5105 ^c | Burgasser | 2020-09-03 | 07:44:53 | 2 × 1200 | 1.34 | N3 | 0 ^h :432×12 | 62.98 | 34.09 | 8.472 |
| J2254+3123 | Prato | 2003-08-10 | 09:20:13 | 10 × 300 | 1.32 | N3 | 0 ^h :432×12 | 63.00 | 34.08 | 16.077 |
| ... | McLean | 2005-07-19 | 12:17:11 | 4 × 600 | 1.06 | N3 | 0 ^h :432×12 | 63.00 | 34.08 | 21.277 |
| ... | McLean | 2004-11-21 | 05:38:26 | 1 × 300 | 1.03 | N5 | 0 ^h :288×24 | 62.61 | 36.90 | -21.596 |
| ... | McLean | 2007-06-26 | 14:15:19 | 4 × 600 | 1.04 | K | 0 ^h :432×24 | 63.00 | 35.65 | 23.945 |
| J2356-1553 | McLean | 2003-07-20 | 12:50:03 | 4 × 600 | 1.36 | N3 | 0 ^h :432×12 | 63.00 | 34.08 | 23.527 |
| ... | McLean | 2005-07-19 | 13:52:18 | 3 × 600 | 1.25 | N3 | 0 ^h :432×12 | 63.00 | 34.08 | 23.519 |
| ... | McLean | 2005-12-10 | 05:21:03 | 6 × 600 | 1.23 | N3 | 0 ^h :432×12 | 63.00 | 34.08 | -29.26 |

^a Values are taken from the configuration of the first file within the same night.

^b The number of files times the individual integration time.

^c Observed with the upgraded NIRSPEC.

^d Filters: N3 (NIRSPEC-3), N5 (NIRSPEC-5), N7 (NIRSPEC-7), and K (NIRSPEC K)

2.2 Forward-Modeling Method

As part of my thesis work, I have implemented a Markov Chain Monte Carlo forward-modeling framework written in Python called *Spectral Modeling Analysis and RV Tool* “SMART”, which can extract precise radial and rotational velocities as well as effective temperatures and surface gravities. My thesis work is focused on the analysis of Keck/NIRSPEC and SDSS/APOGEE. However, the SMART is capable of modeling several instruments, including Keck/NIRSPEC, SDSS/APOGEE, Keck/HIRES (the High-Resolution Echelle Spectrometer; Vogt et al. 1994), Gemini South/IGRINS (Immersion GRating INfrared Spectrometer; Mace et al. 2018), Lick/APF (Automated Planet Finder; Vogt et al. 2014), Keck/OSIRIS (OH-Suppressing Infrared Imaging Spectrograph; Larkin et al. 2006), and Keck/NIRES (Near-Infrared Echellette Spectrometer Wilson et al. 2004). In this section, I described the modeling routines for Keck/NIRSPEC and SDSS/APOGEE.

Overview

The typical approach to spectral reduction is to correct for instrumental and telluric atmospheric effects to infer the target’s emitted spectrum. Here, I model these effects explicitly using a forward-modeling approach, following Blake et al. (2010) and Burgasser et al. (2016) (see also Tanner et al. 2012; Allers et al. 2016; Vos et al. 2017; Cale et al. 2019). The stellar parameters (effective temperature, surface gravity, rotational velocity, and radial velocity), and calibration factors (continuum and wavelength corrections, instrumental line-spread function, and strength of telluric absorption) are determined using a Markov Chain Monte Carlo (MCMC) algorithm (Goodman & Weare 2010) using the package *emcee* (Foreman-Mackey et al. 2013). My forward-modeling method is optimal in those spectral orders with both strong telluric absorption features for

accurate wavelength calibration, and sufficient structure in the stellar spectrum to distinguish it from the telluric absorption. I found order 33 in the K -band ($N7$; 22690–23410 Å) and order 58 in the J -band ($N3$; 12990–13290 Å) to be the ideal orders for the T dwarfs, similar to prior studies (Blake et al. 2010; Konopacky et al. 2010; Burgasser et al. 2012; Tanner et al. 2012). My forward-modeling routine *Spectral Modeling Analysis and RV Tool* (SMART; Hsu et al. 2021) is open source and available online.⁵

To summarize, there are three main steps in my MCMC forward-modeling scheme:

1. An MCMC fit of the telluric spectrum is performed to determine the parameters for the instrumental line-spread function (LSF) and the strength of telluric absorption, which are used to initialize the MCMC of the science spectrum.
2. An initial MCMC fit of the science spectrum is conducted to estimate the stellar parameters for effective temperature (T_{eff}), surface gravity ($\log g$), rotational velocity ($v \sin i$), and radial velocity (RV), as well as calibration and nuisance parameters.
3. The residuals between the best-fit model spectrum and data are used to generate a mask array to identify discrepant pixels, and a final MCMC fit of the masked science spectrum is run to obtain the best estimates of the fit parameters.

Telluric Star Modeling

Each telluric standard star was forward-modeled to obtain initial estimates of the LSF and strength of telluric absorption. The data (D) are modeled as:

$$D[p] = C[p(\lambda)] \times \left[T[p^*(\lambda)]^\alpha \otimes \kappa_G(\Delta v_{\text{inst}}(p)) \right] + C_{\text{flux}}. \quad (2.1)$$

⁵<https://github.com/chihchunhsu/smart>

Here, p is the pixel coordinate, $p^*(\lambda) = p(\lambda) + C_\lambda$ is the mapping of wavelength to pixel with a small constant offset, $C[p]$ is a second-order polynomial representing the continuum correction, $\kappa_G(\Delta v_{\text{inst}})$ is the instrumental LSF, assumed to be Gaussian of velocity width Δv_{inst} (\otimes represents convolution), $T[p]$ is a model for telluric absorption from Moehler et al. (2014), α is a constant that scales with the airmass and precipitable water vapor, and C_{flux} is an additive offset for the overall flux. The default precipitable water vapor (pwv) for the Moehler et al. (2014) models used was 0.5 mm. For some data, a telluric model with pwv = 1.5 mm produced a better fit and these were used instead. I fit the parameters, Δv_{inst} , C_{flux} , C_λ , and α assuming uniform priors (Table 2.3), while the continuum was determined after each iteration through a least-squares fit of the ratio of the data and model to a second-order polynomial (i.e., the continuum fit was done outside of the MCMC). The likelihood function was computed by assuming the noise follows a normal distribution:

$$\ln \mathcal{L} = -0.5 \times [\sum \chi^2 + \sum \ln(2\pi\sigma^2)], \quad (2.2)$$

where $\chi = \frac{\text{Data}[p] - D[p]}{\sigma[p]}$, and Data and σ are the observed spectrum and noise. I used 50 walkers of 400 steps each and a burn-in of 300 steps, with these parameters chosen⁶ to optimize convergence. The convergence of each fit was checked visually and quantified using both the Gelman-Rubin scale reduction factor (Gelman & Rubin 1992) and integrated autocorrelation time statistics (Goodman & Weare 2010). For each fit, I inferred the best-fit parameter values and their uncertainties by computing the 50th, 16th, and 84th percentiles of the marginalized posterior distributions from the residual MCMC chains.

⁶See Section 2.2 for discussions on convergence.

T Dwarf Modeling

The T dwarf spectra were forward-modeled as:

$$D[p] = C[p] \times \left[\left(M \left[p^* \left(\lambda \left[1 + \frac{RV^*}{c} \right] \right), T_{\text{eff}}, \log g \right] \right. \right. \\ \left. \left. \otimes \kappa_R(v \sin i) \right) \times T \left[p^*(\lambda) \right]^\alpha \right] \otimes \kappa_G(\Delta v_{\text{inst}}) + C_{\text{flux}}, \quad (2.3)$$

where the additional terms compared to equation (2.1) include the solar-metallicity stellar atmosphere model⁷ $M[p]$ drawn from the BT-Settl (Allard et al. 2012) and Sonora (Marley et al. 2018) model grids, parameterized by effective temperature (T_{eff}) and surface gravity ($\log g$); $RV^* = RV + v_{\text{bary}}$ is the radial velocity of the source plus barycentric motion of the Earth at the observed epoch; c is the speed of light; κ_R is the rotational broadening profile defined in Gray (1992) assuming a constant limb-darkening coefficient of $\varepsilon = 0.6$ (Claret 2000); and $v \sin i$ is the projected rotational velocity. Atmosphere model log fluxes were linearly interpolated between grid points to approximate a continuous distribution of T_{eff} and $\log g$ values. The likelihood function is:

$$\ln \mathcal{L} = -0.5 \times \left[\sum \chi^2 / C_{\text{noise}}^2 + \sum \ln(2\pi(C_{\text{noise}} \sigma)^2) \right], \quad (2.4)$$

where C_{noise} is a constant scaling factor for the noise (σ) to take into account underestimates or overestimates of observational noise in computing χ^2 ; as well as systematic errors between the model and the spectrum, such as missing line features. I performed an initial MCMC fit for the parameters T_{eff} , $\log g$, RV^* , $v \sin i$, α , C_λ , C_{flux} ⁸, and C_{noise} , modeling the continuum in the same manner as the telluric standard. The nuisance pa-

⁷See Section 2.2.1 for discussions of model selection

⁸The values are determined based on the percentage of median flux $C_{\text{flux}} = C_{\text{flux}^*} \times F$, where F is the median flux.

parameter C_λ takes into account the small shift in instrument alignment between the telluric and science integrations. RVs inferred between subsequent nods are more consistent when this nuisance parameter is included in the forward model. Stellar model parameter prior ranges were chosen to encompass the typical properties of T dwarfs, with $T_{\text{eff}} = 600$ to 1300 K, $\log g = 3.5$ to 5.5 dex (in units of cm s^{-2}), $v \sin i = 0$ to 100 km s^{-1} , and $RV^* = -200$ to $+200 \text{ km s}^{-1}$. The MCMC bounds of T_{eff} are set for the whole range of the available model sets (BT-Settl = 500 to 3500 K and Sonora = 200 to 2400 K) (Table 2.3). The initial MCMC used 50 walkers of 600 steps each and burn-in of 300 steps, and convergence was verified by inspection of parameter chains and a requirement of the Gelman-Rubin scale reduction factor (Gelman & Rubin 1992) of less than 1.32. Typically convergence occurred after the first 100–200 steps.

The Gelman-Rubin scale reduction factor and autocorrelation time suggested by Goodman & Weare (2010) were used to test convergence for a representative set of telluric and science spectra, and to set the number of walkers and steps for all fits. I tested the MCMC runs with 50 chains of 600 to 8,000 steps each. The χ^2 values were similar, and the best-fit parameters were fully consistent within the uncertainties, but longer chains reduced the scale reduction factor from 1.2 to 1.01. The longest autocorrelation time was 120 steps, estimated from the runs with 8000 steps. Among these select sets of fits, I found that longer chains did not significantly improve the fits, which only have lower Gelman-Rubin scale reduction factor and converged autocorrelation times, but not change to the parameter values or uncertainties. Due to my limited computational resources, I chose to run only 600 steps, where the convergence was checked visually and confirmed by the requirement that the Gelman-Rubin scale reduction factors were all less than 1.32 (50th, 16th, and 84th percentiles of $R = 1.05$, 1.03 , and 1.13).

Residuals between the best-fit model and data from this first pass were used to

generate a pixel mask rejecting 2.5σ outliers⁹, typically cosmic rays and bad pixels in the detector. A second MCMC was then run on the masked data using the same MCMC fit parameters and initializing model parameters from the first MCMC fit plus a random offset drawn from uniform parameter ranges spanning $\Delta T_{\text{eff}} = \pm 20$ K, $\Delta \log g = \pm 0.1$ dex, $\Delta v \sin i = \pm 1$ km s⁻¹, and $\Delta RV = \pm 1$ km s⁻¹. The masking step considerably improved the RV and $v \sin i$ uncertainties and the overall spectral fit. The derived RVs were corrected to the heliocentric frame using the *astropy* function `radial_velocity_correction` to compute v_{bary} .

Each individual spectrum was forward-modeled, and measurements both within an epoch and across epochs (for multi-epoch data) were averaged using uncertainty weighting, with weight $W \propto 1/(\sigma_{\text{lower}}^2 + \sigma_{\text{upper}}^2)$, where σ_{lower} , σ_{upper} are the uncertainties associated with the 16th and 84th percentiles of each marginalized parameter distribution. In a few cases where the S/N of an individual spectrum is lower than 10, all spectra in an epoch were coadded before forward-modeling. Table 2.4 lists the RV, $v \sin i$, T_{eff} and $\log g$ values inferred for each source and epoch, along with previously published values from the literature.

2.2.1 Evaluating the Fits

Fit Quality and Parameter Correlations

Figures 2.1–2.4 illustrate representative fits to science data in orders 33 (T2.5 J0136+0933) and 58 (T4.5 J0559–1404).

For the order 33 fit, residuals between the data and the best-fit BT-Settl model are on par with the scaled noise ($\chi_r^2 = 1.3$,¹⁰ for $C_{\text{noise}} = 0.7$), and all of the marginalized

⁹Typically, $\sim 3\%$ of the pixels are masked.

¹⁰ χ_r^2 is the reduced chi-square statistic computed as $\chi_r^2 = \frac{1}{N_{\text{DOF}}} \sum \text{Mask}[p] \left(\frac{\text{Data}[p] - D[p]}{C_{\text{noise}} \sigma[p]} \right)^2$, where $\text{Mask}[p]$ is the pixel mask ($\text{Mask} = 1$ for good data, $\text{Mask} = 0$ for bad data) and N_{DOF} is the number of degrees of freedom computed as $N_{\text{DOF}} = [\text{number of unmasked data pixels}]/3 - [\text{number of fit param-}]$

Table 2.3: Modeling Parameter Ranges

| Description | Symbol (unit) | Priors ^a | Bounds |
|------------------------|--|---------------------|-----------------------------|
| Telluric Standard Star | | | |
| Line Spread Func. | Δv_{inst} (km s ⁻¹) | (3.0, 6.0) | (2.0, 10.0) |
| Flux Offset | C_{flux} | (-1.0, +1.0) | (-500, +500) |
| Wavelength Offset | C_{λ} (Å) | (-0.02, +0.02) | (-0.04, +0.04) ^b |
| Telluric Scaling | α | (0.3, 3.0) | (0.3, 10.0) |
| T Dwarf | | | |
| Effective Temp. | T_{eff} (K) | (600, 1300) | B [±] (500, 3500) |
| ... | ... | ... | S [±] (200, 2400) |
| Surface Gravity | $\log g$ (cm s ⁻²) | (3.5, 5.5) | (3.5, 5.5) |
| Rotational Velocity | $v \sin i$ (km s ⁻¹) | (0, 100) | (0, 100) |
| Radial Velocity | RV (km s ⁻¹) | (-200, +200) | (-200, +200) |
| Flux Offset | C_{flux^*} | (-0.01, +0.01) | (-0.05, +0.05) ^c |
| Wavelength Offset | C_{λ} (Å) | (-0.6, +0.6) | (-0.6, +0.6) ^b |
| Telluric Scaling | α | (0.9, 1.1) | (0.1, 10.0) |
| Noise Factor | C_{noise} | (0.99, 1.01) | (0.1, 5.0) |

^a Uniform priors

^b The Telluric Standard Star wavelength offset bounds range is much smaller than the T Dwarf offset bounds range as the data for the former are used to formally derive the wavelength solution while the data for the latter incur pixel shifts due to instrumental flexure between pointings. See Section 2.2 for more details.

^c BT-Settl model

^d Sonora model

^e The values are determined based on the percentage of median flux $C_{\text{flux}} = C_{\text{flux}^*} \times F$, where F is the median flux.

distributions show normal distributions, modulo parameter limits (e.g., $\log g$). This fit exemplifies parameter correlations found in some (but not all) of the order 33 fits. First, I find a negative correlation between $v \sin i$ ($\Delta v \sin i = 3 \text{ km s}^{-1}$) and $\log g$ ($\Delta \log g = 0.2 \text{ dex}$) that I attribute to a degeneracy between rotational and pressure broadening. A larger $\log g$ results in greater pressure broadening, which is compensated for by a smaller $v \sin i$, and vice-versa. Disentangling this correlation in the line spread shape would require higher resolution and higher signal-to-noise data than is available with the current dataset. Second, I find a positive correlation between T_{eff} ($\Delta T_{\text{eff}} = 50 \text{ K}$) and $\log g$ ($\Delta \log g = 0.2 \text{ dex}$) that I attribute to temperature and pressure effects in the primary carbon reduction reaction, $\text{CO} + 3\text{H}_2 \Leftrightarrow \text{CH}_4 + \text{H}_2\text{O}$. This reaction is driven toward the right (weaker CO and stronger CH₄) at low temperatures and high pressures. Disentangling the T_{eff} - $\log g$ correlation could be achieved with an accurate measure of the surface flux, and hence the luminosity and radius of each source, which is beyond the scope of this work. Finally, I find a positive correlation between RV ($\Delta RV = 0.4 \text{ km s}^{-1}$) and C_λ ($\Delta C_\lambda = 0.03 \text{ \AA}$) which is inherent to the simultaneous fitting of the Doppler shift of the source and instrumental shift of the wavelength calibration. As noted above, the C_λ term is necessary to enforce agreement of RVs measured within a single epoch, which far exceed the slight increase to my marginalized RV uncertainties.

For the order 58 fit, residuals between the data and the best-fit Sonora model are again consistent with uncertainty ($\chi_r^2 = 1.7$ for $C_{\text{noise}} = 1.2$), and marginalized distributions for most parameters reflect normal distributions with the exception of $\log g$ (parameter limit) and $v \sin i$, the latter of which shows a sharp lower cutoff at 17 km s^{-1} . I find only a slight positive correlation between RV ($\Delta RV = 0.2 \text{ km s}^{-1}$) and C_λ ($\Delta C_\lambda = 0.01 \text{ \AA}$).

ters]. The factor of 1/3 takes into account the pixel-to-pixel correlations caused by the finite slit width, typically 3 pixels ($0''.432$). I consider fits with $\chi_r^2 < 2.5$ to be consistent within uncertainties.

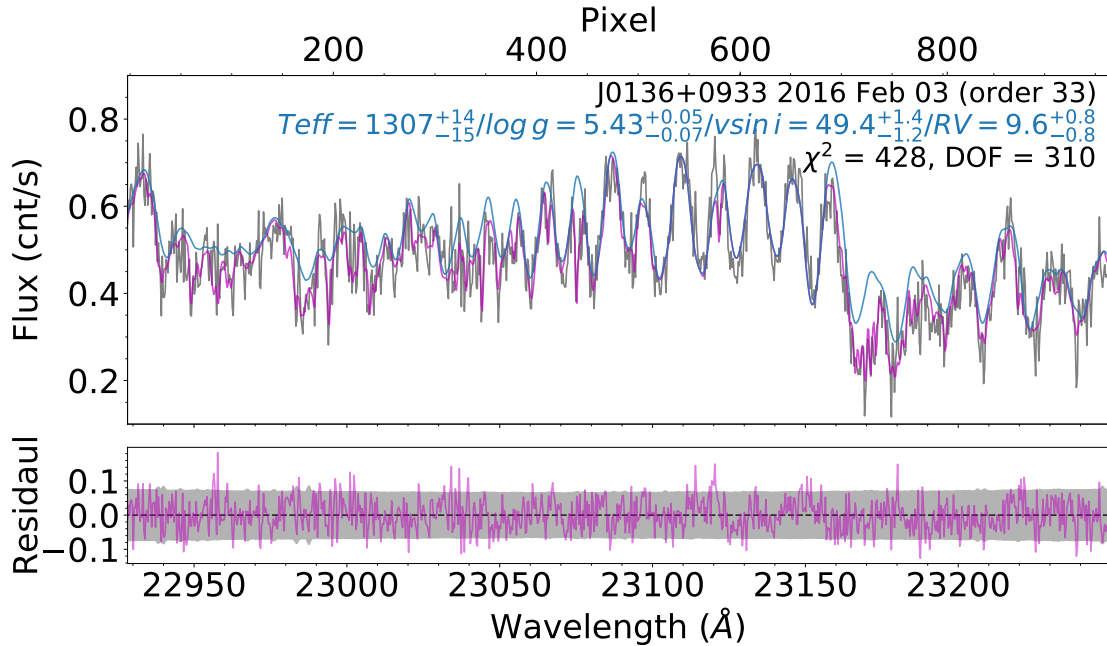


Figure 2.1: BT-Settl model fit of the order 33 spectrum of the T2.5 J0136+0933, observed on 2016 February 3 (UT). The horizontal axis displays both pixel position (top axis) and wavelength (bottom axis). Upper panel: the grey line is the observed spectra; the magenta and blue lines are the stellar model with and without telluric absorption, respectively. Lower panel: difference of the data minus model (magenta) with $\pm 1\sigma$ data uncertainty shaded in grey. The best-fit parameters are listed at the upper right corner of the top panel, with effective temperature (T_{eff}) in K, surface gravity ($\log g$) in cm s^{-2} , rotational velocity ($v \sin i$) in km s^{-1} , and radial velocity (RV) in km s^{-1} .

Substellar Atmosphere Model Selection

Both BT-Settl and Sonora model sets were used for all forward-modeling analyses, and I determined the best choice between these sets for each source and order through a combination of visual inspection, χ^2 , F-test, and Bayesian information criterion¹¹ (BIC). In general, the Sonora models provide significantly better fits to order 58 (J -band) spectra of mid- and late-T dwarfs, while the BT-Settl models provide marginally better fits for order 33 (K -band) spectra of early-T dwarfs. I attribute the significant improvement in

¹¹BIC = $\chi_{\text{min}}^2 + k \log_{10} N$, where χ^2 is the chi-square statistic for the best-fitting model, k is the number of parameters, and N is the number of data points (Schwarz 1978). Statistical significance for ruling out the null hypothesis (in this case, that the model sets provide equivalent fits) is assessed following Kass & Raftery (1995), in which the ΔBIC ranges of 0–2, 2–6, 6–10, and > 10 are categorized as insignificant, positive, strong, and very strong evidence against the null hypothesis, respectively.

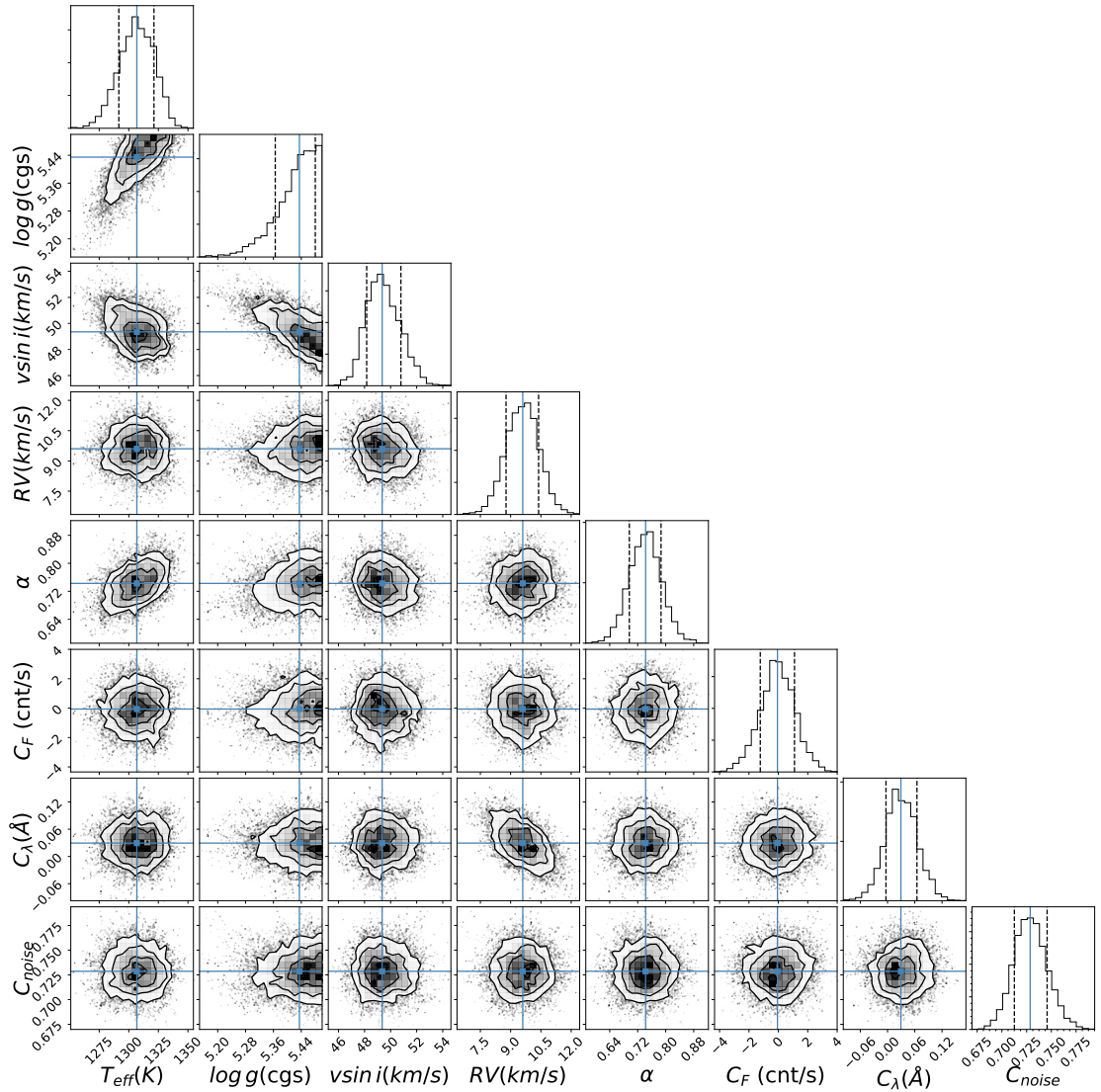


Figure 2.2: The posterior probability distribution of fits to the order 33 spectrum of the T2.5 J0136+0933 observed on 2016 February 3 (UT). The parameters shown are effective temperatures (T_{eff}) in K, surface gravity ($\log g$) in cm s^{-2} , projected rotational velocity ($v \sin i$) in km s^{-1} , radial velocity (RV) in km s^{-1} , telluric scale factor (α), nuisance flux parameter (C_F) in count/s , nuisance wavelength parameter (C_λ) in \AA , and noise scale factor (C_{noise}). The black dash lines are the 16th and 84th percentiles in the marginalized distributions (diagonal plots), and the blue lines denote the median values in both marginalized distributions and interior parameter correlation plots.

Sonora model fits to the J -band data to the updated CH_4 opacities in these models, a particularly important factor for the coldest brown dwarfs. The slightly better fits for the BT-Settl models at K -band may be due to the inclusion of cloud opacity in these models,

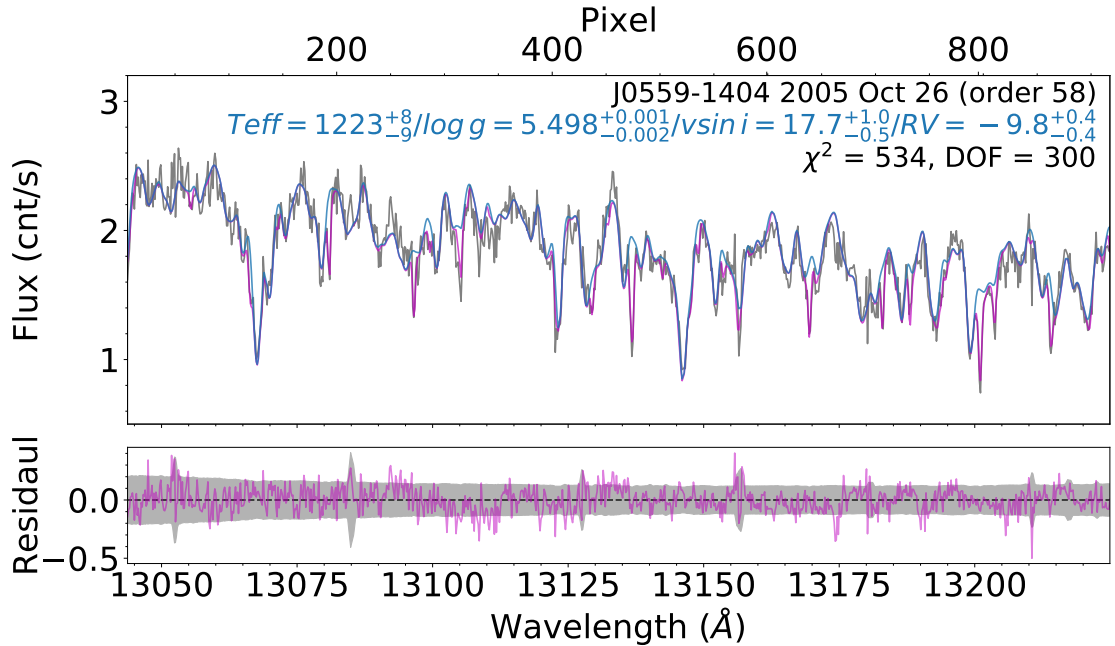


Figure 2.3: Sonora model fit of the order 58 spectrum of the T4.5 J0559–1404, observed on 2005 October 26 (UT). Notation is identical to Figure 2.1.

which are absent in the Sonora grid, although such opacity should have relatively modest influence in the $2 \mu\text{m}$ region.

The choice of model does influence the physical parameters inferred for each source. Comparing the best-fit parameters between the two models across all sources, orders, and epochs, I found that measured RV and $v \sin i$ values are relatively robust to model choice, with median model discrepancies (Sonora minus BT-Settl) of $\Delta RV = 0.6 \pm 1.5 \text{ km s}^{-1}$ and $\Delta v \sin i = -2 \pm 4 \text{ km s}^{-1}$. The RV offset between the models is dominated by order 58 fits of mid- and late- T dwarfs, for which $\Delta RV = 1.2 \text{ km s}^{-1}$. Order 33 fits of early-T dwarfs have $\Delta RV = 0.4 \text{ km s}^{-1}$. The $v \sin i$ offsets are again dominated by order 58 fits, where the velocity kernel must be broadened for the BT-Settl models to compensate for missing CH_4 opacities. The median $\Delta v \sin i$ for order 58 is -2.9 km s^{-1} while the median $\Delta v \sin i$ for order 33 is 0.0 km s^{-1} . The most discrepant $v \sin i$ measurements are among the order 58 fits for mid-T dwarfs, where the Sonora

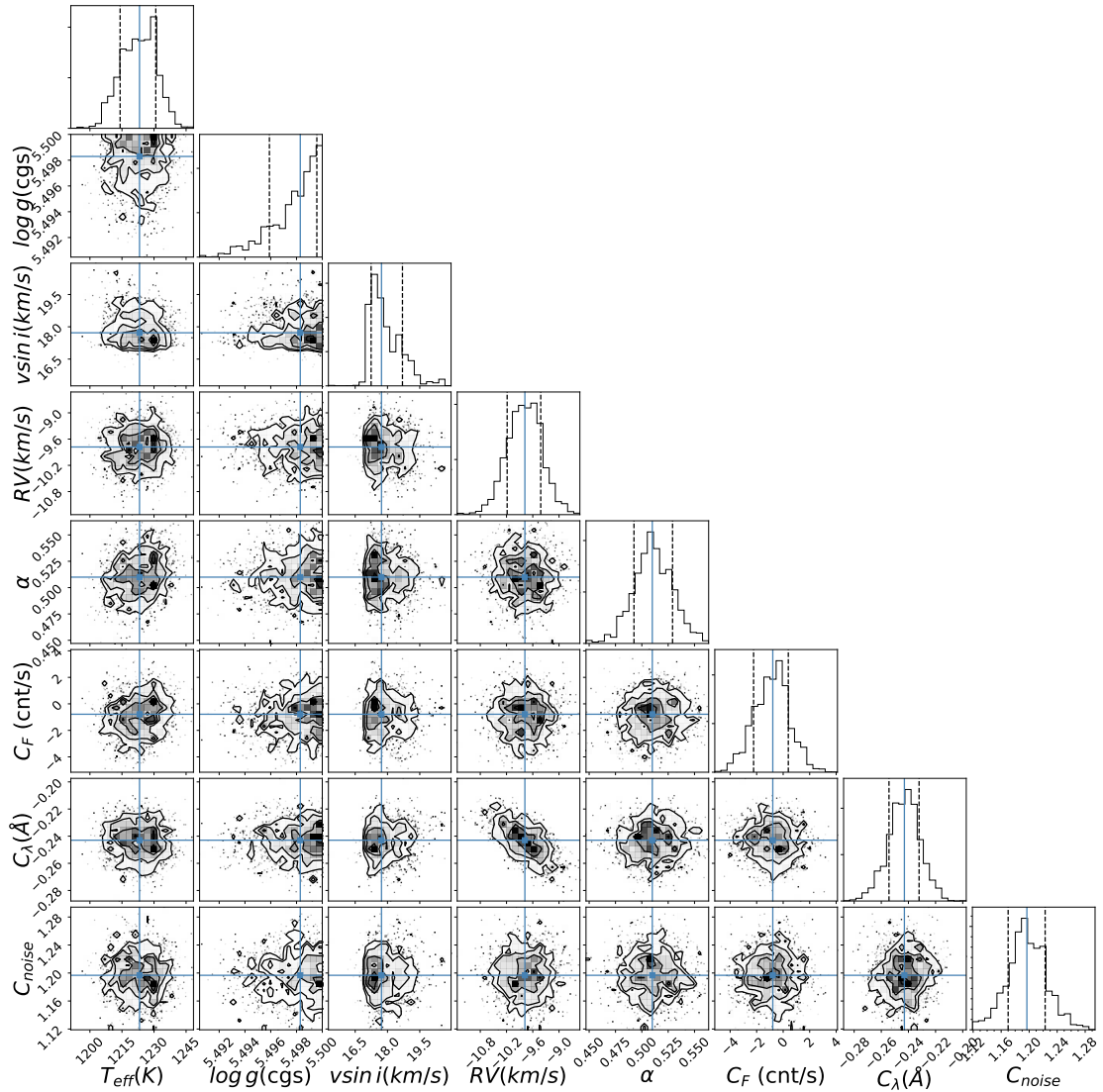


Figure 2.4: The posterior probability distribution of fits to the order 58 spectrum of the T4.5 J0559–1404, observed on 2005 October 26 (UT). Notation is identical to Figure 2.2.

models are far more robust.

The atmosphere parameters T_{eff} and $\log g$ show considerably more variance between the models (Figure 2.5). T_{eff} s inferred from the Sonora model fits are consistently hotter than those inferred from the BT-Settl model fits for early- to mid-T dwarfs in both orders 33 and 58, with a median offset of 240 ± 110 K. For late-T dwarfs, the Sonora model fits are cooler. More striking is the difference in $\log g$ values inferred for

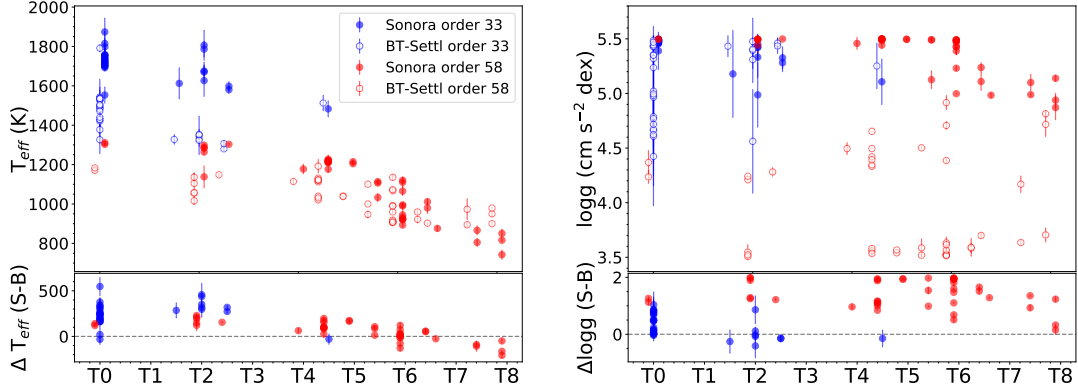


Figure 2.5: Comparison of inferred T_{eff} (left) and $\log g$ (right) parameters between the BT-Settl (open circles) and Sonora (filled circles) models as a function of spectral type, in orders 33 (blue) and 58 (red). Differences (Sonora–BT-Settl) are shown in the lower panels. The Sonora models are slightly offset in subtypes for better visual comparisons.

order 58 (J -band) data, for which BT-Settl models typically converge to $\log g \approx 3.5$ dex, the minimum of the model parameter range. In contrast, $\log g$ values inferred from fits to order 33 (K -band) data are generally consistent between the models, with a median difference of only 0.14 ± 0.40 dex, although both models often converge to the maximum model parameter value of 5.5 dex.

Examination of Fits Across Different Orders

For the sources with measurements in both bands, I examined the consistency of T_{eff} and $\log g$ measurements between orders for six sources with measurements with both J - and K -band spectra. These sources are J0136+0933, J0559–1404, J1106+2754, J1254–0122 (orders 33 and 58), J1928+2356 (orders 37 and 58), and J2126+7617 (orders 33 and 57). T_{eff} values inferred from K -band data are consistently higher than those inferred from J -band data (average $\Delta T_{\text{eff}} = 187$ K, range -182 K to 341 K; excluding J2126+7617 yields an average $\Delta T_{\text{eff}} = 260$ K, range 140 K to 341 K). $\log g$ values differed by up to 1.20 dex between orders but with no clear trend (average $\log g = 0.27$ dex, range

–0.39 dex to 1.20 dex). For J1928+2356 and J2126+7617, the average differences in T_{eff} and $\log g$ between orders are more than 150 K and 0.08 dex, respectively. RV and $v \sin i$ values are generally consistent across the orders, except for sources with low S/N data (J1254–0122 on 2011 Jun 10 and J1928+2356 on 2019 Sep 12¹²) and binaries (J1106+2754 and J2126+7617).

The best-fit parameters for sources observed in multiple orders were determined generally by spectral type: $N7$ for early T dwarfs and $N3$ for mid- and late-T dwarfs. For J1254–0122, I used the order with the higher S/N data.

Minimum $v \sin i$

The finite resolution of NIRSPEC data places a fundamental limit on my ability to measure rotational broadening for the slowest rotators, which scales with the width of the instrumental LSF. Blake et al. (2010) found a minimum detectable $v \sin i$ of 9 km s^{-1} for their NIRSPEC sample of M8–L6 dwarfs. My T dwarf spectra contain a higher density of molecular features, with overlapping CO and CH₄ absorption bands, and lower S/N. I empirically determined the minimum detectable $v \sin i$ limits for order 33 and 58 data by analyzing simulated NIRSPEC data derived from the model grids, using the same forward-modeling method as the science data. I evaluated a representative set of models with $T_{\text{eff}} = 900, 1200, 1500 \text{ K}$; $\log g = 5.0 \text{ dex}$; $\text{RV} = 0 \text{ km s}^{-1}$; $\text{pwv} = 1.5 \text{ mm}$; $\text{airmass} = 1.0$; $\text{instrumental LSF} = 4.8 \text{ km s}^{-1}$ (my typical value); $v \sin i = 1\text{--}15 \text{ km s}^{-1}$ in steps of 1 km s^{-1} , and $15\text{--}25 \text{ km s}^{-1}$ in steps of 5 km s^{-1} ; and $\text{S/N} = 1\text{--}10$ in steps of 1, and $10\text{--}25$ in steps of 5. Gaussian noise was applied using pre-upgrade NIRSPEC values for detector gain, read noise, and dark current, and I assumed an integration time of 1500 s. I defined a robust measurement to be the difference between the true $v \sin i$ and measured $v \sin i$ of less than 1 km s^{-1} . With this benchmark, I determined the minimum robust $v \sin i$ to be

¹²RV values are consistent, but $v \sin i$ values are not.

9 km s^{-1} for $S/N \geq 5$ for both orders 33 and 58, equivalent to the minimum $v \sin i$ for late-M and L dwarfs determined by Blake et al. (2010). Discrepancies generally increase from high to low S/N ¹³. For $S/N < 5$ data, $v \sin i$ fits become much less robust and a more conservative $v \sin i$ lower limit of 15 km s^{-1} is adopted. Hence, the slowest rotators in my sample, J0000+2554 ($v \sin i = 4 \pm 2 \text{ km s}^{-1}$, $S/N = 5$), J0627–1114 ($v \sin i = 5.4^{+2.5}_{-2.0} \text{ km s}^{-1}$, $S/N = 6$), J0819–0335 ($v \sin i = 8.5^{+1.4}_{-2.4} \text{ km s}^{-1}$, $S/N = 9$), and J2236+5105 ($v \sin i = 6.6 \pm 0.9 \text{ km s}^{-1}$, $S/N = 22$) are assigned limits of $< 9 \text{ km s}^{-1}$; while J2030+0749 ($v \sin i = 14.0^{+0.9}_{-1.0}$, $S/N = 4$), is assigned a limit of $< 15 \text{ km s}^{-1}$.

¹³See the diagnostic plots in Appendix A

2.3 Modeled Parameters

2.3.1 Radial Velocities

My RV measurements range over -43 to $+56$ km s^{-1} with a median value of 1.2 km s^{-1} and a median uncertainty of 0.6 km s^{-1} . These measurements are consistent with a population drawn from the local disk, as verified in further detail below. These measurements are also largely consistent with 14 sources previously reported in the literature (Figure 2.6; Table 2.4), but with a median factor of 5.5 improvement in uncertainty. The only significant ($> 3\sigma$) RV outlier is J1346–0031, for which my measurement of $-17.5^{+0.6}_{-0.5}$ km s^{-1} is 5.1 km s^{-1} higher than that reported in Zapatero Osorio et al. (2007). For this source (and others), I found my RVs to be consistent between nod pairs in individual epochs and across 2 epochs, albeit with a relatively large C_λ correction of 4 km s^{-1} , which may explain the difference with the previously reported value. I found no correlation between RV discrepancies and spectral type. The spatial kinematics of my sources are described further in Section 2.5.

2.3.2 Projected Rotational Velocities

My $v \sin i$ measurements range over 4^{14} to 90 km s^{-1} , with a median value of 27 km s^{-1} and a median uncertainty of 0.9 km s^{-1} . These velocities correspond to maximum rotational periods of 1.5 hr to 28 hr for spheres of radius $R = 1 R_{\text{Jup}}$ observed at an inclination of 90° (equator-on), and indicate a population of rapid rotators as previously inferred from other studies (Zapatero Osorio et al. 2006; Prato et al. 2015; Radigan et al. 2012; Metchev et al. 2015; Vos et al. 2017; Tannock et al. 2021). My $v \sin i$ measurements are generally consistent with those previously reported in the literature

¹⁴In Section 2.2.1, I determined the minimum $v \sin i$ to be 9 km s^{-1} , with four sources of my sample under such limit.

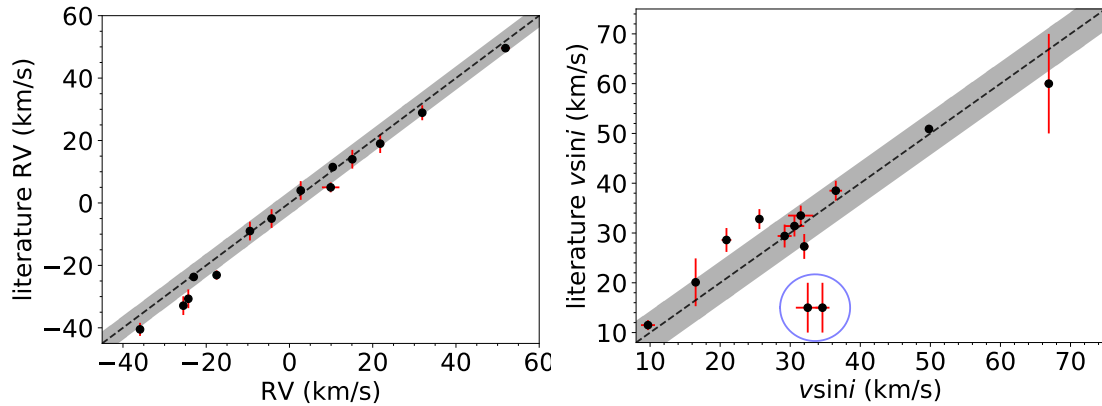


Figure 2.6: Comparison of RV (left) and $v \sin i$ (right) measurements from my NIRSPEC data to previously reported values for the same sources in the literature (see Table 2.4). The black dashed line delineates perfect agreement. The shaded region indicates the $\pm 1\sigma$ scatter (3.8 km s^{-1} for RV and 4.3 km s^{-1} for $v \sin i$) between observed and previously reported values. Two outliers in the $v \sin i$ plot, noted by a blue circle, are excluded in computation of the $v \sin i$ scatter and are discussed in Section 3.3.2.

(Figure 2.6), with a median factor of 2.7 improvement in uncertainties. Again, I found internal agreement between nod pairs and across multiple epochs for $v \sin i$ measurements of these sources. The largest discrepancies were values reported in Prato et al. (2015) for J2254+3123 and J2356–1553. That study visually compared their spectra with spectral templates convolved with a rotational broadening profile for different $v \sin i$ values. Forward-model fits to these spectra with $v \sin i$ values fixed to the Prato et al. (2015) measurements result in significantly worse fits, with p-values¹⁵ of <0.001 and 0.003 , respectively.

Figure 2.7 compares the distribution of my T dwarf $v \sin i$ measurements along with values reported in the literature (Crossfield 2014, and references therein; Tannock et al. 2021) between M4 and T9 dwarfs. The median $v \sin i$ for T dwarfs in my sample is greater than those of both mid/late M dwarfs (12 km s^{-1}) and L dwarfs (20 km s^{-1}), continuing a previously identified trend of increasing rotation rate with decreasing mass

¹⁵Throughout this paper, I adopt the convention that a p-value ≤ 0.1 is marginally significant, a p-value ≤ 0.05 is significant, and a p-value ≤ 0.01 is highly significant (Nuzzo 2014).

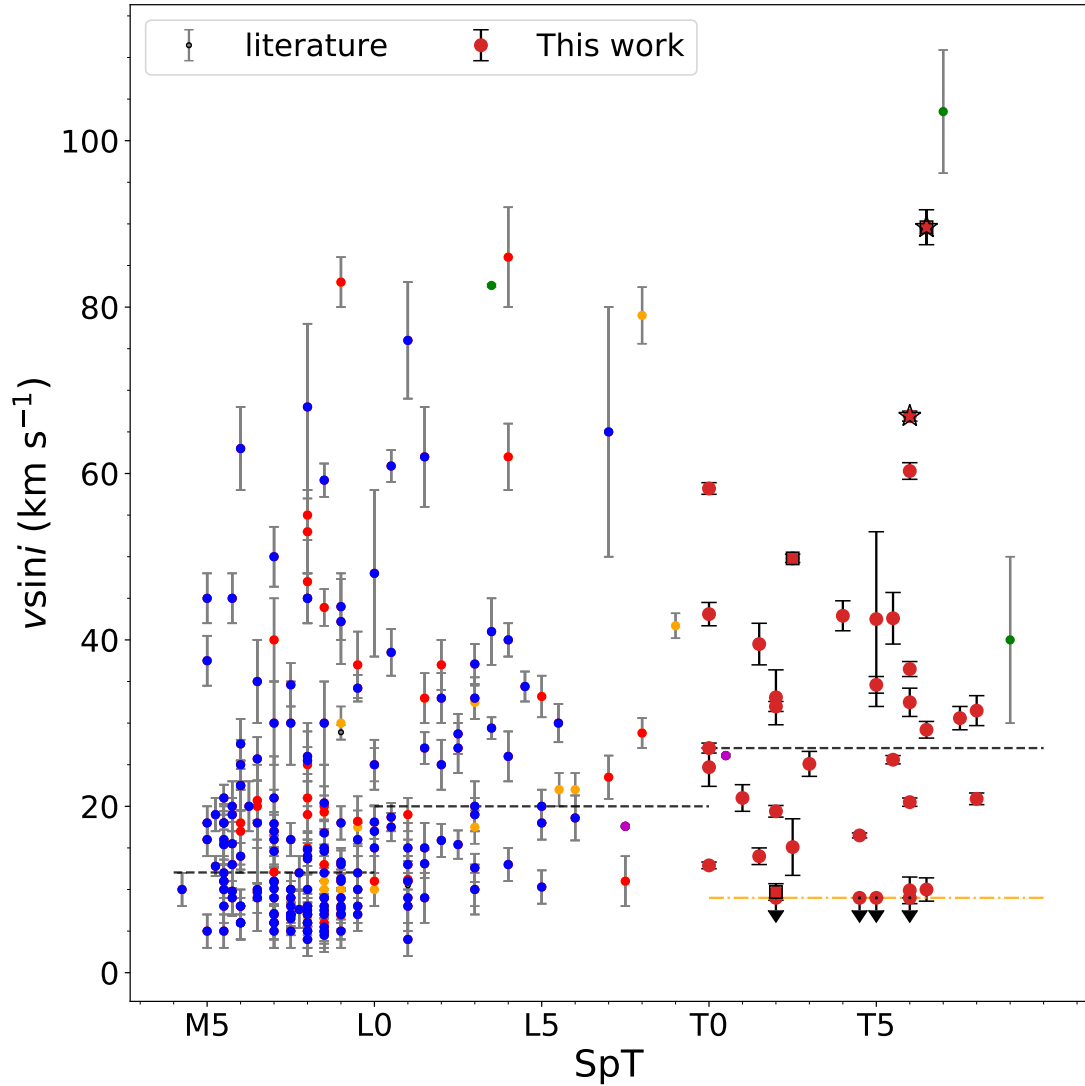


Figure 2.7: $v \sin i$ measurements as a function of spectral type for a compilation of M4–T9 dwarfs from this work (large symbols) and the literature (small symbols). All symbols are color-coded by instrument resolutions (green for $R < 10,000$, orange for $10,000 \leq R < 20,000$, red for $20,000 \leq R < 30,000$, blue for $30,000 \leq R < 50,000$, magenta for $R \geq 50,000$). My T dwarf measurements are further segregated into normal sources (circles), young cluster members (squares), and spectrally peculiar stars (stars). The horizontal grey dashed lines indicate the median rotational velocities for late-M, L, and T dwarfs, respectively, in this sample. The horizontal orange dashed line indicates the NIRSPEC minimum $v \sin i$ floor.

and later spectral type (Mohanty & Basri 2003; Reiners & Basri 2010; Irwin et al. 2011). Such a correlation is expected for both the smaller radii of lower mass stars and brown dwarfs, and the reduced angular momentum loss from weakened magnetic winds among lower-temperature dwarfs (Mohanty & Basri 2003; Reiners & Basri 2008). It should be noted that many of the M and L dwarfs shown in this panel were observed with higher-resolution spectrometers than NIRSPEC, and therefore have a lower $v \sin i$ floor. However, the observed trend persists even when a minimum cutoff of $v \sin i = 9 \text{ km s}^{-1}$ is applied. Among the T dwarfs, there is no significant correlation between $v \sin i$ and spectral type ($R = 0.10$, p-value = 0.56).

2.3.3 Effective Temperatures and Surface Gravities

I evaluated my T_{eff} and $\log g$ values by examining spectral type correlations with RV and $v \sin i$, and comparing to literature measurements. Table 2.4 lists the best-fit T_{eff} and $\log g$ for each source (744 K to 1700 K and 4.2 dex to 5.5 dex, respectively)¹⁶. These are based on order 33 or 58 fits, averaged over all spectra with a specific order. Note that the uncertainties reported here for T_{eff} and $\log g$ are just the Monte Carlo uncertainty, and do not reflect systematic error that may be present due to the narrow spectral bands I chose to model. As expected, T_{eff} is strongly correlated with spectral type, decreasing to later types (Figure 2.8; $R = -0.94$, p-value $< 10^{-3}$), although the scatter about a linear trend can be as high as $\pm 300 \text{ K}$ (standard deviation = 77 K). Differences in T_{eff} among equivalently-classified sources can be related to other physical properties (e.g., metallicity, $\log g$), but may also reflect systematic offsets between orders and between models, as discussed in Section 2.2.1. I also find that my $\log g$ measurements based on Sonora model fits to order 58 data are strongly correlated with spectral type ($R = -0.62$, p-value < 0.01).

¹⁶The observations of J1520+3546 on 2012 Apr 2 and J2126+7617 on 2020 Sep 3 have $T_{\text{eff}} \sim 1700 \text{ K}$, which are determined with a wider T_{eff} prior range to ensure the values are robust. The MCMC bounds are well above these temperatures. See Section 2.2 for more details.

Up to spectral type T5, $\log g$ is consistently around 5.5 dex, and then drops to lower values for later spectral types. This could reflect a systematic error or a real physical shift to lower average masses for cooler brown dwarfs.

Next, I evaluated correlations among T_{eff} , $\log g$, RV, and $v \sin i$. I find my inferred T_{eff} and $\log g$ values to be positively correlated (Figure 2.9) for Sonora model fits because of the temperature and pressure dependence of the $\text{CO} \rightarrow \text{CH}_4$ reduction reaction as described above (see Figure 2.2). Such a trend is not found in BT-Settl model fits, however, for which the lowest $\log g$ values correspond to L+T binaries (J0629+2418 and J2126+7617) and the blue L dwarf J1331–0116 (see Section 2.4.4). Excluding these three sources, the $\log g$ values are greater than 5.2 cm s^{-2} dex for all fits, close to the $\log g$ ceiling of the models. There are clear positive trends between T_{eff} and $\log g$ paralleled to isoage lines (Figure 2.9). I found no significant correlations between $\log g$ and $v \sin i$, $\log g$ and RV, T_{eff} and $v \sin i$, or T_{eff} and RV.

Several T dwarfs in my sample have T_{eff} and $\log g$ values inferred from other analysis, including high-resolution spectra, medium-/low-resolution spectra, and spectral energy distribution (SED) measurements. Figure 2.10 shows my measurements of T_{eff} and $\log g$ compared to the literature measurements.¹⁷ Comparing against high-resolution spectra, my T_{eff} values are on average 22 ± 280 K lower and $\log g$ values on average are 0.6 ± 0.4 dex higher than literature values, indicating overall consistency but with large scatter. Large discrepancies in T_{eff} values inferred from high-resolution spectra have been previously reported in the literature. Gagné et al. (2017) and Vos et al. (2017) analyzed NIRSPEC data for J0136+0933, both using forward-modeling techniques with the same model set, and report T_{eff} and $\log g$ values that differ by 192 K and $1.14 \text{ dex cm s}^{-2}$,

¹⁷The literature T_{eff} and $\log g$ are drawn from Stephens et al. (2009, medium-/low-resolution spectroscopy); Del Burgo et al. (2009, high-resolution spectroscopy); Liu et al. (2011, medium-resolution spectroscopy); Sorahana & Yamamura (2012, low- and medium-resolution spectroscopy); Filippazzo et al. (2015, SEDs); Line et al. (2017, low-resolution spectroscopy); Vos et al. (2017, high-resolution spectroscopy); Gagné et al. (2017, high-resolution spectroscopy); Gagné et al. (2018a, high-resolution spectroscopy); and Miles et al. (2020, low-resolution spectroscopy).

respectively. Del Burgo et al. (2009) found a comparable degree of scatter in $T_{\text{eff}} \approx 200$ K and $\log g \approx 0.7$ dex in fits of PHOENIX AMES-COND cloudless models (Allard et al. 2001) across multiple orders of T dwarf NIRSPEC spectra. Outdated methane opacities in the PHOENIX AMES-COND may be responsible for this scatter, as discussed in Section 2.2.1. Comparing against low- and medium-resolution spectra, I find smaller differences and scatter, with our T_{eff} values on average 63 ± 150 K higher and $\log g$ values on average 0.4 ± 0.4 dex higher than literature values. Similarly, our T_{eff} values are on average 68 ± 145 K higher and $\log g$ values on average 0.3 ± 0.4 dex higher than SED measurements from Filippazzo et al. (2015). Again, such discrepancies are common in the literature, and reflect ongoing challenges in accurately modeling brown dwarf spectra. In accord with my analysis, Logsdon et al. (2018) found that $\log g$ values inferred from medium-resolution spectra of late-T dwarfs were highly dependent on the spectral band used, with the best-fit values of 3.0–3.5 dex in the Y -band (~ 0.95 – $1.12 \mu\text{m}$) and 5.0–5.5 dex in the H -band (~ 1.5 – $1.68 \mu\text{m}$) using the BT-Settl models. Different atmosphere models also yielded significantly different $\log g$ values, as discussed in Section 2.2.1 (see Table 3 in Logsdon et al. 2018).

Given the differences in T_{eff} and $\log g$ values inferred between orders and in comparison with prior results, I urge caution in interpreting these quantities as they may not be accurate. Nevertheless, I have found that they are weakly correlated or uncorrelated with RV and $v \sin i$ and will not significantly influence the subsequent kinematic analysis.

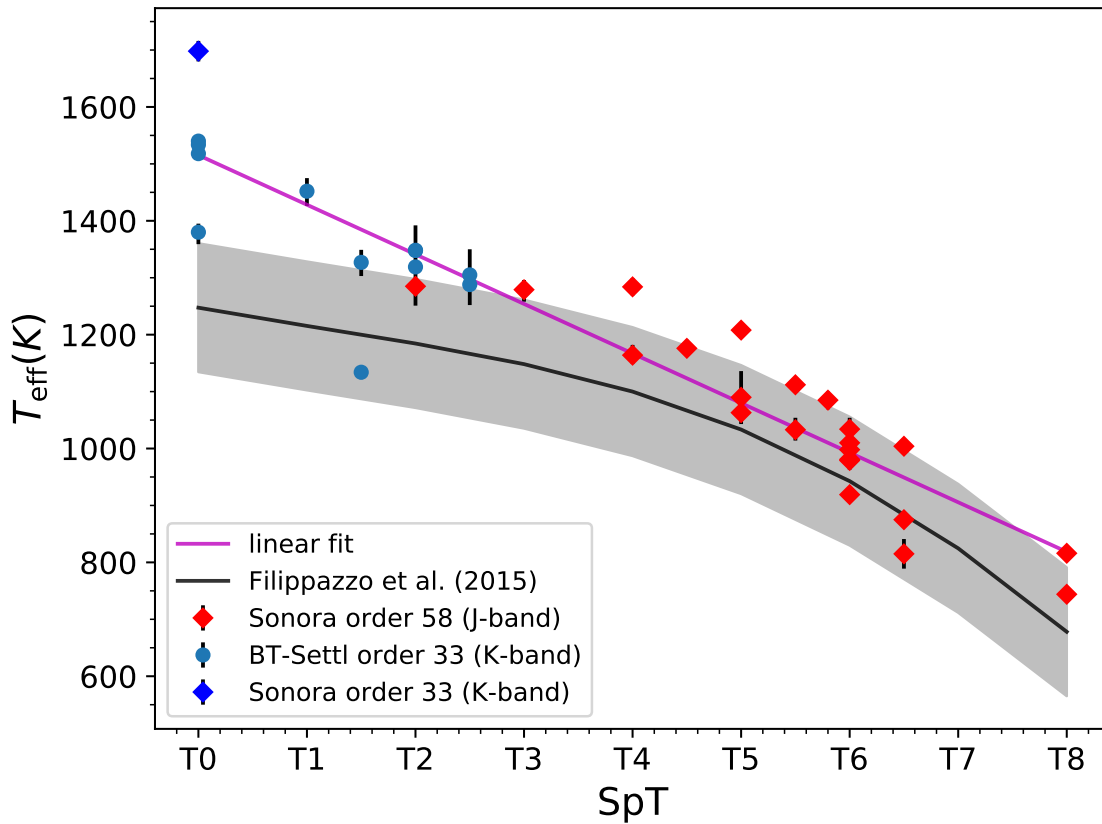


Figure 2.8: Measured T_{eff} values as a function of spectral type based on fits to orders 33 (blue) and 58 (red) data, compared to the T_{eff} /spectral type relation of Filippazzo et al. (2015) (black line with $\pm 1\sigma$ uncertainty shaded in grey). The BT-Settl and Sonora model fits are marked as circles and diamonds, respectively. A linear fit to all of the measurements is indicated by the magenta line.

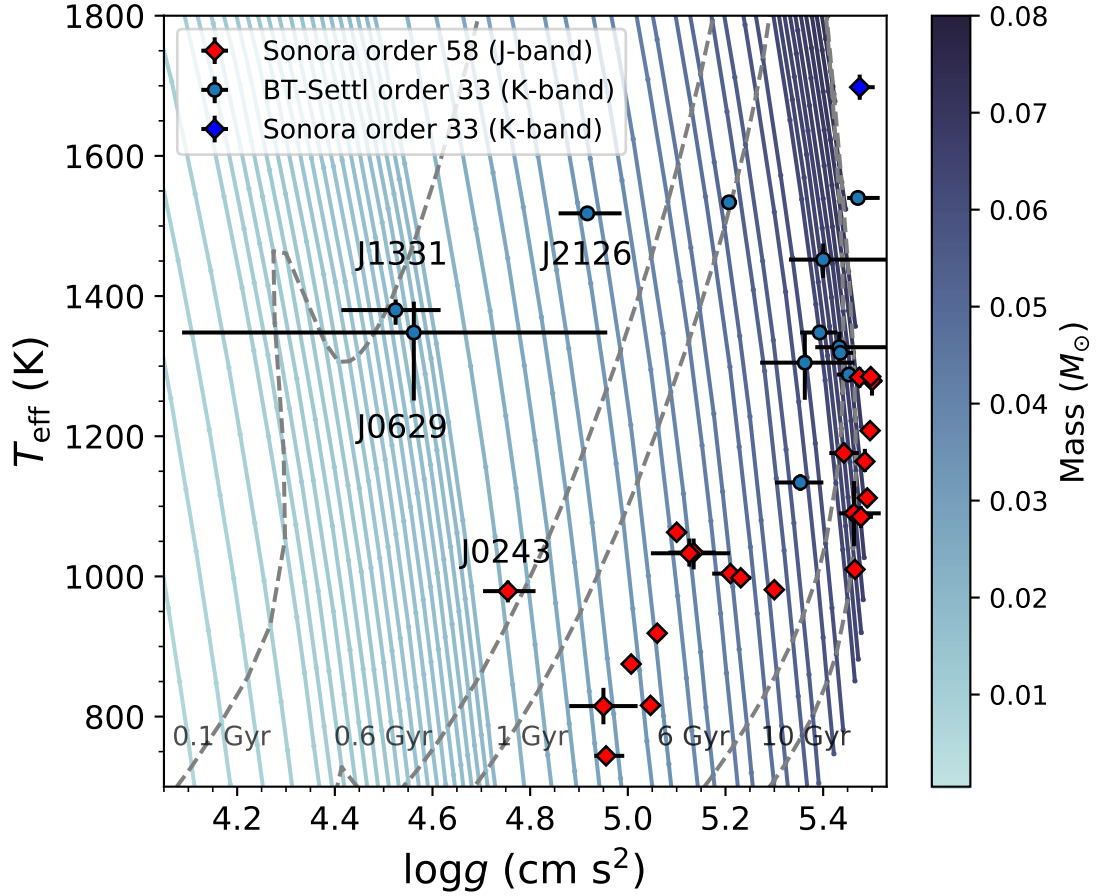


Figure 2.9: Comparison of measured T_{eff} and $\log g$ values based on fits to orders 33 (blue) and 58 (red) data. The BT-Settl and Sonora model fits are marked as circles and diamonds, respectively. The Marley et al. (2018) evolutionary models are plotted, with lines of constant mass indicated by solid color-coded lines and lines of constant age (0.1, 0.6, 1, 6, and 10 Gyr) indicated by labeled dashed grey lines. There are clear positive trends between T_{eff} and $\log g$ for both BT-Settl and Sonora model fits that run parallel to isoage lines. Note that earlier T dwarfs are mostly observed in *K*-band (orders 33), while later T dwarfs are mostly observed in *J*-band (order 58).

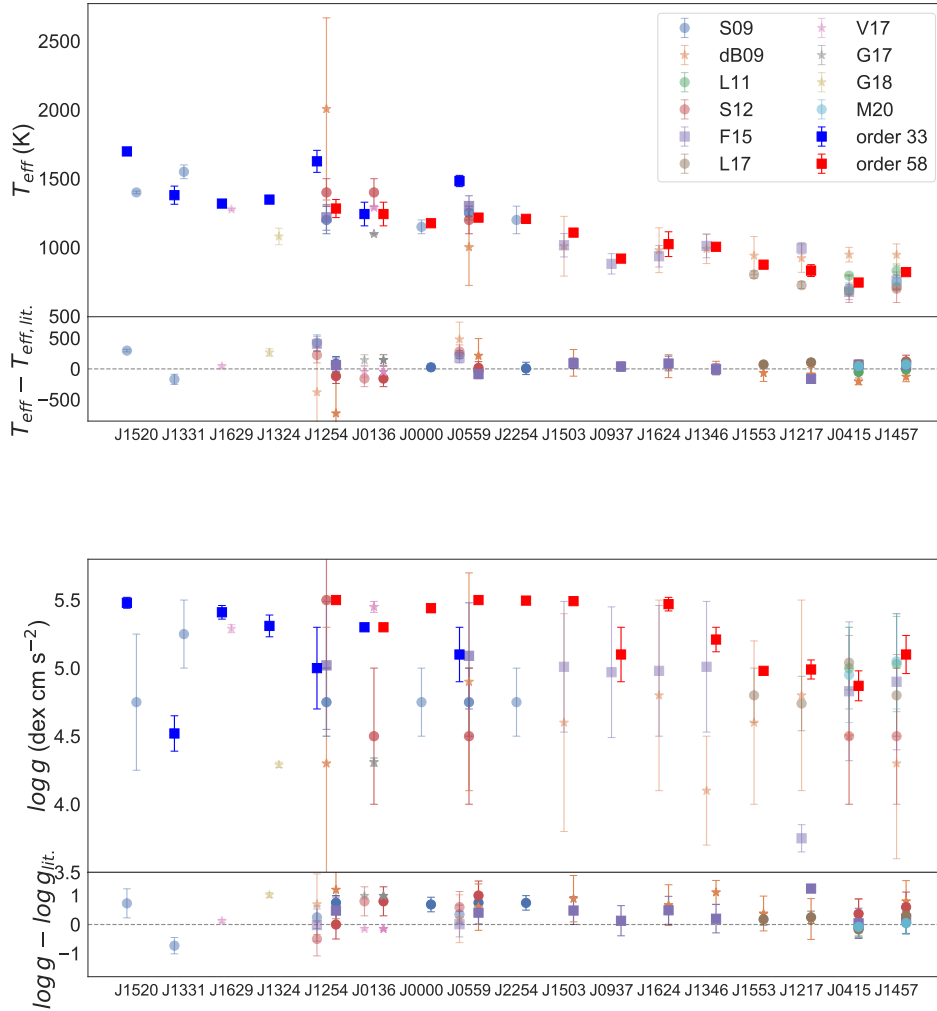


Figure 2.10: Comparison of T_{eff} measurements (top) and $\log g$ measurements (bottom) from my analysis with measurements from the literature. For each figure, the top panels show the measurements, with literature values slightly offset horizontally for clarity; the lower panels show the difference between measurement and literature values for each source. Measurements for orders 33 and 58 fits are labeled as blue and red squares, respectively. Literature references (from top to bottom in the legend) are: (S09): Stephens et al. (2009) (light blue), (dB09): Del Burgo et al. (2009) (orange), (L11): Liu et al. (2011) (green), (S12): Sorahana & Yamamura (2012) (red), (F15): Filippazzo et al. (2015) (purple), (L17): Line et al. (2017) (brown), (V17): Vos et al. (2017) (pink), (G17): Gagné et al. (2017) (grey), (G18): Gagné et al. (2018a) (olive), and (M20): Miles et al. (2020) (cyan). The stars, circles, and squares denote literature measurements based on high-resolution spectroscopy, medium-/low-resolution spectroscopy, and spectral energy distribution, respectively.

Table 2.4: Spectral Model Fit Parameters

| Source | SpT | UT Date | O ^a | S/N | RV (km s ⁻¹) | v sin i (km s ⁻¹) | (RV) ^b (km s ⁻¹) | RV _{LIT} ^c (km s ⁻¹) | (v sin i) ^b (km s ⁻¹) | v sin i _{LIT} ^c (km s ⁻¹) | T _{eff} (K) | (T _{eff}) ^a (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M ^d | Ref. ^e |
|-------------------------|-----------|--------------------------|-----------------|-----|-----------------------------|----------------------------------|--|---|---|--|-------------------------|---|--------------------------------|---|----------------|-------------------|
| J0000+2554 | T4.5 | 2019 Oct 17 | 58 | 5 | 6.4 ^{+0.4} | 4.4 ^{+2.0} | 6.4 ^{+0.4} | ... | < 9k | ... | 1176 ⁺¹³ | 1176 ⁺¹³ | 5.44 ^{+0.03} | 5.442 ^{+0.03} | S | |
| J0034+0523 | T6.5 | 2020 Sep 3 | 58 | 14 | 16.6 ^{+1.4} | 89.6 ^{+2.1} | 16.6 ^{+1.4} | ... | 89.6 ^{+2.1} | ... | 815 ⁺²⁶ | 815 ⁺²⁶ | 4.95 ^{+0.07} | 4.95 ^{+0.07} | S | |
| J0136+0933 ^b | T2.5 | 2008 Dec 4 | 58 | 78 | 10.4 ^{+0.3} | 49.9 ^{+1.2} | 10.4 ^{+0.3} | 11.5 ± 0.4 | 49.8 ^{+0.5} | 50.9 ± 0.8 | 1148 ⁺⁷ | 1148 ⁺⁷ | 4.28 ^{+0.04} | 5.45 ^{+0.04} | B | (4) |
| ... | ... | 2013 Oct 16 | 33 | 10 | 11.6 ^{+0.8} | 48.1 ^{+1.3} | ... | ... | ... | ... | 1291 ⁺⁷ | ... | 5.46 ^{+0.03} | ... | ... | |
| ... | ... | 2016 Feb 3 | 33 | 7 | 9.6 ^{+0.8} | 49.4 ^{+1.2} | ... | ... | ... | ... | 1303 ⁺⁷ | ... | 5.43 ^{+0.05} | ... | ... | |
| J0150+3827 | T0 | 2020 Aug 5 | 33 | 4 | 56.2 ^{+0.9} | 24.7 ^{+2.3} | 56.2 ^{+0.9} | ... | 24.7 ^{+2.3} | ... | 1540 ⁺⁷ | 1540 ⁺⁷ | 5.47 ^{+0.02} | 5.47 ^{+0.02} | B | |
| J0213+3648 | T3 | 2020 Sep 3 | 58 | 4 | -3.8 ^{+1.0} | 25.1 ^{+1.1} | -3.8 ^{+1.0} | ... | 25.1 ^{+1.1} | ... | 1279 ⁺²¹ | 1279 ⁺²¹ | 5.5 ^{+0.01} | 5.5 ^{+0.01} | S | |
| J0243-2453 | T6 | 2021 Jan 1 | 58 | 5 | -0.6 ^{+0.6} | 9.9 ^{+1.6} | -0.6 ^{+0.6} | ... | 9.9 ^{+1.6} | ... | 979 ⁺¹⁶ | 979 ⁺¹⁶ | 4.75 ^{+0.05} | 4.754 ^{+0.05} | S | |
| J0415-0935 | T8 | 2005 Oct 26 | 58 | 5 | 50.4 ^{+2.5} | 34.3 ^{+2.9} | 51.9 ^{+1.1} | 49.6 ± 1.2 | 31.5 ^{+1.8} | 33.5 ± 2.0 | 744 ⁺¹² | 744 ⁺¹² | 4.87 ^{+0.11} | 4.96 ^{+0.02} | S | (2); (1) |
| J0559-1404 ^b | T4.5 | 2000 Oct 10 ^e | 58 | ... | -9.5 ^{+0.1} | ... | -9.5 ^{+0.1} | -9 ± 3 | 16.5 ^{+0.2} | 20.1 ± 4.8 | 1211 ⁺⁴ | 1218 ⁺² | ... | 5.493 ^{+0.01} | ... | (3); (1) |
| ... | ... | 2001 Oct 9 | 58 | 42 | -9.7 ^{+0.5} | 16.5 ^{+1.1} | ... | ... | ... | ... | 1211 ⁺⁴ | ... | 5.5 ^{+0.02} | ... | ... | |
| ... | ... | 2001 Nov 2 | 58 | 59 | -10.3 ^{+0.3} | 15.4 ^{+0.4} | ... | ... | ... | ... | 1218 ⁺⁵ | ... | 5.5 ^{+0.01} | ... | ... | |
| ... | ... | 2001 Dec 29 | 58 ^f | 28 | ... | ... | ... | ... | ... | ... | ... | ... | 5.5 ^{+0.02} | ... | ... | |
| ... | ... | 2004 Dec 5 | 58 | 10 | -6.2 ^{+1.3} | 21.6 ^{+1.5} | ... | ... | ... | ... | 1221 ⁺¹⁰ | ... | 5.49 ^{+0.01} | ... | ... | |
| ... | ... | 2005 Oct 26 | 58 | 35 | -9.6 ^{+0.3} | 18.7 ^{+1.3} | ... | ... | ... | ... | 1215 ⁺⁶ | ... | 5.5 ^{+0.02} | ... | ... | |
| ... | ... | 2005 Oct 27 | 58 | 29 | -8.9 ^{+0.3} | 19.8 ^{+0.7} | ... | ... | ... | ... | 1211 ⁺⁶ | ... | 5.5 ^{+0.01} | ... | ... | |
| ... | ... | 2005 Oct 28 | 58 | 27 | -9.9 ^{+0.3} | 15.6 ^{+0.6} | ... | ... | ... | ... | 1220 ⁺⁶ | ... | 5.5 ^{+0.01} | ... | ... | |
| ... | ... | 2006 Jan 11 | 58 | 23 | -8.0 ^{+0.8} | 15.8 ^{+0.9} | ... | ... | ... | ... | 1222 ⁺⁹ | ... | 5.5 ^{+0.02} | ... | ... | |
| ... | ... | 2008 Mar 19 | 58 | 28 | -9.8 ^{+0.5} | 16.4 ^{+2.0} | ... | ... | ... | ... | 1227 ⁺¹³ | ... | 5.48 ^{+0.01} | ... | ... | |
| ... | ... | 2015 Dec 29 | 33 | 3 | -8.6 ^{+1.1} | 16.8 ^{+1.8} | ... | ... | ... | ... | 1503 ⁺²⁴ | ... | 5.11 ^{+0.21} | ... | ... | |
| ... | ... | 2021 Jan 1 | 58 | 6 | -9.3 ^{+0.2} | 13.0 ^{+0.5} | ... | ... | ... | ... | 1231 ⁺⁵ | ... | 5.48 ^{+0.0} | ... | ... | |
| J0627-1114 | T6 | 2021 Jan 1 | 58 | 6 | 1.2 ^{+0.8} | 5.4 ^{+2.9} | 1.2 ^{+0.8} | ... | < 9k | ... | 1034 ⁺²⁴ | 1034 ⁺²⁴ | 5.13 ^{+0.04} | 5.135 ^{+0.052} | S | |
| J0629+2418 | L7+T5.5 | 2012 Nov 28 | 33 | 1 | 0.5 ^{+2.3} | 33.1 ^{+3.2} | 0.5 ^{+2.3} | ... | 33.1 ^{+3.2} | ... | 1348 ⁺⁹⁷ | 1348 ⁺⁹⁷ | 4.6 ^{+0.5} | 4.6 ^{+0.5} | B | |
| J0755+2212 | T5 | 2021 Jan 1 | 58 | 5 | 22.3 ^{+1.7} | 43.0 ^{+10.0} | 22.3 ^{+1.7} | ... | 43.0 ^{+10.0} | ... | 1090 ⁺⁴⁶ | 1090 ⁺⁴⁶ | 5.46 ^{+0.05} | 5.463 ^{+0.054} | S | |
| J0819-0335 | T4 | 2021 Jan 1 | 58 | 9 | 14.4 ^{+0.8} | 8.5 ^{+1.4} | 14.4 ^{+0.8} | ... | < 9k | ... | 1284 ⁺¹⁵ | 1284 ⁺¹⁵ | 5.47 ^{+0.02} | 5.474 ^{+0.018} | S | |
| J0909+6525 | T1.5+T2.5 | 2010 Dec 26 | 33 | 2 | 37.8 ^{+1.6} | 39.5 ^{+2.5} | 37.8 ^{+1.6} | ... | 39.5 ^{+2.5} | ... | 1327 ⁺²² | 1327 ⁺²² | 5.43 ^{+0.05} | 5.43 ^{+0.05} | B | |
| J0937+2931 | T6p | 2002 Apr 23 | 58 | 20 | -4.4 ^{+1.6} | 64.9 ^{+1.4} | -4.3 ^{+0.4} | -5 ± 3 | 66.9 ^{+0.6} | 60 ± 10 | 932 ⁺¹⁰ | 919 ⁺¹⁴ | 5.48 ^{+0.01} | 5.06 ^{+0.003} | S | (3) |
| ... | ... | 2003 Mar 24 | 58 | 25 | -5.6 ^{+1.0} | 64.9 ^{+1.7} | ... | ... | ... | ... | 893 ⁺¹⁰ | ... | 5.47 ^{+0.02} | ... | ... | |
| ... | ... | 2003 May 12 | 58 | 34 | -3.8 ^{+0.7} | 76.6 ^{+1.6} | ... | ... | ... | ... | 920 ⁺⁸ | ... | 5.0 ^{+0.03} | ... | ... | |
| ... | ... | 2006 Jan 10 | 58 | 15 | -3.2 ^{+1.5} | 63.0 ^{+1.8} | ... | ... | ... | ... | 923 ⁺¹⁵ | ... | 5.49 ^{+0.01} | ... | ... | |
| ... | ... | 2006 May 19 | 58 | 25 | -4.4 ^{+0.6} | 63.3 ^{+0.9} | ... | ... | ... | ... | 923 ⁺¹⁸ | ... | 5.49 ^{+0.03} | ... | ... | |
| J1106+2754 ^b | T0+T4.5 | 2008 Mar 19 | 58 | 20 | -3.1 ^{+0.7} | 26.3 ^{+1.1} | 2.5 ^{+0.2} | ... | 12.9 ^{+0.4} | ... | 1171 ⁺⁸ | 1534 ⁺¹ | 4.24 ^{+0.06} | 5.207 ^{+0.008} | B | |
| ... | ... | 2010 Dec 26 | 58 | 15 | -3.7 ^{+1.6} | 24.3 ^{+2.2} | ... | ... | ... | ... | 1183 ⁺⁶ | ... | 4.37 ^{+0.12} | 4.24 ^{+0.06} | B | |
| ... | ... | 2012 Apr 2 | 33 | 8 | 3.5 ^{+0.7} | 12.7 ^{+1.6} | ... | ... | ... | ... | 1564 ⁺⁶ | ... | 5.49 ^{+0.02} | ... | ... | |
| ... | ... | 2012 Nov 27 | 33 | 3 | 1.6 ^{+0.8} | 13.3 ^{+1.3} | ... | ... | ... | ... | 1490 ⁺¹⁸ | ... | 5.35 ^{+0.09} | ... | ... | |
| ... | ... | 2013 Feb 5 | 33 | 7 | 1.0 ^{+0.8} | 10.4 ^{+1.3} | ... | ... | ... | ... | 1522 ⁺⁴ | ... | 5.0 ^{+0.2} | ... | ... | |
| ... | ... | 2015 Jan 1 | 33 | 1 | 5.9 ^{+1.4} | 19.3 ^{+2.4} | ... | ... | ... | ... | 1480 ⁺³³ | ... | 5.43 ^{+0.06} | ... | ... | |
| ... | ... | 2016 Jan 18 | 33 | 4 | 11.1 ^{+0.9} | 11.6 ^{+2.1} | ... | ... | ... | ... | 1539 ⁺⁵ | ... | 5.44 ^{+0.05} | ... | ... | |
| ... | ... | 2016 Feb 16 | 33 | 8 | 4.8 ^{+0.5} | 12.0 ^{+0.7} | ... | ... | ... | ... | 1532 ⁺² | ... | 5.43 ^{+0.06} | ... | ... | |
| ... | ... | 2016 Apr 22 | 33 | 10 | 5.1 ^{+0.5} | 14.8 ^{+1.0} | ... | ... | ... | ... | 1537 ⁺² | ... | 5.45 ^{+0.04} | ... | ... | |
| ... | ... | 2016 May 22 | 33 | 9 | 2.9 ^{+0.6} | 14.7 ^{+1.0} | ... | ... | ... | ... | 1540 ⁺³ | ... | 5.32 ^{+0.1} | ... | ... | |
| ... | ... | 2017 Mar 22 | 33 | 4 | -1.9 ^{+0.7} | 9.9 ^{+1.3} | ... | ... | ... | ... | 1536 ⁺⁴ | ... | 5.47 ^{+0.02} | ... | ... | |

Table 2.4 (continued)

Table 2.4 (continued)

| Source | SpT | UT Date | O ^a | S/N | RV (km s ⁻¹) | v sin i (km s ⁻¹) | (RV) ^a (km s ⁻¹) | RV _{LIT} ^c (km s ⁻¹) | (v sin i) ^b (km s ⁻¹) | v sin i _{LIT} ^b (km s ⁻¹) | Z _{eff} (K) | (T _{eff}) ^a (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M ^d | Ref. ^e |
|-------------------------|-----------|--------------------------|----------------|-----|-----------------------------|----------------------------------|--|---|---|--|-------------------------|---|--------------------------------|---|----------------|-------------------|
| ... | ... | 2017 May 6 | 33 | 5 | -1.1 ^{+0.8} | 13.7 ^{+1.2} | ... | ... | ... | ... | 1529 ⁺³ | ... | 5.35 ^{+0.1} | ... | B | ... |
| ... | ... | 2018 Jan 1 | 33 | 2 | -21.0 ^{+3.4} | 7.8 ^{+3.0} | ... | ... | ... | ... | 1585 ⁺³⁸ | ... | 5.0 ^{+0.4} | ... | B | ... |
| ... | ... | 2018 Jun 3 | 33 | 8 | -2.6 ^{+0.9} | 6.7 ^{+2.3} | ... | ... | ... | ... | 1523 ⁺⁵ | ... | 5.24 ^{+0.17} | ... | B | ... |
| ... | ... | 2021 Jan 1 | 33 | 6 | -3.8 ^{+1.2} | 11.9 ^{+2.2} | ... | ... | ... | ... | 1524 ⁺⁶ | ... | 5.37 ^{+0.38} | ... | B | ... |
| ... | ... | 2021 Jan 1 | 58 | 8 | -2.5 ^{+1.3} | 20.7 ^{+2.0} | ... | ... | ... | ... | 1171 ⁺¹² | ... | 4.37 ^{+0.15} | ... | B | ... |
| J1217-0311 | T7.5 | 2001 Jun 15 [#] | 58 | 7 | ... | ... | 9.9 ^{+2.3} | 5.0 ± 1.6 | 30.6 ^{+1.3} | 31.4 ± 2.1 | ... | 830 ⁺¹⁴ | ... | 4.993 ^{+0.008} | ... | (2); (1) |
| ... | ... | 2006 Jan 18 | 58 | 4 | 10.0 ^{+2.6} | 30.7 ^{+1.6} | ... | ... | ... | ... | 804 ⁺¹⁸ | ... | 4.99 ^{+0.01} | ... | S | ... |
| ... | ... | 2006 Jan 19 | 58 | 4 | 9.4 ^{+5.0} | 30.3 ^{+2.1} | ... | ... | ... | ... | 860 ⁺²¹ | ... | 5.1 ^{+0.08} | ... | S | ... |
| J1225-2739 | T5.5+T8 | 2002 Apr 23 | 58 | 6 | 18.5 ^{+1.2} | 42.6 ^{+2.7} | 18.5 ^{+1.5} | ... | 42.6 ^{+3.1} | ... | 1033 ⁺¹⁹ | 1033 ⁺¹⁹ | 5.13 ^{+0.08} | 5.13 ^{+0.08} | S | ... |
| J1254-0122 [!] | T2 | 2001 Dec 31 [#] | 58 | 3 | 40.8 ^{+4.3} | 41.1 ^{+4.7} | 2.7 ^{+0.5} | 4 ± 3 | 32.0 ^{+0.6} | 27.3 ± 2.5 | 1137 ⁺³¹ | 1285 ⁺⁶ | 5.44 ^{+0.04} | 5.497 ^{+0.001} | S | (3); (1) |
| ... | ... | 2002 May 17 | 58 | 17 | 0.8 ^{+1.0} | 33.4 ^{+1.2} | ... | ... | ... | ... | 1264 ⁺¹¹ | ... | 5.49 ^{+0.01} | ... | S | ... |
| ... | ... | 2003 May 14 | 58 | 16 | 3.3 ^{+0.9} | 33.7 ^{+1.6} | ... | ... | ... | ... | 1298 ⁺⁹ | ... | 5.5 ^{+0.003} | ... | S | ... |
| ... | ... | 2006 Jan 19 | 58 | 17 | 4.1 ^{+1.2} | 31.5 ^{+1.2} | ... | ... | ... | ... | 1284 ⁺¹³ | ... | 5.5 ^{+0.01} | ... | S | ... |
| ... | ... | 2007 May 31 | 58 | 27 | 1.8 ^{+0.6} | 33.3 ^{+1.2} | ... | ... | ... | ... | 1286 ⁺⁹ | ... | 5.5 ^{+0.01} | ... | S | ... |
| ... | ... | 2011 Jun 10 | 33 | 2 | 1.4 ^{+2.0} | 21.9 ^{+2.6} | ... | ... | ... | ... | 1620 ⁺⁸⁰ | ... | 4.99 ^{+0.28} | ... | S | ... |
| J1324+6358 | T2 | 2016 May 22 | 33 | 6 | -23.0 ^{+0.4} | 9.7 ^{+1.0} | -23.0 ^{+0.5} | -23.7 ± 0.4 | 9.7 ^{+1.0} | 11.5 ± 1.0 | 1348 ⁺⁹ | 1348 ⁺⁹ | 5.31 ^{+0.06} | 5.39 ^{+0.04} | B | (5) |
| J1331-0116 | T0p | 2011 Mar 18 | 33 | 8 | -2.8 ^{+0.5} | 27.7 ^{+0.7} | -3.3 ^{+0.4} | ... | 27.0 ^{+0.6} | ... | 1421 ⁺²⁷ | 1380 ⁺²¹ | 4.61 ^{+0.13} | 4.52 ^{+0.11} | B | ... |
| ... | ... | 2011 Jul 6 | 33 | 4 | -4.7 ^{+0.9} | 25.0 ^{+1.3} | ... | ... | ... | ... | 1328 ⁺²⁰ | ... | 4.4 ^{+0.3} | ... | B | ... |
| J1346-0031 | T6.5 | 2001 Jun 15 | 58 | 10 | -17.5 ^{+0.6} | 10.1 ^{+1.4} | -17.5 ^{+0.6} | -23.1 ± 1.5 | 10.0 ^{+1.2} | < 15 | 1011 ⁺¹⁴ | 1004 ⁺¹² | 5.24 ^{+0.04} | 5.21 ^{+0.04} | S | (2); (1) |
| ... | ... | 2006 Jan 18 | 58 | 4 | -17.5 ^{+1.4} | 9.8 ^{+2.6} | ... | ... | ... | ... | 979 ⁺²⁸ | ... | 5.11 ^{+0.08} | ... | S | ... |
| GL 570D | T8 | 2001 Jun 15 | 58 | 14 | 31.6 ^{+0.3} | 20.5 ^{+1.0} | 31.9 ^{+0.3} | 28.9 ± 2.4 | 20.9 ^{+0.7} | 28.6 ± 2.4 | 814 ⁺⁶ | 816 ⁺⁵ | 5.14 ^{+0.03} | 5.046 ^{+0.014} | S | (2); (1) |
| ... | ... | 2006 Jan 18 | 58 | 20 | 33.8 ^{+1.7} | 25.5 ^{+2.5} | ... | ... | ... | ... | 820 ⁺¹³ | ... | 4.94 ^{+0.04} | ... | S | ... |
| J1503+2525 | T5.5 | 2006 Jan 18 | 58 | 6 | -34.9 ^{+0.6} | 25.3 ^{+1.0} | -35.9 ^{+0.3} | -40.5 ± 2.1 | 25.6 ^{+0.5} | 32.8 ± 2.0 | 1118 ⁺⁷ | 1112 ⁺⁴ | 5.49 ^{+0.01} | 5.49 ^{+0.008} | S | (2); (1) |
| ... | ... | 2008 Mar 19 | 58 | 57 | -37.1 ^{+0.6} | 24.9 ^{+0.6} | ... | ... | ... | ... | 1106 ⁺⁷ | ... | 5.49 ^{+0.01} | ... | S | ... |
| J1506+7027 | T6 | 2020 Sep 3 | 58 | 35 | 2.5 ^{+0.4} | 60.3 ^{+1.0} | 2.5 ^{+0.4} | ... | 60.3 ^{+0.9} | ... | 981 ⁺⁵ | 981 ⁺⁵ | 5.3 ^{+0.01} | 5.3 ^{+0.01} | S | ... |
| J1520+3546 | T0 | 2012 Apr 2 | 33 | 7 | 3.4 ^{+1.4} | 45.9 ^{+2.0} | 4.1 ^{+1.0} | ... | 43.1 ^{+1.4} | ... | 1698 ⁺¹⁸ | 1698 ⁺¹⁸ | 5.48 ^{+0.02} | 5.475 ^{+0.014} | S | ... |
| J1553+1523 | T6.5+T7.5 | 2001 Jun 15 | 58 | 10 | -24.4 ^{+0.8} | 31.8 ^{+1.9} | -25.5 ^{+0.6} | -32.9 ± 3.0 | 29.2 ^{+0.8} | 29.4 ± 2.3 | 875 ⁺⁸ | 875 ⁺⁸ | 4.98 ^{+0.02} | 5.007 ^{+0.011} | S | (2); (1) |
| J1624+0029 | T6 | 2001 Jun 15 | 58 | 13 | -25.0 ^{+0.7} | 34.1 ^{+1.3} | -24.3 ^{+0.5} | -30.7 ± 3.0 | 36.5 ^{+0.9} | 38.5 ± 2.0 | 987 ⁺⁸ | 1010 ⁺⁵ | 5.39 ^{+0.03} | 5.465 ^{+0.007} | S | (2); (1) |
| ... | ... | 2002 May 17 | 58 | 18 | -22.1 ^{+1.4} | 45.4 ^{+2.1} | ... | ... | ... | ... | 1120 ⁺¹⁶ | ... | 5.49 ^{+0.02} | ... | S | ... |
| ... | ... | 2005 Jun 4 | 58 | 5 | -24.1 ^{+1.8} | 36.4 ^{+3.0} | ... | ... | ... | ... | 944 ⁺²⁶ | ... | 5.43 ^{+0.02} | ... | S | ... |
| J1629+0335 | T2 | 2011 Aug 11 | 33 | 3 | 6.4 ^{+1.6} | 19.7 ^{+2.3} | 7.6 ^{+0.6} | ... | 19.4 ^{+0.7} | ... | 1289 ⁺¹⁷ | 1319 ⁺⁷ | 5.41 ^{+0.07} | 5.435 ^{+0.014} | B | ... |
| ... | ... | 2011 Sep 7 | 33 | 4 | 7.7 ^{+1.2} | 20.1 ^{+1.5} | ... | ... | ... | ... | 1329 ⁺⁹ | ... | 5.47 ^{+0.02} | ... | B | ... |
| J1809-0448 | T1 | 2020 Aug 25 | 33 | 6 | -43.4 ^{+1.3} | 21.0 ^{+1.3} | -43.4 ^{+1.3} | ... | 21.0 ^{+1.3} | ... | 1452 ⁺²⁶ | 1452 ⁺²⁶ | 5.4 ^{+0.07} | 5.4 ^{+0.07} | B | ... |
| J1928+2356 [!] | T6 | 2019 Sep 12 | 37 | 5 | -27.1 ^{+1.0} | 25.6 ^{+1.5} | -26.3 ^{+0.3} | ... | 20.5 ^{+0.5} | ... | 1172 ⁺²⁵ | 998 ⁺² | 5.48 ^{+0.02} | 5.23 ^{+0.02} | S | ... |
| ... | ... | 2019 Oct 17 | 58 | 14 | -25.9 ^{+0.5} | 19.9 ^{+0.8} | ... | ... | ... | ... | 998 ⁺⁷ | ... | 5.23 ^{+0.02} | ... | S | ... |
| J1952+7240 | T4 | 2019 Oct 17 | 58 | 5 | -11.8 ^{+2.0} | 40.2 ^{+3.0} | -12.0 ^{+1.3} | ... | 42.9 ^{+1.8} | ... | 1164 ⁺¹⁵ | 1164 ⁺¹⁵ | 5.46 ^{+0.03} | 5.485 ^{+0.008} | S | ... |
| J2030+0749 | T1.5 | 2020 Jul 10 | 33 | 4 | -21.2 ^{+0.7} | 14.0 ^{+1.7} | -21.2 ^{+0.7} | ... | < 15 ^a | ... | 1134 ⁺¹⁸ | 1134 ⁺¹⁸ | 5.35 ^{+0.05} | 5.35 ^{+0.05} | B | ... |
| J2126+7617 | T0p | 2011 Jun 10 | 33 | 6 | -17.7 ^{+1.0} | 58.8 ^{+1.9} | -18.4 ^{+0.4} | ... | 58.2 ^{+0.7} | ... | 1462 ⁺²⁰ | 1518 ⁺⁵ | 4.66 ^{+0.14} | 4.92 ^{+0.06} | B | ... |
| ... | ... | 2011 Jul 6 | 33 | 10 | -18.8 ^{+1.2} | 59.5 ^{+2.8} | ... | ... | ... | ... | 1504 ⁺²¹ | ... | 4.77 ^{+0.15} | ... | B | ... |
| ... | ... | 2011 Aug 11 | 33 | 2 | -24.3 ^{+5.3} | 51.1 ^{+10.3} | ... | ... | ... | ... | 1532 ⁺⁶¹ | ... | 4.7 ^{+0.7} | ... | B | ... |
| ... | ... | 2011 Sep 7 | 33 | 8 | -18.7 ^{+1.6} | 56.1 ^{+2.7} | ... | ... | ... | ... | 1555 ⁺⁸¹ | ... | 5.0 ^{+0.3} | ... | B | ... |
| ... | ... | 2013 Sep 17 | 33 | 5 | -20.3 ^{+2.0} | 58.4 ^{+2.2} | ... | ... | ... | ... | 1474 ⁺³⁴ | ... | 5.0 ^{+0.2} | ... | B | ... |
| ... | ... | 2013 Oct 16 | 33 | 4 | -20.7 ^{+1.8} | 59.7 ^{+2.9} | ... | ... | ... | ... | 1448 ⁺⁴⁹ | ... | 4.6 ^{+0.4} | ... | B | ... |

Table 2.4 (continued)

Table 2.4 (continued)

| Source | SpT | UTDate | O ^a | S/N | RV (km s ⁻¹) | v sin i (km s ⁻¹) | (RV) ^a (km s ⁻¹) | RV _{LIT} ^c (km s ⁻¹) | (v sin i) ^b (km s ⁻¹) | v sin i _{LIT} ^c (km s ⁻¹) | T _{eff} (K) | (T _{eff}) ^a (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M ^d | Ref. ^e |
|------------|------|-------------|-----------------|-----|---------------------------------------|--------------------------------------|--|---|---|--|------------------------------------|---|---|---|----------------|-------------------|
| ... | ... | 2014 Sep 02 | 33 | 6 | -19.5 ^{+1.6} _{-1.7} | 57.5 ^{+2.7} _{-2.5} | ... | ... | ... | ... | 1540 ⁺¹¹ ₋₁₇ | ... | 4.7 ^{+0.3} _{-0.3} | ... | B | |
| ... | ... | 2020 Aug 25 | 33 | 4 | -14.9 ^{+1.7} _{-1.7} | 54.9 ^{+2.1} _{-2.1} | ... | ... | ... | ... | 1507 ⁺¹⁶ ₋₁₆ | ... | 5.2 ^{+0.9} _{-0.9} | ... | B | |
| ... | ... | 2020 Sep 3 | 57 ^j | 14 | -14.1 ^{+0.9} _{-0.9} | 60.4 ^{+1.0} _{-1.0} | ... | ... | ... | ... | 1700 ⁺²² ₋₂₂ | ... | 5.0 ^{+0.6} _{-0.6} | ... | B | |
| HN Peg B | T2.5 | 2017 Jun 09 | 33 | 5 | -19.5 ^{+1.3} _{-1.3} | 15.1 ^{+3.4} _{-3.4} | -19.5 ^{+1.3} _{-1.3} | ... | 15.1 ^{+3.0} _{-3.4} | ... | 1305 ⁺⁵³ ₋₄₈ | ... | 5.36 ^{+0.0} _{-0.0} | 5.36 ^{+0.09} _{-0.10} | B | |
| J2236+5105 | T5 | 2020 Sep 3 | 58 | 22 | -1.2 ^{+0.3} _{-0.3} | 6.6 ^{+0.9} _{-0.9} | -1.2 ^{+0.3} _{-0.3} | ... | < 9 ^k | ... | 1063 ⁺⁸ ₋₈ | ... | 5.1 ^{+0.01} _{-0.01} | 5.1 ^{+0.01} _{-0.01} | B | |
| J2254+3123 | T5 | 2003 Aug 10 | 58 | 17 | 14.3 ^{+0.7} _{-0.7} | 32.5 ^{+1.2} _{-1.2} | 15.1 ^{+0.6} _{-0.6} | 14 ± 3 | 34.6 ^{+0.9} _{-1.0} | 15 ± 5 | 1214 ⁺¹¹ ₋₁₁ | ... | 5.5 ^{+0.03} _{-0.03} | 5.496 ^{+0.002} _{-0.002} | S | (3) |
| ... | ... | 2005 Jul 19 | 58 | 16 | 16.8 ^{+1.0} _{-1.0} | 37.4 ^{+1.3} _{-1.3} | ... | 14 ± 3 | ... | 15 ± 5 | 1204 ⁺⁹ ₋₉ | ... | 5.5 ^{+0.003} _{-0.003} | ... | S | |
| J2356-1553 | T6 | 2005 Jul 19 | 58 | 6 | 23.6 ^{+1.3} _{-1.3} | 30.6 ^{+2.1} _{-2.1} | 21.8 ^{+0.9} _{-1.0} | 19 ± 3 | 32.5 ^{+1.7} _{-1.6} | 15 ± 5 | 1065 ⁺²² ₋₂₂ | 1085 ⁺¹⁶ ₋₁₅ | 5.48 ^{+0.01} _{-0.03} | 5.477 ^{+0.013} _{-0.025} | S | (3) |
| ... | ... | 2005 Dec 10 | 58 | 6 | 20.3 ^{+1.3} _{-1.3} | 35.4 ^{+2.6} _{-2.6} | ... | 19 ± 3 | ... | 15 ± 5 | 1109 ⁺²³ ₋₂₃ | ... | 5.43 ^{+0.07} _{-0.07} | ... | S | |

References – (1) Zapatero Osorio et al. (2006), (2) Zapatero Osorio et al. (2007), (3) Prato et al. (2015), (4) Gagné et al. (2017), (5) Gagné et al. (2018a)

^a Spectral order of data.

^b Weighted average over all epochs.

^c Previously reported values in the literature.

^d Models used: S = Sonora 2018 (Marley et al. 2018); B = BT-Settl (Allard et al. 2012).

^e References for prior RV and v sin i measurements

^f No telluric observations available for this epoch.

^g Measurements are considered unreliable due to low S/N.

^h Adopted T_{eff} and log g are determined using order 33 measurements only; see Section 2.3.3.

ⁱ Adopted T_{eff} and log g are determined using order 58 measurements only; see Section 2.3.3.

^j The spectra of order 57 are modeled in this case, as order 58 spectra are almost featureless due to large large v sin i.

^k The v sin i detection floor for NIRSPEC is 9 km s⁻¹ for S/N ≥ 5, and 15 km s⁻¹ for S/N < 5 data; see Section 2.2.1.

Note – Measurements from individual spectra over individual or multiple epochs are combined using inverse uncertainty weighting (weight = 1/(σ_{upper}² + σ_{lower}²)); upper and lower uncertainties are also combined using inverse uncertainty weighting. In cases where individual spectra have S/N < 10, spectral data are combined first, the modeled.

2.4 Analysis

2.4.1 Galactic UVW Space Motions and Kinematic Populations

I combined astrometry and my measured RVs to compute Galactic UVW space motions for my sample following the prescription of Johnson & Soderblom (1987). UVW velocities are defined here in a right-handed rectangular coordinate system centered on the Sun, with U in the direction toward the Galactic center, V in the direction of Galactic rotation, and W in the direction toward the Galactic North pole (opposite the Galactic angular velocity vector). Uncertainties were propagated from the input quantities using the Monte Carlo method assuming Gaussian noise. I adopted a correction from the heliocentric frame to the local standard of rest (LSR) of $(U_{\odot}, V_{\odot}, W_{\odot}) = (11.1, 12.24, 7.25) \text{ km s}^{-1}$ from Schönrich et al. (2010). The T dwarf J1952+7240 does not have a parallax measurement, so I estimated its distance and uncertainty using the absolute magnitude/spectral type relations in Dupuy & Liu (2012). Results are tabulated in Table 2.5.

Figure 2.11 compares the distribution of UVW velocities to the 2σ velocity dispersion volumes of local thin and thick disk populations from Bensby et al. (2003). The average U and W velocities of the T dwarfs are consistent with zero, while a marginally significant net negative average V velocity ($\langle V \rangle = -3.6 \pm 2.7 \text{ km s}^{-1}$) can be attributed to asymmetric drift (Strömberg 1924). I do not find any significant correlation between UV , UW , or VW velocities.

Following Bensby et al. (2003), I computed relative probabilities of membership in the thick disk versus the thin disk ($P(\text{TD})/P(\text{D})$) and halo versus the thin disk ($P(\text{H})/P(\text{D})$) using the threshold criteria defined in Burgasser et al. (2015a): thin disk membership is assigned for $P(\text{TD})/P(\text{D}) < 0.1$, thick disk membership is assigned for $P(\text{TD})/P(\text{D}) > 10$, and intermediate population membership is assigned for $0.1 < P(\text{TD})/P(\text{D}) < 10$. All but one of my sources are thin disk members, with

J1331–0116 being identified as an intermediate thin disk/thick disk member and an unusually blue L dwarf (see Section 2.4.4). None of the sources in my sample have a significant probability of halo membership.

2.4.2 Galactic Orbits

Additional insight into my sample’s kinematic properties can be inferred by computing their Galactic orbits and orbital parameters. I used the package *galpy* (Bovy 2015) to compute the orbits, which is an ordinary differential equation solver that satisfies conservation of energy and angular momentum. I assumed an axisymmetric Galactic potential in a galactocentric cylindrical coordinate system (R, ϕ, Z) using the parameters of Miyamoto & Nagai (1975), a Solar azimuthal velocity $v_\phi = 220 \text{ km s}^{-1}$ (Bovy & Tremaine 2012), and a Solar coordinate of $(R_\odot, Z_\odot) = (8.43, 0.027)$ kpc at $\phi_\odot = 0$ (Chen et al. 2001; Reid et al. 2014). Orbits were sampled over the period -5 to $+5$ Gyr. Uncertainties in the present-day position and velocity of each source were propagated using Monte Carlo sampling assuming Gaussian noise, resulting in 1,000 orbits per source from which I computed minimum and maximum Galactic cylindrical radius (R_{\max}, R_{\min}) , maximum absolute Galactic vertical height $(|Z|)$, median orbital eccentricity $(e \equiv \langle R_{\max} - R_{\min} \rangle / \langle R_{\max} + R_{\min} \rangle)$, and median orbital inclination $(\tan i \equiv |Z| / \sqrt{X^2 + Y^2})$, with uncertainties determined from the distribution of simulated orbits.

The majority of my sample possess circular and planar orbits ($e \leq 0.20$, $i \leq 2^\circ$) as expected for a thin disk population. The intermediate thin/thick disk star J1331–0116 has the largest inclination and eccentricity in the sample ($i = 2.5^\circ \pm 0.8^\circ$, $e = 0.29 \pm 0.06$, $R_{\min} = 4.6 \pm 0.6$ kpc). The median orbital parameters for the sample, $R_{\min} = 7.5$ kpc, $R_{\max} = 9.2$ kpc, $e = 0.12$, and $i = 0.69^\circ$, are consistent with the orbital parameters of local late-M and L dwarfs reported in Burgasser et al. (2015a).¹⁸

¹⁸These values are $R_{\min} = 8.0$ kpc, $R_{\max} = 9.5$ kpc, and $e = 0.11$ for late-M dwarfs, and $R_{\min} = 7.8$ kpc,

2.4.3 Cluster Membership

UCDs, including T dwarfs, have been found to be members of nearby association and clusters, which provide independent age determinations and can potentially break the age-mass- L_{bol} degeneracy. Cluster membership probability can be determined by the alignment in 6D configuration space (heliocentric XYZ spatial and UVW velocity coordinates) with other association members. XYZ spatial coordinates are defined in the same direction as UVW . I used the BANYAN Σ web tool¹⁹ (Gagné et al. 2018c) to compare the astrometry and radial velocities of my sources to 27 young clusters within 150 pc of the Sun. I confirmed that J0136+0933 (Gagné et al. 2017) and J1324+6358 (Gagné et al. 2018a) are probable members (99%) of the ~ 200 Myr Carina-Near and 130 Myr AB Doradus moving groups, respectively (Zuckerman et al. 2006; Gagné et al. 2018b). I also confirmed that J0819–0335 is a candidate kinematic member of the β Pictoris moving group (age $\tau = 24 \pm 3$ Myr, Bell et al. 2015), with a 95% probability of membership and a 5% probability of being a field dwarf (Zhang et al. 2021b). J1553+1532 is also confirmed as a kinematic member of Carina-Near moving group, with a 98% probability of membership (2% field object; Zhang et al. 2021b). I discuss these two sources in further detail below. I am able to rule out three young moving group candidates reported in Zhang et al. (2021b), identified on the basis of spatial coordinates, proper motion, and the BANYAN Σ tool. These are J0627–1114 (99% field object), J1624+0029 (27% Carina-Near; 73% field object), and J2236+5105 (99% field object). My ability to excluded these candidates highlights the importance of precise RV measurements in assessing cluster membership.

$R_{\text{max}} = 10$ kpc, and $e = 0.16$ for late L dwarfs, with $i \leq 2^\circ$ for both populations.

¹⁹<http://www.exoplanetes.umontreal.ca/banyan/>

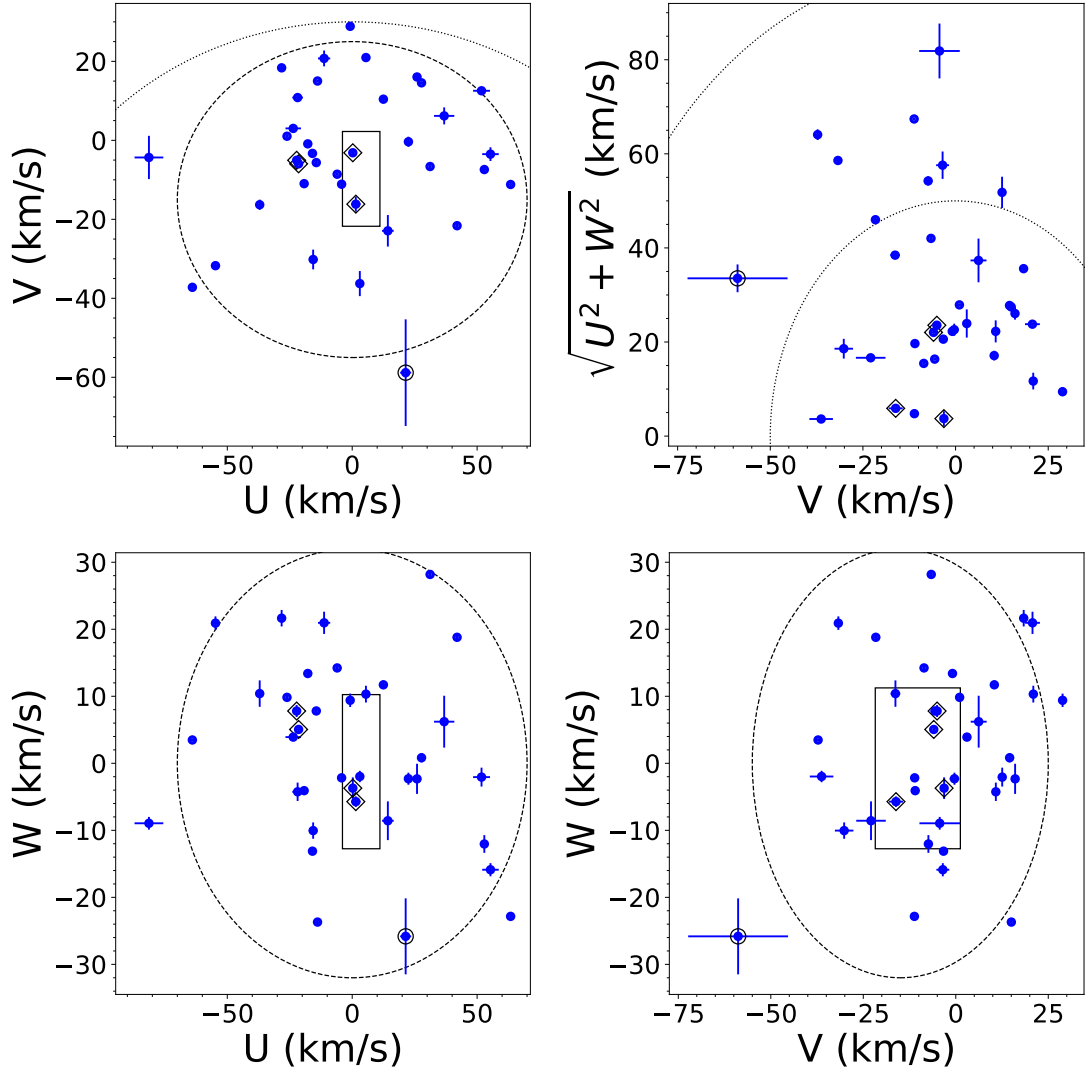


Figure 2.11: UVW space motions of the T dwarf sample in the Local Standard of Rest (Schörrich et al. 2010). The UV , UW , and VW velocities are shown along with the 2σ uncertainty spheres for the thin disk (dashed lines) and thick disk (dotted lines) populations from Bensby et al. (2003). The “good box” from Zuckerman & Song (2004) that segregates members of young moving groups is also labeled. The upper-right corner is a Toomre plot, with total velocities $v_{\text{tot}} = \sqrt{U^2 + V^2 + W^2}$ indicated in steps of 50 km s^{-1} in dotted circles. Young sources and intermediate thin/thick disk sources ($0.1 < P(\text{TD})/P(\text{D}) < 10$) are highlighted with open diamonds and open circles, respectively.

Table 2.5: Radial Velocities and Heliocentric Space Motions

| Source Name | SpT | Adpoted RV (km s ⁻¹) | <i>U</i> (km s ⁻¹) | <i>V</i> (km s ⁻¹) | <i>W</i> (km s ⁻¹) | P[TD]/P[D] ^a | Population ^a |
|-------------|------------------------|---------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-------------------------|-------------------------|
| J0000+2554 | T4.5 | 6.4 ^{+0.4} _{-0.5} | 7.1±0.2 | 21.6±0.4 | 10.5±0.4 | 0.01 | D |
| J0034+0523 | T6.5 | 16.6 ^{+1.4} _{-1.6} | -19.0±0.7 | 11.5±0.8 | -4.6±1.4 | 0.01 | D |
| J0136+0933 | T2.5 | 10.4 ^{+0.3} _{-0.3} | -21.5±0.2 | -6.0±0.1 | 5.1±0.2 | 0.01 | D |
| J0150+3827 | T0 | 56.2 ^{+0.9} _{-0.9} | -94.6±5.0 | -15.5±4.6 | -5.2±0.8 | 0.09 | D |
| J0213+3648 | T3 | -3.8 ^{+1.0} _{-0.9} | 10.7±3.2 | 7.2±3.6 | 10.1±4.1 | 0.01 | D |
| J0243-2453 | T6 | -0.6 ^{+0.6} _{-0.7} | 27.8±0.7 | 14.6±0.3 | 0.8±0.7 | 0.01 | D |
| J0415-0935 | T8 | 51.9 ^{+1.1} _{-1.1} | -54.9±0.8 | -31.8±0.4 | 21.2±0.8 | 0.05 | D |
| J0559-1404 | T4.5 | -9.5 ^{+0.1} _{-0.1} | 31.1±0.1 | -6.4±0.2 | 28.0±0.1 | 0.02 | D |
| J0627-1114 | T6 | 1.2 ^{+0.9} _{-1.1} | 23.8±1.0 | -1.7±1.0 | -3.0±0.5 | 0.01 | D |
| J0629+2418 | L7+T5.5 ^b | 0.5 ^{+2.3} _{-2.1} | 13.9±2.3 | -27.1±3.5 | -17.8±2.3 | 0.01 | D |
| J0755+2212 | T5 | 22.3 ^{+2.1} _{-1.7} | -5.9±2.3 | -10.8±1.1 | 9.0±1.1 | 0.01 | D |
| J0819-0335 | T4 | 14.4 ^{+0.8} _{-0.9} | 0.3±0.6 | -3.5±0.7 | -4.5±0.6 | 0.01 | D |
| J0909+6525 | T1.5+T2.5 ^b | 37.8 ^{+1.6} _{-1.6} | -28.1±1.4 | 19.6±0.8 | 21.0±1.2 | 0.02 | D |
| J0937+2931 | T6 | -4.3 ^{+0.4} _{-0.4} | 42.0±0.4 | -21.6±0.4 | 18.8±0.4 | 0.02 | D |
| J1106+2754 | T0+T4.5 ^b | 2.5 ^{+0.2} _{-0.2} | 3.2±0.2 | -37.0±1.2 | -2.0±0.3 | 0.01 | D |
| J1217-0311 | T7.5 | 9.9 ^{+2.3} _{-1.9} | -37.0±1.2 | -16.3±1.3 | 10.4±2.0 | 0.01 | D |
| J1225-2739 | T5.5+T8 ^b | 18.5 ^{+1.5} _{-1.2} | 52.9±1.3 | -7.4±1.1 | -12.0±1.3 | 0.01 | D |
| J1254-0122 | T2e | 2.7 ^{+0.4} _{-0.5} | -17.8±1.0 | -0.9±0.5 | 13.4±0.5 | 0.01 | D |
| J1324+6358 | T2p | -23.0 ^{+0.5} _{-0.4} | 5.5±0.7 | -12.5±0.8 | -6.8±0.5 | 0.01 | D |
| J1331-0116 | T0 | -3.3 ^{+0.4} _{-0.4} | 25.4±1.6 | -83.8±9.7 | -36.3±4.1 | 0.27 | D/TD |
| J1346-0031 | T6.5 | -17.5 ^{+0.6} _{-0.5} | -19.2±0.8 | -11.0±1.0 | -4.1±0.5 | 0.01 | D |
| J1457-2122 | T8 | 31.9 ^{+0.3} _{-0.3} | 63.4±0.4 | -11.2±0.2 | -22.8±0.5 | 0.04 | D |
| J1503+2525 | T5.5 | -35.9 ^{+0.4} _{-0.3} | -13.8±0.2 | 14.9±0.1 | -23.7±0.4 | 0.02 | D |
| J1506+7027 | T6 | 2.5 ^{+0.4} _{-0.5} | -26.0±0.2 | 1.0±0.4 | 9.8±0.3 | 0.01 | D |
| J1520+3546 | T0 | 4.1 ^{+1.0} _{-1.0} | 42.4±2.4 | 13.3±0.5 | 0.8±1.1 | 0.01 | D |
| J1553+1532 | T6.5+T7.5 ^b | -25.5 ^{+0.6} _{-0.5} | -21.6±0.4 | -4.6±0.2 | 7.1±0.5 | 0.01 | D |
| J1624+0029 | T6 | -24.3 ^{+0.5} _{-0.5} | -14.4±0.4 | -5.6±0.2 | 7.8±0.3 | 0.01 | D |
| J1629+0335 | T2 | 7.6 ^{+0.6} _{-0.6} | 26.0±0.7 | 16.9±0.2 | -2.8±0.8 | 0.01 | D |
| J1809-0448 | T1 | -43.4 ^{+1.3} _{-1.3} | -12.0±1.5 | -38.0±2.0 | -11.8±0.9 | 0.02 | D |
| J1928+2356 | T6 | -26.3 ^{+0.2} _{-0.3} | -5.3±0.2 | -9.1±0.3 | 16.0±0.1 | 0.01 | D |
| J1952+7240 | T4 | -12.0 ^{+1.3} _{-0.7} | 39.2±0.7 | 5.4±1.2 | 9.7±0.5 | 0.01 | D |
| J2030+0749 | T1.5 | -21.2 ^{+0.6} _{-0.7} | -16.2±0.4 | -3.3±0.5 | -13.5±0.3 | 0.01 | D |
| J2126+7617 | L7+T3.5 ^b | -18.4 ^{+0.4} _{-0.4} | -62.6±0.8 | -36.7±0.5 | 3.5±0.1 | 0.05 | D |
| HN Peg B | T2.5 | -19.5 ^{+1.3} _{-1.3} | -4.2±0.4 | -11.1±1.1 | -2.2±0.6 | 0.01 | D |
| J2236+5105 | T5 | -1.2 ^{+0.3} _{-0.3} | -25.2±1.3 | 2.6±0.4 | 3.6±0.2 | 0.01 | D |
| J2254+3123 | T5 | 15.1 ^{+0.3} _{-0.6} | 0.1±0.4 | 28.7±0.6 | 8.9±0.5 | 0.01 | D |
| J2356-1553 | T6 | 21.8 ^{+0.9} _{-1.0} | 55.4±3.3 | -3.5±1.7 | -15.9±1.0 | 0.02 | D |

^a Galactic thin disk (D), thick disk (TD), intermediate populations (D/TD) are assigned according to probability ratios $P(\text{TD})/P(\text{D}) < 0.1$, $P(\text{TD})/P(\text{D}) > 10$, and $0.1 < P(\text{TD})/P(\text{D}) < 10$, respectively, following Bensby et al. (2003).

^b Known or candidate binary.

2.4.4 Individual Sources of Interest

2MASS J00345157+0523050 is a peculiar T6.5/T7 (Chiu et al. 2006; Burgasser et al. 2004). It has the largest $v \sin i$ in my sample ($v \sin i = 90 \pm 2 \text{ km s}^{-1}$), making it one

of the fastest rotating brown dwarfs found to date ²⁰. Assuming a radius of $1 R_{\text{Jup}}$ and edge-on rotation, this corresponds to a *maximum* rotational period of 1.4 hr. Assuming a mass of $0.05 M_{\odot}$ (which corresponds to a 900 K brown dwarf at 5 Gyr; Baraffe et al. 2003), the observed velocity corresponds to 30% of the break-up rotational velocity ($v_{\text{break}} = \sqrt{GM/R} \sim 300 \text{ km s}^{-1}$). The source exhibits a very blue near-infrared color $J - K = -0.93 \pm 0.03$ (Lawrence et al. 2013) and other spectral peculiarities that have been attributed to enhanced H₂ collision-induced absorption (CIA) in the high-pressure atmosphere of a relatively massive (high surface gravity) and/or low-metallicity (low opacity) brown dwarf (Linsky 1969; Burgasser et al. 2004). The absence of the K I doublet absorption at $1.25 \mu\text{m}$, which is generally present in the spectra of T6–T7 dwarfs (Martin et al. 2017), may be an indicator of low metallicity effects or shallowing of the line features due to the object’s fast rotation. Either trait would imply that J0034+0523 is a relatively old brown dwarf with a high mass and compact radius which has not undergone significant angular momentum loss. I note that my forward-modeling fit utilizes solar-metallicity atmosphere models, and the potential subsolar metallicity of this peculiar T dwarf may influence the derived parameters, including $v \sin i$.

2MASS J02431371–2453298 (Burgasser et al. 1999) stands out in Figure 2.9 as the only non-binary or unusually blue L dwarf with a gravity-based model age significantly less than 1 Gyr. This T6 dwarf had previously been identified as a candidate member of the ~ 400 Myr Ursa Majoris moving group based on its distance and proper motion (Bannister & Jameson 2007; Jameson et al. 2008b), and prior low-resolution spectral analyses have also indicated evidence of low surface gravity (Burgasser et al. 2006a). This source thus exhibits both kinematic and spectral indicators of relative youth, and is a potential benchmark for spectral age indicators for mid- and late-type T

²⁰Other unusually fast rotators plotted in Figure 2.7 include *2MASS J04070752+1546457* ($82.6 \pm 0.2 \text{ km s}^{-1}$), *LP 349-25B* ($83 \pm 3 \text{ km s}^{-1}$), *HD 130948BC* ($86 \pm 6 \text{ km s}^{-1}$), and *2MASS J03480772–6022270* ($104 \pm 7 \text{ km s}^{-1}$); see Konopacky et al. (2012); Tannock et al. (2021).

dwarfs. However, it should be noted that two other mid- to late-type T dwarfs identified by (Bannister & Jameson 2007) as potential members of the ~ 650 Myr Hyades moving group, the T7 J1217–0311 and the T6 J1624+0029, are not identified as low surface gravity objects in this analysis.

2MASS J05591914–1404488 (Burgasser et al. 2000b) is a relatively bright and seemingly overluminous T4.5 ($M_J = 13.7$), but has not yet been confirmed as a binary system (Burgasser et al. 2003a; Golimowski et al. 2004; Liu et al. 2006; Stephens et al. 2009; Burgasser et al. 2010; Dupuy & Liu 2017; Manjavacas et al. 2019). It is one of five sources in my sample that has multi-epoch observations, with 10 observations spanning 2001 Oct 9 to 2021 Jan 1. These measurements show significant evidence of RV variation, differing from a constant velocity model by $\chi^2 = 26$, (Degrees of freedom DOF = 9, p-value ≤ 0.005 ; Figure 2.12). This is in contrast to the conclusions of Zapatero Osorio et al. (2007) and Prato et al. (2015) who report constant—but differing—RVs based on subsets of the same data. Indeed, the standard deviation of my re-analyzed measurements ($\sigma_{RV} = 1.2 \text{ km s}^{-1}$) is smaller than the difference between the previously published RVs ($RV_{Zap} - RV_{Pra} = -5.0 \text{ km s}^{-1}$). The sparse sampling of the data prevents a robust assessment of potential orbital motion, and follow-up RV measurements are warranted to validate this RV variation and assess the multiplicity of this potentially unresolved source.

2MASS J08195820–0335266 (Kirkpatrick et al. 2011) is a T4 dwarf with spatial and kinematic evidence of membership in the 24 Myr-old β Pictoris moving group (see Section 2.4.3), consistent with Zhang et al. (2021b) on the basis of 5D kinematics. At this age, and assuming $T_{\text{eff}} = 1100 \text{ K}$ based on Filippazzo et al. (2015), evolutionary models predict a mass of only 7 Jupiter masses, well below the deuterium burning mass limit (Baraffe et al. 2003). However, spectral evidence of youth for this source is not clear. Its near-infrared low-resolution spectrum is fully consistent with the T4 standard

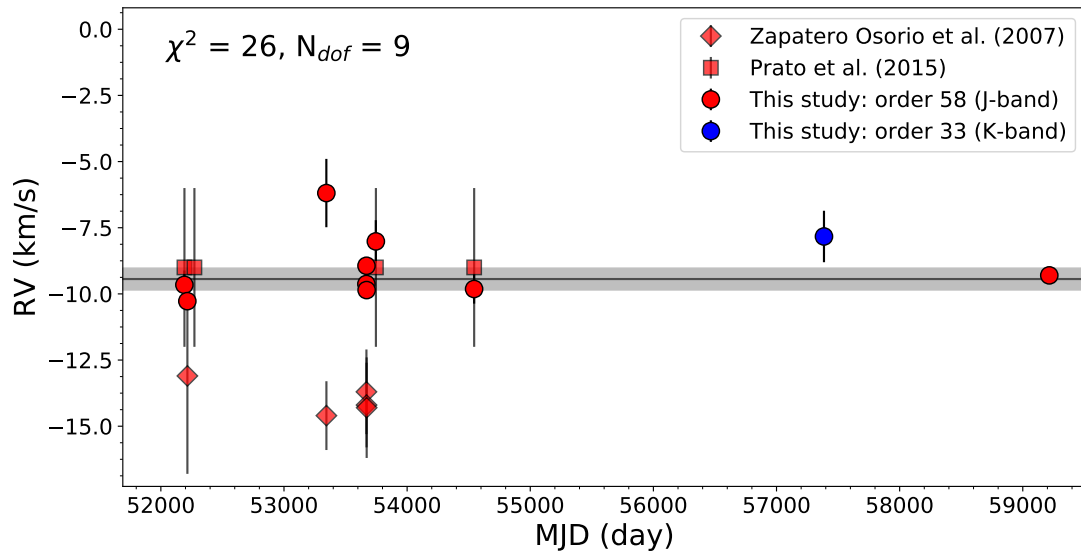


Figure 2.12: RV time series for all of the NIRSPEC measurement epochs for 2MASS J0559–1404. Measurements made in order 33 and 58 are shown as blue and red circles, respectively. The weighted average of my measurements and uncertainty are indicated by the horizontal line and grey shading. Prior measurements reported by Zapatero Osorio et al. (2007) and Prato et al. (2015) based on NIRSPEC data are indicated by red diamonds and red squares, respectively.

2MASS J2254188+312349 (Figure 2.13; Burgasser et al. 2004). Pineda et al. (2016) reported the red optical ($0.7\text{--}1.0\ \mu\text{m}$) spectrum of this source, recommending it as the T4 optical standard with features that naturally transition between T2 and T5 optical standards (Burgasser et al. 2003a). They found no evidence of $\text{H}\alpha$ emission to a limit of $\log_{10} L_{\text{H}\alpha}/L_{\text{bol}} < -5.7$. The lack of activity is consistent with its small $v \sin i$, for which I am only able to determine an upper limit of $v \sin i < 9\ \text{km s}^{-1}$. Heinze et al. (2015) report the possible detection of variability ($> 3.6\%$ in amplitude) at red optical wavelengths ($0.7\text{--}0.95\ \mu\text{m}$), which is common for both young brown dwarfs and objects spanning the L dwarf/T dwarf transition (Radigan et al. 2012; Metchev et al. 2015). Taken together, I suspect that this source is a field brown dwarf with a chance kinematic alignment with the β Pictoris moving group.

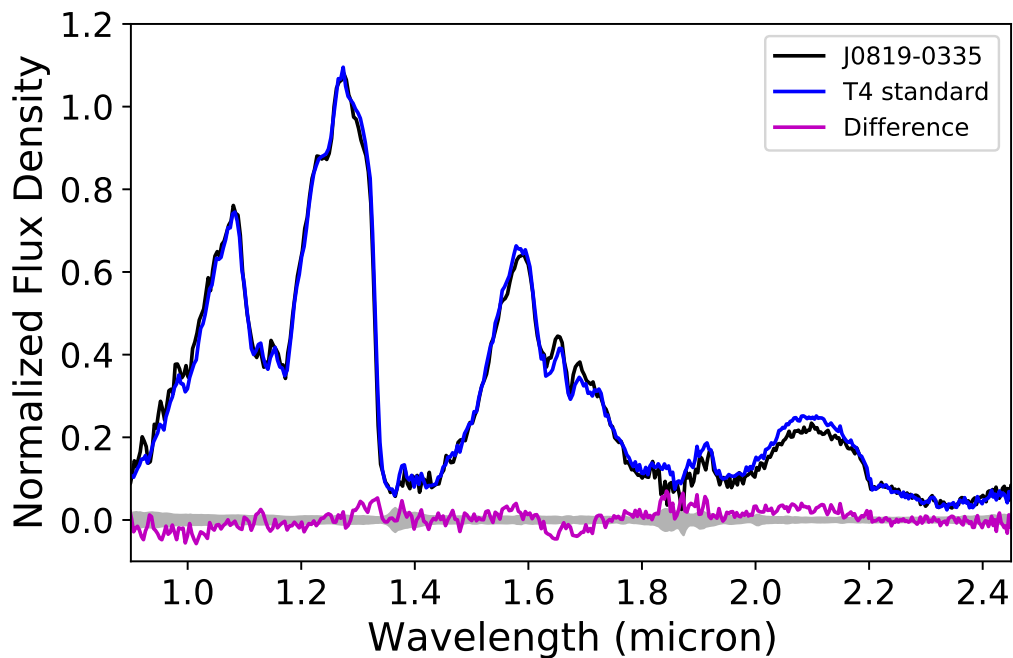


Figure 2.13: Low-resolution near-infrared spectrum of the T dwarf 2MASS J0819–0335 (black lines; uncertainty in grey shading centered at zero flux) from Burgasser et al. (2004) compared to (blue lines) the T4 near-infrared spectral standard 2MASS J2254188+312349 (data from Kirkpatrick et al. 2011). The spectra are normalized to align in the $0.90\text{--}1.25\ \mu\text{m}$ region, and the magenta lines show the difference spectra (template minus J0819–0335).

2MASS J0937347+293142 (Burgasser et al. 2002) is a peculiar T6 dwarf with the second largest rotational velocity in my sample, $v \sin i = 66.9^{+0.5}_{-0.6}$ km s⁻¹. Assuming a radius of 1 R_{Jup}, this rotational speed corresponds to a maximum rotation period of 2 hours. Like J0034+0523, J0937+2931 has an unusually blue near-infrared color $J - K = -1.10 \pm 0.06$ (Leggett et al. 2010). This and other spectral peculiarities, including the weak or absent K I lines at 1.25 μ m, have been cited as evidence of high surface gravity and/or subsolar metallicity for this source (Burgasser et al. 2002, 2006a; McLean et al. 2007; Prato et al. 2015; Martin et al. 2017; Zhang et al. 2019). The rapid rotation of J0937+2931 may also be partly responsible for the weakened atomic features. Again, these physical traits imply an old age, indicating that J0937+2931 is a massive and compact brown dwarf that has not had appreciable angular momentum loss in its late evolution.

2MASS J11061197+2754225 (Looper et al. 2007) is a previously reported candidate binary system with hypothesized T0.0+T4.5 components based on analysis of its low-resolution near-infrared spectrum (Looper et al. 2007; Burgasser et al. 2010; Bardalez Gagliuffi et al. 2014). It is also highly overluminous (Manjavacas et al. 2013), but has not been resolved by direct imaging (Looper et al. 2008). My measurements show highly significant RV variations over 15 epochs spanning 2008 Mar 19 to 2021 Jan 1, deviating from a constant velocity model by $\chi^2 = 318$ (DOF = 15, p-value < 0.001; Figure 2.14). I performed a preliminary orbit fit on 11 epochs of these data ($\chi^2 = 155$, p-value < 0.001), rejecting order 33 data from 2016 Jan 18 and 2018 Jan 1 due to the slit width 0".432 being wider than the seeing on these nights; and order 58 data on 2008 Mar 19 and 2010 Dec 26 which are likely contaminated by light from the secondary, which is brighter than the primary in the *J*-band (see Burgasser et al. 2010). I used the package *RadVel* (Fulton et al. 2018), and converged on a set of solutions with primary semi-amplitude $K_1 = 6.30 \pm 0.05$ km s⁻¹, period $P = 3.92^{+0.07}_{-0.09}$ yr, eccentricity

$e = 0.33^{+0.04}_{-0.02}$, and center of mass radial velocity $V_{\text{COM}} = 2.0 \pm 0.1 \text{ km s}^{-1}$. This system is examined in further detail in a companion paper (Burgasser et al., in prep).

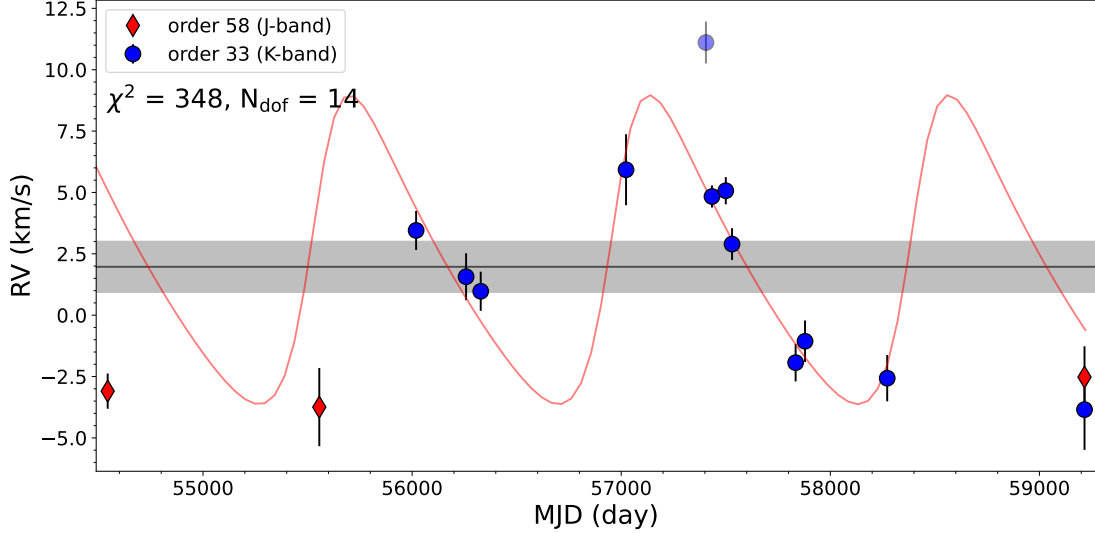


Figure 2.14: RV time series for all of the NIRSPEC measurement epochs of 2MASS J1106+2754. Measurements of orders 33 (*K*-band) and 58 (*J*-band) are labeled as blue circles and red diamonds, respectively. The horizontal line is the weighted average of my measurements, with the uncertainty shaded in grey. Also shown is a best-fit RV orbital curve with a semi-amplitude of $K_1 = 6.30 \text{ km s}^{-1}$ and a period of $P = 3.92 \text{ yr}$, based on eleven epochs in order 33 with a removal of a bad observation on 2016 Jan 18 (light blue) and 2018 Jan 1 (outside of the range presented here). The data in order 58 were not fit because the secondary component is brighter at *J*-band. See Section 2.4.4 for details.

SDSS J133148.92–011651.4 (Hawley et al. 2002) is the only source in my sample identified as an intermediate member in the Galactic thin and thick disk populations. Like J0937+2931, this source has an unusually blue near-infrared color for an early-T dwarf ($J - K = 1.279 \pm 0.008$; Lawrence et al. 2007) and a peculiar spectrum that has challenged classification. Optical spectral classifications have ranged from L1 pec (Marocco et al. 2013) to L6 (Hawley et al. 2002) while near-infrared spectral classifications have ranged from L6 (Bardalez Gagliuffi et al. 2014) to T0 (Schneider et al. 2014). There are also conflicting determinations of this source being either metal-poor (Marocco et al. 2013) or lacking in subdwarf spectral features (Kirkpatrick et al. 2016), and model fits indicate

unusually thin clouds for a late L dwarf (Stephens et al. 2009). Figure 2.15 shows the low-resolution near-infrared spectrum of this source from Bardalez Gagliuffi et al. (2014) compared to L6 and T0 spectral standards, and the near-infrared spectrum of the L subdwarf 2MASS J11181292–0856106 (Kirkpatrick et al. 2010). The L subdwarf is the best match of the three, meaning that J1331–0116 is likely an old, slightly metal-poor L dwarf whose spectrum is shaped by enhanced H₂ CIA and possibly atmospheric condensates. Given its distinct classification from the rest of the T sample, I exclude this source from the T dwarf kinematic analysis presented below.

2MASS J15530228+1532369AB (Burgasser et al. 2002) is a resolved T6.5+T7.5 binary with a separation of $0''349 \pm 0''005$, $\Delta M_{\text{bol}} = 0.31 \pm 0.12$, and mass ratio $q = 0.90 \pm 0.02$. Here, I find spatial and kinematic evidence of membership in the ~ 200 Myr-old Carina-Near moving group (see Section 2.4.3), consistent with Zhang et al. (2021b) on the basis of 5D kinematics. At this age, and assuming component $T_{\text{effs}} = 750$ K and 890 K based on Filippazzo et al. (2015), evolutionary models predict masses of $10_{-1.6}^{+0.8}$ and $11.3_{-0.5}^{+0.4}$ Jupiter masses, below the deuterium burning mass limit (Baraffe et al. 2003). The kinematically young late-type T binary could join an exclusive club of AB Doradus T3.5 GU Psc b (Naud et al. 2014), AB Doradus T5.5 SDSS J111010.01+011613.1 (Gagné et al. 2015a), and candidate AB Doradus L+T binary WISE J135501.90–825838.9 (Bardalez Gagliuffi et al. 2018), and TW Hydrae L7 binary 2MASS J11193254–1137466 (Best et al. 2017). However, spectral evidence of youth for this source is lacking. Its near-infrared low-resolution spectrum is fully consistent with the T7 standard 2MASS J07271824+1710012 (Figure 2.16; Burgasser et al. 2010) and inconsistent with the 20 Myr T dwarf 51 Eri b²¹ ($T_{\text{eff}}=760\pm 20$ K; data from VLT/SPHERE and Gemini Planet Imager; Macintosh et al. 2015; Samland et al. 2017). Line et al. (2017) measured a $\log g$

²¹The spectral features might not be the same between 20 Myr and 200 Myr T7 dwarf, as L dwarfs have different spectral features between intermediate and very-low gravity in Allers & Liu (2013). T7 dwarfs at the ages of 20 Myr and 200 Myr correspond to $\log g=3.5\text{--}4.0$ dex and $4.2\text{--}4.5$ dex, respectively, using Baraffe et al. (2003) models.

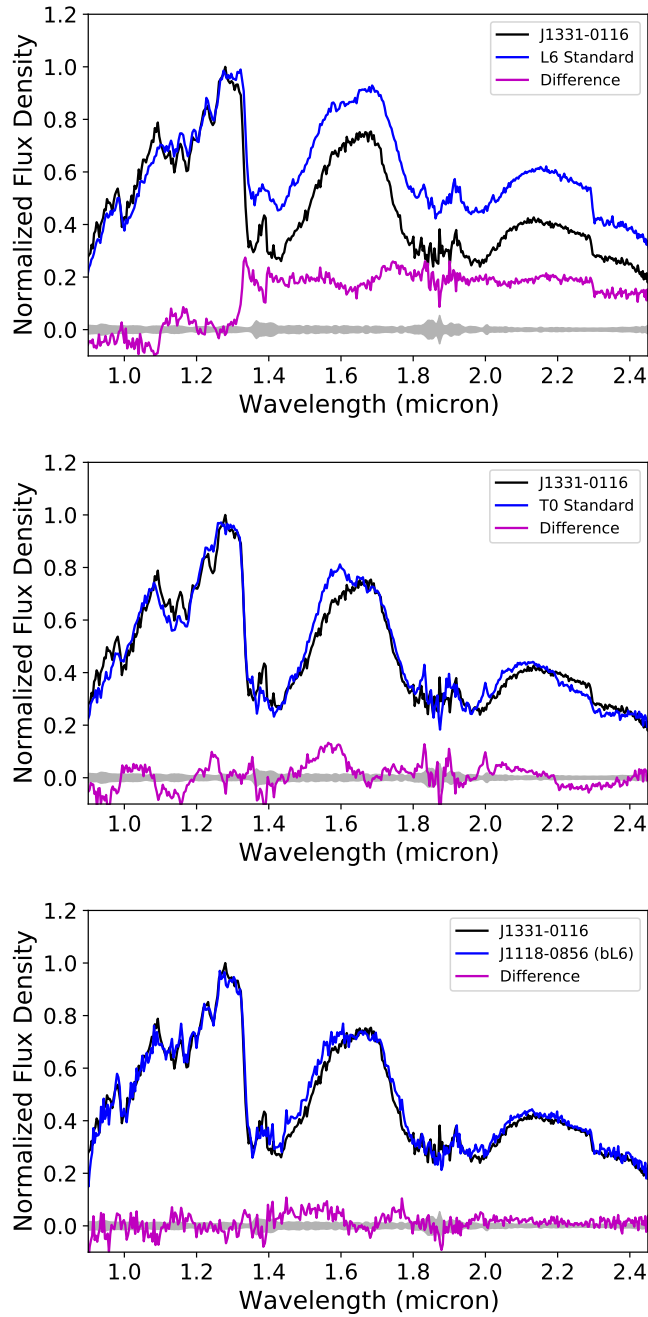


Figure 2.15: Low-resolution near-infrared spectrum of the peculiar L dwarf J1331–0116 (black lines; uncertainty in grey shading centered at zero flux) from Bardalez Gagliuffi et al. (2014) compared to (blue lines) the L6 near-infrared spectral standard 2MASSI J1010148–040649 (top; data from Reid et al. 2006), the T0 spectral standard SDSS J120747.17+024424.8 (middle; data fromLooper et al. 2007), and the unusually blue L6 dwarf 2MASS J11181292–0856106 (bottom; data from Kirkpatrick et al. 2010). All spectra are normalized to align in the 0.90–1.25 μm region, and the magenta lines show the difference spectra (template minus J1331–0116).

of $4.8_{-0.2}^{+0.1}$ dex for J1553+1532 after correcting for binarity, but with subsolar metallicity ($[M/H] = -0.19_{-0.06}^{+0.04}$ dex and supersolar $\log C/O = -0.11_{-0.09}^{+0.09}$). This source does not exhibit significant variability in JHK_S or J_S (Koen et al. 2004; Wilson et al. 2014). Taken together, I suspect that this source is also a field brown dwarf with a chance kinematic alignment with the Carina-Near moving group.

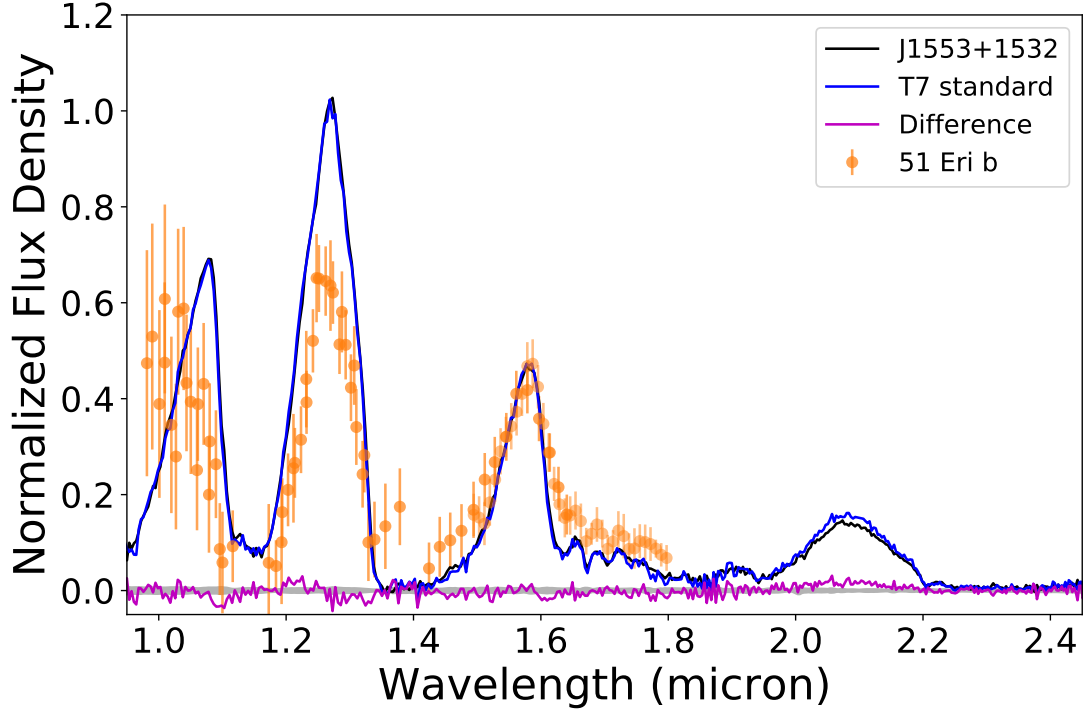


Figure 2.16: Low-resolution near-infrared spectrum of the T dwarf 2MASS J1553+1532 (black line; uncertainty in grey shading centered at zero flux) from Burgasser et al. (2010) compared to the T7 near-infrared spectral standard 2MASS J07271824+1710012 (blue line; data from Burgasser et al. 2006a). The spectra are normalized to align in the $0.90\text{--}1.25\ \mu\text{m}$ region, and the magenta line shows the difference spectrum (template minus J1553+1532). Also shown is the 51 Eri b spectrum from Samland et al. (2017), normalized to H band peak.

2MASS J21265916+7617440 is a T0p dwarf proposed to be an L7+T3.5 blended-light binary based on medium-resolution spectroscopy (Kirkpatrick et al. 2010). High-resolution imaging by Bardalez Gagliuffi et al. (2015) failed to resolve the system and constrained its angular separation to <106 mas or <1.3 au. My measurements

show significant RV variations over 10 epochs spanning 2011 Jun 10 to 2020 Sep 3, deviating from a constant velocity model by $\chi^2=39$ (DOF = 9, p-value < 0.001; Figure 2.17). Following the analysis of J1106+2754, I performed a preliminary orbit fit to the RV data using *RadVel*, and converged on a set of solutions with primary semi-amplitude $K_1 = 3.0^{+0.7}_{-0.6}$ km s⁻¹, period $P = 12.0^{+1.5}_{-1.2}$ yr, and center of mass radial velocity $V_{\text{COM}} = -17.5 \pm 0.4$ km s⁻¹. This system is examined in detail in a companion paper (Hsu et al., in prep).

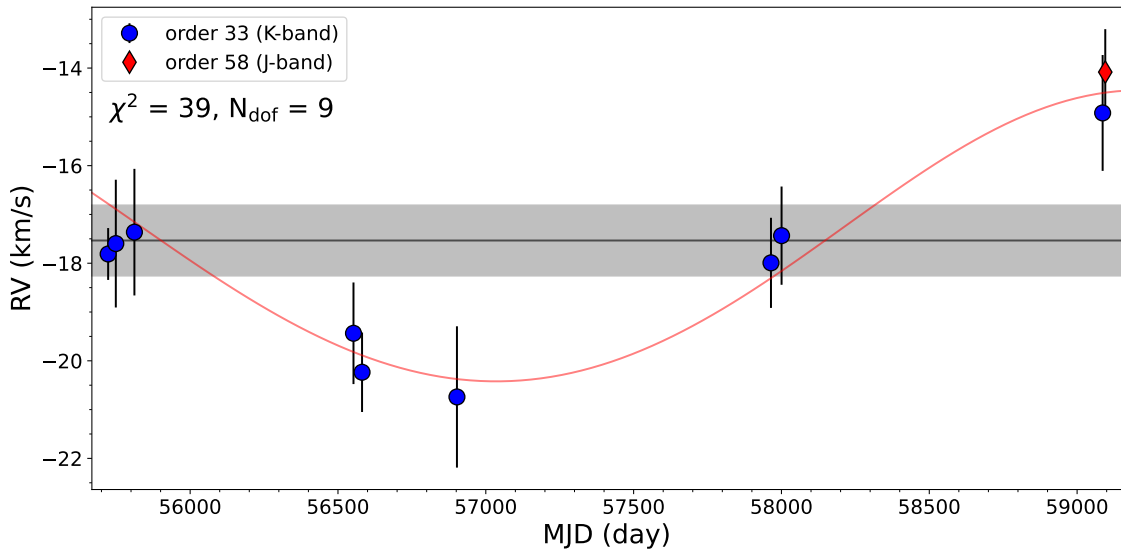


Figure 2.17: RV time series for all of the NIRSPEC measurement epochs of 2MASS J2126+7617. Measurements of orders 33 (*K*-band) and 57 (*J*-band) are labeled as blue circles and red diamonds, respectively. The horizontal line is the weighted average of my measurements, with the uncertainty shaded in grey. Also shown is a best-fit RV orbital curve with a semi-amplitude $K_1 = 3.0$ km s⁻¹ and period $P = 12.0$ yr.

HN Peg B (Luhman et al. 2007) is a T2.5 dwarf that is a wide companion (782 au) to the young (~ 300 Myr) G0V star *HN Peg*. It is an important benchmark for testing brown dwarf evolutionary models near the L dwarf/T dwarf transition (Leggett et al. 2008). My best-fit models of *HN Peg B* for data from 2017 Jun 9 yield $RV = -19.5 \pm 1.3$ km s⁻¹, consistent with the primary star’s $RV = -17.18 \pm 0.17$ km s⁻¹ (Gaia Collaboration et al. 2018b). *HN Peg B* is also a photometrically variable source (Metchev

et al. 2015; Zhou et al. 2018; Vos et al. 2019). My $v \sin i = 15 \pm 3 \text{ km s}^{-1}$ combined with the period measurement from Zhou et al. (2018) of $15.4 \pm 0.5 \text{ hr}$ yields a rotation axis inclination angle of $63^\circ \pm 7^\circ$ assuming a model radius of $0.108^{+0.014}_{-0.006} R_\odot$ using the theoretical evolutionary models of Burrows et al. (1997) and Baraffe et al. (2003) (Luhman et al. 2007). This is consistent with the current hypothesis that the frequency and amplitude of variability are higher for brown dwarfs observed at intermediate-to-high viewing angles ($i > 60^\circ$; Heinze et al. 2013; Metchev et al. 2015; Vos et al. 2017).

2.5 Ultracool Dwarf Kinematics in the Local Neighborhood

2.5.1 Velocity Dispersions and the Kinematic Age of T Dwarfs

The velocity dispersion,

$$\sigma_{\text{tot}}^2 = \sigma_U^2 + \sigma_V^2 + \sigma_W^2 \quad (2.5)$$

of a stellar population evolves as the population ages, as gravitational interactions with Galactic structures perturb orbits, increasing Galactic scale heights and relative velocities over time (Wielen 1977). Velocity dispersions thus provide a means of measuring the ages of stellar populations, including UCDs, which depend on the mass function, star formation history, and thermal evolution of brown dwarfs (Burgasser 2004).

I measured a total velocity dispersion for my T dwarfs to be $\sigma_{\text{tot}} = 39.0 \pm 1.0 \text{ km s}^{-1}$. To convert this into an age, I evaluated two age-dispersion relations. The first is the exponential decay law from Wielen (1977) based on the $|W|$ -weighted total velocity dispersion:

$$\bar{\sigma}_{\text{tot}}(\tau)^3 = \sigma_{\text{tot},0}^3 + 1.5 \gamma_{v,p} T_\gamma (e^{\tau/T_\gamma} - 1), \quad (2.6)$$

where τ is the statistical age in Gyr, $\sigma_{\text{tot},0} = 10 \text{ km s}^{-1}$, $\gamma_{v,p} = 1.1 \times 10^4 (\text{km s}^{-1})^3 \text{ Gyr}^{-1}$, $T_\gamma = 5 \text{ Gyr}$, and $\bar{\sigma}_{\text{tot}}$ is the $|W|$ -weighted total velocity dispersion in km s^{-1} :

$$\begin{aligned} \bar{\sigma}_{\text{tot}}^2 = & \frac{\sum_i |W_i| (U_i - \bar{U})^2}{\sum_i |W_i|} + \frac{\sum_i |W_i| (V_i - \bar{V})^2}{\sum_i |W_i|} \\ & + 0.5 \frac{\sum_i |W_i| (W_i - \bar{W})^2}{\sum_i |W_i|}, \end{aligned} \quad (2.7)$$

I also examined the age-dispersion law from Aumer & Binney (2009):

$$\sigma_{\text{tot}} = v_{1,0} \left(\frac{\tau + \tau_1}{10 \text{Gyr} + \tau_1} \right)^\beta, \quad (2.8)$$

where $v_{1,0} \in (55.179, 57.975)$ km s⁻¹, $\tau_1 \in (0.148, 0.261)$ Gyr, and $\beta \in (0.349, 0.385)$ are model parameters drawn from Table 2 of Aumer & Binney (2009). It is noted that Bird (2019) measured a very similar $\beta = 0.389 \pm 0.018$ using *Gaia* and APOGEE red clump stars.

Kinematic ages were inferred by inverting these relations to solve for τ . The age uncertainty was estimated statistically through Monte-Carlo sampling, assuming that *UVW* velocity uncertainties follow normal distributions. To account for the small sample bias, I applied a Jackknife test by iteratively removing one source from my sample and recomputing dispersions and kinematic ages for each of the resulting subsamples. The resulting *UVW* dispersions are summarized in Table 2.6.

Using the Aumer & Binney (2009) relation (averaged over all model parameters), I inferred a kinematic age of 3.5 ± 0.3 Gyr for my full sample of 36 T dwarfs (excluding J1331–0116). The Wielen relation yields a smaller but statistically consistent age of 3.0 ± 0.1 Gyr. To mitigate possible velocity biases, I also examined kinematic ages for the sample excluding the resolved and candidate binaries J0629+2418, J0909+6525, J1106+2754, J1225–2739, J1553+1532, and J2126+7617 (Burgasser et al. 2006c; Dupuy & Liu 2012; Manjavacas et al. 2013; Bardalez Gagliuffi et al. 2014); and separately the young T dwarfs J0136+0933, J0819–0335, J1324+6538, J1553+1532, and HN Peg b (Gagné et al. 2017, 2018a; Leggett et al. 2008; Zhang et al. 2021b), and found equivalent ages as the full sample (Table 2.6). I also found consistent kinematic ages between early-T (T0–T4; 3.3 ± 0.6 Gyr) and late-T (T5–T8; 3.6 ± 0.4 Gyr) subgroups. The age of local T dwarfs from the Aumer & Binney (2009) relation is consistent with the age of

local M dwarfs, but is younger than local L dwarfs (Reid et al. 2002; Reiners & Basri 2009a; Blake et al. 2010; Seifahrt et al. 2010; Burgasser et al. 2015a), as discussed in further detail below.

Figure 2.18 shows UVW velocity probability plots, or probit plots, following Lutz & Upgren (1980) and based on the percent point function defined in Filliben (1975); see also Reid et al. (2002) and Bochanski et al. (2007a). Probit plots are linear if the velocities are drawn from a single normal distribution, with the slope equal to the distribution width (σ). Both U and V velocities show two populations, with an inner “shallow” population in the $\pm 1\sigma$ region and a steeper “wide” population. To quantify the difference in kinematic ages, I performed a piece-wise linear fit to each component and used the slopes to compute ages with the Aumer & Binney (2009) relations and Monte Carlo uncertainties (Bochanski et al. 2007a; Burgasser et al. 2015a). The ages for the inner and outer components are 3.2 ± 0.5 Gyr and 4.0 ± 0.3 Gyr, respectively, and hence marginally consistent.

Table 2.6: Velocity Dispersions and Group Kinematic Ages

| Sample | N | $\langle U \rangle$ (km s ⁻¹) | $\langle V \rangle$ (km s ⁻¹) | $\langle W \rangle$ (km s ⁻¹) | σ_U (km s ⁻¹) | σ_V (km s ⁻¹) | σ_W (km s ⁻¹) | σ_{tot} (km s ⁻¹) | Age (Gyr) | Note |
|------------------------------|----|--|--|--|-------------------------------------|-------------------------------------|-------------------------------------|---|--------------|-------------|
| All Sources | 36 | -1.6 ± 5.5 | -3.6 ± 2.7 | 2.1 ± 2.0 | 33.1 ± 0.8 | 16.5 ± 0.5 | 12.3 ± 0.3 | 39.0 ± 1.0 | 3.5 ± 0.3 | Unweighted |
| Shallow ^a | 24 | -2.7 ± 3.5 | -2.6 ± 1.7 | 2.3 ± 1.4 | 35.5 ± 0.9 | 16.4 ± 0.5 | 11.6 ± 0.3 | 40.8 ± 0.8 | 3.0 ± 0.1 | W Weighted |
| Wide ^a | 12 | 0.9 ± 15.0 | -5.0 ± 7.4 | 2.3 ± 5.5 | 31.9 ± 2.2 | 15.8 ± 1.0 | 12.7 ± 1.0 | 37.8 ± 1.9 | 3.2 ± 0.5 | Unweighted |
| Not Young T Dwarfs | 31 | -0.2 ± 6.3 | -2.6 ± 3.1 | 2.6 ± 2.3 | 34.7 ± 1.0 | 17.2 ± 0.7 | 12.9 ± 0.7 | 40.8 ± 0.9 | 4.0 ± 0.3 | Unweighted |
| Not Binary T Dwarfs | 30 | -0.3 ± 5.9 | -1.0 ± 2.7 | 2.4 ± 2.3 | 35.1 ± 1.0 | 17.4 ± 0.5 | 13.1 ± 0.3 | 41.3 ± 1.1 | 4.1 ± 0.4 | Unweighted |
| | | | | | 36.3 ± 1.1 | 16.8 ± 0.5 | 12.0 ± 0.3 | 41.8 ± 1.0 | 3.1 ± 0.2 | W Weighted |
| | | | | | 32.1 ± 1.1 | 14.6 ± 0.4 | 12.6 ± 0.3 | 37.4 ± 1.2 | 3.1 ± 0.3 | Unweighted |
| | | | | | 35.3 ± 1.2 | 15.9 ± 0.6 | 11.9 ± 0.3 | 40.5 ± 1.0 | 2.9 ± 0.2 | W Weighted |
| Not Binary or Young T Dwarfs | 26 | 0.6 ± 6.7 | 0.2 ± 3.0 | 3.0 ± 2.6 | 34.2 ± 1.2 | 15.1 ± 0.5 | 13.3 ± 0.4 | 39.7 ± 1.3 | 3.7 ± 0.4 | Unweighted |
| | | | | | 36.1 ± 1.3 | 16.2 ± 0.6 | 12.1 ± 0.4 | 41.4 ± 1.2 | 3.1 ± 0.2 | W Weighted |
| T0–T4 dwarfs | 18 | -3.7 ± 7.6 | -5.2 ± 4.1 | 2.3 ± 2.6 | 32.1 ± 1.9 | 17.5 ± 0.7 | 11.0 ± 0.6 | 38.2 ± 2.1 | 3.3 ± 0.6 | Unweighted |
| | | | | | 31.1 ± 2.3 | 15.8 ± 0.9 | 10.2 ± 0.5 | 36.4 ± 2.0 | 2.3 ± 0.3 | W Weighted |
| T5–T8 dwarfs | 18 | 0.7 ± 7.9 | -1.6 ± 3.5 | 2.2 ± 3.2 | 33.7 ± 1.1 | 14.9 ± 0.6 | 13.5 ± 0.5 | 39.2 ± 1.4 | 3.6 ± 0.4 | Unweighted |
| | | | | | 39.2 ± 1.4 | 17.0 ± 0.8 | 12.2 ± 0.4 | 44.5 ± 1.3 | 3.6 ± 0.2 | W Weighted |

Note – Ages for unweighted velocities are computed from equation (2.8) using the parameters in Aumer & Binney (2009). Ages for |W|-weighted velocities are computed from equation (2.6) using the parameters in Wielen (1977).

^a Piece-wise linear fits to unweighted velocities, with separate fits for sources within $\pm 1\sigma$ (shallow) and outside of $\pm 1\sigma$ (wide); see Section 2.5.1.

2.5.2 Velocity Dispersions and the Kinematic Ages of Late-M and L Dwarfs

To place the T dwarf velocity dispersions and kinematic ages in context, I compiled all late-M and L dwarfs within 20 pc with published RV measurements that have uncertainties of $\leq 3 \text{ km s}^{-1}$, based on medium and high-resolution spectroscopic measurements (Table 2.7). There are 65 late-M dwarfs (M7–M9) and 71 L dwarfs (L0–L9) that match these criteria (J1331–0116 is included here; see Section 2.4.4 for more details). Figure 2.19 shows the spectral type distribution of the full late-M, L, and T dwarf RV sample, overplotted with a simulated local population and local 20 pc UCDs found to date (see Section 2.5.4 for further discussion). I combined RV measurements with *Gaia* DR2 and eDR3 parallaxes and proper motions where available to improve the *UVW* precisions over prior studies, following the same analysis as that done for the T dwarfs.

Results are summarized in Table 2.8 and Figure 2.20. I note that two late-M dwarfs in this sample (M7 2MASS J02530084+1652532 and M9 2MASS J03341218–4953322) are kinematically associated with the thick disk population, the L5.5 2MASSI J1721039+334415 is associated with the intermediate thick disk/halo population, and 17 sources (6 late-M dwarfs and 11 L dwarfs) are associated with intermediate thin/thick disk population, which includes J1331–0116, which I classify as a blue L6. Evaluating the distribution of *UVW* velocities, I find that the L dwarfs in this sample exhibit significant correlations between *UV* ($R = 0.33$, p-value < 0.01), *UW* ($R = -0.32$, p-value < 0.01) and *VW* velocities ($R = -0.27$, p-value = 0.02). For the late-M dwarfs, I find a significant correlation between *UV* velocities ($R = 0.32$, p-value < 0.01), but not between *UW* or *VW* velocities. The *UV* velocity correlation for the L dwarfs is weaker than that previously reported in Burgasser et al. (2015a, $R = 0.43 \pm 0.03$), but nevertheless significant. If I remove the thick disk, intermediate thick disk/halo, and intermediate thin/thick disk population

members from my sample, the UV velocity correlation becomes less significant for the late-M dwarf sample ($R = 0.25$, p-value = 0.06) and insignificant for the L dwarfs in all three velocity pairs. This result indicates that the UVW velocity correlations are driven by the older kinematic populations. As noted above, the T dwarfs, which are all thin disk sources, show no significant correlations in UV , UW , or VW velocity pairs. The average U and W velocities of the late-M and L dwarfs are each consistent with zero, while the negative average V velocity (greater for the L dwarfs) can again be attributed to asymmetric drift. I note that the average U velocity offset for the L dwarfs reported in Burgasser et al. (2015a) is not seen here and is likely an artifact of small sample statistics in that study.

The corresponding kinematic ages for all of the late-M and L dwarfs in my sample using the Wielen (1977) and Aumer & Binney (2009) relations are given in Table 2.9. In my sample, I find highly significant correlations between v_{tot}^2 and $|W|$ for the late-M dwarfs ($N = 65$, $R = 0.42$, p-value < 0.001) and L dwarfs ($N = 71$, $R = 0.61$, p-value $< 10^{-4}$), and significant correlation for T dwarfs ($N = 37$, $R = 0.33$, p-value = 0.05). However, if the thin/thick disk sources are removed, the significances of these correlations are reduced: marginally significant for late-M dwarfs ($N = 57$, $R = 0.22$ and p-value = 0.09), significant for L dwarfs ($N = 59$, $R = 0.27$ and p-value < 0.05), and insignificant for T dwarfs ($N = 36$, $R = 0.25$ and p-value = 0.13). These results suggest that the v_{tot}^2 , $|W|$ correlation is dominated by a few sources from a distinct population, so that Wielen's age-dispersion relation may not be as accurate for this sample as the Aumer and Binney relations. The ages from the latter relations are 4.9 ± 0.3 Gyr and 7.1 ± 0.4 Gyr, respectively, for the full late-M and L dwarf samples (Figure 2.21, upper left panel). These values confirm the significant (4.4σ) discrepancy between late-M and L dwarf kinematic ages found in previous studies. If I remove the thick disk sources, the kinematic ages are reduced to 4.1 ± 0.3 Gyr for the late-M dwarfs and 5.8 ± 0.3 Gyr for

the L dwarfs. These ages are still significantly (4.0σ) discrepant, while the late-M and T dwarfs in my sample have statistically equivalent ages.

Figure 2.22 displays the log probability of thin disk to thick disk membership for late-M, L and T dwarfs, again following Bensby et al. (2003). These distributions show that there is a marginally higher proportion of intermediate thin/thick disk and thick disk sources relative to thin disk sources among the L dwarfs ($8_{-2}^{+5}\%$), as compared to the late-M dwarfs ($3_{-1}^{+3}\%$) and T dwarfs ($3_{-2}^{+6}\%$), with ratio statistics computed using binomial statistics following Burgasser et al. (2003c). The intermediate thin/thick disk sources in particular skew the kinematic dispersions and ages toward higher values. To truly assess the kinematic age of the thin disk population without discarding too many old thin disk sources, I refined my selection requirement to $P[\text{TD}]/P[\text{D}] \leq 1.0$, since $P[\text{TD}]/P[\text{D}] = 1.0$ denotes a 50% probability as a thin or thick disk source. This thin disk sample has similar kinematic ages of 4.1 ± 0.3 Gyr and 4.2 ± 0.3 Gyr for the late-M and L dwarfs, respectively, which are slightly older but consistent with the T dwarfs. These values imply equivalent ages across the entire late-MLT sequence.

Refining the sample to high-probability thin disk sources appears to resolve the long-standing discrepancy between late-M and L dwarf kinematics (Faherty et al. 2009; Seifahrt et al. 2010; Burgasser et al. 2015a). In Section 2.5.4, I will show the observed thin disk ages of late-MLT dwarfs are also consistent with my population simulations. What remains unclear is why the local L dwarf sample has a higher fraction of thick disk sources compared to late-M and T dwarfs. I will evaluate the properties of the thick disk L dwarfs, several of which are classified as unusually blue L dwarfs, in Section 2.6.2.

For completeness, I evaluated the more recent age-velocity dispersion relation of Yu & Liu (2018), based on the kinematics and ages of >3500 sub-giant and giant branch stars. The ages were estimated from empirical trends in $[\text{C}/\text{M}]$ and $[\text{N}/\text{M}]$ abundances (Ho et al. 2017). Yu & Liu (2018) fit power-law relations to the velocity dispersions

in Galactic cylindrical coordinates, $\text{age} = C\sigma_i^\beta$, where $i = R, \phi,$ and Z direction, and $C = 1 \text{ Gyr} (\text{km s}^{-1})^{-\beta}$ is a unit conversion factor. Using the z -coordinate relation from this study with $\beta_z = 0.56 \pm 0.14$, and propagating uncertainties with Monte Carlo sampling, I compute ages for late-M dwarfs (all/thin disk = $4.9^{+2.4}_{-1.6} \text{ Gyr}/4.8^{+2.3}_{-1.5} \text{ Gyr}$), L dwarfs (all/thin disk = $5.1^{+2.5}_{-1.7} \text{ Gyr}/4.6^{+2.1}_{-1.4} \text{ Gyr}$), and T dwarfs ($4.1^{+1.7}_{-1.2} \text{ Gyr}$) that are consistent with each other, albeit with higher statistical uncertainties. The R and ϕ relations of Yu & Liu (2018) yield significantly younger ages (2.6–3.4 Gyr) which may be attributed to the very different spatial distributions of the sub-giant/giant sample as compared to the local ultracool dwarf sample.

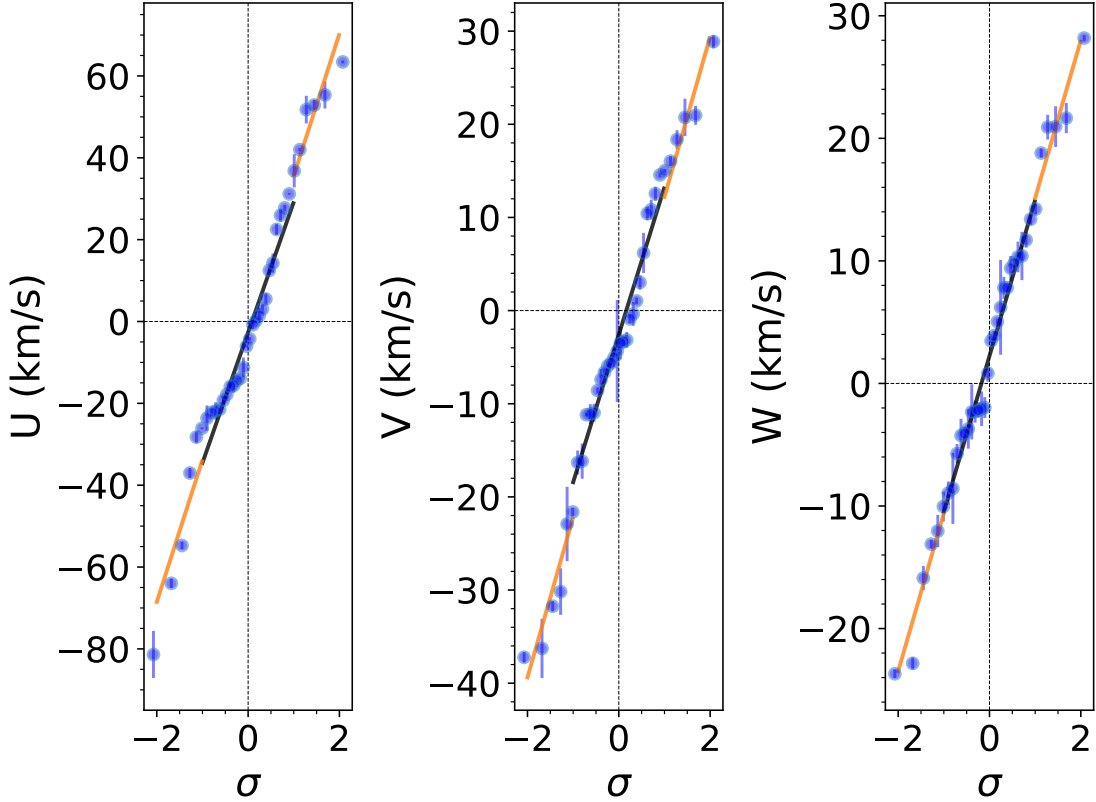


Figure 2.18: Space velocity probability plots (probit plots) of the T dwarf sample. Individual velocities are indicated by blue circles, while a piece-wise linear fit broken at $\pm 1\sigma$ for each velocity component (black and orange dashed lines, respectively) are shown. Note that the unusually blue L dwarf J1331–0116 is not included here.

Table 2.7: Late-M and L Dwarf Sample at the Local 20 pc

| Source Name | Coordinates (J2000) | SpT | 2MASS J (mag) | $J - K_s$ (mag) | μ_α (mas yr $^{-1}$) | μ_δ (mas yr $^{-1}$) | d (pc) | Published RV (km s $^{-1}$) | References ^a |
|-------------------------|-------------------------|---------|--------------------|--------------------|-----------------------------------|-----------------------------------|----------------|---------------------------------|-------------------------|
| J0004-4044 | 00 04 34.86 -40 44 06.4 | L5+L5 | 13.11 ± 0.02 | 1.71 ± 0.04 | 671.1 ± 0.4 | -1498.2 ± 0.5 | 12.18 ± 0.06 | 32.8 ± 0.2 | (17); (53); (53); (61) |
| J0004-2058 | 00 04 41.46 -20 58 29.8 | M9 | 12.4 ± 0.02 | 1.01 ± 0.03 | 758.2 ± 0.3 | 85.2 ± 0.2 | 15.08 ± 0.04 | -33 ± 2 | (18); (53); (53); (47) |
| J0015+3516 | 00 15 44.77 +35 16 02.6 | L1 | 13.88 ± 0.03 | 1.62 ± 0.04 | 55.2 ± 0.5 | -257.1 ± 0.3 | 17.06 ± 0.11 | -37.4 ± 0.2 | (33); (53); (53); (61) |
| J0019+5213 | 00 19 45.83 +52 13 17.5 | M9 | 12.79 ± 0.02 | 1.17 ± 0.03 | 310.7 ± 0.2 | -279.1 ± 0.2 | 19.96 ± 0.07 | -29 ± 3 | (16); (53); (53); (60) |
| J0024-0158 | 00 24 24.63 -01 58 19.9 | L0.5 | 11.99 ± 0.04 | 1.45 ± 0.04 | -77.2 ± 0.5 | 141.1 ± 0.3 | 12.51 ± 0.03 | 11.6 ± 1.6 | (33); (53); (53); (39) |
| J0024-2708B | 00 24 44.22 -27 08 25.0 | M8.5 | 9.25 ± 0.03 | 1.01 ± 0.05 | -107 ± 6 | 691 ± 8 | 7.72 ± 0.15 | -35 ± 3 | (2); (48); (42); (60) |
| J0027+2219 | 00 27 55.98 +22 19 32.8 | M8e | 10.61 ± 0.02 | 1.05 ± 0.03 | 406 ± 5 | -170 ± 2 | 15.3 ± 0.9 | -11.9 ± 1.3 | (10); (41); (46); (20) |
| J0036+1821 | 00 36 16.11 +18 21 10.2 | L3.5 | 12.47 ± 0.03 | 1.41 ± 0.03 | 901.6 ± 0.4 | 124.0 ± 0.2 | 8.74 ± 0.02 | 20.9 ± 0.14 | (3); (53); (53); (71) |
| J0045+1634b | 00 45 21.41 +16 34 44.7 | L0β | 13.06 ± 0.02 | 1.69 ± 0.03 | 358.9 ± 0.4 | -48.1 ± 0.2 | 15.38 ± 0.05 | 3.3 ± 0.2 | (39); (53); (53); (61) |
| J0047+6803 ^c | 00 47 00.38 +68 03 54.3 | L7 | 15.6 ± 0.07 | 2.55 ± 0.07 | 380.7 ± 1.1 | -204.2 ± 1.4 | 12.3 ± 0.3 | -19.4 ± 1.2 | (29); (50); (52); (71) |
| J0102-3737 | 01 02 51.05 -37 37 43.7 | M9 | 11.13 ± 0.02 | 1.06 ± 0.03 | 1470.1 ± 0.3 | 251.19 ± 0.14 | 11.38 ± 0.02 | -5 ± 2 | (32); (53); (53); (47) |
| J0107+0041 | 01 07 52.42 +00 41 56.4 | L8 | 15.82 ± 0.06 | 2.11 ± 0.07 | 623 ± 10 | 91.0 ± 1.0 | 15.6 ± 1.1 | 8.2 ± 0.5 | (31); (16); (44); (71) |
| J0109-5100 | 01 09 01.52 -51 00 49.4 | M8.5e | 12.23 ± 0.02 | 1.14 ± 0.03 | 219.19 ± 0.14 | 77.7 ± 0.2 | 15.91 ± 0.03 | -1.3 ± 0.2 | (13); (53); (53); (59) |
| J0109+2949 | 01 09 21.87 +29 49 26.4 | M9.5 | 12.91 ± 0.02 | 1.23 ± 0.03 | 1011.3 ± 0.5 | 368.2 ± 0.3 | 15.93 ± 0.06 | 38.9 ± 0.8 | (17); (53); (53); (56) |
| J0109-0343 | 01 09 51.20 -03 43 26.3 | M9e | 11.69 ± 0.02 | 1.27 ± 0.03 | 372.0 ± 0.6 | 8.7 ± 0.3 | 10.59 ± 0.04 | -6.3 ± 1.8 | (10); (53); (53); (64) |
| J0140+2701 | 01 40 02.64 +27 01 50.0 | M8.5 | 12.49 ± 0.02 | 1.06 ± 0.03 | 60.3 ± 0.3 | -255.3 ± 0.3 | 18.99 ± 0.06 | 8.2 ± 0.4 | (25); (53); (53); (56) |
| J0144-0716 | 01 44 35.40 -07 16 14.3 | L6.5 | 14.19 ± 0.03 | 1.92 ± 0.03 | 384.0 ± 1.1 | -196.9 ± 0.7 | 12.7 ± 0.1 | -2.6 ± 0.1 | (31); (53); (53); (61) |
| J0205-1159 | 02 05 29.40 -11 59 29.6 | L7+L7 | 14.59 ± 0.03 | 1.59 ± 0.04 | 427.0 ± 0.4 | 52.0 ± 0.5 | 19.8 ± 0.6 | 7 ± 2 | (15); (16); (44); (69) |
| J0213+4444 | 02 13 28.79 +44 44 45.2 | L1.5 | 13.49 ± 0.03 | 1.28 ± 0.03 | -52.1 ± 0.6 | -145.8 ± 0.4 | 19.35 ± 0.14 | -23.47 ± 0.11 | (16); (53); (53); (61) |
| J0215-3040 | 02 15 08.04 -30 40 01.3 | M8 | 11.62 ± 0.03 | 1.08 ± 0.03 | 768.6 ± 0.3 | -360.3 ± 0.3 | 14.06 ± 0.03 | 0.005 ± 0.009 | (16); (53); (53); (68) |
| J0217+3526 ^d | 02 17 10.01 +35 26 32.5 | M7 | 9.98 ± 0.02 | 0.97 ± 0.03 | 548.4 ± 0.2 | -260.3 ± 0.2 | 10.339 ± 0.012 | 11 ± 3 | (30); (53); (53); (70) |
| J0255-4700 | 02 55 03.69 -47 00 51.3 | L9 | 13.25 ± 0.03 | 1.69 ± 0.04 | 1011.2 ± 0.4 | -554.8 ± 0.5 | 4.87 ± 0.006 | 18 ± 3 | (31); (53); (53); (58) |
| J0253+1652 | 02 53 02.41 +16 52 34.9 | M7 | 8.39 ± 0.03 | 0.81 ± 0.05 | 3429.5 ± 0.3 | -3806.2 ± 0.3 | 3.831 ± 0.004 | 68.30 ± 0.05 | (73); (53); (53); (66) |
| J0306-3647 | 03 06 11.59 -36 47 52.8 | M9 | 11.69 ± 0.02 | 1.06 ± 0.03 | -172.48 ± 0.12 | -669.3 ± 0.2 | 13.26 ± 0.02 | 11.4 ± 0.2 | (33); (53); (53); (61) |
| J0314+1603 | 03 14 03.44 +16 03 05.4 | M9.5 | 12.53 ± 0.02 | 1.29 ± 0.03 | -242.4 ± 0.3 | -55.1 ± 0.3 | 13.62 ± 0.05 | -6.8 ± 0.2 | (24); (53); (53); (66) |
| J0320+1854 | 03 20 59.71 +18 54 22.7 | M8 | 11.76 ± 0.02 | 1.12 ± 0.03 | 353.0 ± 0.3 | -257.2 ± 0.2 | 14.65 ± 0.03 | 45.5 ± 0.6 | (24); (53); (53); (66) |
| J0331-3042 | 03 31 30.25 -30 42 38.8 | M7.5 | 11.36 ± 0.02 | 1.1 ± 0.03 | 51.76 ± 0.14 | -403.3 ± 0.2 | 12.51 ± 0.02 | 19 ± 2 | (9); (53); (53); (47) |
| J0334-4953 | 03 34 12.59 -49 53 30.4 | M9 | 11.38 ± 0.03 | 0.98 ± 0.03 | 2360.51 ± 0.15 | 482.2 ± 0.2 | 8.878 ± 0.007 | 70.2 ± 1.0 | (18); (53); (53); (58) |
| J0339-3525 ^e | 03 39 35.25 -35 25 43.6 | M9β | 10.73 ± 0.02 | 1.18 ± 0.03 | 308.9 ± 0.2 | 268.2 ± 0.2 | 6.42 ± 0.004 | 7.4 ± 0.7 | (5); (53); (53); (39) |
| J0351-0052 | 03 51 00.02 -00 52 44.9 | M8 | 11.3 ± 0.02 | 1.07 ± 0.03 | 11.1 ± 0.3 | -470.2 ± 0.2 | 14.7 ± 0.04 | -11 ± 2 | (25); (53); (53); (47) |
| J0355+1133 ^c | 03 55 23.37 +11 33 43.7 | L3-L6γ | 14.05 ± 0.02 | 2.52 ± 0.03 | 219.8 ± 1.6 | -631.3 ± 0.8 | 9.12 ± 0.06 | 11.9 ± 0.2 | (37); (53); (53); (61) |
| J0417-0800 | 04 17 37.49 -08 00 00.5 | M7.5 | 12.18 ± 0.03 | 1.09 ± 0.04 | 454.6 ± 0.2 | 48.96 ± 0.15 | 18.09 ± 0.05 | 40.6 ± 1.4 | (25); (53); (53); (64) |
| J0423-0414 | 04 23 48.58 -04 14 03.2 | L6.5+T2 | 14.47 ± 0.03 | 1.54 ± 0.04 | -347 ± 2 | 70.2 ± 1.1 | 14.7 ± 0.3 | 30.5 ± 0.6 | (26); (53); (53); (71) |
| J0429-3123A | 04 29 18.46 -31 23 56.7 | M7.5 | 10.87 ± 0.02 | 1.1 ± 0.03 | 67.0 ± 0.3 | 100.5 ± 0.4 | 16.84 ± 0.06 | 40 ± 3 | (16); (53); (53); (60) |
| J0435-1606 | 04 35 16.14 -16 06 57.2 | M8e | 10.41 ± 0.03 | 1.05 ± 0.03 | 161.3 ± 0.4 | 317.8 ± 0.3 | 10.58 ± 0.03 | 48.5 ± 1.4 | (5); (53); (53); (64) |
| J0440-0530 ^d | 04 40 23.27 -05 30 08.1 | M7.5e | 10.66 ± 0.02 | 1.11 ± 0.03 | 333.1 ± 0.2 | 128.15 ± 0.13 | 9.76 ± 0.01 | 29.9 ± 0.2 | (5); (53); (53); (65) |
| J0500+0330 | 05 00 21.01 +03 30 50.0 | L4p | 13.67 ± 0.02 | 1.61 ± 0.03 | 10.2 ± 0.6 | -351.7 ± 0.4 | 13.12 ± 0.06 | 15.9 ± 0.2 | (37); (53); (53); (61) |

Table 2.7 (continued)

Table 2.7 (continued)

| Source Name | Coordinates (J2000) | SpT | 2MASS J (mag) | $J - K_s$ (mag) | μ_α (mas yr ⁻¹) | μ_δ (mas yr ⁻¹) | d (pc) | Published RV (km s ⁻¹) | References ^a |
|-------------------------|--------------------------|-----------|------------------|--------------------|---|---|----------------|---------------------------------------|-------------------------|
| J0501-0010 ^e | 05 01 24.08 -00 10 45.5 | L4γ | 14.98 ± 0.04 | 2.02 ± 0.05 | 189.3 ± 1.5 | -145.3 ± 1.2 | 13.1 ± 0.8 | 21.8 ± 0.7 | (37); (53); (44); (39) |
| J0517-3349 | 05 17 37.69 -33 49 03.0 | M8 | 12.0 ± 0.02 | 1.17 ± 0.03 | 446.5 ± 0.2 | -332.6 ± 0.2 | 16.87 ± 0.03 | -39 ± 2 | (25); (53); (53); (47) |
| J0523-1403 | 05 23 38.22 -14 03 02.0 | L2.5 | 13.08 ± 0.02 | 1.45 ± 0.04 | 107.3 ± 0.3 | 160.9 ± 0.3 | 12.76 ± 0.03 | 12.21 ± 0.09 | (16); (53); (53); (61) |
| J0539-0059 | 05 39 52.00 -00 59 01.4 | L5 | 13.85 ± 0.03 | 1.32 ± 0.04 | 162.4 ± 0.8 | 321.1 ± 0.8 | 12.73 ± 0.09 | 13.9 ± 0.2 | (31); (53); (53); (61) |
| J0602+3911 ^e | 06 02 30.46 +39 10 58.5 | L1β | 12.3 ± 0.02 | 1.44 ± 0.03 | 156.9 ± 0.3 | -506.3 ± 0.3 | 11.68 ± 0.02 | 7.94 ± 0.05 | (11); (53); (53); (61) |
| J0641-4322 | 06 41 18.42 -43 22 32.4 | L2.5 | 13.75 ± 0.03 | 1.3 ± 0.04 | 211.8 ± 0.4 | 632.0 ± 0.4 | 19.5 ± 0.07 | 74 ± 2 | (33); (53); (53); (47) |
| J0652-2534 | 06 52 19.76 -25 34 50.4 | M9 | 12.76 ± 0.02 | 1.24 ± 0.03 | -235.5 ± 0.2 | 88.2 ± 0.3 | 16.01 ± 0.04 | 12 ± 2 | (33); (53); (53); (47) |
| J0652+4710 | 06 52 30.71 +47 10 34.9 | L3.5+L6.5 | 13.51 ± 0.02 | 1.82 ± 0.03 | -118.8 ± 0.7 | 131.9 ± 0.8 | 9.12 ± 0.04 | -7.03 ± 0.07 | (20); (53); (53); (61) |
| J0700+3157 | 07 00 36.71 +31 57 25.5 | L3+L6.5 | 12.92 ± 0.02 | 1.61 ± 0.03 | 92.1 ± 0.6 | -552.3 ± 0.5 | 11.33 ± 0.04 | -42.42 ± 0.09 | (26); (53); (53); (61) |
| J0714+3702 ^e | 07 14 03.94 +37 02 46.0 | M7.5β | 11.98 ± 0.02 | 1.14 ± 0.03 | -89.0 ± 0.3 | -183.1 ± 0.3 | 15.61 ± 0.07 | 40.03 ± 0.11 | (16); (53); (53); (57) |
| J0720-0846 | 07 20 03.25 -08 46 49.9 | M9.5+T5 | 10.63 ± 0.02 | 1.16 ± 0.03 | -58 ± 6 | -126 ± 6 | 6.0 ± 1.0 | 83.8 ± 0.3 | (34); (51); (34); (23) |
| J0741+1738 | 07 41 06.78 +17 38 44.8 | M7 | 12.01 ± 0.02 | 1.07 ± 0.03 | -201.7 ± 0.3 | -499.1 ± 0.2 | 18.69 ± 0.08 | 41.8 ± 1.2 | (25); (53); (53); (64) |
| J0746+2000 | 07 46 42.49 +20 00 32.6 | L0.5 | 11.76 ± 0.02 | 1.29 ± 0.03 | -370 ± 4 | -42.0 ± 1.0 | 11.6 ± 0.05 | 52.37 ± 0.06 | (3); (41); (44); (61) |
| J0751-2530 | 07 51 16.30 -25 30 43.0 | L1 | 13.16 ± 0.02 | 1.17 ± 0.03 | -879.0 ± 0.2 | 146.0 ± 0.2 | 17.68 ± 0.02 | 32 ± 2 | (33); (53); (53); (47) |
| J0825+2115 | 08 25 19.61 +21 15 51.5 | L7.5 | 15.1 ± 0.03 | 2.07 ± 0.04 | -508.5 ± 1.8 | -303.7 ± 1.3 | 10.84 ± 0.14 | 20 ± 2 | (3); (53); (53); (57) |
| J0828-1309 | 08 28 34.17 -13 09 19.8 | L2 | 12.8 ± 0.03 | 1.5 ± 0.04 | -581.6 ± 0.2 | 27.5 ± 0.2 | 11.69 ± 0.02 | 25.85 ± 0.08 | (8); (53); (53); (61) |
| J0830+0947 | 08 30 32.57 +09 47 15.4 | M7.5 | 11.89 ± 0.02 | 1.13 ± 0.03 | -489.6 ± 0.2 | -458.87 ± 0.14 | 16.69 ± 0.04 | 41 ± 2 | (12); (53); (53); (47) |
| J0835-0819 | 08 35 42.53 -08 19 23.3 | L6.5 | 13.17 ± 0.02 | 2.03 ± 0.03 | -535.7 ± 0.4 | 302.7 ± 0.4 | 7.214 ± 0.014 | 29.89 ± 0.06 | (31); (53); (53); (61) |
| J0847-1532 | 08 47 28.74 -15 32 37.3 | L1.5 | 13.51 ± 0.03 | 1.45 ± 0.03 | 132.7 ± 0.5 | -199.7 ± 0.6 | 17.567 ± 0.098 | 2.0 ± 0.1 | (31); (53); (53); (61) |
| J0853-0329 | 08 53 36.16 -03 29 32.2 | M9e | 11.21 ± 0.03 | 1.27 ± 0.04 | -516.9 ± 0.2 | -199.41 ± 0.13 | 8.673 ± 0.009 | 7 ± 2 | (14); (53); (53); (47) |
| J0921-2104 | 09 21 14.10 -21 04 44.4 | L1 | 12.78 ± 0.02 | 1.09 ± 0.03 | 245.9 ± 0.3 | -911.6 ± 0.3 | 12.61 ± 0.04 | 80.53 ± 0.11 | (31); (53); (53); (61) |
| J0949+0806 | 09 49 22.23 +08 06 45.1 | M8.5 | 12.31 ± 0.02 | 1.1 ± 0.04 | 39.5 ± 0.3 | -894.9 ± 0.3 | 16.53 ± 0.05 | 16 ± 2 | (33); (53); (53); (47) |
| J1004-3335 | 10 04 39.32 -33 35 19.1 | L5 | 14.48 ± 0.04 | 1.56 ± 0.04 | 345.8 ± 0.9 | -354.3 ± 0.9 | 18.8 ± 0.2 | -8 ± 2 | (27); (53); (53); (47) |
| J1022+5825 ^e | 10 22 48.22 +58 25 45.3 | L1β | 13.5 ± 0.03 | 1.34 ± 0.04 | -810.8 ± 0.3 | -737.0 ± 0.3 | 18.4 ± 0.11 | 19.29 ± 0.11 | (33); (53); (53); (61) |
| J1029+1626 | 10 29 21.70 +16 26 51.8 | L2.5 | 14.29 ± 0.03 | 1.67 ± 0.03 | 355.2 ± 1.0 | -364.4 ± 0.9 | 19.1 ± 0.3 | -28.2 ± 1.4 | (3); (53); (53); (62) |
| J1045-0149 | 10 45 23.98 -01 49 57.7 | L2 | 13.08 ± 0.01 | 1.3 ± 0.01 | -507.7 ± 0.4 | -10.2 ± 0.3 | 17.05 ± 0.07 | 6.3 ± 0.1 | (27); (53); (53); (61) |
| J1048-3956 | 10 48 14.57 -39 56 06.8 | M9 | 9.54 ± 0.02 | 1.09 ± 0.03 | -1179.2 ± 0.2 | -988.1 ± 0.2 | 4.045 ± 0.002 | -11 ± 2 | (12); (53); (53); (47) |
| J1055+0808 | 10 55 47.34 +08 08 42.9 | M9 | 12.55 ± 0.03 | 1.18 ± 0.03 | -329.8 ± 0.2 | -138.2 ± 0.2 | 15.05 ± 0.05 | 24.25 ± 0.06 | (31); (53); (53); (61) |
| J1058-1548 | 10 58 47.83 -15 48 17.2 | L2.5 | 14.16 ± 0.04 | 1.62 ± 0.05 | 258.1 ± 0.8 | 31.1 ± 0.7 | 18.3 ± 0.2 | 5 ± 2 | (21); (53); (53); (47) |
| J1108+6830 ^e | 11 08 30.77 +68 30 16.7 | L1γ | 13.12 ± 0.02 | 1.54 ± 0.03 | -237.6 ± 0.3 | -198.1 ± 0.4 | 16.3 ± 0.05 | -9.84 ± 0.11 | (31); (53); (53); (55) |
| J1121-1313 | 11 21 49.17 -13 13 08.7 | M8.5 | 11.93 ± 0.02 | 1.19 ± 0.03 | -472.2 ± 0.3 | -46.3 ± 0.2 | 14.39 ± 0.04 | 33.8 ± 0.3 | (37); (53); (53); (61) |
| J1124+3808 | 11 24 04.88 +38 08 05.4 | M8.5 | 12.71 ± 0.02 | 1.14 ± 0.03 | 125.5 ± 0.2 | -9.0 ± 0.3 | 18.47 ± 0.07 | -14 ± 3 | (9); (53); (53); (60) |
| J1126-5003 | 11 26 39.80 -50 03 54.8 | L5 | 14.0 ± 0.03 | 1.17 ± 0.04 | -1589.2 ± 0.5 | 451.0 ± 0.4 | 16.23 ± 0.09 | 49.3 ± 1.1 | (31); (53); (53); (71) |
| J1141-2232 | 11 41 44.04 -22 32 15.01 | M8 | 12.63 ± 0.02 | 1.06 ± 0.03 | -166.2 ± 0.3 | 404.7 ± 0.2 | 19.01 ± 0.07 | 8 ± 3 | (9); (53); (53); (60) |
| J1155-3727 | 11 55 39.53 -37 27 35.5 | L2.5 | 12.81 ± 0.02 | 1.35 ± 0.03 | 43.1 ± 0.2 | -790.9 ± 0.2 | 11.82 ± 0.03 | 45.51 ± 0.11 | (33); (53); (53); (61) |
| J1155-2224 | 11 55 42.85 -22 24 58.7 | M7.5 | 10.93 ± 0.02 | 1.05 ± 0.03 | -374.0 ± 0.2 | -187.49 ± 0.13 | 10.92 ± 0.02 | -13 ± 3 | (32); (53); (53); (60) |
| J1203+0016 | 12 03 58.13 +00 15 50.1 | L5 | 14.01 ± 0.03 | 1.53 ± 0.04 | -1217.6 ± 1.3 | -282.6 ± 0.5 | 14.87 ± 0.12 | -0.2 ± 0.2 | (33); (53); (53); (61) |

Table 2.7 (continued)

Table 2.7 (continued)

| Source Name | Coordinates (J2000) | SpT | 2MASS J (mag) | $J - K_s$ (mag) | μ_α (mas yr ⁻¹) | μ_δ (mas yr ⁻¹) | d (pc) | Published RV (km s ⁻¹) | References ^a |
|-------------------------|-------------------------|-----------------|------------------|--------------------|---|---|----------------|---------------------------------------|-------------------------|
| J1221+0257 | 12 21 27.71 +02 57 19.7 | L0.5 | 13.07 ± 0.01 | 1.16 ± 0.01 | -145.4 ± 0.5 | -43.5 ± 0.3 | 18.54 ± 0.09 | -8.79 ± 0.14 | (31); (53); (53); (61) |
| J1224-1238 | 12 24 52.18 -12 38 35.7 | M9 | 12.57 ± 0.02 | 1.22 ± 0.03 | -304.6 ± 0.4 | -189.0 ± 0.3 | 17.21 ± 0.06 | -2.9 ± 0.6 | (7); (53); (53); (39) |
| J1300+1912 | 13 00 42.50 +19 12 34.6 | L1.5 | 12.72 ± 0.02 | 1.09 ± 0.03 | -810.5 ± 0.3 | -1248.5 ± 0.2 | 13.95 ± 0.04 | -17.6 ± 0.12 | (33); (53); (53); (61) |
| J1305-2541 | 13 05 40.17 -25 41 05.8 | L2+L3.5 | 13.41 ± 0.03 | 1.67 ± 0.03 | -313.5 ± 1.2 | -20.0 ± 0.8 | 18.6 ± 0.2 | 6.4 ± 0.4 | (28); (53); (53); (61) |
| J1309-2330 | 13 09 21.85 -23 30 35.7 | M8 | 11.79 ± 0.02 | 1.12 ± 0.03 | 16.5 ± 0.3 | -382.8 ± 0.3 | 15.0 ± 0.04 | 15 ± 2 | (7); (53); (53); (47) |
| J1315-2649 | 13 15 30.86 -26 49 51.8 | L3.5+T7 | 15.2 ± 0.05 | 1.73 ± 0.07 | -688.6 ± 1.9 | -288.1 ± 1.4 | 18.6 ± 0.4 | -8 ± 3 | (23); (53); (53); (47) |
| J1332-0441 | 13 32 24.48 -04 41 12.6 | M7.5 | 12.37 ± 0.03 | 1.09 ± 0.03 | 87 ± 87 | 50 ± 50 | 19 ± 2 | -12 ± 2 | (16); (16); (47); (47) |
| J1356+4343 | 13 56 41.46 +43 42 59.1 | M8 | 11.71 ± 0.02 | 1.06 ± 0.03 | -452.5 ± 0.7 | 38.5 ± 0.7 | 20.0 ± 0.2 | -22 ± 3 | (36); (53); (53); (60) |
| J1403+3007 | 14 03 22.29 +30 07 54.6 | M8.5 | 12.68 ± 0.02 | 1.08 ± 0.03 | -802.5 ± 0.3 | 39.0 ± 0.3 | 19.81 ± 0.08 | -39.2 ± 0.4 | (21); (53); (53); (56) |
| J1425-3650 ^c | 14 25 27.98 -36 50 23.2 | L4 ^y | 13.75 ± 0.03 | 1.94 ± 0.04 | -283.9 ± 0.6 | -469.3 ± 0.5 | 11.83 ± 0.05 | 5.4 ± 0.2 | (37); (53); (53); (61) |
| J1428+3310 | 14 28 43.22 +33 10 39.2 | M9 | 11.99 ± 0.02 | 1.25 ± 0.03 | -346.76 ± 0.10 | -710.1 ± 0.2 | 10.99 ± 0.02 | -39.1 ± 0.4 | (14); (53); (53); (39) |
| J1438+6408 | 14 38 08.26 +64 08 36.3 | L0 | 12.99 ± 0.02 | 1.34 ± 0.03 | 643.8 ± 0.4 | -206.3 ± 0.3 | 17.04 ± 0.04 | -45 ± 3 | (33); (53); (53); (60) |
| J1439+1929 | 14 39 28.36 +19 29 14.9 | L1 | 12.76 ± 0.02 | 1.21 ± 0.03 | -1236 ± 57 | 402 ± 19 | 14.4 ± 0.1 | -26.74 ± 0.09 | (31); (16); (44); (61) |
| J1450+2354 | 14 50 16.00 +23 54 41.8 | L4 | 13.8 ± 0.5 | 1.54 ± 0.71 | 144.7 ± 0.8 | 32.4 ± 0.7 | 17.9 ± 0.3 | 5 ± 3 | (6); (18); (44); (20) |
| J1454+1606B | 14 54 29.41 +16 06 08.6 | M8.5 | ... | ... | 315.8 ± 1.0 | -187.8 ± 1.2 | 9.7 ± 0.2 | -10.5 ± 0.2 | (1); (53); (26); (20) |
| J1456-2809 ^c | 14 56 38.26 -28 09 48.6 | M7e | 9.97 ± 0.03 | 1.04 ± 0.04 | -491.1 ± 0.2 | -843.3 ± 0.2 | 7.058 ± 0.005 | 1.0 ± 1.5 | (35); (53); (53); (64) |
| J1501+2250 | 15 01 08.18 +22 50 02.1 | M9 | 11.87 ± 0.02 | 1.16 ± 0.03 | -43.8 ± 0.3 | -64.0 ± 0.3 | 10.7 ± 0.02 | 6 ± 2 | (24); (53); (53); (47) |
| J1504-2355 | 15 04 16.17 -23 55 56.5 | M7.5 | 12.01 ± 0.03 | 0.98 ± 0.04 | -331.3 ± 0.3 | -87.6 ± 0.3 | 19.68 ± 0.07 | -29 ± 2 | (7); (53); (53); (47) |
| J1506+1321 | 15 06 54.32 +13 21 06.0 | L3 | 13.37 ± 0.02 | 1.62 ± 0.03 | -1071.0 ± 0.4 | -11.9 ± 0.4 | 11.68 ± 0.04 | -0.68 ± 0.11 | (31); (53); (53); (61) |
| J1507-1627 | 15 07 47.67 -16 27 40.1 | L5 | 12.83 ± 0.03 | 1.52 ± 0.04 | -151.6 ± 0.6 | -895.7 ± 0.6 | 7.39 ± 0.02 | -39.85 ± 0.05 | (3); (53); (53); (61) |
| J1510-0241 | 15 10 16.83 -02 41 08.0 | M9 | 12.61 ± 0.02 | 1.27 ± 0.03 | -399.1 ± 0.7 | 32.1 ± 0.5 | 18.04 ± 0.11 | -41 ± 2 | (24); (53); (53); (47) |
| J1515+4847 | 15 15 00.83 +48 47 41.6 | L6 | 14.11 ± 0.03 | 1.61 ± 0.04 | -950.0 ± 21.0 | 1471.0 ± 21.0 | 9.75 ± 0.06 | -29.97 ± 0.11 | (16); (43); (52); (61) |
| J1521+5053 | 15 21 01.05 +50 53 22.7 | M7.5 | 12.01 ± 0.02 | 1.09 ± 0.03 | 53.9 ± 0.2 | -172.6 ± 0.2 | 16.13 ± 0.03 | 1 ± 3 | (16); (53); (53); (60) |
| J1524+2925 | 15 24 24.75 +29 25 31.5 | M7.5 | 11.21 ± 0.02 | 1.05 ± 0.03 | -56.8 ± 0.1 | -629.04 ± 0.11 | 13.072 ± 0.015 | -15.9 ± 0.5 | (24); (53); (53); (56) |
| J1534-1418 | 15 34 56.93 -14 18 49.2 | M7 | 11.38 ± 0.02 | 1.08 ± 0.03 | -918.5 ± 0.3 | -330.2 ± 0.2 | 10.91 ± 0.02 | -71 ± 2 | (33); (53); (53); (47) |
| J1539-0520 | 15 39 41.92 -05 20 42.7 | L4 | 13.92 ± 0.03 | 1.35 ± 0.04 | 590.2 ± 0.7 | 104.6 ± 0.7 | 17.0 ± 0.12 | 27.3 ± 0.2 | (33); (53); (53); (61) |
| J1555-0956 | 15 55 15.77 -09 56 06.0 | L1.5 | 12.56 ± 0.02 | 1.11 ± 0.03 | 931.6 ± 0.4 | -785.1 ± 0.2 | 13.58 ± 0.03 | 14.8 ± 0.1 | (33); (53); (53); (61) |
| J1607-0442 | 16 07 31.23 -04 42 09.6 | M9 | 11.9 ± 0.02 | 1.18 ± 0.03 | -14.7 ± 0.4 | -422.7 ± 0.2 | 15.24 ± 0.05 | 11 ± 2 | (17); (53); (53); (47) |
| J1615+0546 | 16 15 42.45 +05 46 40.0 | M9 | 12.88 ± 0.02 | 1.14 ± 0.03 | 141.6 ± 0.3 | -103.22 ± 0.15 | 17.83 ± 0.06 | 7 ± 2 | (16); (53); (53); (47) |
| J1632+1904 | 16 32 29.11 +19 04 40.7 | L8 | 15.87 ± 0.07 | 1.87 ± 0.08 | 293.0 ± 1.0 | -54.0 ± 1.0 | 19.98 ± 0.15 | -20.2 ± 0.9 | (3); (53); (53); (57) |
| J1645-1320 | 16 45 22.09 -13 19 52.2 | L1 | 12.45 ± 0.03 | 1.31 ± 0.04 | -362.1 ± 0.3 | -528.7 ± 0.8 | 15.2 ± 0.5 | -6 ± 2 | (31); (18); (44); (58) |
| J1655-0823 | 16 55 35.25 -08 23 40.7 | M7 | 9.78 ± 0.03 | 0.96 ± 0.04 | -813.4 ± 0.2 | -808.25 ± 0.15 | 11.26 ± 0.02 | 26.58 ± 0.06 | (31); (53); (53); (61) |
| J1658+7026 | 16 58 03.80 +70 27 01.7 | L1 | 13.29 ± 0.02 | 1.37 ± 0.03 | -139.5 ± 0.3 | -870.61 ± 0.11 | 6.501 ± 0.005 | 15.39 ± 0.11 | (1); (53); (53); (63) |
| J1705-0516 | 17 05 48.35 -05 16 46.3 | L1 | 13.31 ± 0.03 | 1.28 ± 0.04 | 116.7 ± 0.6 | -120.2 ± 0.4 | 18.48 ± 0.07 | -25.6 ± 0.12 | (16); (53); (53); (61) |
| J1707+6439 | 17 07 18.30 +64 39 33.1 | M8.5 | 12.54 ± 0.02 | 1.16 ± 0.03 | 227.3 ± 0.2 | -94.6 ± 0.3 | 18.06 ± 0.04 | -10.1 ± 0.06 | (38); (53); (53); (66) |
| J1707-0558 | 17 07 23.43 -05 58 24.9 | M9+L3 | 12.05 ± 0.02 | 1.34 ± 0.03 | 100 ± 55 | 45 ± 24 | 16.5 ± 1.0 | 3 ± 2 | (17); (16); (47); (47) |
| J1721+3344 | 17 21 03.60 +33 44 16.9 | M9 | 13.63 ± 0.02 | 1.14 ± 0.03 | -1855.6 ± 0.4 | 591.6 ± 0.4 | 16.31 ± 0.05 | -102.8 ± 0.2 | (33); (53); (53); (71) |

Table 2.7 (continued)

Table 2.7 (*continued*)

| Source Name | Coordinates (J2000) | SpT | 2MASS <i>J</i> (mag) | <i>J</i> - <i>K_s</i> (mag) | μ_{α} (mas yr ⁻¹) | μ_{δ} (mas yr ⁻¹) | <i>d</i> (pc) | Published RV (km s ⁻¹) | References ^a |
|-------------------------|-------------------------|-----------|-------------------------|--|---|---|------------------|---------------------------------------|-------------------------|
| J1731+2721 ^c | 17 31 29.74 +27 21 23.2 | L0 | 12.09 ± 0.03 | 1.18 ± 0.03 | -90.2 ± 0.2 | -252.9 ± 0.2 | 11.94 ± 0.02 | -29.76 ± 0.11 | (17); (53); (53); (61) |
| J1745-1640 | 17 45 34.66 -16 40 53.9 | L1.5 | 13.65 ± 0.03 | 1.24 ± 0.04 | 106.9 ± 0.5 | -100.3 ± 0.4 | 19.6 ± 0.11 | 26 ± 2 | (33); (53); (53); (47) |
| J1750-0016 | 17 50 24.81 -00 16 15.0 | L5 | 13.29 ± 0.02 | 1.45 ± 0.03 | -397.2 ± 0.5 | 197.9 ± 0.4 | 9.24 ± 0.02 | 19 ± 3 | (40); (53); (53); (47) |
| J1757+7042 | 17 57 15.40 +70 42 01.1 | M7.5 | 11.45 ± 0.02 | 1.06 ± 0.03 | 6.1 ± 0.4 | 331.5 ± 0.6 | 19.02 ± 0.09 | -12.3 ± 0.6 | (25); (53); (53); (66) |
| J1807+5015 | 18 07 15.93 +50 15 31.6 | L1 | 12.93 ± 0.02 | 1.33 ± 0.03 | 24.5 ± 0.2 | -136.9 ± 0.3 | 14.63 ± 0.03 | -0.4 ± 0.5 | (31); (53); (53); (61) |
| J1821+1413 ^f | 18 21 28.15 +14 14 00.8 | L5 | 13.43 ± 0.02 | 1.78 ± 0.03 | 227.3 ± 0.5 | -246.4 ± 0.6 | 9.36 ± 0.02 | 9.8 ± 0.2 | (31); (53); (53); (61) |
| J1835+3259 | 18 35 37.88 +32 59 53.3 | M8.5 | 10.27 ± 0.02 | 1.1 ± 0.03 | -72.8 ± 0.2 | -754.84 ± 0.15 | 5.687 ± 0.003 | 8 ± 2 | (25); (53); (53); (64) |
| J1843+4040 | 18 43 22.12 +40 40 21.3 | M7.5e | 11.31 ± 0.02 | 1.01 ± 0.03 | -120.5 ± 0.2 | 591.6 ± 0.2 | 14.4 ± 0.02 | -19 ± 2 | (10); (53); (53); (64) |
| J1845-6357B | 18 45 05.25 -63 57 47.4 | M8.5+T6 | 9.54 ± 0.02 | 1.04 ± 0.03 | 2584.3 ± 0.13 | 589.0 ± 0.2 | 4.001 ± 0.002 | -18 ± 2 | (34); (53); (53); (47) |
| J1906+4011 | 19 06 48.07 +40 11 08.5 | L1 | 13.08 ± 0.02 | 1.31 ± 0.03 | 438.3 ± 0.2 | -180.0 ± 0.3 | 16.79 ± 0.04 | -22.8 ± 0.3 | (22); (53); (53); (71) |
| J1916+0508 | 19 16 57.61 +05 09 01.5 | M8 | 9.91 ± 0.03 | 1.14 ± 0.03 | -598.2 ± 0.2 | -1365.3 ± 0.2 | 5.918 ± 0.005 | 35.0 ± 1.5 | (1); (53); (53); (58) |
| J2057-0252 ^e | 20 57 54.09 -02 52 30.2 | L2β | 13.12 ± 0.02 | 1.4 ± 0.03 | -2.9 ± 0.4 | -102.2 ± 0.2 | 15.51 ± 0.06 | -24.7 ± 0.4 | (31); (53); (53); (61) |
| J2104-1037 | 21 04 14.96 -10 37 37.3 | L2 | 13.84 ± 0.03 | 1.47 ± 0.04 | 594.6 ± 0.7 | -295.7 ± 0.4 | 17.19 ± 0.12 | -21.09 ± 0.12 | (31); (53); (53); (61) |
| J2139+0220 ^f | 21 39 26.76 +02 20 22.7 | L8.5+T3.5 | 14.71 ± 0.0 | 1.13 ± 0.04 | 486 ± 2 | 125 ± 3 | 9.9 ± 0.2 | -25.1 ± 0.3 | (19); (45); (45); (71) |
| J2148+4003 | 21 48 16.29 +40 03 59.3 | L7 | 14.15 ± 0.03 | 2.38 ± 0.04 | 773.3 ± 0.7 | 458.0 ± 0.9 | 8.11 ± 0.03 | -14.5 ± 0.7 | (31); (53); (53); (39) |
| J2224-0158 | 22 24 43.85 -01 58 53.2 | L4.5 | 14.07 ± 0.03 | 2.05 ± 0.04 | 471.0 ± 0.8 | -874.9 ± 0.8 | 11.55 ± 0.09 | -36.48 ± 0.01 | (3); (53); (53); (39) |
| J2234+2359 | 22 34 14.01 +23 59 55.8 | M9.5 | 13.15 ± 0.02 | 1.31 ± 0.03 | 851.7 ± 0.4 | -57.8 ± 0.3 | 18.48 ± 0.07 | 17.2 ± 0.6 | (4); (53); (53); (56) |
| J2244+2043 ^c | 22 44 31.67 +20 43 43.3 | L6-L8γ | 16.48 ± 0.14 | 2.46 ± 0.16 | 230.3 ± 0.9 | -234.8 ± 1.0 | 17.0 ± 0.3 | -16.0 ± 0.9 | (39); (50); (50); (72) |
| J2306-0502 | 23 06 29.36 -05 02 29.0 | M8 | 11.35 ± 0.02 | 1.06 ± 0.03 | 930.9 ± 0.2 | -479.4 ± 0.2 | 12.43 ± 0.02 | -54 ± 2 | (16); (53); (53); (47) |
| J2322-3133 ^e | 23 22 46.82 -31 33 23.4 | L2β | 13.58 ± 0.03 | 1.25 ± 0.04 | -203.2 ± 0.5 | -540.5 ± 0.6 | 19.9 ± 0.2 | 33.9 ± 1.1 | (33); (53); (53); (39) |
| J2331-2749 | 23 31 21.74 -27 49 49.6 | M7 | 11.65 ± 0.02 | 1.0 ± 0.03 | 90.4 ± 0.3 | 745.2 ± 0.3 | 13.66 ± 0.03 | -3.0 ± 1.5 | (25); (53); (53); (64) |
| J2346+1129 | 23 46 46.02 +11 29 09.4 | M8 | 12.8 ± 0.02 | 1.19 ± 0.03 | -386.2 ± 0.4 | -83.6 ± 0.2 | 19.67 ± 0.07 | 0 ± 2 | (16); (53); (53); (47) |

Table 2.7 (*continued*)

Table 2.7 (*continued*)

| Source Name | Coordinates (J2000) | SpT | 2MASS J (mag) | $J - K_s$ (mag) | μ_α (mas yr ⁻¹) | μ_δ (mas yr ⁻¹) | d (pc) | Published RV (km s ⁻¹) | References ^a |
|--|------------------------|-----|--------------------|--------------------|---|---|-------------|---------------------------------------|-------------------------|
| ^a References are in the order of spectral classification, astrometry, and RV measurement. | | | | | | | | | |
| ^b Identified as a member of the Argus moving group using BANYAN Σ | | | | | | | | | |
| ^c Identified as a member of the AB Doradus moving group using BANYAN Σ | | | | | | | | | |
| ^d Identified as a member of the Carina-Near moving group using BANYAN Σ | | | | | | | | | |
| ^e Suspected young source from Faherty et al. (2016) | | | | | | | | | |
| ^f Weirid red L dwarf; also reported as L4pec in Faherty et al. (2016) | | | | | | | | | |
| References – Classification: (1) Kirkpatrick et al. (1991), (2) Leinert et al. (2000), (3) Reid et al. (2000), (4) Gizis et al. (2000), (5) McCaughrean et al. (2002), (6) Goto et al. (2002), (7) Gizis (2002), (8) Scholz & Meusinger (2002), (9) Cruz et al. (2003), (10) Reid et al. (2003), (11) Salim et al. (2003), (12) Henry et al. (2004), (13) Lodieu et al. (2005), (14) Reid & Gizis (2005), (15) Reid et al. (2006), (16) Schmidt et al. (2007), (17) Reid et al. (2008), (18) Faherty et al. (2009), (19) Burgasser et al. (2010), (20) Konopacky et al. (2010), (21) West et al. (2011), (22) Gizis et al. (2011), (23) Burgasser et al. (2011), (24) Kirkpatrick et al. (2011), (25) Deshpande et al. (2012), (26) Dupuy & Liu (2012), (27) Marocco et al. (2013), (28) Koen (2013), (29) Thompson et al. (2013), (30) Newton et al. (2014), (31) Schneider et al. (2014), (32) Dieterich et al. (2014), (33) Bardalez Gagliuffi et al. (2014), (34) Burgasser et al. (2015b), (35) Davison et al. (2015), (36) West et al. (2015), (37) Gagné et al. (2015b), (38) Metodiev et al. (2015), (39) Faherty et al. (2016), (40) Koen et al. (2017), (73) Burgasser et al. (2008); Astrometry: (41) Monet et al. (2003), (42) Costa et al. (2005), (43) Jameson et al. (2008a), (44) Faherty et al. (2012), (45) Smart et al. (2013), (46) Dittmann et al. (2014), (47) Burgasser et al. (2015a), (48) Weinberger et al. (2016), (49) Schneider et al. (2016), (50) Liu et al. (2016), (51) Kirkpatrick et al. (2016), (52) Dahn et al. (2017), (53) Gaia Collaboration et al. (2018b), (54) Gagné et al. (2018a); Radial Velocity: (55) Basri et al. (2000), (56) Reid et al. (2002), (57) Baileer-Jones (2004), (58) Zapatero Osorio et al. (2007), (59) Blake et al. (2007), (60) Reiners & Basri (2009a), (61) Blake et al. (2010), (62) Seifahrt et al. (2010), (63) Morin et al. (2010), (64) Deshpande et al. (2012), (65) Shkolnik et al. (2012), (66) Tanner et al. (2012), (67) Deshpande et al. (2013) (68) Bames et al. (2014), (69) Prato et al. (2015), (70) Terrien et al. (2015), (71) Vos et al. (2017), (72) Vos et al. (2018) | | | | | | | | | |

Table 2.8: Radial Velocities and Heliocentric Space Motions of Late-M and L Dwarfs
Within 20 pc of the Sun

| Source Name | SpT | Published RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P[TD]/P[ID] ^g | Population ^g |
|-------------|---------|---------------------------------------|----------------------------|----------------------------|----------------------------|--------------------------|-------------------------|
| J0004–4044 | L5+L5 | 32.84 ± 0.17 | 21.68 ± 0.05 | -85.7 ± 0.4 | -11.90 ± 0.17 | 3.42 | D/TD |
| J0004–2058 | M9 | -33 ± 2 | -42.5 ± 0.2 | -13.2 ± 0.4 | 30 ± 2 | 0.04 | D |
| J0015+3516 | L1 | -37.35 ± 0.16 | 28.01 ± 0.07 | -27.23 ± 0.14 | 5.31 ± 0.14 | 0.01 | D |
| J0019+5213 | M9 | -29 ± 3 | 4.2 ± 1.4 | -30 ± 3 | -16.9 ± 0.6 | 0.02 | D |
| J0024–0158 | L0.5 | 11.65 ± 1.6 | 9.4 ± 0.2 | 25.8 ± 0.7 | 0.8 ± 1.4 | 0.01 | D |
| J0024–2708B | M8.5 | -35 ± 3 | -0.1 ± 0.4 | 31.2 ± 0.5 | 43 ± 3 | 0.24 | D/TD |
| J0027+2219 | M8e | -11.9 ± 1.3 | -5 ± 3 | -17 ± 3 | 3 ± 3 | 0.01 | D |
| J0036+1821 | L3.5 | 20.90 ± 0.14 | -29.83 ± 0.08 | 9.08 ± 0.09 | -5.9 ± 0.1 | 0.01 | D |
| J0045+1634 | L0β | 3.29 ± 0.17 | -10.8 ± 0.1 | -1.89 ± 0.12 | 1.82 ± 0.12 | 0.01 | D |
| J0047+6803 | L7 | -19.4 ± 1.3 | 21.5 ± 0.7 | -4.1 ± 1.1 | 5.48 ± 0.11 | 0.01 | D |
| J0102–3737 | M9 | -5 ± 2 | -62.27 ± 0.16 | -20.6 ± 0.4 | 13 ± 2 | 0.03 | D |
| J0107+0041 | L8 | 8.2 ± 0.5 | -32 ± 3 | -6.2 ± 1.7 | 6.1 ± 0.7 | 0.01 | D |
| J0109–5100 | M8.5e | -1.3 ± 0.2 | -5.85 ± 0.05 | 7.7 ± 0.6 | 7.22 ± 0.18 | 0.01 | D |
| J0109+2949 | M9.5 | 38.9 ± 0.8 | -78.6 ± 0.5 | 7.4 ± 0.6 | 14.6 ± 0.5 | 0.05 | D |
| J0109–0343 | M9e | -6.3 ± 1.8 | -2.6 ± 0.5 | 0.04 ± 0.5 | 14.5 ± 1.65 | 0.01 | D |
| J0140+2701 | M8.5 | 8.2 ± 0.4 | 7.6 ± 0.2 | 1.0 ± 0.2 | -14.8 ± 0.2 | 0.01 | D |
| J0144–0716 | L6.5 | -2.6 ± 0.1 | 0.9 ± 0.1 | -11.5 ± 0.2 | 10.2 ± 0.1 | 0.01 | D |
| J0205–1159 | L7+L7 | 7 ± 2 | -23 ± 4 | -9 ± 5 | 13 ± 3 | 0.01 | D |
| J0213+4444 | L1.5 | -23.47 ± 0.11 | 30.89 ± 0.09 | -5.3 ± 0.08 | -0.06 ± 0.12 | 0.01 | D |
| J0215–3040 | M8 | 0.005 ± 0.009 | -7.87 ± 0.04 | -38.29 ± 0.11 | 24.28 ± 0.04 | 0.04 | D |
| J0217+3526 | M7 | 11 ± 3 | -14 ± 2 | -6 ± 2 | 0.5 ± 1.1 | 0.01 | D |
| J0253+1652 | M7 | 68.30 ± 0.05 | -58.11 ± 0.04 | -58.93 ± 0.09 | -51.64 ± 0.03 | 14.17 | TD |
| J0255–4700 | L9 | 18 ± 3 | 6.2 ± 0.2 | -19.2 ± 1.4 | 6.2 ± 2.4 | 0.01 | D |
| J0306–3647 | M8.5 | 11.44 ± 0.19 | 47.63 ± 0.07 | -10.95 ± 0.09 | -4.81 ± 0.16 | 0.01 | D |
| J0314+1603 | M9.5 | -6.8 ± 0.2 | 25.9 ± 0.2 | 18.77 ± 0.06 | 0.76 ± 0.14 | 0.01 | D |
| J0320+1854 | M8 | 45.5 ± 0.6 | -34.96 ± 0.5 | -6.94 ± 0.15 | -15.12 ± 0.31 | 0.01 | D |
| J0331–3042 | M7.5 | 19 ± 2 | 21.3 ± 0.8 | -12.6 ± 0.9 | -7.7 ± 1.6 | 0.01 | D |
| J0334–4953 | M9 | 71 ± 3 | -60.60 ± 0.12 | -88.1 ± 0.6 | 5.6 ± 0.8 | 10.77 | TD |
| J0339–3525 | M9β | 7.4 ± 0.7 | -2.4 ± 0.2 | 6.9 ± 0.4 | 6.8 ± 0.6 | 0.01 | D |
| J0351–0052 | M8 | -11 ± 2 | 35.4 ± 1.5 | -11.2 ± 0.3 | 0.0 ± 1.3 | 0.01 | D |
| J0355+1133 | L3–L6γ | 11.9 ± 0.2 | 5.79 ± 0.19 | -14.25 ± 0.19 | -8.47 ± 0.14 | 0.01 | D |
| J0417–0800 | M7.5 | 40.6 ± 1.4 | -34.0 ± 1.0 | -21.5 ± 0.4 | 11.1 ± 0.9 | 0.01 | D |
| J0423–0414 | L6.5+T2 | 30.5 ± 0.6 | -8.1 ± 0.5 | 23.3 ± 0.5 | -25.2 ± 0.5 | 0.03 | D |
| J0429–3123A | M7.5 | 40 ± 3 | -15.2 ± 1.4 | -9.8 ± 1.7 | -14.8 ± 2.0 | 0.01 | D |
| J0435–1606 | M8e | 48.5 ± 1.4 | -34.5 ± 0.9 | -3.5 ± 0.6 | -11.3 ± 0.9 | 0.01 | D |
| J0440–0530 | M7.5e | 29.9 ± 0.2 | -19.6 ± 0.16 | -2.64 ± 0.06 | 5.55 ± 0.11 | 0.01 | D |

Table 2.8 (continued)

Table 2.8 (continued)

| Source Name | SpT | Published RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P(TD)/P(D) ^a | Population ^a |
|-------------|-----------|---------------------------------------|----------------------------|----------------------------|----------------------------|-------------------------|-------------------------|
| J0500+0330 | L4p | 15.94 ± 0.16 | 6.30 ± 0.15 | -8.9 ± 0.1 | -9.00 ± 0.08 | 0.01 | D |
| J0501-0010 | L4γ | 21.8 ± 0.7 | -5.3 ± 0.7 | -8.03 ± 1.13 | 3.7 ± 0.8 | 0.01 | D |
| J0517-3349 | M8 | -39 ± 2 | 48.7 ± 0.9 | 8.0 ± 1.4 | 52.8 ± 1.1 | 0.9 | D/TD |
| J0523-1403 | L2.5 | 12.21 ± 0.09 | -4.94 ± 0.07 | 8.28 ± 0.05 | 10.86 ± 0.05 | 0.01 | D |
| J0539-0059 | L5 | 13.91 ± 0.15 | -10.82 ± 0.15 | 15.6 ± 0.1 | 20.45 ± 0.14 | 0.01 | D |
| J0602+3911 | L1β | 7.94 ± 0.05 | -1.11 ± 0.05 | -15.20 ± 0.06 | 2.51 ± 0.02 | 0.01 | D |
| J0641-4322 | L2.5 | 74 ± 2 | -60.3 ± 0.6 | -51.6 ± 1.8 | 17.5 ± 0.7 | 0.2 | D/TD |
| J0652-2534 | M9 | 12 ± 2 | -5.4 ± 1.1 | 12.2 ± 1.6 | -8.2 ± 0.4 | 0.01 | D |
| J0652+4710 | L3.5+L6.5 | -7.03 ± 0.07 | 17.96 ± 0.07 | 18.14 ± 0.04 | 2.10 ± 0.04 | 0.01 | D |
| J0700+3157 | L3+L6.5 | -42.42 ± 0.09 | 52.30 ± 0.09 | -13.74 ± 0.12 | -10.94 ± 0.05 | 0.02 | D |
| J0714+3702 | M7.5β | 40.03 ± 0.11 | -30.1 ± 0.1 | 1.18 ± 0.06 | 10.94 ± 0.07 | 0.01 | D |
| J0720-0846 | M9.5+T5 | 83.8 ± 0.3 | -47.6 ± 0.4 | -47.7 ± 0.4 | 7.5 ± 0.6 | 0.07 | D |
| J0741+1738 | M7 | 41.8 ± 1.2 | -23.1 ± 1.1 | -37.7 ± 0.5 | -11.7 ± 0.4 | 0.02 | D |
| J0746+2000 | L0.5 | 52.37 ± 0.06 | -43.3 ± 0.5 | -1.8 ± 0.5 | 7.7 ± 1.1 | 0.01 | D |
| J0751-2530 | L1 | 32 ± 2 | -46.9 ± 0.9 | 5.9 ± 1.8 | -49.26 ± 0.16 | 0.44 | D/TD |
| J0825+2115 | L7.5 | 21 ± 2 | -16.8 ± 1.6 | -5.6 ± 0.7 | -8.6 ± 1.1 | 0.01 | D |
| J0828-1309 | L2 | 25.85 ± 0.08 | -22.18 ± 0.06 | -3.6 ± 0.07 | -11.49 ± 0.06 | 0.01 | D |
| J0830+0947 | M7.5 | 41 ± 2 | -28.1 ± 1.5 | -35 ± 1.0 | -19.9 ± 0.9 | 0.03 | D |
| J0835-0819 | L6.5 | 29.89 ± 0.06 | -22.66 ± 0.05 | -1.78 ± 0.05 | 7.52 ± 0.03 | 0.01 | D |
| J0847-1532 | L1.5 | 2.0 ± 0.1 | 27.54 ± 0.11 | 0.7 ± 0.1 | 7.14 ± 0.05 | 0.01 | D |
| J0853-0329 | M9e | 7 ± 2 | -2.3 ± 1.1 | 2.7 ± 1.4 | -10.0 ± 0.9 | 0.01 | D |
| J0921-2104 | L1 | 80.53 ± 0.11 | 31.37 ± 0.13 | -83.91 ± 0.12 | 11.14 ± 0.08 | 2.99 | D/TD |
| J0949+0806 | M8.5 | 16 ± 2 | 34.9 ± 1.0 | -54.5 ± 1.1 | -5.5 ± 1.4 | 0.08 | D |
| J1004-3335 | L5 | -8 ± 2 | 55.0 ± 0.5 | 16.2 ± 1.9 | -0.6 ± 0.6 | 0.02 | D |
| J1022+5825 | L1β | 19.29 ± 0.11 | -58.8 ± 0.4 | -55.8 ± 0.4 | 7.14 ± 0.12 | 0.19 | D/TD |
| J1029+1626 | L2.5 | -28.2 ± 1.4 | 61.9 ± 0.8 | 0.8 ± 0.6 | -7.1 ± 1.2 | 0.02 | D |
| J1045-0149 | L2 | 6.3 ± 0.1 | -24.54 ± 0.14 | -3.12 ± 0.08 | -7.51 ± 0.11 | 0.01 | D |
| J1048-3956 | M9 | -11 ± 2 | -0.1 ± 0.3 | 13.0 ± 1.9 | -22.2 ± 0.6 | 0.01 | D |
| J1048+0111 | L1 | 24.25 ± 0.06 | -13.12 ± 0.07 | -23.14 ± 0.08 | 4.53 ± 0.09 | 0.01 | D |
| J1055+0808 | M9 | 5 ± 2 | -9.7 ± 0.5 | -8.8 ± 1.0 | -5.4 ± 1.7 | 0.01 | D |
| J1058-1548 | L2.5 | 19 ± 2 | -10.2 ± 0.2 | -7.7 ± 1.6 | 11.6 ± 1.3 | 0.01 | D |
| J1108+6830 | L1γ | -9.84 ± 0.11 | 0.84 ± 0.08 | -10.88 ± 0.08 | 1.90 ± 0.08 | 0.01 | D |
| J1121-1313 | M8.5 | 33.9 ± 0.3 | -14.65 ± 0.07 | -25.4 ± 0.2 | 17.93 ± 0.19 | 0.01 | D |
| J1124+3808 | M8.5 | -14 ± 3 | 26.0 ± 1.1 | 15.16 ± 0.07 | -2 ± 3 | 0.01 | D |
| J1126-5003 | L5 | 49.3 ± 1.1 | -92.2 ± 0.7 | -76.6 ± 1.1 | 9.3 ± 0.2 | 9.53 | D/TD |
| J1141-2232 | M8 | 8 ± 3 | -17.1 ± 0.5 | 17 ± 2 | 35.6 ± 1.8 | 0.06 | D |
| J1155-3727 | L2.5 | 45.51 ± 0.11 | 43.98 ± 0.06 | -38.3 ± 0.1 | -13.0 ± 0.1 | 0.04 | D |
| J1155-2224 | M7.5 | -13 ± 3 | -4.5 ± 0.7 | 9 ± 2 | -12 ± 2 | 0.01 | D |
| J1203+0016 | L5 | -0.22 ± 0.16 | -54.2 ± 0.6 | -41.5 ± 0.5 | -17.7 ± 0.3 | 0.07 | D |

Table 2.8 (continued)

Table 2.8 (continued)

| Source Name | SpT | Published RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P[TD]/P[ID] ^a | Population ^a |
|-------------|-----------|---------------------------------------|----------------------------|----------------------------|----------------------------|--------------------------|-------------------------|
| J1221+0257 | L0.5 | -8.79 ± 0.14 | 0.96 ± 0.07 | 6.67 ± 0.08 | -3.75 ± 0.13 | 0.01 | D |
| J1224-1238 | M9 | -2.9 ± 0.6 | -4.26 ± 0.16 | -8.1 ± 0.4 | -7.4 ± 0.5 | 0.01 | D |
| J1300+1912 | L1.5 | -17.60 ± 0.12 | 10.31 ± 0.03 | -84.1 ± 0.3 | -19.65 ± 0.12 | 3.55 | D/TD |
| J1305-2541 | L2+L3.5 | 6.4 ± 0.4 | -8.0 ± 0.4 | -8.4 ± 0.3 | 11.2 ± 0.2 | 0.01 | D |
| J1309-2330 | M8 | 15 ± 2 | 28.0 ± 1.0 | -11.2 ± 1.2 | -4.4 ± 1.3 | 0.01 | D |
| J1315-2649 | L3.5+T7 | -8 ± 3 | -34.9 ± 1.8 | -31 ± 2 | -12.3 ± 1.8 | 0.02 | D |
| J1331-0116 | T0/L6blue | -3.3 ± 0.4 | 21.4 ± 2.2 | -58.8 ± 13.5 | -25.8 ± 5.7 | 0.27 | D/TD |
| J1332-0441 | M7.5 | -12 ± 2 | 10 ± 7 | 24 ± 7 | -2 ± 5 | 0.01 | D |
| J1356+4343 | M8 | -22 ± 3 | -23.0 ± 0.4 | -20.4 ± 1.1 | -3.7 ± 3 | 0.01 | D |
| J1403+3007 | M8.5 | -39.2 ± 0.4 | -52.9 ± 0.2 | -41.1 ± 0.2 | -9.8 ± 0.4 | 0.05 | D |
| J1425-3650 | L4γ | 5.4 ± 0.3 | 5.78 ± 0.19 | -14.70 ± 0.17 | -7.63 ± 0.12 | 0.01 | D |
| J1428+3310 | M9e | -39.1 ± 0.4 | 17.45 ± 0.08 | -37.08 ± 0.13 | -20.2 ± 0.4 | 0.03 | D |
| J1438+6408 | L0 | -45 ± 3 | 64 ± 0.5 | 11.5 ± 1.9 | -39 ± 2 | 0.22 | D/TD |
| J1439+1929 | L1 | -26.74 ± 0.09 | -71 ± 4 | -28 ± 4 | 21.7 ± 1.7 | 0.08 | D |
| J1450+2354 | L4 | 5 ± 3 | 18.3 ± 1.0 | 23.5 ± 0.7 | 6 ± 2 | 0.01 | D |
| J1454+1606B | M8.5 | -10.5 ± 0.2 | 17.1 ± 0.2 | 14.92 ± 0.11 | -8.8 ± 0.2 | 0.01 | D |
| J1456-2809 | M7e | 1.0 ± 1.5 | 5.7 ± 1.2 | -17.0 ± 0.6 | -6.3 ± 0.7 | 0.01 | D |
| J1501+2250 | M9 | 6 ± 2 | 14.6 ± 0.8 | 10.1 ± 0.5 | 13.1 ± 1.7 | 0.01 | D |
| J1504-2355 | M7.5 | -29.0 ± 2.0 | -28.35 ± 1.61 | -4.49 ± 0.65 | 1.97 ± 0.99 | 0.01 | D |
| J1506+1321 | L3 | -0.68 ± 0.11 | -21.87 ± 0.13 | -27.94 ± 0.14 | 35.87 ± 0.13 | 0.07 | D |
| J1507-1627 | L5 | -39.85 ± 0.05 | -14.52 ± 0.04 | -4.71 ± 0.07 | -33.47 ± 0.05 | 0.03 | D |
| J1510-0241 | M9 | -41 ± 2 | -37.7 ± 1.4 | -6.86 ± 0.16 | -3.3 ± 1.4 | 0.01 | D |
| J1515+4847 | L6 | -29.97 ± 0.11 | -72.2 ± 1.1 | -1.3 ± 0.8 | -10.6 ± 0.6 | 0.03 | D |
| J1521+5053 | M7.5 | 1 ± 3 | 24.6 ± 0.2 | 9.6 ± 1.8 | 9 ± 2 | 0.01 | D |
| J1524+2925 | M7.5 | -15.9 ± 0.5 | 33.41 ± 0.19 | -21.0 ± 0.2 | -6.2 ± 0.4 | 0.01 | D |
| J1534-1418 | M7 | -71 ± 2 | -65.5 ± 1.7 | -23.4 ± 0.3 | -13.9 ± 1.1 | 0.04 | D |
| J1539-0520 | L4 | 27.3 ± 0.2 | 50.8 ± 0.2 | 50.4 ± 0.3 | 0.2 ± 0.2 | 0.14 | D/TD |
| J1555-0956 | L1.5 | 14.8 ± 0.1 | 65.30 ± 0.14 | 13.37 ± 0.02 | -51.33 ± 0.18 | 1.34 | D/TD |
| J1607-0442 | M9 | 11 ± 2 | 32.7 ± 1.7 | -10.4 ± 0.2 | -1.5 ± 1.1 | 0.01 | D |
| J1615+0546 | M9 | 7 ± 2 | 25.3 ± 1.5 | 15.4 ± 0.5 | -0.3 ± 1.2 | 0.01 | D |
| J1615+3559 | L3 | -20.2 ± 0.9 | 46.2 ± 0.5 | -26.1 ± 0.6 | -7.6 ± 0.7 | 0.02 | D |
| J1632+1904 | L8 | -6 ± 2 | 16.0 ± 1.4 | 20.4 ± 1.1 | -13.0 ± 1.5 | 0.01 | D |
| J1645-1320 | L1 | 26.58 ± 0.06 | 43.5 ± 0.06 | -31.25 ± 0.08 | 7.18 ± 0.03 | 0.02 | D |
| J1655-0823 | M7 | 15.39 ± 0.11 | 30.0 ± 0.1 | -20.99 ± 0.03 | 18.36 ± 0.04 | 0.01 | D |
| J1658+7026 | L1 | -25.6 ± 0.12 | 40.2 ± 0.1 | -14.5 ± 0.1 | 8.7 ± 0.1 | 0.01 | D |
| J1705-0516 | L1 | 12.19 ± 0.11 | 28.04 ± 0.11 | 13.09 ± 0.06 | -2.16 ± 0.11 | 0.01 | D |
| J1707+6439 | M8.5 | -10.10 ± 0.06 | 22.41 ± 0.03 | 15.19 ± 0.06 | -12.99 ± 0.05 | 0.01 | D |
| J1707-0558 | M9+L3 | 3 ± 2 | 14 ± 3 | 20 ± 4 | 4 ± 4 | 0.01 | D |
| J1721+3344 | L5 | -102.8 ± 0.2 | -88.9 ± 0.2 | -122.5 ± 0.3 | 78.6 ± 0.4 | >100 | TD/H |

Table 2.8 (continued)

Table 2.8 (*continued*)

| Source Name | SpT | Published RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P(TD)/P(D) ^a | Population ^a |
|-------------|-----------|---------------------------------------|----------------------------|----------------------------|----------------------------|-------------------------|-------------------------|
| J1731+2721 | L0 | -29.76 ± 0.11 | 6.28 ± 0.06 | -17.78 ± 0.08 | -6.62 ± 0.05 | 0.01 | D |
| J1745-1640 | L1.5 | 26 ± 2 | 38.5 ± 2.0 | 14.4 ± 0.4 | -3.1 ± 0.2 | 0.01 | D |
| J1750-0016 | L5 | 19 ± 3 | 24 ± 3 | 17.7 ± 1.3 | 30.6 ± 0.7 | 0.04 | D |
| J1757+7042 | M7.5 | -12.3 ± 0.6 | -16.28 ± 0.17 | -3.2 ± 0.5 | -0.4 ± 0.3 | 0.01 | D |
| J1807+5015 | L1 | -0.4 ± 0.5 | 20.18 ± 0.09 | 11.6 ± 0.4 | 4.0 ± 0.2 | 0.01 | D |
| J1821+1413 | L5 | 9.78 ± 0.16 | 24.16 ± 0.12 | 16.67 ± 0.11 | -4.00 ± 0.05 | 0.01 | D |
| J1835+3259 | M8.5 | 8 ± 2 | 33.0 ± 0.9 | 11.5 ± 1.7 | 4.3 ± 0.6 | 0.01 | D |
| J1843+4040 | M7.5e | -19 ± 2 | -30.4 ± 0.7 | 0.6 ± 1.8 | 21.7 ± 0.6 | 0.01 | D |
| J1845-6357B | M8.5+T6 | -18 ± 2 | -8.0 ± 1.6 | 49.0 ± 0.9 | -26.5 ± 0.8 | 0.18 | D/TD |
| J1906+4011 | L1 | -22.8 ± 0.3 | 6.0 ± 0.1 | 0.6 ± 0.3 | -34.93 ± 0.11 | 0.02 | D |
| J1916+0508 | M8 | 35.0 ± 1.5 | 64.6 ± 1.1 | 3.0 ± 1.0 | 2.15 ± 0.09 | 0.03 | D |
| J2057-0252 | L2β | -24.7 ± 0.4 | -0.4 ± 0.3 | -9.1 ± 0.3 | 16.2 ± 0.2 | 0.01 | D |
| J2104-1037 | L2 | -21.09 ± 0.12 | -26.02 ± 0.19 | -18.04 ± 0.16 | -25.6 ± 0.3 | 0.02 | D |
| J2139+0220 | L8.5+T3.5 | -25.1 ± 0.3 | -19.8 ± 0.4 | -2.6 ± 0.2 | 9.6 ± 0.3 | 0.01 | D |
| J2148+4003 | L7 | -14.5 ± 0.7 | -23.23 ± 0.13 | -2.5 ± 0.7 | 4.21 ± 0.13 | 0.01 | D |
| J2224-0158 | L4.5 | -36.48 ± 0.01 | 0.84 ± 0.04 | -52.0 ± 0.4 | -0.5 ± 0.3 | 0.04 | D |
| J2234+2359 | M9.5 | 17.2 ± 0.7 | -47.5 ± 0.2 | 7.7 ± 0.6 | -42.1 ± 0.4 | 0.17 | D/TD |
| J2244+2043 | L6-L8γ | -16.0 ± 0.9 | 4.77 ± 0.13 | -15.1 ± 0.8 | -5.9 ± 0.6 | 0.01 | D |
| J2306-0502 | M8 | -54 ± 2 | -33.3 ± 0.4 | -55.5 ± 1.0 | 19.9 ± 1.7 | 0.16 | D/TD |
| J2322-3133 | L2β | 33.9 ± 1.1 | 57.5 ± 0.5 | -25.3 ± 0.5 | -16.0 ± 1.1 | 0.03 | D |
| J2331-2749 | M7 | -3.0 ± 1.5 | -14.2 ± 0.4 | 53.8 ± 0.2 | 9.0 ± 1.4 | 0.11 | D/TD |
| J2346+1129 | M8 | 0 ± 2 | 46.3 ± 0.2 | 22.3 ± 1.3 | 11.4 ± 1.5 | 0.02 | D |

^a Galactic thin disk (D), thick disk (TD), intermediate thin/thick disk populations (D/TD), and intermediate thick disk/halo populations (D/H) assigned in the same manner as Table 2.5.

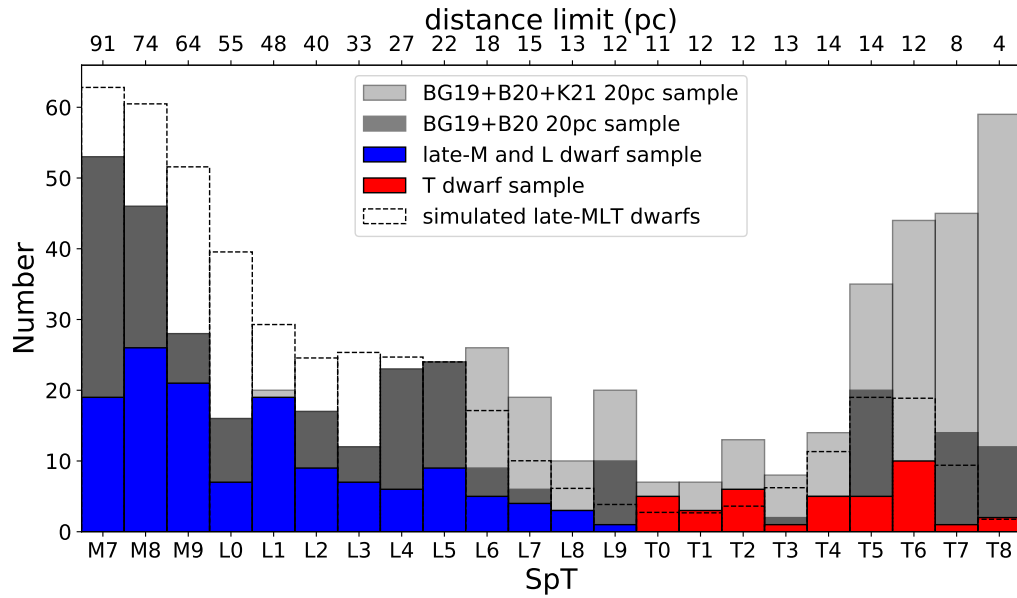


Figure 2.19: Spectral type distribution of my 20 pc late-M and L dwarf kinematic sample with RV uncertainty of $\leq 3 \text{ km s}^{-1}$ (blue histogram), and my NIRSPEC T dwarf sample (red histogram). Also shown are the combined volume-limited samples of M7–L5 dwarfs from Bardalez Gagliuffi et al. (BG19; 2019b) and L0–T8 dwarfs from (B20; Best et al. 2020) (dark grey), a 20 pc full sample from BG19, B20, and Kirkpatrick et al. (K21; 2021) (light grey), and a simulated population (dashed histogram; Section 2.5.4) normalized to agree with the observed sample at spectral type L5. Distance limits assuming an apparent magnitude limit of $J, K < 15.5$ are shown along the top x-axis.

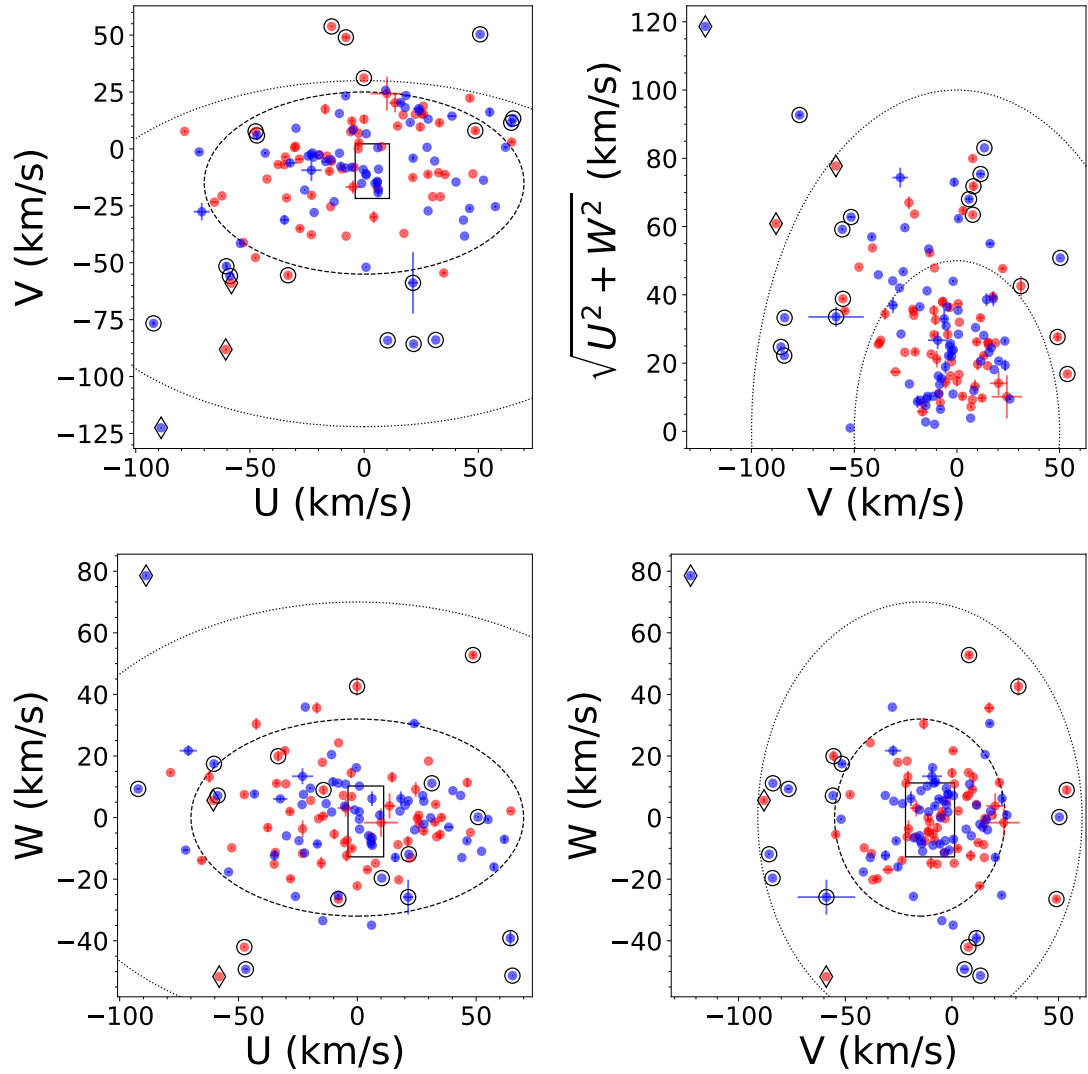


Figure 2.20: Same as Figure 2.11 for the late-M (red) and L dwarfs (blue) in my kinematic sample. The thick disk sources ($P[\text{TD}]/P[\text{D}] > 10$) are highlighted as open diamonds.

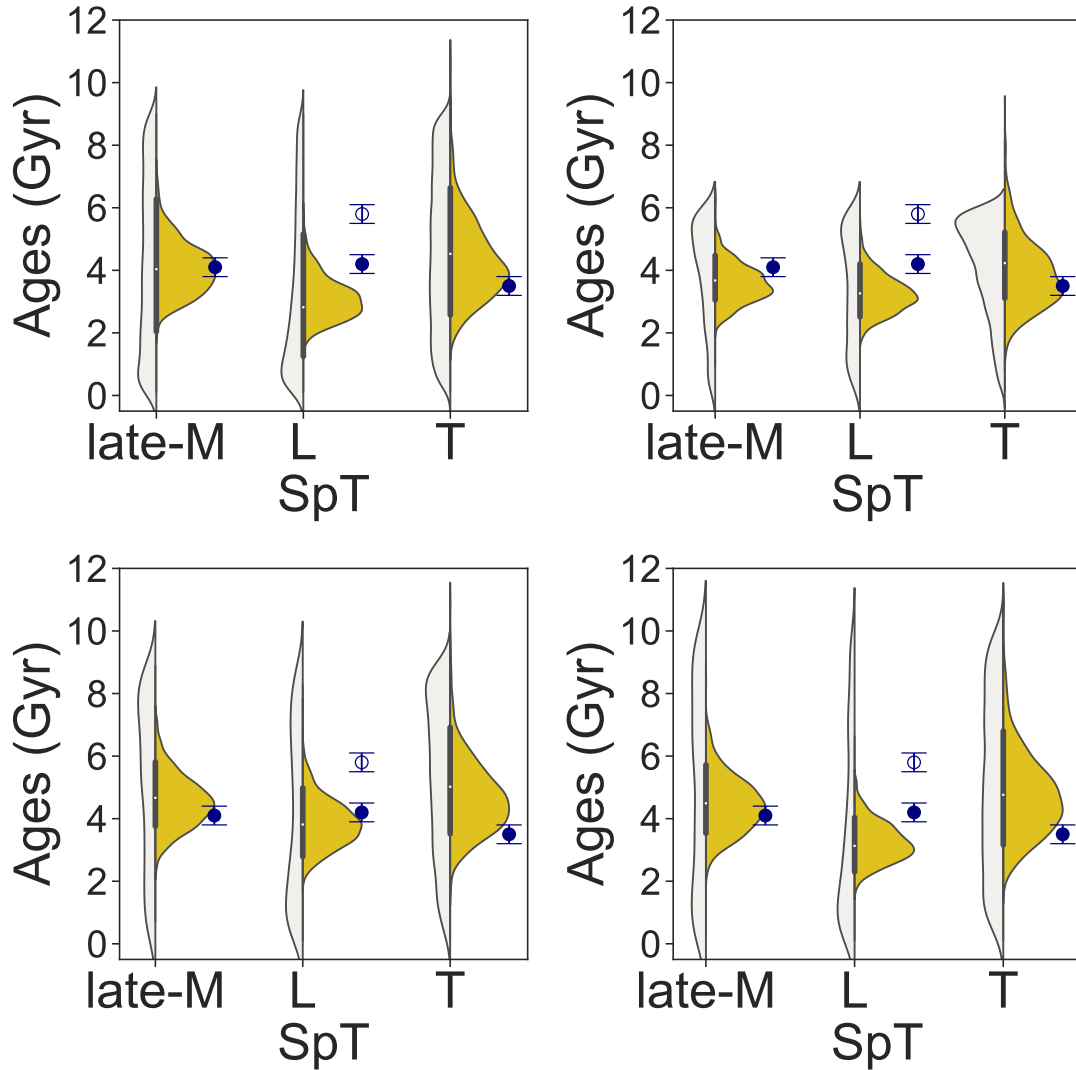


Figure 2.21: Simulated age distributions (white/yellow violin plots for individual/inferred ages, respectively) and measured kinematic ages (offset blue points and sampling uncertainties indicated) for all (empty blue points) and thin disk ($P(\text{TD})/P(\text{D}) \leq 1$; solid blue point) late-M, L, and T dwarfs. Panels are for simulations that assume a mass function $dN/dM \propto M^{-0.5}$, Baraffe et al. (2003) evolutionary models, and the following star formation rates and population ages: *Upper left*: constant birthrate over 9 Gyr (baseline simulation); *Upper right*: Rujopakarn et al. (2013) cosmic birthrate over 6 Gyr; *Lower left*: Aumer & Binney (2009) exponential birthrate over 9 Gyr; *Lower right*: constant birthrate over 12 Gyr.

Table 2.9: Velocity Dispersions and Group Kinematic Ages of Late-M and L Dwarfs at Local 20 pc

| Sample | N^a | $\langle U \rangle$ (km s $^{-1}$) | $\langle V \rangle$ (km s $^{-1}$) | $\langle W \rangle$ (km s $^{-1}$) | σ_U (km s $^{-1}$) | σ_V (km s $^{-1}$) | σ_W (km s $^{-1}$) | σ_{tot} (km s $^{-1}$) | Age (Gyr) | Note |
|-----------------------------------|-------|--|--|--|-------------------------------|-------------------------------|-------------------------------|-----------------------------------|---------------|-------------|
| late-M dwarfs | 65 | -4.7 ± 3.9 | -6.8 ± 3.0 | 0.5 ± 2.1 | 31.9 ± 0.3 | 24.8 ± 0.4 | 17.3 ± 0.3 | 43.9 ± 0.6 | 4.9 ± 0.3 | Unweighted |
| late-M dwarfs No Youth | 60 | -4.8 ± 4.2 | -6.9 ± 3.3 | 0.0 ± 2.3 | 34.1 ± 0.5 | 27.7 ± 0.5 | 21.2 ± 0.7 | 48.8 ± 0.5 | 4.4 ± 0.1 | W Weighted |
| late-M dwarfs NTD ^b | 63 | -3.7 ± 3.8 | -4.5 ± 2.8 | 1.0 ± 2.0 | 33.9 ± 0.6 | 28.4 ± 0.6 | 22.2 ± 1.0 | 49.5 ± 0.7 | 5.3 ± 0.3 | Unweighted |
| late-M dwarfs D ^c | 63 | -3.7 ± 3.8 | -4.5 ± 2.8 | 1.0 ± 2.0 | 30.5 ± 0.4 | 22.1 ± 0.4 | 16.3 ± 0.3 | 41.0 ± 0.6 | 4.1 ± 0.3 | W Weighted |
| L dwarfs | 71 | 0.6 ± 4.2 | -12.8 ± 3.5 | -1.4 ± 2.2 | 34.5 ± 0.6 | 24.4 ± 0.4 | 18.1 ± 0.4 | 46.0 ± 0.5 | 3.9 ± 0.1 | W Weighted |
| L dwarfs NTD ^b | 70 | 1.9 ± 4.1 | -11.2 ± 3.2 | -2.6 ± 1.9 | 30.5 ± 0.3 | 22.1 ± 0.3 | 16.3 ± 0.3 | 41.0 ± 0.6 | 4.1 ± 0.3 | Unweighted |
| L dwarfs NB ^d | 67 | 3.8 ± 4.0 | -10.8 ± 3.2 | -3.3 ± 2.0 | 34.4 ± 0.4 | 26.8 ± 0.5 | 16.2 ± 0.3 | 46.5 ± 0.7 | 5.8 ± 0.3 | W Weighted |
| L dwarfs No Youth | 57 | 0.9 ± 5.0 | -12.4 ± 4.3 | -1.7 ± 2.7 | 39.1 ± 0.5 | 30.8 ± 1.1 | 18.9 ± 0.4 | 53.3 ± 0.8 | 5.2 ± 0.1 | W Weighted |
| L dwarfs No Binary | 63 | 0.7 ± 4.6 | -12.7 ± 3.7 | -1.2 ± 2.4 | 33.0 ± 0.4 | 26.0 ± 0.5 | 16.1 ± 0.3 | 45.0 ± 0.7 | 5.3 ± 0.3 | Unweighted |
| L dwarfs No Binary D ^c | 58 | 2.0 ± 4.3 | -7.7 ± 2.8 | -1.8 ± 2.0 | 38.4 ± 0.6 | 30.2 ± 1.1 | 19.2 ± 0.3 | 52.5 ± 0.8 | 5.1 ± 0.1 | W Weighted |
| L0-L5 dwarfs | 57 | 3.3 ± 5.0 | -14.3 ± 4.2 | -1.3 ± 2.6 | 38.1 ± 0.5 | 32.5 ± 0.7 | 20.4 ± 0.5 | 54.0 ± 1.0 | 8.8 ± 0.6 | Unweighted |
| L0-L5 dwarfs D ^c | 51 | 4.8 ± 4.7 | -7.3 ± 3.0 | -1.8 ± 2.2 | 48.5 ± 1.2 | 49.8 ± 2.5 | 25.6 ± 0.8 | 74.1 ± 2.6 | 8.9 ± 0.4 | W Weighted |
| L6-L9 dwarfs | 14 | -10.5 ± 6.5 | -6.7 ± 4.9 | -1.9 ± 3.3 | 36.7 ± 0.5 | 29.4 ± 0.7 | 19.2 ± 0.5 | 50.8 ± 1.0 | 7.4 ± 0.5 | Unweighted |
| L0-L1 dwarfs | 26 | 10.1 ± 6.9 | -12.7 ± 5.3 | -4.5 ± 3.7 | 47.7 ± 1.2 | 47.1 ± 2.8 | 25.3 ± 0.9 | 71.6 ± 2.8 | 8.5 ± 0.5 | W Weighted |
| L1-L2 dwarfs | 28 | 8.8 ± 6.6 | -15.0 ± 4.7 | -3.6 ± 3.5 | 33.0 ± 0.4 | 21.2 ± 0.7 | 15.4 ± 0.3 | 42.1 ± 0.9 | 4.4 ± 0.3 | Unweighted |
| L2-L3 dwarfs | 16 | -0.9 ± 8.7 | -13.0 ± 4.5 | -1.3 ± 3.7 | 37.0 ± 0.7 | 21.5 ± 1.6 | 18.3 ± 0.4 | 46.5 ± 1.0 | 4.0 ± 0.2 | W Weighted |
| L3-L4 dwarfs | 13 | 8.6 ± 7.6 | -7.4 ± 7.2 | -1.1 ± 3.4 | 32.5 ± 0.4 | 20.9 ± 0.6 | 15.3 ± 0.3 | 41.5 ± 0.8 | 4.2 ± 0.3 | Unweighted |
| | | | | | 36.3 ± 0.6 | 22.0 ± 1.4 | 17.6 ± 0.4 | 46.0 ± 0.9 | 3.9 ± 0.2 | W Weighted |
| | | | | | 49.9 ± 1.3 | 49.6 ± 2.5 | 26.0 ± 0.9 | 75.0 ± 2.7 | 9.0 ± 0.5 | Unweighted |
| | | | | | 33.6 ± 0.5 | 21.4 ± 0.3 | 15.9 ± 0.3 | 42.9 ± 0.7 | 4.6 ± 0.3 | W Weighted |
| | | | | | 38.8 ± 0.8 | 20.3 ± 0.5 | 18.5 ± 0.4 | 47.6 ± 0.7 | 4.1 ± 0.1 | W Weighted |
| | | | | | 24.0 ± 2.1 | 18.4 ± 3.3 | 12.6 ± 1.0 | 32.8 ± 4.0 | 2.2 ± 0.8 | Unweighted |
| | | | | | 26.0 ± 1.9 | 26.8 ± 6.0 | 15.1 ± 1.8 | 40.5 ± 4.9 | 3.0 ± 0.8 | W Weighted |
| | | | | | 45.7 ± 1.4 | 31.0 ± 1.8 | 24.9 ± 0.8 | 60.6 ± 1.3 | 6.4 ± 0.7 | Unweighted |
| | | | | | 34.8 ± 0.9 | 25.0 ± 1.0 | 18.3 ± 0.6 | 46.6 ± 1.5 | 5.8 ± 0.6 | Unweighted |
| | | | | | 43.7 ± 1.3 | 31.0 ± 1.7 | 22.4 ± 0.9 | 58.1 ± 1.4 | 6.1 ± 0.3 | W Weighted |
| | | | | | 35.5 ± 1.3 | 18.0 ± 0.8 | 14.6 ± 0.9 | 41.6 ± 1.8 | 4.2 ± 0.6 | Unweighted |
| | | | | | 35.7 ± 2.0 | 28.1 ± 1.9 | 14.4 ± 1.1 | 47.7 ± 2.1 | 4.2 ± 0.4 | W Weighted |
| | | | | | 27.4 ± 1.3 | 25.8 ± 1.7 | 11.9 ± 1.8 | 39.5 ± 2.8 | 3.7 ± 0.8 | Unweighted |
| | | | | | 28.9 ± 1.7 | 28.6 ± 3.5 | 15.6 ± 3.3 | 43.7 ± 2.5 | 3.5 ± 0.4 | W Weighted |

Table 2.9 (continued)

Table 2.9 (*continued*)

| Sample | N^a | $\langle U \rangle$ (km s^{-1}) | $\langle V \rangle$ (km s^{-1}) | $\langle W \rangle$ (km s^{-1}) | σ_U (km s^{-1}) | σ_V (km s^{-1}) | σ_W (km s^{-1}) | σ_{tot} (km s^{-1}) | Age (Gyr) | Note |
|------------------------------|-------|---|---|---|--------------------------------------|--------------------------------------|--------------------------------------|--|----------------|-------------|
| L4–L5 dwarfs | 15 | -3.9 ± 11.0 | -18.3 ± 12.0 | 4.3 ± 6.4 | 42.2 ± 2.4 | 46.1 ± 2.6 | 24.4 ± 2.7 | 67.1 ± 4.4 | 16.2 ± 3.0 | Unweighted |
| L4–L5 dwarfs NB ^d | 12 | 11.1 ± 8.1 | -7.6 ± 10.3 | -3.7 ± 4.2 | 57.2 ± 7.3 | 72.9 ± 11.0 | 39.5 ± 6.2 | 100.8 ± 14.3 | 12.9 ± 2.0 | W Weighted |
| L4–L5 dwarfs D ^c | 12 | 8.4 ± 8.2 | 0.8 ± 7.9 | -1.0 ± 4.5 | 26.6 ± 3.1 | 32.1 ± 3.9 | 17.9 ± 2.6 | 45.6 ± 3.1 | 6.1 ± 1.4 | Unweighted |
| L5–L6 dwarfs | 15 | -14.1 ± 11.1 | -22.0 ± 11.2 | 1.4 ± 6.9 | 28.2 ± 2.1 | 27.2 ± 1.8 | 15.6 ± 1.3 | 42.2 ± 3.1 | 3.8 ± 0.5 | W Weighted |
| L5–L6 dwarfs NB ^d | 11 | -3.7 ± 10.5 | -8.0 ± 9.2 | -5.5 ± 5.1 | 25.1 ± 2.4 | 20.3 ± 2.1 | 19.4 ± 2.1 | 37.7 ± 2.3 | 4.4 ± 1.0 | W Weighted |
| L5–L6 dwarfs D ^c | 12 | -4.4 ± 9.7 | -3.8 ± 7.0 | -4.5 ± 5.4 | 42.7 ± 1.8 | 43.3 ± 2.5 | 26.7 ± 2.5 | 66.4 ± 4.0 | 2.5 ± 0.4 | W Weighted |
| L6–L7 dwarfs | 10 | -11.8 ± 8.2 | -8.7 ± 6.1 | -3.5 ± 4.2 | 50.6 ± 5.2 | 69.0 ± 8.7 | 32.4 ± 4.5 | 91.5 ± 10.8 | 15.8 ± 2.7 | Unweighted |
| L6–L7 dwarfs NB ^d | 9 | -15.4 ± 8.2 | -3.1 ± 3.5 | -1.0 ± 3.9 | 34.9 ± 2.5 | 30.0 ± 3.7 | 16.7 ± 1.4 | 48.9 ± 4.7 | 11.6 ± 1.6 | W Weighted |
| L7–L8 dwarfs | 7 | -11.1 ± 7.4 | -1.4 ± 3.5 | 2.5 ± 3.4 | 29.7 ± 2.5 | 30.0 ± 3.4 | 16.5 ± 0.9 | 45.5 ± 2.8 | 6.8 ± 1.8 | Unweighted |
| L7–L8 dwarfs NB ^d | 6 | -9.7 ± 8.4 | -1.2 ± 4.0 | 1.3 ± 3.7 | 33.4 ± 2.3 | 24.1 ± 3.2 | 18.6 ± 1.2 | 45.2 ± 4.2 | 3.8 ± 0.5 | W Weighted |
| L8–L9 dwarfs | 4 | -7.5 ± 9.7 | -1.9 ± 7.1 | 2.2 ± 4.4 | 28.3 ± 1.8 | 28.3 ± 5.1 | 17.1 ± 0.8 | 43.7 ± 3.7 | 5.4 ± 1.4 | Unweighted |
| L8–L9 dwarfs NB ^d | 3 | -3.4 ± 12.1 | -1.7 ± 9.5 | -0.2 ± 5.2 | 25.7 ± 2.9 | 18.9 ± 4.5 | 13.3 ± 1.4 | 34.6 ± 5.5 | 3.5 ± 0.6 | W Weighted |
| | | | | | 27.2 ± 2.5 | 28.6 ± 7.5 | 16.3 ± 2.2 | 43.1 ± 6.1 | 2.6 ± 1.2 | Unweighted |
| | | | | | 23.1 ± 3.8 | 14.3 ± 2.9 | 13.3 ± 2.1 | 30.6 ± 2.6 | 3.4 ± 1.0 | W Weighted |
| | | | | | 19.1 ± 2.1 | 8.7 ± 2.7 | 8.7 ± 1.2 | 22.8 ± 3.6 | 1.5 ± 0.7 | Unweighted |
| | | | | | 21.4 ± 3.3 | 10.8 ± 3.1 | 7.6 ± 1.2 | 25.3 ± 4.0 | 1.5 ± 0.3 | W Weighted |
| | | | | | 20.2 ± 2.1 | 9.3 ± 3.1 | 8.9 ± 1.3 | 24.0 ± 3.9 | 0.7 ± 0.4 | W Weighted |
| | | | | | 24.5 ± 4.2 | 11.3 ± 3.6 | 8.2 ± 1.3 | 28.3 ± 4.9 | 0.8 ± 0.5 | Unweighted |
| | | | | | 18.1 ± 2.8 | 12.9 ± 3.9 | 7.7 ± 3.4 | 23.6 ± 5.9 | 1.2 ± 0.6 | W Weighted |
| | | | | | 20.3 ± 3.1 | 14.4 ± 3.7 | 7.6 ± 3.7 | 26.6 ± 2.7 | 0.9 ± 0.7 | Unweighted |
| | | | | | 15.9 ± 8.3 | 13.3 ± 5.5 | 6.8 ± 4.1 | 21.8 ± 10.8 | 1.0 ± 0.3 | W Weighted |
| | | | | | 19.2 ± 8.7 | 12.6 ± 5.0 | 5.5 ± 3.6 | 25.6 ± 4.0 | 1.0 ± 1.3 | Unweighted |
| | | | | | | | | | 0.9 ± 0.4 | W Weighted |

Ages for unweighted velocities are computed from equation (2.8) using the parameters in Aumer & Binney (2009). Ages for |W|-weighted velocities are computed from equation (2.6) using the parameters in Wielen (1977).

^a Number of sources in sample

^b Excluding thick disk sources

^c Thin disk sources only

^d Excluding unusual blue L dwarfs

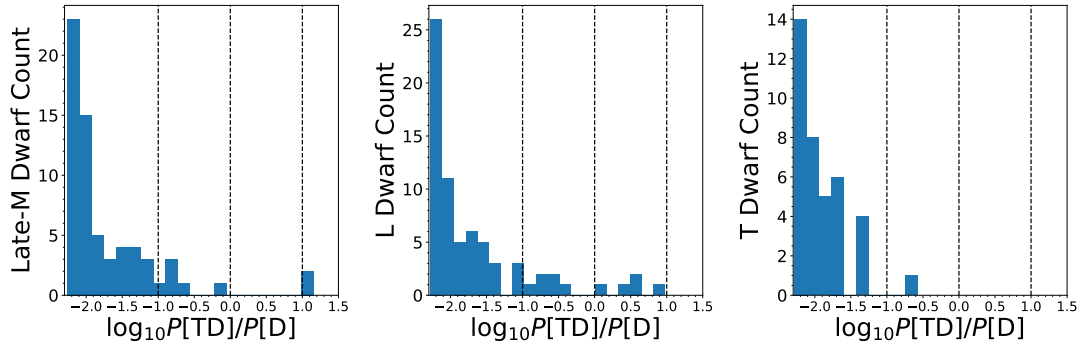


Figure 2.22: Distributions of log probability ratios of thick/thin disk (TD/D) sources for late-M, L, and T dwarfs, respectively. The vertical dashed lines denote the probability ratios of 0.1, 1, and 10, respectively.

2.5.3 Vertical Action Dispersion

Vertical action (J_Z) measures the excursion of momentum perpendicular to the Galactic plane, which is invariant under orbital evolution provided that the Galactic potential is axisymmetric and perturbations are on average planar. The Galactic potential does have non-axisymmetric components, such as the spiral arms, interior bar, and giant molecular clouds above and below the Galactic disk, all of which can perturb J_Z and the planar actions J_R and J_ϕ (Beane et al. 2018; Ting & Rix 2019). Nevertheless, it has been argued that vertical action may be a better physical quantity to probe statistical ages for stellar populations than UVW velocities (Kiman et al. 2019; Ting & Rix 2019).

Vertical actions and their dispersion can be computed directly from 6D spatial and velocity coordinates. I used *galpy* (Bovy 2015) to calculate J_Z , using a Galactocentric solar position of $(R_\odot, Z_\odot) = (8.2, 0.025)$ kpc, an LSR Galactic circular velocity at the solar radius of $v_\phi(R_\odot) = 240 \text{ km s}^{-1}$ (Ting & Rix 2019), and the LSR solar velocity vector used above. The position and circular velocity used here differ from my prior assumptions in Section 2.4.2 in order to align my analysis with that of Ting & Rix (2019).

By analyzing the APOGEE-*Gaia* DR2 red clump giant sample (Ting et al. 2018;

Gaia Collaboration et al. 2018b), Ting & Rix (2019) derived an empirical relation to estimate kinematic age from the mean vertical action \widehat{J}_Z (kpc km s⁻¹) as a function of mean Galactic radius \overline{R}_{GC} (kpc) and age τ for a star:

$$\begin{aligned}
\widehat{J}_Z(\overline{R}_{GC}, \tau) &= \widehat{J}_{Z,0}(\overline{R}_{GC}) + \Delta\widehat{J}_{Z,1\text{Gyr}} \left(\frac{\tau}{1\text{Gyr}} \right)^{\gamma(\overline{R}_{GC})} \\
&= (0.91 + 0.18\Delta R_{GC} + 0.087\Delta R_{GC}^2 \\
&\quad + 0.014\Delta R_{GC}^3) \\
&\quad + (1.81 + 0.050\Delta R_{GC}) \tau^{1.09+0.060\Delta R_{GC}},
\end{aligned} \tag{2.9}$$

where $\Delta R_{GC} = \overline{R}_{GC} - 8$ kpc, $\overline{R}_{GC} = \frac{(R_{GC} + R_{\text{birth}})}{2}$, R_{birth} is the birth Galactic radius, and R_{GC} is the current Galactic radius. Since I cannot determine the birth radii for the sample, I simply use $\overline{R}_{GC} = R_{GC}$.

The Ting & Rix (2019) relation turns out to be problematic for this sample, as the zero-age baseline vertical action $\widehat{J}_{Z,0}(\overline{R}_{GC}) = 0.95$ kpc km s⁻¹ is greater than the J_Z values of 66% of my sample, resulting in negative ages for these sources. Applying equation (2.9) to the remaining sources yields vertical action ages of 1.9 ± 2.7 Gyr for late-M dwarfs (1.7 ± 2.3 Gyr for thin disk), 2.3 ± 2.5 Gyr for L dwarfs (1.9 ± 2.1 Gyr for thin disk), and 0.9 ± 0.7 Gyr for T dwarfs. These values are similar to the age of 2.7 ± 2.2 Gyr inferred from vertical action analysis of late-M and L dwarfs with SDSS spectra by Kiman et al. (2019), and both are considerably younger than the ages inferred from velocity dispersions. These age estimates are likely in error, as the Ting & Rix (2019) relations produce negative ages for a significant fraction of the stars in my sample. I therefore discard these age determinations as absolute measures, but note that the relative consistency of ages for thin disk late-M, L, and T dwarfs is concurrent with my velocity dispersion analysis.

2.5.4 Comparison to Simulated Populations

Baseline Simulations

To evaluate whether the kinematic ages determined here are consistent with my understanding of the formation and evolution of UCDs, I conducted a Monte-Carlo population simulation for local thin disk late-M, L, and T dwarfs. I simulated 10^5 sources assuming a uniform spatial distribution and a uniform star formation rate over $0.1 \text{ Gyr} \leq \tau \leq 9 \text{ Gyr}$, with masses sampling the range $0.01 M_\odot \leq M \leq 0.15 M_\odot$ ²² drawn according to a power-law initial mass function

$$\frac{dN}{dM} \propto M^{-\alpha}, \quad (2.10)$$

where M is mass, N is the number density of stars in the local volume, and α is a power-law index. I chose a baseline value $\alpha = 0.5$, which is roughly consistent with UCD populations in young clusters (Bastian et al. 2010) and the local Galactic environment (Kirkpatrick et al. 2019, 2021). I used the evolutionary models of Baraffe et al. (2003) to convert ages and masses into effective temperatures (T_{eff}), and assigned spectral types (SpT) using the empirical SpT- T_{eff} relation of Filippazzo et al. (2015). UVW space velocities in the LSR were then assigned based on age, by assuming²³ $UVW = 0$ at $\tau = 0$ and drawing from normal distributions in all three components using widths based on the Aumer & Binney (2009) age-dispersion relations for each axis of motion. For the V

²²The choice of lowest-mass $0.01 M_\odot$ is limited by evolutionary models for the field sample. Saumon & Marley (2008) models have the lowest-mass $0.01 M_\odot$ that evolve to 10 Gyr. A $10 M_{\text{Jup}}$ T dwarf is relatively young (Baraffe 2003 models for $T_{\text{eff}} = 953 \text{ K}$ and mass = $0.01 M_\odot = 100 \text{ Myr}$), so it is unlikely that lower mass objects will be significant contributors to the field sample.

²³This is consistent with my kinematic analysis for the observed sample; see Sections 2.5.1 and 2.5.2 for more details.

Table 2.10: Simulated UCD Population Parameters

| Sample | Simulated | | | Kinematic | |
|---------------|---------------------------|--|--|--|--------------|
| | Age ^a (Gyr) | $\langle U \rangle$ (km s ⁻¹) | $\langle V \rangle$ (km s ⁻¹) | $\langle W \rangle$ (km s ⁻¹) | Age (Gyr) |
| late-M dwarfs | 4.1 | 1 ± 4 | -13 ± 3 | 0 ± 2 | 4.1 ± 0.8 |
| L dwarfs | 2.8 | 0 ± 4 | -11 ± 3 | 0.1 ± 1.7 | 3.1 ± 0.7 |
| T dwarfs | 4.6 | 0 ± 6 | -14 ± 4 | 0 ± 3 | 4.3 ± 1.2 |

Note – Ages for simulated populations are computed from equation (2.8) using the parameters in Aumer & Binney (2009), with sampling errors accounted for using a Jackknife test statistic; see Section 2.5.4.

^a Median simulation age $\langle \tau \rangle$

velocity, I also added a time-dependent asymmetric drift term (Aumer & Binney 2009):

$$V_a = \frac{-\sigma_U^2(\tau)}{74 \text{ km s}^{-1}} = 23.7 \left(\frac{\tau}{10 \text{ Gyr}} \right)^{0.614} \text{ km s}^{-1}. \quad (2.11)$$

From this simulated (and assumed volume-complete) velocity sample, I computed the kinematic ages of UCD spectral subgroups using the same analysis as that of my observational sample. I simulated sample selection effects by making 1,000 random draws of $N_s - 1$ sources from the simulated population, where N_s corresponds to the sizes of my late-M, L, and T dwarf RV samples (63, 65, and 36 sources, respectively) and -1 corresponds to the Jackknife sampling. The median values and standard deviations from this sampling are summarized in Table 2.10 and Figure 2.23.

The resulting kinematic ages are 4.1 ± 0.8 Gyr, 3.1 ± 0.7 Gyr, and 4.3 ± 1.2 Gyr for late-M, L, and T dwarfs, respectively. These ages are statistically equivalent, although the L dwarfs are about 1 Gyr younger on average. The relatively large uncertainties highlight the importance of sampling effects. Comparing to the kinematic ages of the observed thin disk sample, I find excellent agreement for the late-M and T dwarfs, but significant disagreement ($\Delta\tau = 4.0$ Gyr, 5.0σ deviation) compared to the full sample of L dwarfs. However, if I exclude potential thick disk sources ($P[\text{TD}]/P[\text{D}] > 1$), the discrepancy for the L dwarfs is significantly reduced ($\Delta\tau = 1.1$ Gyr) with only marginal

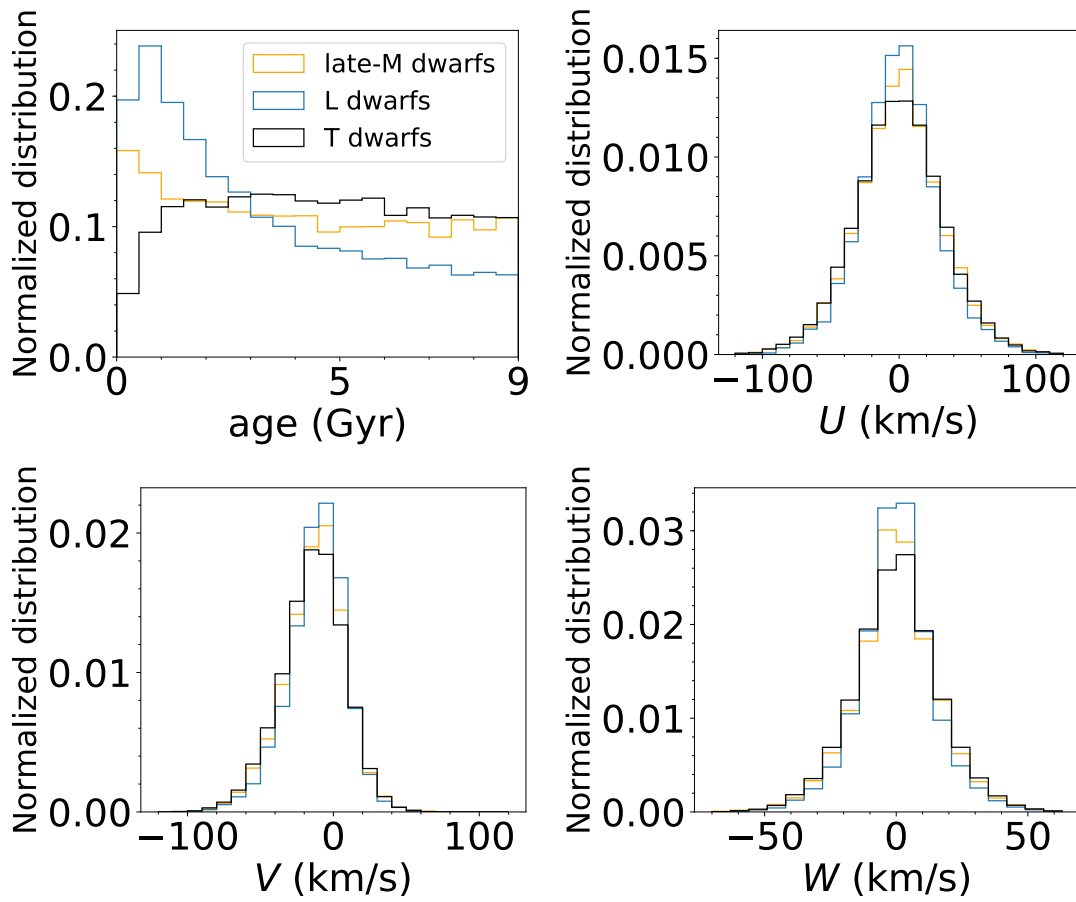


Figure 2.23: Normalized distributions of ages (upper-left) and UVW space motions for my baseline simulated population. Distributions are segregated between late-M (orange), L (blue), and T dwarfs (black).

significance of deviation (1.4σ). Again, accounting for potential thick disk sources appears to mostly resolve the previously identified discrepancy between observed and simulated ages for L dwarfs, although my baseline simulations still predict a young L dwarf population compared to late-M and T dwarfs.

Variations on Simulated Populations

The modest disagreement between simulated and observed kinematics suggests the need for some fine-tuning of simulation parameters as they relate to the kinematics of late-M, L, and T dwarfs. To explore this, I evaluated the the influence of following simulation parameters on the ages of the late-M, L, and T dwarf disk population:

- *Star formation rate (SFR)*: In addition to a uniform star formation rate, I examined an exponentially declining birth rate, $\text{SFR} \propto e^{\gamma\tau}$, where $\gamma = 0.117 \text{ Gyr}^{-1}$ and τ is age in Gyr (Aumer & Binney 2009); and a star formation rate that reflects cosmic star formation history, $\text{SFR} \propto (1 + z(\tau))^\beta$, where z is the redshift and $\beta = 3.5$ (Rujopakarn et al. 2010; Planck Collaboration et al. 2016).
- *Mass function*: I examined additional power-law relations with $\alpha = -1.5, -0.5,$ and $+1.5$; and two cases of an age-dependent mass function: $\alpha = 0.0 \Rightarrow +1.0$ and $\alpha = +1.0 \Rightarrow 0.0$ 10 Gyr in the past²⁴ (cf. Burgasser et al. 2015a). I also examined a log-normal mass function from Chabrier (2003).
- *Choice of brown dwarf evolution model*: In addition to the Baraffe et al. (2003) evolutionary models, I evaluated the models of Burrows et al. (2001), Saumon & Marley (2008), Marley et al. (2018), and Phillips et al. (2020).

²⁴The cosmological star formation rate peaks at $z \sim 2$, corresponding to a cosmic age of ~ 3 Gyr (~ 10 Gyr in the past) under the standard Λ CDM cosmology (Madau & Dickinson 2014). The star formation rate of the inner Milky Way ($R \leq 10$ kpc) peaks at $\sim z = 1-3$ ($\sim 8-12$ Gyr ago) (Haywood et al. 2016).

- *Maximum simulation age*: In addition to the baseline maximum age of 9 Gyr, I considered maximum ages of 6 Gyr and 12 Gyr.
- *Minimum brown dwarf mass (MBDM)*: The lowest-mass brown dwarfs are also the youngest in the L dwarf phase, which may skew simulated ages downward. I considered additional minimum masses for my simulation of $0.02 M_{\odot}$ and $0.03 M_{\odot}$ to explore this effect.

For computational expediency, the number of simulated sources used for these simulations was 10^4 versus 10^5 for my baseline simulations. Varying each of these parameters individually, I produced 578 additional simulations. For Marley et al. (2018) and Phillips et al. (2020) models, I only ran the simulations for uniform star formation rate, $\alpha = 0.5$ and minimum brown dwarf mass of $0.01 M_{\odot}$. I quantified the agreement of the simulations to the observations using a χ^2 statistic:

$$\chi^2 = \sum_i \frac{(\tau_{\text{obs},i} - \tau_{\text{sim},i})^2}{\sigma_{\tau_{\text{obs},i}}^2 + \sigma_{\tau_{\text{sim},i}}^2} \quad (2.12)$$

with τ_{obs} and τ_{sim} being the observed and simulated ages, σ_{obs} and σ_{sim} the observed and simulated age uncertainties, and $i = \text{late-M, L, and T dwarf thin disk samples (P[TD]/P[D]} \leq 1)$. A select set of the results discussed here are summarized in Table 2.11. All simulations are fully compiled in Table B.1.

Table 2.11: Select Simulated UCD Population Ages Under Different Assumptions

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|--|--------------------------|----------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| Observations | | | | | | | | |
| ALL SOURCES | | | | | 4.9 ± 0.3 | 7.1 ± 0.4 | 3.5 ± 0.3 | ... |
| NOT THICK DISK ($P(\text{TD})/P(\text{D}) < 10$) | | | | | 4.1 ± 0.3 | 5.8 ± 0.3 | 3.5 ± 0.3 | ... |
| THIN DISK ($P(\text{TD})/P(\text{D}) < 1$) | | | | | 4.1 ± 0.3 | 4.2 ± 0.3 | 3.5 ± 0.3 | ... |
| Simulations | | | | | | | | |
| 9 ^a | uniform | 0.5 | B03 | 0.01 | 4.1 ± 0.8 | 3.1 ± 0.7 | 4.3 ± 1.2 | 2.1 |
| 9 | uniform | 0.5 | B01 | 0.01 | 3.5 ± 0.7 | 3.1 ± 0.6 | 4.2 ± 1.2 | 3.0 |
| 9 | uniform | 0.5 | S08 | 0.01 | 4.3 ± 0.8 | 3.4 ± 0.7 | 4.5 ± 1.2 | 1.7 |
| 9 | uniform | 0.5 | M19 | 0.01 | 1.6 ± 0.3 | 3.1 ± 0.6 | 4.0 ± 1.1 | 42.1 |

Table 2.11 (*continued*)

Table 2.11 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|--------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 9 | uniform | 0.5 | P20C | 0.01 | 0.2 ± 0.0 | 2.6 ± 0.5 | 4.2 ± 1.2 | 172.0 |
| 9 | uniform | 0.5 | P20NW | 0.01 | 0.3 ± 0.0 | 2.6 ± 0.6 | 4.3 ± 1.2 | 162.3 |
| 9 | uniform | 0.5 | P20NS | 0.01 | 0.4 ± 0.0 | 2.7 ± 0.6 | 4.1 ± 1.2 | 154.4 |
| 9 | exponential | 0.5 | B03 | 0.01 | 4.5 ± 0.8 | 3.8 ± 0.8 | 4.7 ± 1.2 | 1.3 |
| 9 | exponential | 0.5 | B01 | 0.01 | 3.6 ± 0.6 | 3.7 ± 0.7 | 4.9 ± 1.4 | 1.7 |
| 9 | exponential | 0.5 | S08 | 0.01 | 4.6 ± 0.8 | 4.2 ± 0.8 | 4.8 ± 1.2 | 1.5 |
| 9 | log-normal | 0.5 | B03 | 0.01 | 6.8 ± 1.3 | 6.1 ± 1.0 | 6.5 ± 1.6 | 11.6 |
| 9 | log-normal | 0.5 | B01 | 0.01 | 7.4 ± 1.3 | 6.0 ± 1.0 | 6.2 ± 1.5 | 12.7 |
| 9 | log-normal | 0.5 | S08 | 0.01 | 6.4 ± 1.0 | 6.2 ± 1.1 | 6.4 ± 1.6 | 11.3 |
| 9 ^b | exponential | 0.0/1.0/3.0 | B03 | 0.01 | 5.3 ± 1.0 | 5.0 ± 0.9 | 4.2 ± 1.2 | 2.5 |
| 9 ^c | exponential | 1.0/0.0/3.0 | B03 | 0.01 | 4.2 ± 0.7 | 4.8 ± 0.8 | 5.2 ± 1.3 | 2.3 |
| 9 ^d | uniform | 0.5 | B03 | 0.01 | 4.0 ± 0.8 | 3.0 ± 0.6 | 3.8 ± 1.1 | 2.8 |
| 9 ^e | uniform | 0.5 | B03* | 0.01 | 4.1 ± 0.8 | 4.1 ± 0.8 | 4.4 ± 1.2 | 0.5 |
| 9 ^c | uniform | 1.5/−0.5/3.0 | B03 | 0.01 | 3.4 ± 0.6 | 3.5 ± 0.7 | 5.0 ± 1.2 | 3.2 |
| 9 ^c | uniform | 1.5/−0.5/4.5 | B03 | 0.01 | 2.9 ± 0.6 | 3.5 ± 0.7 | 5.4 ± 1.4 | 5.6 |
| 9 ^c | uniform | 1.5/−0.5/6.0 | B03 | 0.01 | 3.2 ± 0.7 | 3.4 ± 0.7 | 4.3 ± 1.1 | 2.7 |

Note — Kinematics ages computed using the Aumer & Binney (2009) relation and the procedure described in Section 2.5.4. τ is the maximum age of the sample, α is the mass function power law index ($\frac{dN}{dM} = M^{-\alpha}$), MBDM is the minimum brown dwarf mass. Evolving mass functions are labeled in the order of early α , late α , and age (in Gyr) of transition. A log-normal mass function from Chabrier (2003) is labeled as “log-normal”. Star formation rates considered in my simulations: uniform, exponential (Aumer & Binney 2009), and cosmic star formation rate (Rujopakarn et al. 2010). Brown dwarf evolution models are B03 (Baraffe et al. 2003), B01 (Burrows et al. 2001), S08 (Saumon & Marley 2008), M19 (Marley et al. 2018), and P20 (Phillips et al. 2020). For the last model set, C, NW, and NS stand for chemical equilibrium, weak, and strong chemical disequilibrium, respectively. Note that only substellar models are available in the P20 set. See Table B.1 in Appendix B for the full list of simulations.

^a Baseline simulation

^b Simulations with an evolving mass function from top-heavy to bottom-heavy over time using Baraffe et al. (2003) evolutionary models. See Section 2.5.4 for details.

^c Simulations with an evolving mass function from bottom-heavy to top-heavy over time using Baraffe et al. (2003) evolutionary models. See Section 2.5.4 for details.

^d Baseline simulation with selection within 20 pc and J or $K < 15.5$. See Section 2.6.1 for details.

^e Simulation with an artificial decrease in the HBMM for the Baraffe et al. (2003) evolutionary models by fixing the temperatures of brown dwarfs down to masses of $0.060 M_{\odot}$ to their 1 Gyr values. See Section 2.5.4 for details.

Several simulations are consistent with the observed ages, which provides some constraints on the local UCD formation history. To explore these, I first compared the results for a fixed power-law mass function with $\alpha = 0.5$ and MBDM = $0.01 M_{\odot}$. Figure 2.24 shows the χ^2 distribution for different SFRs and evolved ages for each of the Baraffe et al. (2003), Burrows et al. (2001), and Saumon & Marley (2008) models. The diagonal elements of the simulations show the best agreements with the observed ages, which are cosmic/6 Gyr, exponential/9 Gyr, and uniform/12 Gyr, with the second of these being consistently best between the models. These parameters generally produce similar ages for late-M, L, T populations, with L dwarfs being slightly younger and T dwarfs being slightly older. The agreement between these parameter sets indicates a clear degeneracy between the SFR and population age that cannot be resolved by this coarse kinematic age

comparison, although I am able to strongly rule out some combinations. For example, the cosmic/12 Gyr SFR/age combination can be ruled out to high probability using a BIC test ($\Delta\text{BIC} > 10$, highly significant).

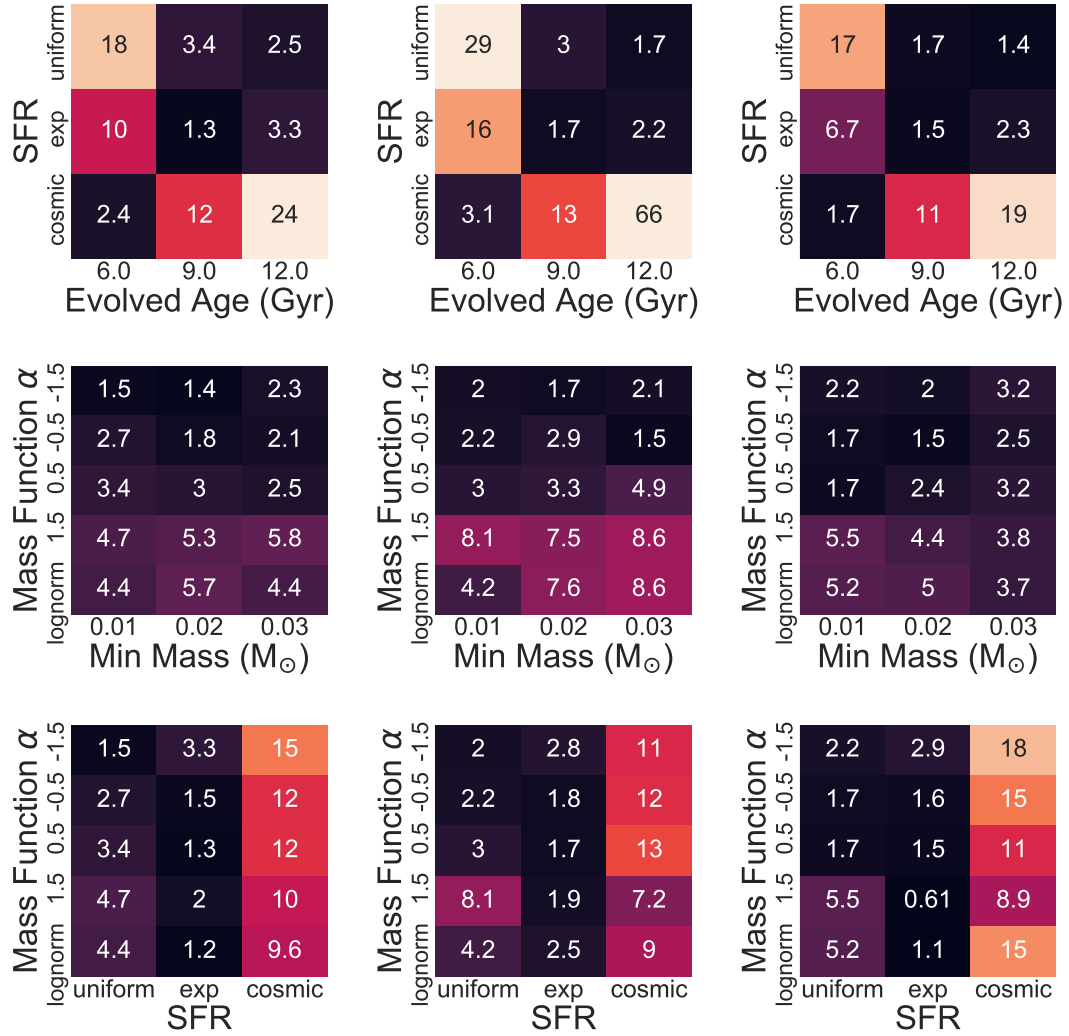


Figure 2.24: χ^2 distributions of simulated populations as a function of (1) *top row*: star formation rate (SFR) and evolved age; (2) *middle row*: minimum brown dwarf mass and mass function; (3) *bottom row*: star formation rate (SFR) and mass function across brown dwarf evolution models: *left column*: Baraffe et al. (2003); *middle column*: Burrows et al. (2001); *right column*: Saumon & Marley (2008). Lower χ^2 values have darker color.

Holding the SFR and sample age fixed to my baseline parameters, I compared the mass function power-law index to the MBDM (Figure 2.24 middle panels). The mass

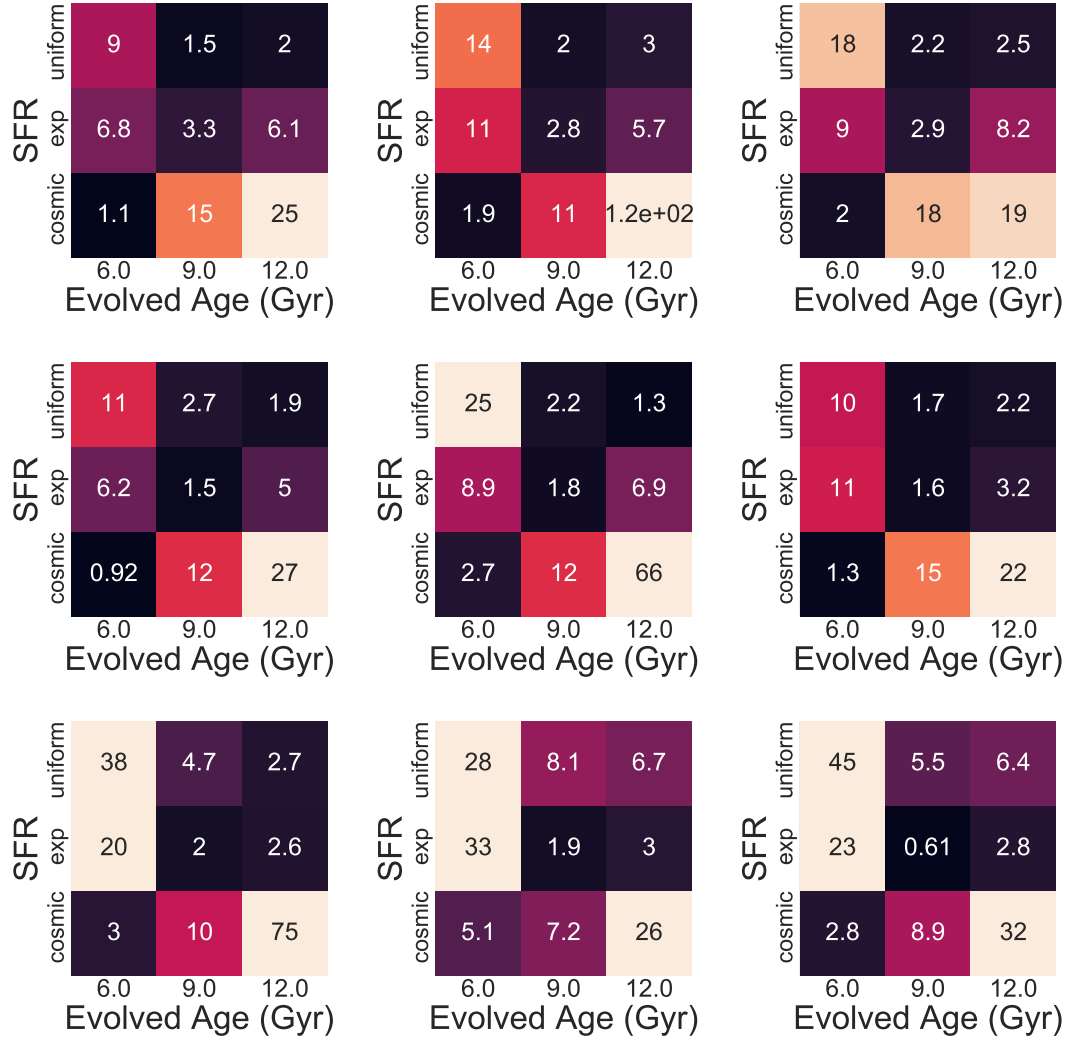


Figure 2.25: Same as Figure 2.24 top panel for $\alpha = -1.5$ (top), -0.5 (middle) and 1.5 (bottom).

functions with $\alpha = 0.5$, -0.5 , and -1.5 are statistically equivalent, while the bottom-heavy $\alpha = 1.5$ and log-normal mass functions are not favored ($\Delta\text{BIC} > 2$, positive; also see Figure 2.25). The results are insensitive to MBDM or evolutionary models. I also compared the SFR and mass function for a fixed age of 9 Gyr and MBDM = $0.01 M_{\odot}$ (Figure 2.24 bottom panels). Models using the cosmic star formation rate are significantly worse than other models. Again, the mass functions $\alpha = 0.5$, -0.5 , and -1.5 are statistically equivalent, while $\alpha = 1.5$ and log-normal mass functions using the uniform star formation rate are not favored ($\Delta\text{BIC} > 2$, positive).

Burgasser et al. (2015a) considered whether the observed older L dwarfs in their sample could be the outcome of a mass function that evolves from bottom-heavy to top-heavy over time (i.e., α decreasing over time). Figure 2.26 shows that the original hypothesis $\alpha = 1.5 \rightarrow -0.5$ at 4.5 Gyr is not consistent with the observed ages of late-MLT dwarfs ($\chi^2 = 5.6$; $\Delta\text{BIC} = 3.5$), overestimating in particular the ages of T dwarfs (5.4 ± 1.4 Gyr). However, scenarios with the same transition in at different transition ages (3 Gyr and 6 Gyr) are consistent ($\Delta\text{BIC} \leq 2$). Similarly, a narrower range of mass function of evolution, either $\alpha = 0 \rightarrow 1$ or $\alpha = 1 \rightarrow 0$ with uniform and exponential birth rates cannot be ruled out ($\Delta\text{BIC} \leq 2$; Figure 2.27).

Comparing the outcomes of different evolutionary models, I found the predictions of the Burrows et al. (2001), Saumon & Marley (2008), and Baraffe et al. (2003) models yield roughly identical results. Late-M dwarf ages using the Marley et al. (2018) and Phillips et al. (2020) cloudless atmosphere models were too young compared to L and T dwarfs, likely due to temperature limits in the model parameter space. I also found that increasing the maximum age or minimum brown dwarf mass in the simulations increased the mean ages of ultracool dwarfs, but retained the relative ages for late-M, L, and T dwarfs.

Errors in evolutionary models could contribute to the marginal age discrepancy

between simulations and observations for the L dwarfs. The ratio of L-type stars and brown dwarfs and the thermal evolution of the most massive brown dwarfs depends on the efficiency of hydrogen fusion reactions close to the critical temperature. An offset in the HBMM, particularly toward lower masses so that more L dwarfs are stars, could potentially increase the ages of L dwarfs in the simulations. To explore this effect, I imposed an artificial decrease in the HBMM for the Baraffe et al. (2003) evolutionary models by fixing the temperatures of brown dwarfs with masses $M \geq 0.06 M_{\odot}$ to their 1 Gyr values. The resulting ages for late-M, L, and T dwarfs in these simulations are 4.1 ± 0.8 Gyr, 4.1 ± 0.8 Gyr, 4.4 ± 1.2 Gyr, respectively, fully consistent with my observed ages (Figure 2.28). The fact that this adjustment provides the best match between the simulations and observed sources is suggestive of potential evolutionary model issues, which have also been raised with mass and luminosity measurements of brown dwarf companions to age-dated stars (Dupuy & Liu 2017) and the surprisingly high masses T-type brown dwarfs in binaries (e.g. Dupuy et al. 2019; Brandt et al. 2020; Sahlmann et al. 2020, 2021). These studies suggest that evolutionary model predictions of the temperatures and luminosities of objects around the HBMM may not align with the observed properties of these systems. However, with only a marginal age discrepancy, potential selection biases in my L dwarf kinematic sample (see below), and the degeneracies present among other simulation parameters, further work is needed to confirm this result. I note that increasing the timescale of cooling could also produce older L-type brown dwarfs, but also drives up the ages of T dwarfs and is therefore an unlikely scenario.

In summary, several variations in simulation parameters were able to reproduce the observed kinematic ages of the local late-M, L, and T dwarf populations self-consistently, and highlight some degeneracies in this approach. Nevertheless, I am able to rule out several parameter sets, and identify a potential indicator of a lower

HBMM.

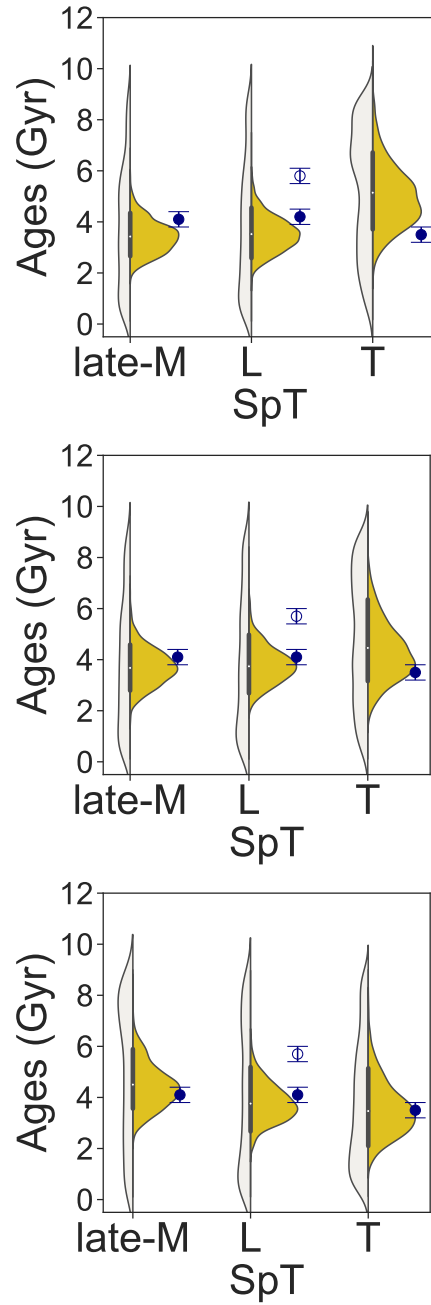


Figure 2.26: Same as Figure 2.21 comparing three simulations with baseline parameters and mass functions that evolve over time: (Top) $\alpha = 1.5 \rightarrow -0.5$ (bottom-heavy to top-heavy; same model as Burgasser et al. 2015a); (Middle) $\alpha = 1 \rightarrow 0$ (bottom-heavy to top-heavy); and (Bottom) $\alpha = 0 \rightarrow 1$ (top-heavy to bottom-heavy).

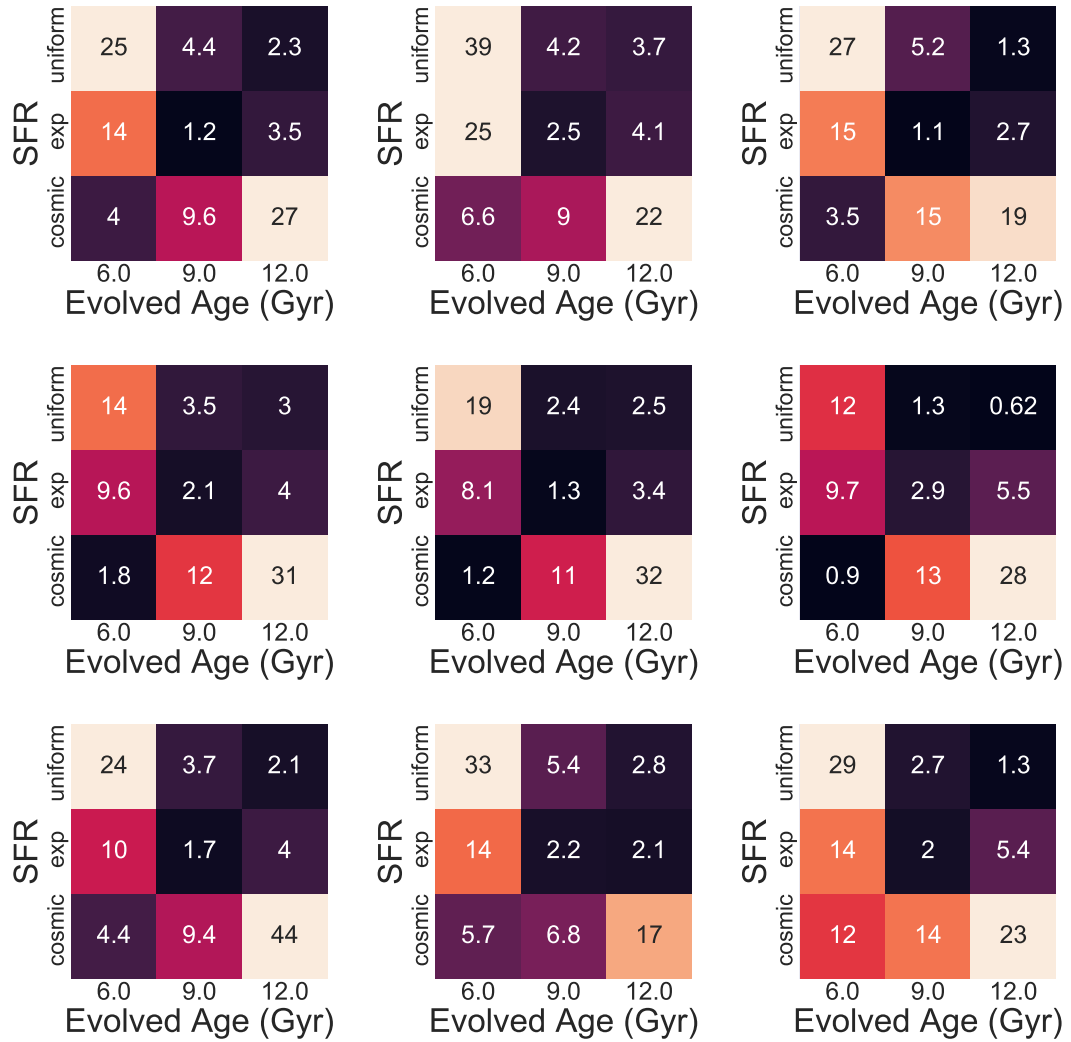


Figure 2.27: Same as Figure 2.24 top panel for the Chabrier et al. (2000) log-normal mass function (top), and for evolving mass functions $\alpha = 0 \rightarrow 1$ at 3 Gyr (middle) and $\alpha = 1 \rightarrow 0$ at 3 Gyr (bottom).

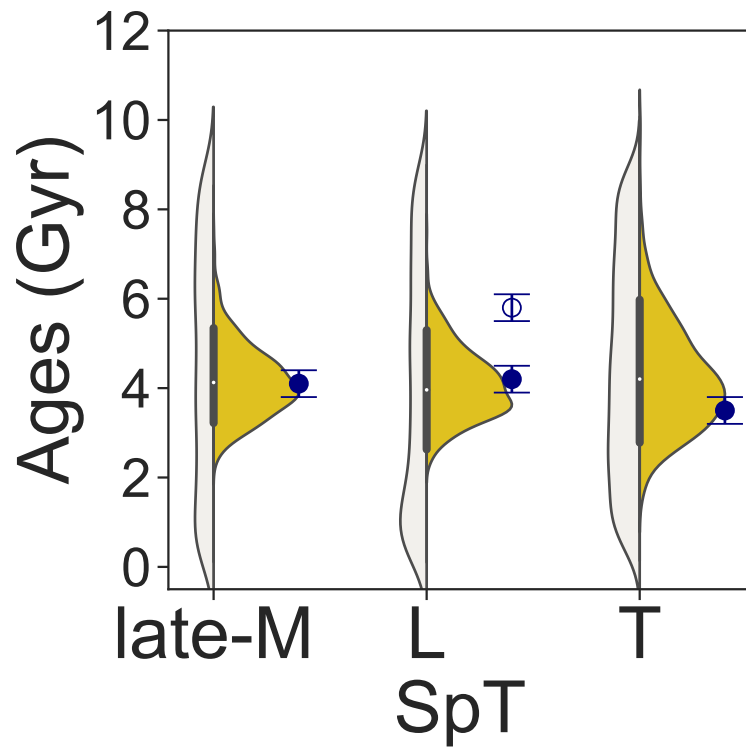


Figure 2.28: Same as Figure 2.21, comparing observed kinematic ages to a simulation assuming baseline parameters and a hydrogen burning minimum mass with an artificial decrease for the Baraffe et al. (2003) evolutionary models by fixing the temperatures of brown dwarfs with masses $M \geq 0.06 M_{\odot}$ to their 1 Gyr values.

2.6 Discussion

While my simulations are able to reproduce the kinematic ages of UCDs in the local thin disk population, the origin of the relatively high fraction of local thick disk L dwarfs remains unclear. As L dwarfs span the HBMM, in the local Galactic environment they consist of a mixed population of stars and (young) brown dwarfs. Accurate characterization of this population is therefore critical for validating brown dwarf evolutionary models and measuring brown dwarf formation history in the Galaxy. Here I explore some possible explanation as to why the local L dwarf sample studied in this paper are less well-modeled as compared to local late-M and T dwarfs.

2.6.1 Sample incompleteness

The kinematic sample examined in this study, while larger than previous studies and limited to $d < 20$ pc, is not uniformly volume complete. One primary reason for this is that fainter late-L and T dwarfs are detected at smaller distances for a given sensitivity limit. For Keck/NIRSPEC, an effective magnitude limit of 15 restricts observations of L5 dwarfs to 22 pc (K -band) and T5 dwarfs to 14 pc (J -band). RV measurements from the literature are also not volume- or magnitude-complete, as measurements were obtained with different optical and near-infrared spectrographs with varying sensitivity thresholds.

The underlying target sample is itself not volume-complete, either, particularly in the Galactic plane where nearby ultracool dwarfs sample smaller scale heights, and are hence younger, but where source contamination and crowding is high. Bardalez Gagliuffi et al. (2019b) determined that the sample of late-M and early- to mid-L dwarfs is $62^{+8}_{-7}\%$ and $83^{+10}_{-9}\%$ complete within 20 pc, and new nearby sources are still being uncovered in wide-field surveys such as PanSTARRS (Best et al. 2020), *Gaia* (Faherty et al. 2018; Reyl e 2018; Scholz 2020), and *WISE* (Meisner et al. 2020; Kirkpatrick

et al. 2021). Figure 2.19 compares my simulated population to the 20 pc samples of Bardalez Gagliuffi et al. (2019b, hereafter BG19), Best et al. (2020, hereafter B20), and Kirkpatrick et al. (2021, hereafter K21). While these UCD samples are the most volume-complete constructed to date, there remain gaps particularly among the late-M, late-L, and T dwarfs. My kinematic sample contains 48%–52% of the 20 pc UCDs in the BG19 and B20 samples, and based on these studies’ completeness estimates, only 32%–42% of M7–T8 dwarfs within 20 pc. Compared to K21, my sample contains only 27% of L0–T8 dwarfs within 20 pc.

One way this incompleteness can produce an age discrepancy is if the fraction of early-type and late-type L dwarfs in my sample is imbalanced. Early-type L dwarfs are predominantly low-mass stars of all ages and very young brown dwarfs, while late-type L dwarfs are predominantly young brown dwarfs, according to my simulations and the data. Figure 2.29 illustrates this trend in my kinematic sample, which shows a clear decline in velocity dispersion and inferred age as a function of L dwarf spectral subclass, with the exception of the L4–L6 subtypes (discussed in further detail below). More coarsely, while the overall kinematic age of thin disk L dwarfs is 4.2 ± 0.3 Gyr, the kinematic age of 14 L6–L9 dwarfs is only 2.2 ± 0.8 Gyr. I computed the ratio of L0–L5 to L5–L9 dwarfs in my baseline simulation sample, my kinematic sample, the samples of B20 and K21, and the combined sample of BG19 and B20. These ratios were found to be 1.3 (simulated), 4.1 (kinematic sample, L0–L5:L5–L9 = 57:14), 1.0 (B20, L0–L5:L5–L9 = 21:22), 1.3 (K21, L0–L5:L5–L9 = 96:75), and 3.3 (B19+B20, L0–L5:L5–L9 = 105:32), respectively. My kinematic sample is clearly biased toward early L dwarfs compared to the simulated, B20, and K21 samples, but not compared to the combined B19 and B20 sample. However, if I try to reproduce the kinematic sample asymmetry through forced random draws from my baseline simulation, I find an average age for thin disk L dwarfs (3.0 ± 0.6 Gyr) that is still younger than observed. Similarly, sampling with replacement

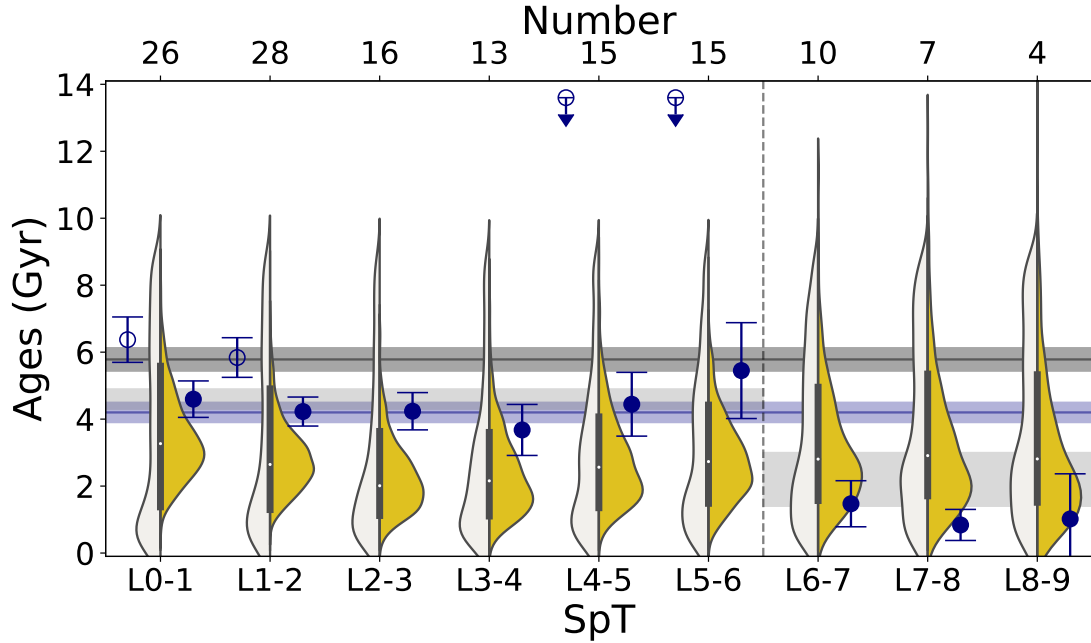


Figure 2.29: Age distributions of L dwarfs from the baseline simulation binned in groupings of two subtypes compared to measured kinematic ages with similar binning. Simulated age distributions are shown as individual source ages (white violin plots) and derived kinematic ages (yellow violin plots). Observed kinematic ages are shown with (open blue points) and without (solid blue points) L dwarfs for $P[\text{TD}]/P[\text{D}] > 1$. My derived kinematic ages and uncertainties (5.8 ± 0.3 Gyr, 4.2 ± 0.3 Gyr) for my nominal L dwarf sample ($P[\text{TD}]/P[\text{D}] < 10$) are indicated by the black line, and for my constrained thin disk sample ($P[\text{TD}]/P[\text{D}] < 1$) by the blue line. I also show the average kinematic ages for early- and late-L dwarfs separately as grey bands. The number of sources in each subtype bin is labeled at top. The ages of the discrepant L4–L5 and L5–L6 subtype bins are due to four unusually blue L dwarfs within these groups. Note that the very old tails of inferred ages for L6–L9 are due to small sampling effect.

the thin disk L dwarfs from my kinematic sample to force a ratio of early-to-late L dwarfs of 1.3 (simulations) or 1.0 (B20) results a nearly identical age (4.1 ± 0.8 Gyr) as the original sample.

My sample is also biased toward early T dwarfs due to the intrinsic faintness of later subtypes, with an early-to-late T dwarf ratio ($T_0\text{--}T_4/T_5\text{--}T_8$) of 1.0, much higher than the most recent T dwarf sample from K21 (0.14) and my baseline population simulation (0.22). Again, if I randomly draw from the simulation to match the spectral type ratio of the observed kinematic sample, I find an older but statistically equivalent age of 4.3 ± 1.2 Gyr. Drawing from the kinematic sample to match the simulation T dwarf spectral type ratio yields a nearby identical age of 3.5 ± 0.2 Gyr.

Another selection bias is the magnitude limit of the observed kinematic sample, which can similarly skew the number of early-type and later-type L dwarfs. I modeled this in my baseline simulation by assigning distances up to 20 pc over a uniform-density volume, assigning apparent magnitudes using the Dupuy & Liu (2012) absolute magnitude-spectral type relations, and constraining the simulated sample to be brighter than J or $K < 15$. The resulting magnitude-limited simulated late-M, L, and T dwarf kinematic ages are 4.0 ± 0.8 Gyr, 3.0 ± 0.6 Gyr, and 3.8 ± 1.1 Gyr, respectively, fully consistent with my baseline simulation. Hence, a magnitude limit does not explain the older age for L dwarfs in the kinematic sample. A magnitude-limited sample can preferentially select younger sources, which haven't fully contracted to their fully degenerate radii. This would affect all sources in my sample, but particularly those subgroups whose limiting magnitudes place them within the volume limit. This bias may explain the slightly younger kinematic age of T dwarfs compared to the simulations, but does not explain the presence of older L dwarfs in the kinematic sample.

2.6.2 Contamination by Distinct Sub-populations

My kinematic L dwarf sample contains eight L-type binaries, fourteen young L dwarfs and four unusually blue L dwarfs, the latter based on the color outlier criteria of Faherty et al. (2009)²⁵. Like the thick disk population, these distinct sub-populations have the potential of skewing the kinematic dispersions and ages of the overall sample, so I re-evaluated the velocity dispersions and kinematic ages of the L dwarfs after removing each of these subgroups (Table 2.9). Removal of young L dwarfs and binaries increases the age of the total population to 8.8 ± 0.6 Gyr and 7.4 ± 0.5 Gyr. The former is expected as removal of young sources makes the population older while the latter is consistent with no change (when thick disk stars are left in). Removal of blue L dwarfs reduces the kinematic age to 5.3 ± 0.3 Gyr, consistent with removal of thick disk stars. This result confirms the interpretation that unusually blue features are associated with higher surface gravities and/or lower metallicities, both of which correlate with older ages. I also examined whether removing L dwarfs with ages younger than 500 Myr in my baseline simulation would elevate the ages of the remaining sources; only a marginal shift to 3.4 ± 0.7 Gyr was found. Finally, I considered the age without the binaries (8 sources) for my thin disk L dwarf sample, which results in a slightly older but statistically consistent age of 4.4 ± 0.3 Gyr.

2.6.3 Evidence of a Kinematic Indicator of the Main Sequence Terminus

Kinematic variations as a function of spectral type, rather than across whole sub-classes, provides a finer examination of UCD ages. Prior simulation work has predicted

²⁵The blue L dwarfs in my sample are 2MASS J05395200–0059019 (Geballe et al. 2002), DENIS J112639.9–500355 (Phan-Bao et al. 2008), 2MASS J1721039+334415 (Bardalez Gagliuffi et al. 2014), and 2MASS J05395200–0059019 (Fan et al. 2000).

subtype age structure particularly among the L dwarfs due to brown dwarf evolutionary effects and the changing mixture of stars and brown dwarfs with spectral type (cf. Burgasser 2004). At late-M and early L subtypes, only the youngest and most massive brown dwarfs will have temperatures consistent with these types, restricting their representation among the overall sample and resulting in a relatively low brown dwarf-to-star ratio. As I proceed to later types, the mass range of stars with the appropriate temperatures declines, while both the age and mass range of allowed brown dwarfs expands, increasing the brown dwarf-to-star ratio. Since these brown dwarfs are preferentially young, this changing ratio drives down the average age of the population. At late enough spectral types, temperatures become sufficiently low that stars are not present, resulting in a “pure” brown dwarf sample that is relatively young but increases in mean age through the T and Y dwarf sequences.

As a preliminary assessment of these effects, I examined a more refined breakdown of L dwarfs by subtype. Figure 2.29 displays the observed kinematic ages and simulation predictions of thin disk L dwarfs broken down in bins of two subtypes. Both observations and simulations confirm an overall downward trend of age with later spectral type, declining from 5.8 ± 0.6 Gyr at L1–L2 to 0.9 ± 0.7 Gyr for L8–L9. However, in the L4–L5 and L5–L6 subtypes this downward trend briefly reverses, with the latter having an average age of 5.4 ± 1.4 Gyr. I note that this increase is present even with the removal of both thick-disk and unusually blue L dwarfs, which are clustered among these mid-L subtypes. The simulations show a concurrent reversal in average kinematic age, skewed by an older population of stars near the HBMM. By spectral type L6–L7, the observed kinematic ages drop back to the downward trend line, while the simulations show a more modest decrease in mean age and a broadened distribution of ages overall.

I interpret this newly-discerned “kinematic break” around spectral types L5–L6 to be an observable of the terminus of the stellar Main Sequence. The effective temperature

range of L5–L6 dwarfs, $1500 \text{ K} \lesssim T_{\text{eff}} \lesssim 1600 \text{ K}$ (Filippazzo et al. 2015), corresponds to evolutionary model predictions for the HBMM at ages of 4–5 Gyr (Baraffe et al. 2003), in rough agreement with the average age of the local UCD population. Dupuy & Liu (2017) identify a similar HBMM boundary at slightly earlier spectral types of L3–L5 based on the distribution of 38 dynamical mass measurements from binaries; while Dieterich et al. (2014) anchor the HBMM at $\sim 2075 \text{ K}$, corresponding to L1–L2 subtypes, based on an inferred radius minimum. The differences among these empirical indicators of the HBMM may reflect both sample variations and sensitivity to specific brown dwarf indicators. For example, the L1–L2 range may represent a threshold in the brown dwarf-to-star ratio in the field population, while the L5–L6 range represents the disappearance of stars entirely. I emphasize that all of these subtype samples are small and need to be expanded to confirm and quantify these empirical indicators of the transition between stars and brown dwarfs in the Galactic field population.

2.6.4 Refining Constraints on UCD Population Parameters

The segregation of kinematic ages by subtype also provides an opportunity to more finely constrain population parameters, albeit with lower statistical accuracy. In particular, the age distribution of the underlying population plays a specific role in setting the relative balance of stars and brown dwarfs, and the terminus of the Main Sequence, within the L dwarf class. To explore these effects, I compared a subset of my simulations to two subtype breakdowns of my kinematic sample. Following Section 2.5.4, I evaluated variations in SFR and population age with the MF, minimum mass, and evolutionary model fixed to my baseline assumptions. Here I compare these to my thin disk L dwarf sample in groups of two subtypes, and my overall sample in groups of three subtypes to account for the small sample for T dwarfs. Figures 2.30 and 2.31 shows the χ^2 distributions and best-fit distributions of simulated kinematic ages for these comparisons.

For the L dwarf sample, I find the cosmic/9 Gyr SFR/age combination provides the best overall fit, exceeding my baseline model ($\Delta\text{BIC} > 10$, highly significant) but consistent with the exponential/9 Gyr ($\Delta\text{BIC} = 2.3$, positive) and exponential/12 Gyr ($\Delta\text{BIC} = 1.0$, not significant). I can now rule out the cosmic/6 Gyr SFR/age combination by a BIC test ($\Delta\text{BIC} > 10$, highly significant). For the UCD sample, the exponential/9 Gyr SFR/age combination provides the best overall fit, exceeding my baseline model ($\Delta\text{BIC} = 3.2$, positive) but consistent with the uniform/12 Gyr model ($\Delta\text{BIC} = 1.4$, not significant). Therefore, exponential/9 Gyr combination gives consistently the best fit for both forms of sample binning.

The refinement of the population parameters from this analysis is clearly limited, a consequence of the small sample statistics and the necessity to average over spectral types. Nevertheless, these outcomes show that a larger and more complete kinematic sample broken down by subtype could break some of the simulation parameter degeneracies and lead to a well-constrained assessment of the local UCD population properties, particularly in conjunction with other observable distributions such as the luminosity function and independent age or mass diagnostics.

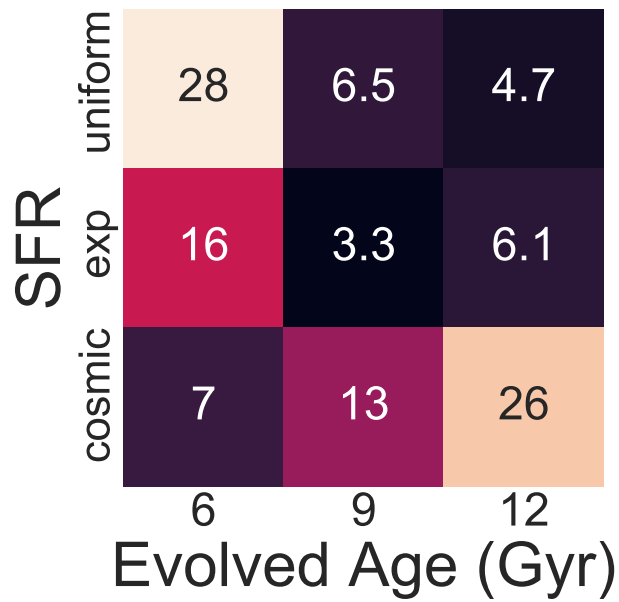
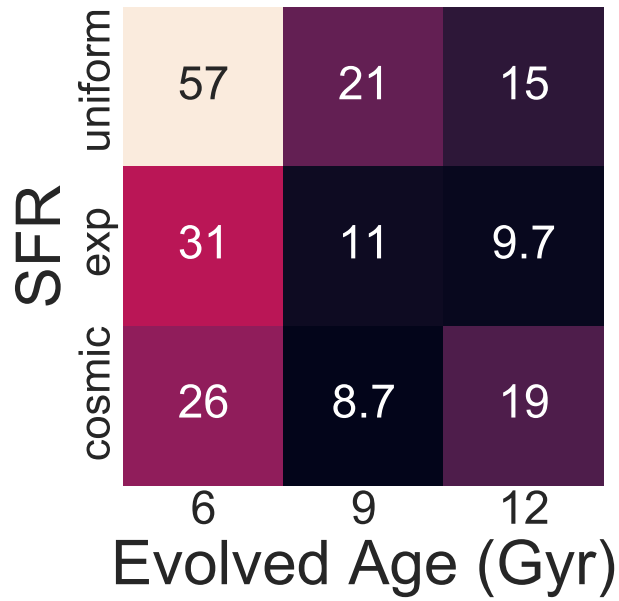


Figure 2.30: χ^2 distributions of simulated populations as a function of star formation rate (SFR) and evolved age for the L dwarf subtype (top) and UCD subtype samples (bottom). All simulations assume a power-law mass function with $\alpha = 0.5$, Baraffe et al. (2003) evolutionary models, and minimum mass of $0.01 M_{\odot}$.

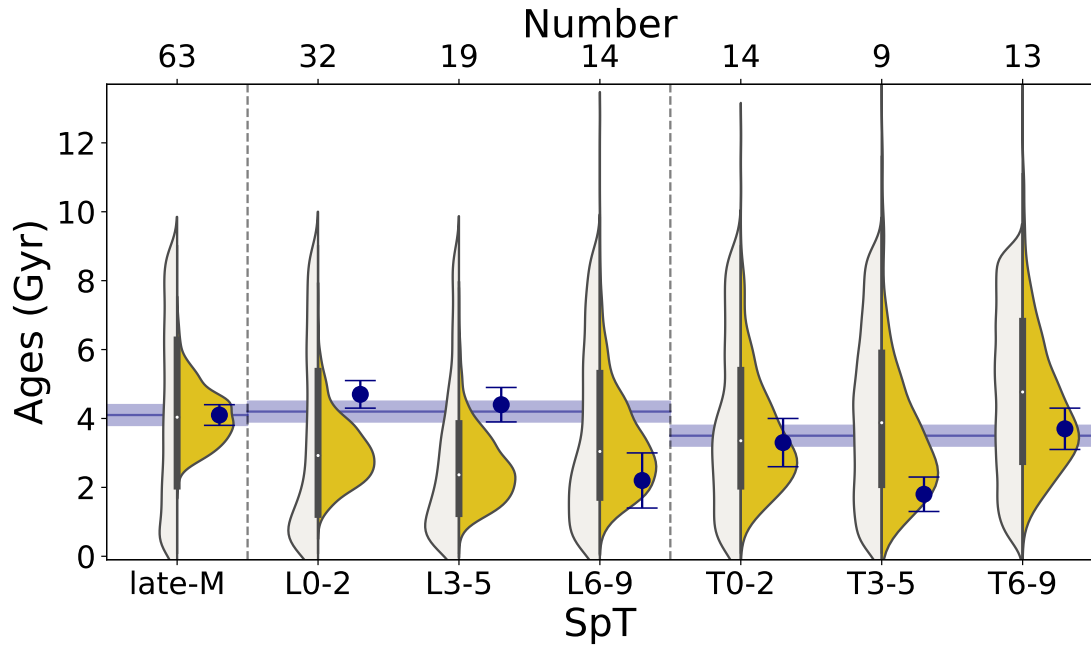


Figure 2.31: Observed kinematic ages of thin-disk UCDs in my kinematic sample grouped into bins of three subtypes (solid blue points) compared to similarly-binned best-fit simulation predictions using a power-law mass function with $\alpha = 0.5$, Baraffe et al. (2003) evolutionary models, minimum mass of $0.01 M_{\odot}$, the Aumer & Binney (2009) exponential SFR, and a population age of 9 Gyr (white/yellow violin plots for simulated ages/inferred population kinematic ages). The derived kinematic ages and uncertainties for the late-M, L, and T dwarf subgroups are indicated by blue bands. The number of sources in each subtype bin is labeled at top.

Chapter 2, in full, is a reprint of the material as it appears in the *Astrophysical Journal Supplement Series* 2021, Volume 257, Number 45. Hsu, Chih-Chun; Burgasser, Adam J.; Theissen, Christopher A.; Gelino, Christopher R.; Birky, Jessica L.; Diamant, Sharon J. M.; Bardalez Gagliuffi, Daniella C.; Aganze, Christian; Blake, Cullen H., Faherty, Jacqueline K. The thesis author was the primary investigator and author of this paper.

Chapter 3

SDSS/APOGEE

3.1 APOGEE Sample

My ML dwarf sample is curated from SDSS/APOGEE DR17 (Abdurro’uf et al. 2022) based on observations obtained with the 2.5m Sloan Foundation Telescope at the Apache Point Observatory (Gunn et al. 2006) and 2.5m-meter du Pont Telescope at the Las Campanas Observatory (Bowen & Vaughan 1973). My targets were proposed from SDSS-III Project 176 (PI: Suvrath Mahadevan and Cullen Blake) titled “A Radial Velocity Survey of Bright M Dwarfs with APOGEE: Companions, vsini, Fe/H” and SDSS-IV Project 0288 (PI: Adam Burgasser) titled “APOGEE-2 and eBOSS Observations of the Lowest-Mass Stars and Brown Dwarfs in the Solar Neighborhood” as the M dwarf Ancillary Program. I start with `allStar-dr17-synspec.fits` to curate my sample (while I fit individual `apVisit` spectra; see Section 3.2). I constructed two UCD samples for my analysis: a comprehensive sample selected using color and magnitude criteria, and a “gold” sample based on sources with literature classifications of M6 and later. The full sample was constructed by matching APOGEE sources to 2MASS (Skrutskie et al. 2006) and *Gaia* EDR3 (Gaia Collaboration et al. 2021) photometry and astrometry. Using the

Gaia $G - G_{\text{RP}}$ relation Kiman et al. (2019) and the *Gaia* color-magnitude distribution with the known UCDs in my gold sample, I conservatively selected sources with

- *Gaia* parallaxes $\pi > 2.5$ mas (distances < 400 pc),
- *Gaia* $M_G > 10$,
- *Gaia* $2.2 > G - G_{\text{RP}} > 1.25$, and
- Galactic latitude $|b| > 15^\circ$.

The *Gaia* absolute magnitude and color criteria correspond to spectral types \gtrsim M4–M5, while the last criterion is aimed at reducing contamination from reddened background sources. Additionally, I also used 2MASS photometric information and an empirically determined 2MASS J , K and *Gaia* G , G_{RP} color and magnitudes criterion to remove reddened sources:

- $4 > M_J > 20$,
- $J - K > 0$,
-

$$1.25 \times G - G_{\text{RP}} + \frac{23}{16} - (G - J) > 0$$

The reddening cut also removed potentially young sources, but the known young sources with spectral classifications are included in my gold sample.

This sample of 8,055 spectra of 1,563 sources with further reduced by selecting only those APOGEE spectra with median signal-to-noise ratios (SNRs) > 10 , resulting in 7,915 spectra of 1,468 sources. My full sample is summarized in Table B.2.

I also created a high-fidelity “gold sample” of APOGEE sources selected on the basis of previous published spectral types of M6 or later, as reported in SIMBAD

(Wenger et al. 2000), the Late-Type Extension to MoVeRS (LaTE-MoVeRS; Theissen et al. 2016, 2017), Reyl  (2018), and Best et al. (2021). For my gold sample, I visually inspected each of these sources’ SIMBAD and 2MASS coordinates to confirm their UCD status, in particular examining their location on color-magnitude and color-color diagrams combining 2MASS and *Gaia* data (Figure 3.3). Published spectral types are a mixture of photometric and spectroscopic measurements; as discussed below, follow-up spectroscopy of a subset of these sources revealed 28 to be classified earlier than M6 (see below). For the remainder of this study I use the most recent, preferably spectroscopic, classification as my adopted value. The gold sample includes sources in the full sample, plus additional sources that do not satisfy all of the criteria given above, including sources not present in *Gaia*. Indeed, there are 70 sources out of 182 in my gold sample not included in the full sample because of (1) lack of *Gaia* parallax (so no M_G and M_J), (2) sources near the Galactic plane (Galactic $|b| \leq 15^\circ$), (3) removal from the reddening cut (mostly for sources in the Upper Scorpius young cluster. With the SNR > 10 cut, the gold sample is composed of 671 spectra of 182 sources as summarized in Table 3.2.

Figures 3.1, 3.2, and 3.3 summarize the observable properties of my full and gold samples. The distribution of my targets across the sky is highly dependent on APOGEE’s survey pointings. Notably, one-third of the gold sample includes known members of nearby young moving groups, targeted as part of the programs listed below (Zasowski et al. 2013, 2017; Beaton et al. 2021; Santana et al. 2021)¹:

- ‘APOGEE Ancillary’: Ancillary target,
- ‘APOGEE MDWARF’: RVs of M Dwarfs (Blake, Mahadevan, Hearty, Deshpande, Nidever, Bender, Crepp, Carlberg, Terrien, Schneider),
- ‘APOGEE2 Ancillary’: Ancillary target,

¹<https://www.sdss.org/dr17/irspec/apogee-bitmasks/>

- ‘APOGEE2_APOKASC’: Ancillary APOKASC faint giants (Pinsonneault),
- ‘APOGEE2_CALIB_CLUSTER’: Selected as calibration cluster member,
- ‘APOGEE2_CIS’: Carnegie program target,
- ‘APOGEE2_CNTAC’: Chilean community target,
- ‘APOGEE2_GAIA_OVERLAP’: Overlap with Gaia,
- ‘APOGEE2_K2’: K2 Galactic Archeology Program Star,
- ‘APOGEE2_MANGA_LED’: Star on a shared MaNGA-led design,
- ‘APOGEE2_MDWARF’: Selected as part of the M dwarf study,
- ‘APOGEE2_NORMAL_SAMPLE’: Selected as part of the random sample,
- ‘APOGEE2_ONEBIN_GT_0_3’: Selected in single $(J - K_s)_o > 0.3$ color bin,
- ‘APOGEE2_SFD_DERED’: Selected with SFD_EBV dereddening,
- ‘APOGEE2_SHORT’: Selected as part of a short cohort,
- ‘APOGEE2_ULTRACOOOL’: Ancillary Ultracool Dwarfs Program (Burgasser)
- ‘APOGEE2_YOUNG_CLUSTER’: Selected as part of the young cluster study (IN-SYNC; Covey & Tan)

(see section 3.4.3). My full sample has 19% of the sources previously identified as members of nearby young clusters of moving groups, but it should be noted that only 5.3% of the full sample has spectral classifications in the literature. There are also a handful of gold sample sources located close to the Galactic plane. The majority of my full (92%) and gold sample (70%) sources have distances larger than 30 pc, with the M6.5Ve G 51–15 (2MASS J08294949+2646348) being the closest sources in the

sample at a distance of 3.5810 ± 0.0008 pc. In terms of brightness, the apparent H -band magnitudes of my targets extend to 14.57, which is slightly fainter than the APOGEE magnitude limit of 13.8 for S/N of 100. For the gold sample, spectral types range from M4 to L2, and generally decreases from M6 to later types, with a total of 155 late-M dwarfs and 6 L dwarfs. For the full sample, I used the *Gaia* $G - G_{\text{RP}}$ color to spectral type relation in Kiman et al. (2019) to derive their spectral types, which range from M4 to L5, with a total of 268 late-M dwarfs and 61 L dwarfs. Figure 3.3 shows the color-magnitude and color-color relations, as well as the apparent H magnitude distribution. There are two sources with $G - G_{\text{RP}} < 1.25$, which are M4 2MASS J15175638+0656388 and M7 2MASS J15512179+2931062. The full sample follows the trend for the gold sample in M_G vs. $G - G_{\text{RP}}$, M_G vs. $G - J$, M_G vs. $J - K$, and $G - J$ vs. $J - K$, but has more earlier type dwarfs due to my more conservative selection criteria described above. A similar trend is found in $G - J$ vs. $G - G_{\text{RP}}$ with more reddened sources present in the lower corner.

The majority (75%) of my sample have spectral observations taken over multiple epochs, enabling more precise determinations of radial velocities and the possibility of measuring radial velocity variations. I define multi-epoch subsamples in my full and gold samples as those sources with at least four observations satisfying $\text{SNR} > 10$ separated by a day or more. These subsamples include 527 sources in the full sample and 52 sources in the gold sample.

Note that the requirement for a *Gaia* detection likely resulted in the rejection of true UCDs in the APOGEE DR17 sample due to sensitivity limitations (Theissen 2018), while APOGEE targeting was not intended to be uniform across the sky (Zasowski et al. 2013). My APOGEE UCD sample is therefore not expected to be area- or volume-complete, but rather representative of the broader UCD population.

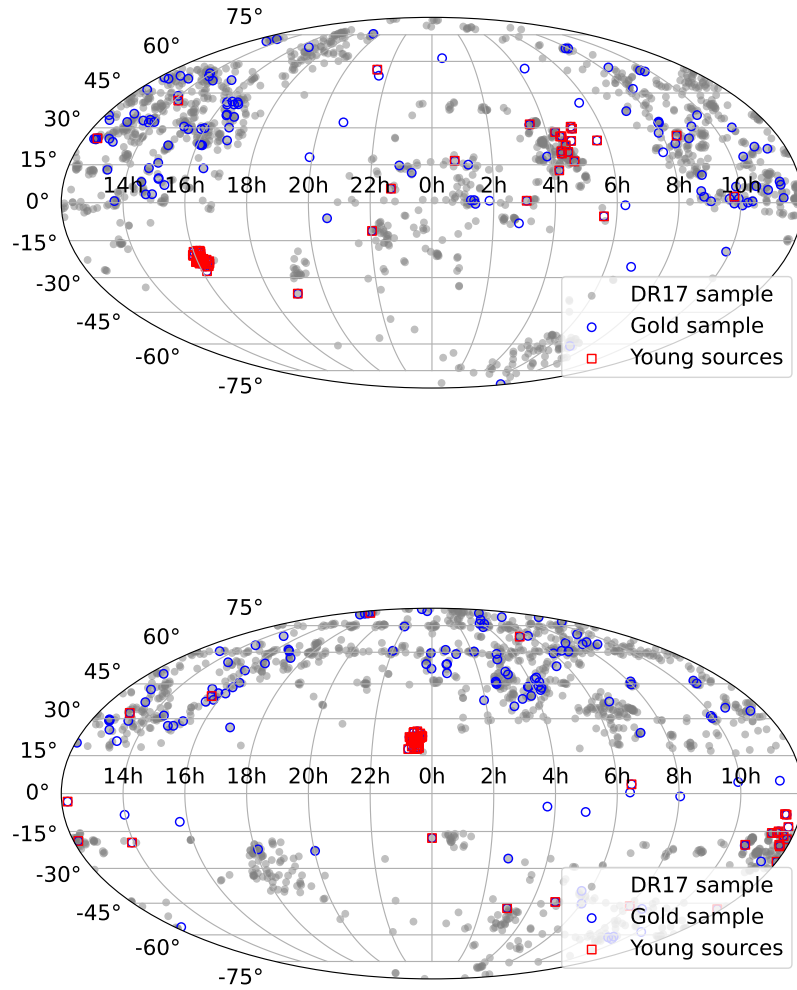


Figure 3.1: Sky distribution of my sample. My DR17 full ML dwarf and DR17 gold sample are labeled in grey and blue, respectively. Young sources in my gold sample are labeled in red squares. *Top:* Equatorial coordinate system projection. *Bottom:* Galactic coordinate system projection.

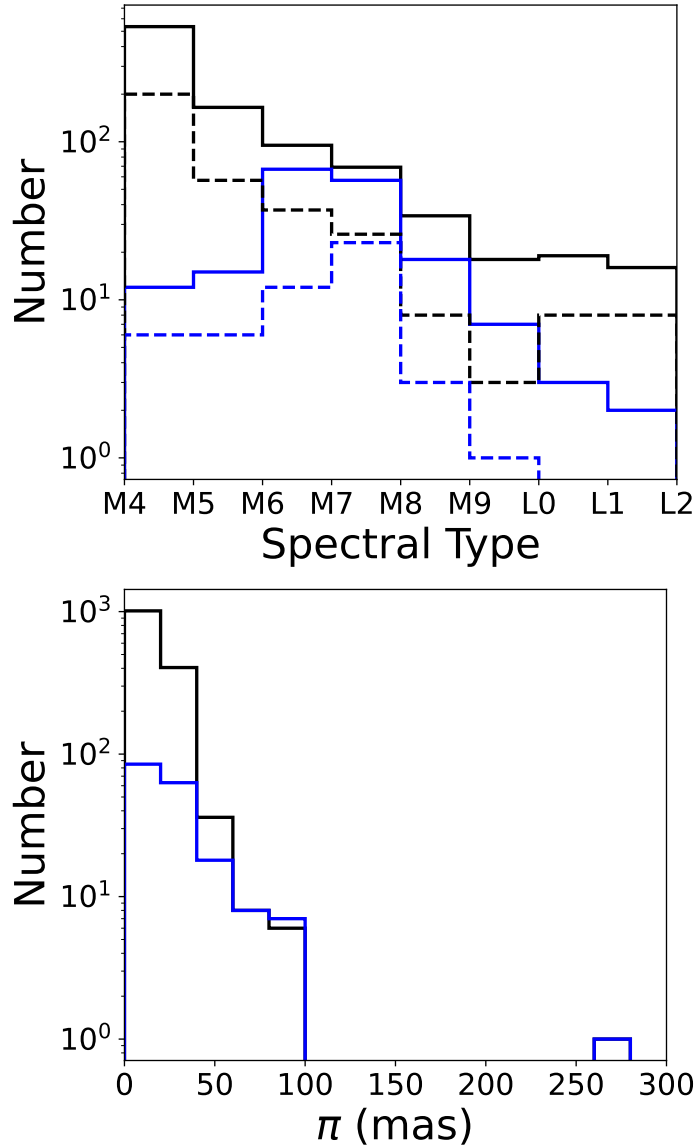


Figure 3.2: Observable properties of my UCD APOGEE sample. *Top:* Spectral type distribution for my full DR17 ML dwarf sample (black) and my DR17 gold sample (blue). The spectral types of my DR17 full sample are estimated from *Gaia* color and magnitude selection criteria (see Section 3.1 for details), while the gold sample literature type is drawn from the literature (see Table 3.2 for references). The dashed lines indicate the sources with the number of visits greater than or equal to 4. There are 527 sources in the DR17 full sample and 52 sources in the gold sample with at least four epochs of observations. *Bottom:* Parallax distribution for my DR17 late-M/L sample (black) and my DR17 gold sample (blue).

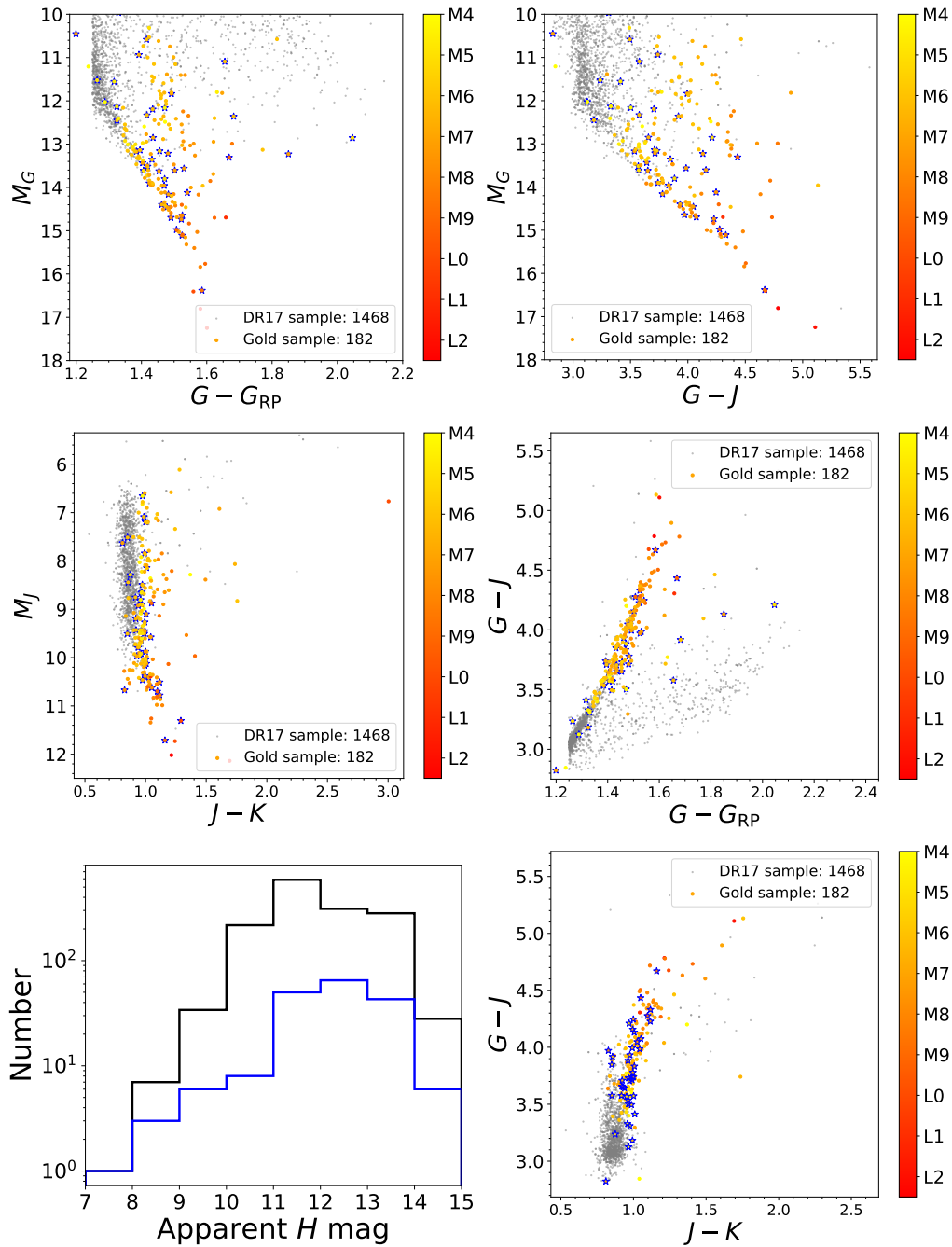


Figure 3.3: Color-magnitude properties of the UCD APOGEE sample. The full sample is indicated in grey dots, and the gold sample in color dots color-coded with spectral type. Blue stars indicate binary candidates. (top left): M_G versus $G - G_{RP}$ color-magnitude diagram. (top right): M_G versus $G - J$ color-magnitude diagram. (middle left): M_J versus $J - K$ color-magnitude diagram. (middle right): $G - J$ versus $G - G_{RP}$ color-color diagram. (bottom left): Apparent H magnitude distribution for my gold (blue) and full DR17 sample (black). (bottom right): $G - J$ versus $J - K$ color-color diagram.

3.1.1 Supporting Observations

A number of sources in my sample lack spectroscopic classifications², which hinder precise spectral characterization of the sample. I obtained additional low-resolution optical spectra with the Kast Double Spectrograph (Miller & Stone 1994) on the Shane 3-m Telescope at the Lick Observatory. I used the 600/7500 grating and 2'' slit to obtain 6000-9000 Å spectra at an average resolution of $\lambda/\Delta\lambda \approx 1800$. Data acquisition included observations of flat-field and arc lamps for pixel response and wavelength calibration, nightly observations of a spectral flux standard from Hamuy et al. (1992, 1994) for relative flux calibration, and observations of a nearby G2 V or A0 V star at similar airmass for telluric absorption and continuum correction. All data were reduced using the `kastredux` package³. An example spectrum of the M9 dwarf 2M21272531+5553150 (aka LSPM J2127+5553) is shown in Figure 3.4. Table 3.1 summarizes the observations and corresponding measurements, including classifications based on comparison to SDSS templates from Bochanski et al. (2007b); Schmidt et al. (2014), and Kesseli et al. (2017); measurements of the metallicity index ζ defined by Lépine et al. (2007), all indicating dwarf metallicity classifications; and relative luminosity in H α emission ($\log_{10} L_{H\alpha}/L_{bol}$) using the χ factor relations of Douglas et al. (2014) and Schmidt et al. (2014), all indicating these sources are magnetically active.

Table 3.1: Shane/Kast Observations of APOGEE Targets

| Source | Obs. Date (UT) | Airmass | Exp. Time (s) | S/N ^a | SpT | ζ^b | $\log_{10} L_{H\alpha}/L_{bol}^c$ |
|-------------------|-------------------|---------|------------------|------------------|------|-------------|-----------------------------------|
| J07552256+2755318 | 2021 Nov 27 | 1.02 | 3000 | 130 | M6.0 | 1.118±0.002 | -4.01±0.09 |
| J08080189+3157054 | 2021 Jan 17 | 1.11 | 3000 | 55 | M7.0 | 1.007±0.003 | -4.22±0.16 |
| J11210854+2126274 | 2021 May 15 | 1.05 | 2400 | 97 | M6.0 | 1.048±0.002 | -4.11±0.09 |
| J12215013+4632447 | 2018 Jan 21 | 1.02 | 2400 | 156 | M7.0 | 1.008±0.001 | -4.17±0.16 |
| J12493960+5255340 | 2021 May 16 | 1.06 | 3000 | 16 | M9.0 | 1.506±0.043 | -4.93±0.14 |
| J13342918+3303043 | 2020 Feb 05 | 1.02 | 3600 | 84 | M7.0 | 1.031±0.002 | -4.91±0.12 |
| J14554964+0321420 | 2021 May 15 | 1.21 | 2400 | 73 | M5.0 | 1.195±0.004 | -4.81±0.12 |
| J15042797+0942464 | 2021 May 15 | 1.42 | 3000 | 47 | M5.0 | 1.093±0.007 | -3.75±0.08 |
| J16572919+2448509 | 2022 Mar 11 | 1.06 | 3000 | 113 | M7.0 | 0.919±0.002 | -4.05±0.13 |

Table 3.1 (*continued*)

²High-resolution spectra are not ideal for spectral classifications (See Section 3.3.3).

³<https://github.com/aburgasser/kastredux>

Table 3.1 (*continued*)

| Source | Obs. Date (UT) | Airmass | Exp. Time (s) | S/N ^a | SpT | ζ^b | $\log_{10} L_{H\alpha}/L_{bol}^c$ |
|-------------------|-------------------|---------|------------------|------------------|------|-------------|-----------------------------------|
| J19544358+1801581 | 2020 Aug 14 | 1.07 | 3600 | 98 | M9.0 | 1.207±0.003 | -4.70±0.11 |
| J21272531+5553150 | 2020 Aug 14 | 1.06 | 3600 | 96 | M9.0 | 1.080±0.003 | -4.78±0.10 |
| J21381698+5257188 | 2020 Dec 14 | 1.22 | 3000 | 85 | M7.0 | 1.005±0.002 | -4.17±0.14 |

^a Median signal-to-noise ratio in the 7200–7400 Å region.

^b Metallicity index defined in Lépine et al. (2007), where $\zeta > 0.875$ indicates a dwarf metallicity classification.

^c Relative luminosity in H α emission based on the measured H α equivalent width and χ correction factors compiled by Douglas et al. (2014) and Schmidt et al. (2014).

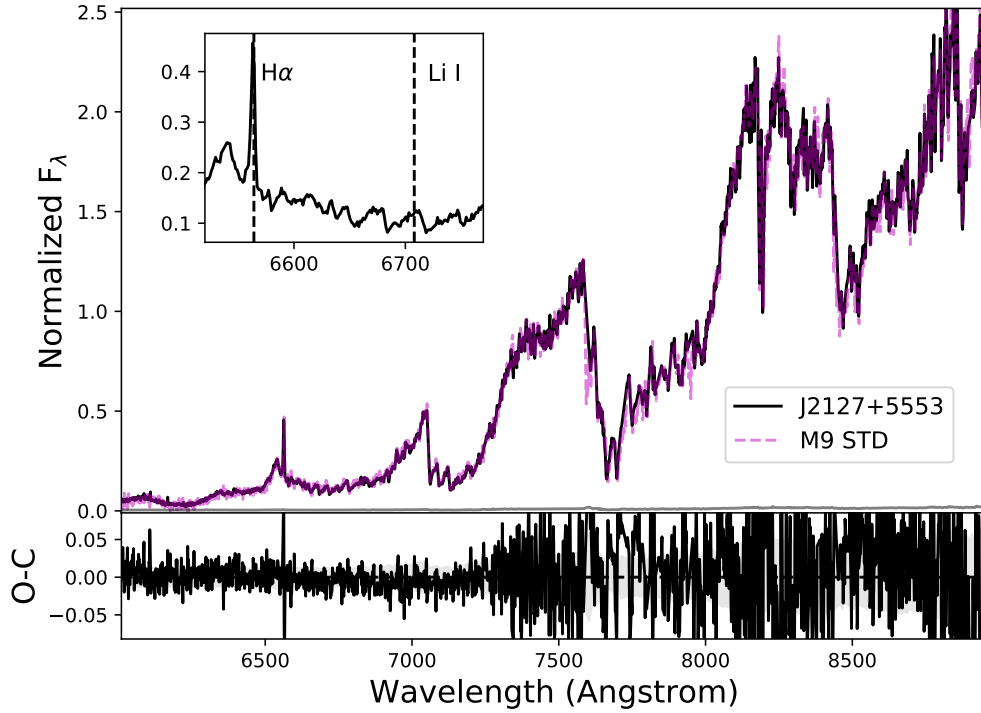


Figure 3.4: Normalized Shane/Kast spectrum of J21272531+5553150 (black line) compared to the best-match M9 spectral template from Bochanski et al. (2007b, magenta line). The lower panel compares the difference between these spectra to the measurement uncertainty (grey band). The inset box highlights the region around H α emission at 6563 Å and Li I absorption at 6708 Å.

Table 3.2: APOGEE DR17 Sample

| APOGEE ID | RA (deg) | Dec (deg) | Gaia eDR3 Source ID | SpT | SpT Ref | N_{obs} | 2MASS H (mag) | μ_{α} (mas yr $^{-1}$) | μ_{δ} (mas yr $^{-1}$) | μ Ref | π (mas) | π Ref |
|----------------------|------------|------------|----------------------|---------|----------|------------------|-----------------|----------------------------------|----------------------------------|-----------|---------------|-----------|
| 2N000312793+6139333 | 7.866401 | +61.659252 | 430215470915266560 | M7 | (59, 71) | 6 | 12.483 ± 0.028 | 369.52 ± 0.07 | 158.0 ± 0.07 | (72) | 27.86 ± 0.07 | (72) |
| 2N000452143+1634416 | 11.339104 | +16.579082 | 2781513733917711616 | L2beta | (31) | 3 | 12.059 ± 0.035 | 359.07 ± 0.2 | -47.91 ± 0.14 | (72) | 65.41 ± 0.18 | (72) |
| 2N001120002+1502170 | 18.000104 | +15.038074 | 2591201534008672256 | M5.5e | (4) | 3 | 11.351 ± 0.02 | 166.12 ± 0.15 | 317.0 ± 0.09 | (72) | 35.08 ± 0.1 | (72) |
| 2N001154176+0059317 | 18.924037 | +0.992157 | 2535273088355573120 | M6 | (76) | 2 | 12.651 ± 0.027 | 163.82 ± 0.15 | 24.1 ± 0.13 | (72) | 15.77 ± 0.13 | (72) |
| 2N001215816+01101007 | 20.492347 | +1.016877 | 2535133209860543616 | M6.5 | (76) | 2 | 12.429 ± 0.026 | 161.94 ± 0.16 | -78.8 ± 0.09 | (72) | 26.49 ± 0.12 | (72) |
| 2N001243124+0027556 | 21.130173 | -0.465459 | 25333946665015570304 | M7 | (35) | 2 | 11.506 ± 0.029 | 66.72 ± 0.32 | -170.47 ± 0.18 | (72) | 29.17 ± 0.25 | (72) |
| 2N001514363+0046188 | 27.931833 | +0.771889 | 2510880216734767232 | M7 | (65) | 3 | 12.431 ± 0.023 | 126.98 ± 0.12 | 30.41 ± 0.08 | (72) | 26.32 ± 0.1 | (72) |
| 2N002500239+0808417 | 42.509966 | -8.144931 | 5174318457801944448 | M5.5 | (13) | 2 | 11.186 ± 0.023 | 567.33 ± 0.07 | 101.0 ± 0.07 | (72) | 41.9 ± 0.06 | (72) |
| 2N003040207+0045512 | 46.008629 | +0.76423 | 3266760032372995072 | M6 | (36) | 16 | 11.216 ± 0.027 | 251.94 ± 0.06 | 34.3 ± 0.05 | (72) | 33.49 ± 0.05 | (72) |
| 2N003282839+3116273 | 52.118321 | +31.274265 | 121029704500767488 | M6.9 | (41) | 10 | 13.927 ± 0.049 | 6.34 ± 0.23 | -9.72 ± 0.17 | (72) | 3.27 ± 0.22 | (72) |
| 2N003293053+3127280 | 52.377236 | +31.457779 | 121412953022160256 | M6.9 | (41) | 10 | 13.014 ± 0.034 | 6.61 ± 0.18 | -10.18 ± 0.14 | (72) | 3.58 ± 0.15 | (72) |
| 2N003505737+1818069 | 57.739064 | +18.30192 | 50667699128858624 | M9 | (40) | 1 | 12.213 ± 0.022 | 179.42 ± 0.14 | -37.58 ± 0.1 | (72) | 27.12 ± 0.12 | (72) |
| 2N004110642+1247481 | 62.776762 | +12.796713 | 3304478125929665152 | M6 | (24) | 1 | 12.128 ± 0.028 | 132.35 ± 0.13 | -13.39 ± 0.1 | (72) | 23.07 ± 0.1 | (72) |
| 2N004185115+2814332 | 64.713151 | +28.242567 | 16449533291866624 | M7.5e | (60) | 1 | 13.241 ± 0.029 | 8.48 ± 0.25 | -24.69 ± 0.18 | (72) | 7.77 ± 0.22 | (72) |
| 2N004204796+5624202 | 65.199861 | +56.405624 | 2768706042751495568 | M8 | (68) | 7 | 12.313 ± 0.023 | 511.73 ± 0.12 | -220.26 ± 0.09 | (72) | 30.75 ± 0.11 | (72) |
| 2N004214435+2024105 | 65.434833 | +20.402943 | 49131681384221184 | M7 | (59) | 2 | 12.862 ± 0.027 | 104.08 ± 0.14 | -33.6 ± 0.1 | (72) | 20.28 ± 0.12 | (72) |
| 2N004214955+1929086 | 65.456494 | +19.485744 | 48190739948429184 | M7+M9.5 | (32) | 1 | 12.06 ± 0.022 | 125.41 ± 0.34 | -35.86 ± 0.24 | (72) | 23.62 ± 0.3 | (72) |
| 2N004262939+2624137 | 66.622465 | +26.40383 | 151283870746458496 | M6e | (10) | 3 | 12.501 ± 0.022 | 11.28 ± 0.19 | -17.67 ± 0.14 | (72) | 6.36 ± 0.16 | (72) |
| 2N004294568+2630468 | 67.440334 | +26.513002 | 151327159721125888 | M7.5e | (10) | 3 | 11.918 ± 0.024 | 7.4 ± 0.18 | -21.02 ± 0.12 | (72) | 8.02 ± 0.16 | (72) |
| 2N004330945+2246487 | 68.289405 | +22.780195 | 145947077527182848 | M7 | (61) | 3 | 12.142 ± 0.021 | 12.3 ± 0.36 | -17.85 ± 0.28 | (72) | 5.67 ± 0.31 | (72) |
| 2N004331354+2008014 | 68.806455 | +20.133726 | 3410856112139584000 | M7.5 | (59) | 2 | 12.986 ± 0.021 | 101.48 ± 0.17 | -41.8 ± 0.12 | (72) | 21.95 ± 0.14 | (72) |
| 2N004440164+1621324 | 71.006848 | +16.359003 | 3406128761895758072 | M6 | (46) | 2 | 12.768 ± 0.022 | 11.54 ± 0.14 | -18.99 ± 0.1 | (72) | 6.89 ± 0.12 | (72) |
| 2N004464498+2436404 | 71.687455 | +24.611223 | 147258180719392512 | M7 | (59) | 1 | 12.493 ± 0.024 | 100.12 ± 0.11 | -62.3 ± 0.07 | (72) | 23.95 ± 0.08 | (72) |
| 2N004523333+3027366 | 73.84721 | +30.460171 | 156915290131026816 | M6e | (17) | 4 | 12.384 ± 0.023 | 4.74 ± 0.14 | -24.96 ± 0.1 | (72) | 6.22 ± 0.13 | (72) |
| 2N004565141+2939310 | 74.214224 | +29.658638 | 156629039151095328 | M7 | (57) | 4 | 13.167 ± 0.027 | 4.94 ± 0.16 | -24.65 ± 0.11 | (72) | 6.61 ± 0.13 | (72) |
| 2N005350162+0521489 | 83.75676 | -5.363606 | 0 | L0 | (19) | 2 | 13.065 ± 0.051 | 0.0 ± 0.40 | 0.0 ± 0.40 | (50) | 2.42 ± 0.04 | (23) |
| 2N005392474+4038437 | 84.853102 | +40.645485 | 191109281417914880 | M8e | (12) | 3 | 10.446 ± 0.021 | 646.15 ± 0.09 | -83.49 ± 0.05 | (72) | 87.97 ± 0.08 | (72) |
| 2N005402570+2448090 | 85.107108 | +24.802505 | 0 | M7 | (44) | 4 | 8.384 ± 0.023 | 107.0 ± 0.2 | -376.0 ± 8.0 | (42) | 97.6 ± 2.8 | (48) |
| 2N006154934+0100415 | 93.955603 | -1.01155 | 312120080755320448 | L2.5 | (30) | 6 | 12.984 ± 0.023 | 198.85 ± 0.25 | -56.7 ± 0.24 | (72) | 44.97 ± 0.23 | (72) |
| 2N006521977+2534505 | 103.082387 | -25.580719 | 2920995300823950720 | L0 | (30) | 3 | 12.02 ± 0.022 | -235.57 ± 0.07 | 87.92 ± 0.09 | (72) | 62.26 ± 0.09 | (72) |
| 2N007025026+6102482 | 105.70944 | -61.046738 | 5479255432103480320 | M6.5e | (16) | 1 | 9.854 ± 0.024 | 520.13 ± 0.28 | 597.17 ± 0.24 | (72) | 57.02 ± 0.2 | (72) |
| 2N007140394+3702459 | 108.516439 | +37.046108 | 898275195732381440 | M8 | (25) | 3 | 11.252 ± 0.03 | -89.02 ± 0.12 | -182.52 ± 0.11 | (72) | 63.41 ± 0.14 | (72) |
| 2N007464256+2000321 | 116.677342 | +20.00894 | 0 | L0+L1.5 | (58) | 2 | 11.007 ± 0.022 | -370.0 ± 0.0 | -42.0 ± 1.0 | (11) | 81.2 ± 0.2 | (70) |
| 2N007475737+6653337 | 116.989056 | +66.892715 | 1096135130646349568 | M7 | (59) | 18 | 13.599 ± 0.029 | 23.59 ± 0.08 | -0.79 ± 0.14 | (72) | 16.73 ± 0.16 | (72) |
| 2N007552256+2755318 | 118.844027 | +27.925526 | 874683391345874816 | M6 | (73) | 3 | 11.616 ± 0.023 | -286.55 ± 0.06 | -29.3 ± 0.04 | (72) | 31.17 ± 0.07 | (72) |
| 2N007564895+6649595 | 119.203963 | +66.833221 | 109534547943185984 | M7.5 | (59) | 17 | 13.309 ± 0.036 | 161.93 ± 0.07 | -212.0 ± 0.11 | (72) | 23.5 ± 0.12 | (72) |
| 2N008072607+3213101 | 121.858652 | +32.21949 | 901941452829250560 | M8 | (25) | 4 | 11.455 ± 0.03 | -372.94 ± 0.11 | -255.51 ± 0.08 | (72) | 52.75 ± 0.09 | (72) |
| 2N008080189+3157054 | 122.007879 | +31.951508 | 90192292930351872 | M7 | (73) | 4 | 12.082 ± 0.018 | -23.97 ± 0.09 | -139.0 ± 0.08 | (72) | 38.82 ± 0.09 | (72) |
| 2N008092892+3235226 | 122.370536 | +32.589619 | 901979660858285824 | M4 | (67) | 4 | 12.657 ± 0.018 | -28.52 ± 0.33 | 1.78 ± 0.27 | (72) | 11.92 ± 0.38 | (72) |
| 2N008144389+4650522 | 123.62914 | +46.847851 | 92963980000008832 | M4 | (67) | 2 | 12.236 ± 0.021 | -42.43 ± 0.07 | -77.9 ± 0.06 | (72) | 16.7 ± 0.07 | (72) |
| 2N008185804+2333522 | 124.741863 | +23.564503 | 677439114220755616 | M7e | (4) | 4 | 11.552 ± 0.023 | -259.12 ± 0.08 | -331.58 ± 0.06 | (72) | 44.32 ± 0.08 | (72) |
| 2N008211639+5683858 | 125.318327 | +56.97662 | 103481873871597760 | M6.5 | (76) | 3 | 12.805 ± 0.019 | 20.92 ± 0.1 | -30.9 ± 0.11 | (72) | 11.52 ± 0.13 | (72) |
| 2N008294994+2646348 | 127.456242 | +27.767339 | 703790044252850688 | M6.5e | (16) | 5 | 7.617 ± 0.018 | -113.69 ± 0.06 | -61.2 ± 0.05 | (72) | 279.25 ± 0.06 | (72) |
| 2N008440350+0434356 | 131.014597 | +4.576577 | 582212198844179298 | M9 | (35) | 2 | 12.827 ± 0.031 | -329.09 ± 0.17 | 272.84 ± 0.13 | (72) | 36.38 ± 0.16 | (72) |
| 2N008490052+0220155 | 132.252168 | +2.337659 | 577960765337401856 | M7.3 | (47) | 4 | 12.299 ± 0.021 | -92.65 ± 0.11 | -105.93 ± 0.07 | (72) | 32.52 ± 0.09 | (72) |
| 2N008501918+1056436 | 132.579937 | +10.945469 | 59865669661309648 | M5e+M6e | (34) | 23 | 10.675 ± 0.022 | -172.16 ± 0.03 | 64.68 ± 0.02 | (72) | 25.19 ± 0.03 | (72) |
| 2N008522464+2540591 | 133.102704 | +25.683105 | 690896346271732480 | M7 | (35) | 1 | 11.56 ± 0.031 | -205.52 ± 0.31 | -74.91 ± 0.22 | (72) | 24.04 ± 0.31 | (72) |
| 2N009020690+0033195 | 135.528784 | +0.555434 | 576506489410890572 | M6 | (2) | 2 | 11.538 ± 0.023 | -465.14 ± 0.09 | -97.98 ± 0.06 | (72) | 46.01 ± 0.07 | (72) |
| 2N009130162+3037583 | 138.256788 | +30.632866 | 699795277990232176 | M7 | (64) | 8 | 12.82 ± 0.025 | -109.82 ± 0.11 | -224.0 ± 0.09 | (72) | 17.26 ± 0.11 | (72) |
| 2N009373349+5534057 | 144.389577 | +55.568275 | 1021744377229927040 | M4 | (35) | 20 | 13.674 ± 0.043 | -33.88 ± 0.12 | -13.14 ± 0.11 | (72) | 7.78 ± 0.12 | (72) |
| 2N009381783+0132490 | 144.574292 | +1.546969 | 3847224106513033472 | M6 | (55) | 7 | 12.266 ± 0.033 | -25.95 ± 0.05 | -52.3 ± 0.04 | (72) | 5.66 ± 0.05 | (72) |
| 2N009442625+3521233 | 146.109388 | +35.356476 | 794874515210822144 | M5 | (55) | 6 | 12.65 ± 0.023 | -220.98 ± 0.09 | 58.7 ± 0.08 | (72) | 21.89 ± 0.11 | (72) |

Table 3.2 (continued)

Table 3.2 (continued)

| APOGEEID | RA (deg) | Dec (deg) | Gal α eDR3 | Source ID | SpT | SpT Ref | N _{obs} | 2MASS H (mag) | M_z ($m_{\text{sol}} \text{ yr}^{-1}$) | M_{g} ($m_{\text{sol}} \text{ yr}^{-1}$) | μ Ref | π (mas) | π Ref |
|---------------------|-------------|--------------|----------------------|-----------|------|---------|------------------|--------------------|---|--|-----------|----------------|-----------|
| 2M09453388+5458511 | 146.391184 | +54.980881 | 1021788250320230016 | M7 | (59) | 10 | 13.777 ± 0.037 | -14.08 ± 0.14 | -35.7 ± 0.15 | -13.69 ± 0.15 | (72) | 13.69 ± 0.15 | (72) |
| 2M09472006+0020093 | 146.833623 | -0.335929 | 3833990796878014720 | M7 | (65) | 2 | 11.63 ± 0.024 | -214.15 ± 0.06 | 47.85 ± 0.06 | 37.29 ± 0.06 | (72) | 37.29 ± 0.06 | (72) |
| 2M09474477+0242317 | 146.93657 | +2.409108 | 3847024152835801344 | M8.2 | (47) | 2 | 12.485 ± 0.024 | -106.83 ± 0.17 | -162.4 ± 0.12 | 29.85 ± 0.15 | (72) | 29.85 ± 0.15 | (72) |
| 2M09522188+1924319 | 148.091198 | -19.408888 | 5671384265738139984 | M7e | (6) | 3 | 11.256 ± 0.024 | -73.0 ± 0.1 | -99.48 ± 0.1 | 35.32 ± 0.1 | (72) | 35.32 ± 0.1 | (72) |
| 2M09524622+0620410 | 148.192586 | +6.344746 | 3850426468488570624 | M7.3 | (47) | 4 | 11.832 ± 0.022 | -87.56 ± 0.11 | -67.43 ± 0.12 | 25.08 ± 0.09 | (72) | 25.08 ± 0.09 | (72) |
| 2M09560888+0134128 | 149.037012 | +1.570232 | 3834702043462197504 | M5 | (71) | 4 | 12.397 ± 0.023 | -245.45 ± 0.09 | 0.68 ± 0.09 | 25.36 ± 0.08 | (72) | 25.36 ± 0.08 | (72) |
| 2M10031918+0105079 | 150.829957 | -1.085538 | 3830128624846458752 | M7e | (9) | 2 | 11.667 ± 0.023 | -498.71 ± 0.09 | 46.9 ± 0.1 | 50.14 ± 0.1 | (72) | 50.14 ± 0.1 | (72) |
| 2M10134315+0000406 | 153.42981 | +0.011291 | 3831671274019947648 | M6 | (5) | 2 | 11.953 ± 0.022 | 323.86 ± 0.06 | -281.51 ± 0.07 | 27.33 ± 0.07 | (72) | 27.33 ± 0.07 | (72) |
| 2M10225094+0032169 | 155.712113 | +0.538033 | 3831375157499435648 | M8 | (64) | 3 | 12.613 ± 0.023 | -85.11 ± 0.45 | -215.0 ± 0.6 | 28.03 ± 0.3 | (72) | 28.03 ± 0.3 | (72) |
| 2M10240997+1815533 | 156.041547 | +18.26482 | 624312666575349888 | M7e | (4) | 3 | 11.62 ± 0.021 | -161.85 ± 0.33 | -76.98 ± 0.37 | 28.76 ± 0.31 | (72) | 28.76 ± 0.31 | (72) |
| 2M10323297+0630074 | 158.137415 | +6.502077 | 3862117335108574848 | M6 | (44) | 2 | 9.901 ± 0.022 | -232.2 ± 0.03 | -193.22 ± 0.03 | 51.45 ± 0.03 | (72) | 51.45 ± 0.03 | (72) |
| 2M10372897+3011117 | 159.370735 | +30.186594 | 735453264711448064 | M8 | (53) | 2 | 11.286 ± 0.022 | -819.76 ± 0.05 | -572.97 ± 0.04 | 49.84 ± 0.05 | (72) | 49.84 ± 0.05 | (72) |
| 2M10541102+8050223 | 163.545954 | -85.083984 | 5190838276414527872 | M8 | (9) | 2 | 12.071 ± 0.024 | -427.83 ± 0.14 | 285.33 ± 0.1 | 53.7 ± 0.1 | (72) | 53.7 ± 0.1 | (72) |
| 2M10543366+0503467 | 163.640277 | +5.062998 | 38160815391681625696 | L1 | (76) | 2 | 12.712 ± 0.022 | 153.7 ± 0.47 | -257.0 ± 0.42 | 25.64 ± 0.4 | (72) | 25.64 ± 0.4 | (72) |
| 2M10570380+2217203 | 164.265858 | +22.28899 | 3988944695702883584 | M6 | (44) | 2 | 10.693 ± 0.02 | -154.93 ± 0.04 | -131.21 ± 0.03 | 37.56 ± 0.03 | (72) | 37.56 ± 0.03 | (72) |
| 2M11194647+0820356 | 169.943658 | +8.343246 | 3818676249170081408 | M8 | (35) | 3 | 12.22 ± 0.025 | 371.4 ± 0.1 | -351.6 ± 0.1 | 35.64 ± 0.09 | (72) | 35.64 ± 0.09 | (72) |
| 2M11203609+0704135 | 170.1504 | +7.070432 | 3817502486148556032 | M6 | (35) | 3 | 12.363 ± 0.025 | 12.09 ± 0.07 | -245.67 ± 0.06 | 22.91 ± 0.07 | (72) | 22.91 ± 0.07 | (72) |
| 2M11210854+2126274 | 170.285592 | +21.440952 | 3990812761663064960 | M6 | (74) | 1 | 11.105 ± 0.023 | -240.04 ± 0.06 | -2.85 ± 0.07 | 38.18 ± 0.07 | (72) | 38.18 ± 0.07 | (72) |
| 2M11232934+0154040 | 170.872272 | +1.901134 | 3810750831918988928 | M7 | (49) | 3 | 11.739 ± 0.026 | -168.06 ± 0.35 | 16.2 ± 0.27 | 33.38 ± 0.3 | (72) | 33.38 ± 0.3 | (72) |
| 2M12080810+3520281 | 182.033775 | -35.341141 | 4029757983210057088 | M7V | (35) | 2 | 11.791 ± 0.021 | -607.68 ± 0.06 | -70.85 ± 0.08 | 32.19 ± 0.09 | (72) | 32.19 ± 0.09 | (72) |
| 2M12153877+5205050 | 183.911576 | +52.084747 | 0 | M4.5 | (55) | 1 | 11.024 ± 0.032 | -45.5 ± 3.7 | 3.8 ± 6.6 | 18.0 ± 6.0 | (73) | 18.0 ± 6.0 | (73) |
| 2M1220116643315379 | 185.048621 | +33.260536 | 4016348232027455104 | M8 | (35) | 2 | 12.8 ± 0.022 | 118.93 ± 0.12 | -219.31 ± 0.12 | 27.06 ± 0.13 | (72) | 27.06 ± 0.13 | (72) |
| 2M122054394+2525568 | 185.226666 | +25.432447 | 4008305476265035136 | M6 | (39) | 1 | 14.309 ± 0.049 | 64.98 ± 0.36 | 1.16 ± 0.27 | 11.17 ± 0.32 | (72) | 11.17 ± 0.32 | (72) |
| 2M12215013+4632447 | 185.458875 | +46.54753 | 0 | M8 | (73) | 2 | 10.599 ± 0.028 | 78.0 ± 3.0 | -24.0 ± 3.0 | 34.0 ± 7.0 | (62) | 34.0 ± 7.0 | (62) |
| 2M12235346+2534559 | 185.97279 | +25.582199 | 4008273903960972416 | M6 | (39) | 4 | 14.117 ± 0.044 | 1.04 ± 0.15 | 61.7 ± 0.16 | 7.86 ± 0.15 | (72) | 7.86 ± 0.15 | (72) |
| 2M12252076+2517082 | 186.336518 | +25.28562 | 0 | M7 | (35) | 7 | 13.5 ± 0.039 | -82.6 ± 3.1 | 26.32 ± 2.55 | 51.35 ± 5.09 | (66) | 51.35 ± 5.09 | (66) |
| 2M12270429+2541012 | 186.767875 | +25.683676 | 3960341892843205248 | M6.4 | (26) | 7 | 13.395 ± 0.04 | -12.31 ± 0.16 | -8.1 ± 0.16 | 11.22 ± 0.17 | (72) | 11.22 ± 0.17 | (72) |
| 2M13065144+7056376 | 196.714226 | +70.943779 | 1686366029157264128 | M7 | (59) | 12 | 13.585 ± 0.038 | 186.98 ± 0.14 | -103.0 ± 0.12 | 19.01 ± 0.11 | (72) | 19.01 ± 0.11 | (72) |
| 2M13192677+1301119 | 199.861563 | +13.019995 | 3742613512230508288 | M4.8 | (71) | 3 | 12.107 ± 0.023 | -303.51 ± 0.08 | -200.0 ± 0.08 | 25.23 ± 0.07 | (72) | 25.23 ± 0.07 | (72) |
| 2M12493960+5255340 | 192.415014 | +52.926117 | 1569931222385549056 | M9 | (35) | 1 | 12.857 ± 0.024 | -181.71 ± 0.1 | -242.0 ± 0.11 | 26.19 ± 0.12 | (72) | 26.19 ± 0.12 | (72) |
| 2M13202007+7213140 | 200.08364 | +72.220581 | 1687938811801144832 | M7.5 | (59) | 12 | 13.222 ± 0.033 | 1.72 ± 0.18 | -16.7 ± 0.18 | 20.2 ± 0.15 | (72) | 20.2 ± 0.15 | (72) |
| 2M13232423+5132272 | 200.85079 | +51.54089 | 1662758730081761152 | M6 | (35) | 7 | 11.096 ± 0.022 | -163.1 ± 0.06 | 48.95 ± 0.07 | 22.78 ± 0.07 | (72) | 22.78 ± 0.07 | (72) |
| 2M13342918+3303043 | 203.621597 | +33.051212 | 1469086764666230912 | M7 | (73) | 1 | 11.928 ± 0.033 | -657.08 ± 0.05 | -36.4 ± 0.04 | 35.63 ± 0.08 | (72) | 35.63 ± 0.08 | (72) |
| 2M13430646+0038442 | 205.776953 | +0.645635 | 3663165619505342976 | M4 | (76) | 15 | 13.779 ± 0.029 | -55.56 ± 0.14 | -17.7 ± 0.1 | 7.68 ± 0.13 | (72) | 7.68 ± 0.13 | (72) |
| 2M13482307+3321508 | 207.096155 | +33.364117 | 1458504515004327168 | M4.5 | (76) | 7 | 13.792 ± 0.029 | -19.72 ± 0.07 | -3.0 ± 0.07 | 5.5 ± 0.1 | (72) | 5.5 ± 0.1 | (72) |
| 2M13500476+3207596 | 207.519873 | +32.133228 | 1457430910619077632 | M4.5 | (55) | 15 | 13.143 ± 0.027 | 10.48 ± 0.05 | -70.3 ± 0.06 | 9.18 ± 0.08 | (72) | 9.18 ± 0.08 | (72) |
| 2M13564148+3432587 | 209.172854 | +34.316324 | 1502523188143833088 | M8 | (53) | 3 | 11.043 ± 0.021 | -445.85 ± 0.44 | 45.15 ± 0.5 | 46.3 ± 0.58 | (72) | 46.3 ± 0.58 | (72) |
| 2M13573443+5408223 | 209.393463 | +54.139549 | 1561218520448360448 | M5 | (55) | 2 | 12.4 ± 0.021 | -208.78 ± 0.05 | -19.1 ± 0.07 | 18.23 ± 0.06 | (72) | 18.23 ± 0.06 | (72) |
| 2M14005977+3226109 | 210.249064 | +32.436386 | 1457632808444610556 | M7 | (35) | 16 | 13.562 ± 0.028 | 23.0 ± 0.1 | 23.0 ± 0.1 | 14.46 ± 0.12 | (72) | 14.46 ± 0.12 | (72) |
| 2M14081562+5236281 | 212.065096 | +52.607822 | 151282605872467712 | M4.5 | (67) | 3 | 12.319 ± 0.029 | 36.33 ± 0.04 | -202.0 ± 0.05 | 16.96 ± 0.04 | (72) | 16.96 ± 0.04 | (72) |
| 2M140952004+138080 | 212.38335 | +41.655582 | 1498145551317160336 | M6 | (44) | 1 | 10.187 ± 0.016 | -217.32 ± 0.02 | 72.55 ± 0.02 | 40.96 ± 0.03 | (72) | 40.96 ± 0.03 | (72) |
| 2M14320849+0811313 | 218.035409 | +8.192037 | 1172618435080418176 | M6 | (44) | 3 | 9.529 ± 0.02 | -477.1 ± 0.04 | 10.06 ± 0.04 | 78.56 ± 0.04 | (72) | 78.56 ± 0.04 | (72) |
| 2M14340140+5039480 | 218.505854 | +50.663361 | 16037701701992226368 | M7 | (59) | 3 | 13.035 ± 0.031 | -100.67 ± 0.07 | 39.9 ± 0.08 | 21.34 ± 0.08 | (72) | 21.34 ± 0.08 | (72) |
| 2M14402293+1339230 | 220.09555 | +13.656391 | 1179654519224224640 | M7 | (35) | 9 | 11.71 ± 0.02 | -145.08 ± 0.09 | -306.07 ± 0.07 | 39.13 ± 0.08 | (72) | 39.13 ± 0.08 | (72) |
| 2M14432796+0316543 | 220.866533 | +3.281762 | 3655776282891585664 | M7 | (28) | 1 | 12.632 ± 0.027 | -211.74 ± 0.15 | 7.41 ± 0.13 | 32.59 ± 0.12 | (72) | 32.59 ± 0.12 | (72) |
| 2M14533384+1545593 | 223.891033 | +15.766495 | 1187077906338788736 | M4.5 | (55) | 3 | 11.968 ± 0.028 | -8.2 ± 0.41 | -116.0 ± 0.4 | 12.01 ± 0.41 | (72) | 12.01 ± 0.41 | (72) |
| 2M14549644+0321420 | 223.956845 | +3.361681 | 1154963095836913920 | M5 | (73) | 2 | 11.108 ± 0.025 | -171.34 ± 0.05 | -545.0 ± 0.04 | 35.82 ± 0.05 | (72) | 35.82 ± 0.05 | (72) |
| 2M15010818+2250020 | 225.284113 | +22.8339 | 1262763648249073440 | M8.5 | (7) | 5 | 11.181 ± 0.03 | -43.12 ± 0.11 | -65.1 ± 0.14 | 93.17 ± 0.14 | (72) | 93.17 ± 0.14 | (72) |

Table 3.2 (continued)

Table 3.2 (continued)

| APOGEE ID | RA (deg) | Dec (deg) | Gal α eDR3 | Source ID | SpT | SpT Ref | N _{obs} | 2MASS H (mag) | μ_{α} (mas yr ⁻¹) | μ_{δ} (mas yr ⁻¹) | μ Ref | π (mas) | π Ref |
|--------------------|-------------|--------------|----------------------|-----------|------|---------|------------------|--------------------|---|---|--------------|----------------|-----------|
| 2M15041028+0923232 | 226.042873 | +9.3898 | 1167816588027341184 | M7.5 | (64) | 3 | 12.5 ± 0.028 | -257.35 ± 0.14 | 64.2 ± 0.13 | 72 | 20.01 ± 0.12 | (72) | |
| 2M15042797+0942464 | 226.116574 | +9.712908 | 11679083832299960576 | M5 | (73) | 1 | 12.493 ± 0.027 | -67.07 ± 0.07 | 15.2 ± 0.06 | (72) | 5.36 ± 0.06 | (72) | |
| 2M15115124+3033065 | 227.963533 | +30.551817 | 1276260600140069888 | M4 | (13) | 2 | 12.423 ± 0.018 | -392.57 ± 0.03 | -262.0 ± 0.04 | (72) | 20.17 ± 0.05 | (72) | |
| 2M15175638+0656388 | 229.484941 | +6.944124 | 1163173320960329968 | M4 | (76) | 2 | 12.402 ± 0.025 | -31.06 ± 0.05 | -25.7 ± 0.05 | (72) | 11.02 ± 0.05 | (72) | |
| 2M15210103+2053230 | 230.254331 | +50.889729 | 159552056881511744 | M7.5 | (25) | 1 | 10.327 ± 0.015 | 54.19 ± 0.07 | -173.13 ± 0.08 | (72) | 62.04 ± 0.06 | (72) | |
| 2M15242475+2925318 | 231.103156 | +29.425508 | 1272178319624018816 | M7.5 | (38) | 4 | 10.535 ± 0.021 | 56.77 ± 0.03 | -629.24 ± 0.04 | (72) | 76.46 ± 0.04 | (72) | |
| 2M15512179+2931062 | 237.840811 | +29.518406 | 1320795047312113152 | M7 | (1) | 4 | 8.38 ± 0.04 | -226.53 ± 0.02 | -443.61 ± 0.03 | (72) | 54.11 ± 0.03 | (72) | |
| 2M15555600-2045187 | 238.98336 | -20.755109 | 6246820788606409600 | M6.5 | (15) | 2 | 12.807 ± 0.023 | -13.64 ± 0.18 | -22.48 ± 0.12 | (72) | 6.85 ± 0.15 | (72) | |
| 2M15560104-2338081 | 239.004338 | -23.635588 | 6237048805996330624 | M6.5 | (15) | 2 | 13.242 ± 0.025 | -18.69 ± 0.16 | -26.98 ± 0.1 | (72) | 8.14 ± 0.14 | (72) | |
| 2M15560497-2106461 | 239.020713 | -21.112816 | 6246606452553142996 | M7 | (15) | 2 | 13.41 ± 0.033 | -13.48 ± 0.23 | -22.43 ± 0.2 | (72) | 6.8 ± 0.22 | (72) | |
| 2M15574011+2952379 | 239.417144 | +29.877197 | 1320476498177466368 | M4.5 | (71) | 4 | 11.943 ± 0.022 | -35.06 ± 0.03 | -158.0 ± 0.04 | (72) | 25.54 ± 0.04 | (72) | |
| 2M15592591-2305081 | 239.857994 | -23.085611 | 6237173192548569600 | M6e | (8) | 2 | 11.908 ± 0.022 | -12.05 ± 0.08 | -24.45 ± 0.05 | (72) | 7.04 ± 0.07 | (72) | |
| 2M15594439-1928191 | 239.954967 | -19.471992 | 6247395008547695488 | M7.5 | (60) | 1 | 13.817 ± 0.068 | -10.98 ± 0.38 | -21.92 ± 0.19 | (72) | 6.54 ± 0.25 | (72) | |
| 2M16001944-2256287 | 240.081011 | -22.941326 | 6243186456003514752 | M8 | (15) | 2 | 13.83 ± 0.037 | -11.35 ± 0.4 | -24.58 ± 0.24 | (72) | 6.88 ± 0.31 | (72) | |
| 2M16002844-2209228 | 240.118537 | -22.156357 | 6243438347235850112 | M6 | (8) | 3 | 12.847 ± 0.033 | -48.21 ± 0.13 | -22.0 ± 0.08 | (72) | 6.75 ± 0.12 | (72) | |
| 2M16003023-2334457 | 240.125981 | -23.579365 | 6237098906793757544 | M6e | (8) | 3 | 12.203 ± 0.026 | -12.7 ± 0.1 | -24.57 ± 0.06 | (72) | 6.97 ± 0.08 | (72) | |
| 2M16014955-2351082 | 240.456488 | -23.852278 | 6236326362439449728 | M6e | (3) | 1 | 12.293 ± 0.026 | -11.68 ± 0.15 | -23.36 ± 0.08 | (72) | 6.84 ± 0.12 | (72) | |
| 2M16022385-2414081 | 240.607737 | -24.235594 | 6236235375348191360 | M7.25 | (60) | 1 | 13.509 ± 0.032 | -13.57 ± 0.33 | -24.96 ± 0.2 | (72) | 7.72 ± 0.28 | (72) | |
| 2M16044026-2254323 | 241.167776 | -22.908993 | 6242403771219113216 | M6 | (60) | 1 | 13.755 ± 0.028 | -13.31 ± 0.27 | -22.88 ± 0.13 | (72) | 6.65 ± 0.2 | (72) | |
| 2M16044519-2254108 | 241.166658 | -22.403019 | 6243263383155595392 | M8 | (60) | 1 | 13.314 ± 0.032 | -9.73 ± 0.27 | -23.02 ± 0.16 | (72) | 6.26 ± 0.2 | (72) | |
| 2M16065178-2206212 | 241.465754 | -22.10589 | 6243298911123311616 | M6 | (60) | 1 | 13.34 ± 0.024 | -10.99 ± 0.17 | -23.44 ± 0.09 | (72) | 6.53 ± 0.14 | (72) | |
| 2M16055380+2303058 | 241.474204 | +23.051626 | 1206719582058487552 | M7 | (35) | 11 | 12.829 ± 0.031 | 11.99 ± 0.06 | 24.02 ± 0.08 | (72) | 18.83 ± 0.08 | (72) | |
| 2M16063110-1904576 | 241.629617 | -19.08268 | 6248770050921318656 | M6 | (60) | 2 | 13.667 ± 0.027 | -9.49 ± 0.18 | -24.46 ± 0.14 | (72) | 7.11 ± 0.15 | (72) | |
| 2M16063390+4054216 | 241.64125 | +40.906013 | 1380293091823646720 | M6e | (14) | 3 | 10.423 ± 0.015 | -716.3 ± 0.04 | 162.49 ± 0.05 | (72) | 63.42 ± 0.03 | (72) | |
| 2M16081226+2252448 | 242.051112 | +22.881889 | 1206516511708376208 | M5.5 | (55) | 4 | 13.485 ± 0.028 | 39.75 ± 0.09 | -33.4 ± 0.1 | (72) | 11.36 ± 0.12 | (72) | |
| 2M16090197-2151225 | 242.258238 | -21.85626 | 6242933877561854848 | M6 | (60) | 1 | 13.079 ± 0.036 | -11.32 ± 0.2 | -24.1 ± 0.16 | (72) | 7.34 ± 0.16 | (72) | |
| 2M16090451-2245323 | 242.268814 | -22.414553 | 6242480432095204480 | M7 | (29) | 3 | 12.363 ± 0.024 | -9.88 ± 0.18 | -23.86 ± 0.12 | (72) | 6.86 ± 0.13 | (72) | |
| 2M16090568-2245166 | 242.275669 | -22.754614 | 6242453734573995520 | M8.25 | (60) | 1 | 14.463 ± 0.041 | -23.51 ± 0.51 | -24.8 ± 0.25 | (72) | 7.02 ± 0.25 | (72) | |
| 2M16093019-2059536 | 242.375792 | -20.998228 | 6243843994013465088 | M6 | (21) | 1 | 13.354 ± 0.024 | -9.86 ± 0.76 | -21.68 ± 0.12 | (72) | 19.0 ± 0.6 | (73) | |
| 2M16095107-2722418 | 242.475792 | -27.3783 | 6042503181382356352 | M6 | (15) | 1 | 12.743 ± 0.028 | -13.05 ± 0.19 | -25.55 ± 0.13 | (72) | 7.13 ± 0.26 | (72) | |
| 2M16095852-2345186 | 242.493853 | -23.755169 | 6242136284952026176 | M6.5 | (15) | 1 | 13.646 ± 0.024 | -10.47 ± 0.17 | 22.13 ± 0.14 | (72) | 6.76 ± 0.14 | (72) | |
| 2M16095990-2155424 | 242.499612 | -21.928471 | 6242943498288490752 | M6.5 | (21) | 1 | 11.996 ± 0.035 | -10.6 ± 0.25 | -23.85 ± 0.13 | (72) | 7.14 ± 0.14 | (72) | |
| 2M16100608-2127440 | 242.525341 | -21.462229 | 6242973459980848608 | M8.5 | (15) | 1 | 14.15 ± 0.045 | -10.06 ± 0.49 | -24.46 ± 0.18 | (72) | 7.11 ± 0.21 | (72) | |
| 2M16103014-2315167 | 242.625606 | -23.254652 | 6242235958259594256 | M7.5 | (15) | 1 | 13.783 ± 0.033 | -10.34 ± 0.39 | -23.29 ± 0.34 | (72) | 7.09 ± 0.38 | (72) | |
| 2M16103040+3954258 | 242.62668 | +39.907169 | 0 | M7.5 | (55) | 2 | 11.91 ± 0.028 | 110.0 ± 3.0 | -24.8 ± 0.25 | (72) | 7.02 ± 0.25 | (72) | |
| 2M16103232-1913085 | 242.634701 | -19.219044 | 6245761404854620416 | M8.5-9.5 | (43) | 1 | 13.18 ± 0.098 | -7.98 ± 0.38 | -24.89 ± 0.25 | (72) | 19.0 ± 0.6 | (73) | |
| 2M16103232+2249116 | 242.634684 | +22.819895 | 1206549297940917888 | M7 | (35) | 11 | 13.286 ± 0.032 | 21.0 ± 0.13 | 22.13 ± 0.14 | (72) | 7.13 ± 0.26 | (72) | |
| 2M16104714-2239492 | 242.69642 | -22.663685 | 624645251461275136 | M9 | (33) | 2 | 14.573 ± 0.054 | -10.79 ± 0.87 | -26.76 ± 0.66 | (72) | 12.9 ± 0.15 | (72) | |
| 2M16113837-2307072 | 242.909892 | -23.118687 | 6242198265623040896 | M6.25 | (33) | 2 | 13.208 ± 0.029 | -11.76 ± 0.18 | -24.23 ± 0.13 | (72) | 8.08 ± 0.59 | (72) | |
| 2M16114261-2525511 | 242.927382 | -25.430885 | 6049537169580902272 | M7 | (60) | 2 | 11.719 ± 0.023 | -10.06 ± 0.14 | -26.36 ± 0.09 | (72) | 6.74 ± 0.13 | (72) | |
| 2M16115439-2236491 | 242.976644 | -22.613663 | 6242649340270424704 | M6.25 | (33) | 1 | 13.608 ± 0.027 | -10.94 ± 0.28 | -24.56 ± 0.09 | (72) | 7.39 ± 0.09 | (72) | |
| 2M1612270313250 | 243.112661 | -20.223621 | 6245446154254329216 | M6 | (60) | 1 | 12.608 ± 0.023 | -9.64 ± 0.11 | -22.63 ± 0.07 | (72) | 7.01 ± 0.25 | (72) | |
| 2M16124726-1903531 | 243.196957 | -19.064766 | 6245819786343951744 | M6e | (8) | 2 | 12.15 ± 0.024 | -7.96 ± 0.11 | -24.74 ± 0.07 | (72) | 7.16 ± 0.08 | (72) | |
| 2M16132665-2230348 | 243.361072 | -22.509678 | 6242661061238878592 | M6.25 | (33) | 2 | 12.95 ± 0.024 | -9.62 ± 0.16 | -26.24 ± 0.11 | (72) | 7.18 ± 0.08 | (72) | |
| 2M16132809-1924324 | 243.367055 | -19.414564 | 6245601945303400960 | M6 | (29) | 2 | 12.26 ± 0.024 | -7.96 ± 0.12 | -23.76 ± 0.09 | (72) | 7.2 ± 0.13 | (72) | |
| 2M16134027-2233192 | 243.417794 | -22.553533 | 6242615020286496000 | M6.5 | (60) | 1 | 12.937 ± 0.033 | -9.62 ± 0.15 | -23.76 ± 0.09 | (72) | 7.2 ± 0.13 | (72) | |
| 2M16134079-2219459 | 243.41998 | -22.329437 | 6242671777180877312 | M7.5 | (33) | 1 | 14.185 ± 0.04 | -8.61 ± 0.48 | -24.04 ± 0.31 | (72) | 6.91 ± 0.12 | (72) | |
| 2M16134264-2301279 | 243.427696 | -23.02442 | 6242562861106321024 | M6.25 | (33) | 1 | 13.123 ± 0.023 | -9.34 ± 0.16 | -22.08 ± 0.11 | (72) | 6.56 ± 0.35 | (72) | |
| 2M16143287-2242133 | 243.636959 | -22.703707 | 62425958676516326400 | M6.5 | (29) | 1 | 13.664 ± 0.033 | -8.11 ± 0.23 | -23.9 ± 0.16 | (72) | 6.09 ± 0.13 | (72) | |
| 2M16172079+4113032 | 244.336648 | +41.217567 | 1380878856638339984 | M5 | (55) | 3 | 11.855 ± 0.02 | -130.24 ± 0.04 | -158.0 ± 0.05 | (72) | 6.28 ± 0.18 | (72) | |
| 2M16183317-2517504 | 244.638232 | -25.297361 | 6048838533014900992 | M6 | (15) | 2 | 11.709 ± 0.023 | -10.92 ± 0.19 | -20.07 ± 0.16 | (72) | 25.08 ± 0.04 | (72) | |
| 2M16195143-2241332 | 244.964321 | -22.692577 | 605050078414963712 | M6.75 | (60) | 2 | 13.868 ± 0.036 | -7.88 ± 0.37 | -22.29 ± 0.24 | (72) | 5.1 ± 0.16 | (72) | |
| 2M16204144-2425491 | 245.172688 | -24.430326 | 604927874568878232 | M7.5 | (15) | 1 | 13.419 ± 0.027 | -10.01 ± 0.42 | -21.93 ± 0.29 | (72) | 6.77 ± 0.29 | (72) | |
| | | | | | | | | | | | | | (72) |

Table 3.2 (continued)

Table 3.2 (continued)

| APOGEEID | RA (deg) | Dec (deg) | Gaia eDR3 Source ID | SpT | SpT Ref | N _{obs} | 2MASS H (mag) | μ_z (mas yr ⁻¹) | μ_α (mas yr ⁻¹) | μ_δ (mas yr ⁻¹) | μ Ref | π (mas) | π Ref |
|----------------------|-------------|--------------|---------------------|-------------------|----------|------------------|------------------|------------------------------------|---|---|-----------|----------------|-----------|
| 2M16222304-2407108 | 245.59603 | -24.119675 | 604939570623805440 | M6 | (60) | 1 | 13.838 ± 0.041 | -12.2 ± 0.79 | -20.23 ± 0.57 | -20.23 ± 0.57 | (72) | 6.07 ± 0.66 | (72) |
| 2M16222521-2405139 | 245.605058 | -24.087208 | 6049407594709184256 | M9+M9.5 | (27) | 1 | 13.804 ± 0.049 | -15.98 ± 0.34 | -24.61 ± 0.24 | -24.61 ± 0.24 | (72) | 7.6 ± 0.29 | (72) |
| 2M16235155-2317270 | 245.964832 | -23.290842 | 6050211681303674368 | M7.5 | (21) | 1 | 12.894 ± 0.024 | -7.73 ± 0.19 | -16.75 ± 0.15 | -16.75 ± 0.15 | (72) | 20.89 ± 0.12 | (72) |
| 2M16256988-3954482 | 246.73745 | +39.913391 | 1332811575551596800 | M7.5 | (13) | 12 | 12.664 ± 0.022 | 41.76 ± 0.13 | -17.75 ± 0.15 | -17.75 ± 0.15 | (72) | 9.44 ± 0.11 | (72) |
| 2M16271693+3514132 | 246.820553 | +35.237011 | 1329273106595583872 | M6 | (35) | 3 | 12.546 ± 0.025 | 22.14 ± 0.11 | 37.86 ± 0.14 | 37.86 ± 0.14 | (72) | 36.57 ± 0.04 | (72) |
| 2M16271825+3538347 | 246.82605 | +35.642998 | 1329300388227708800 | M7 | (65) | 4 | 11.73 ± 0.024 | -105.33 ± 0.04 | 162.12 ± 0.05 | 162.12 ± 0.05 | (72) | 25.38 ± 0.27 | (72) |
| 2M16281707+1334204 | 247.071157 | +13.572345 | 4460652192092375040 | M6 | (53) | 2 | 10.997 ± 0.021 | -184.05 ± 0.21 | -100.99 ± 0.18 | -100.99 ± 0.18 | (72) | 88.82 ± 0.03 | (72) |
| 2M16311879+4051516 | 247.828309 | +40.864334 | 1332966881549315456 | M6 | (44) | 12 | 8.869 ± 0.023 | -143.43 ± 0.03 | 306.27 ± 0.03 | 306.27 ± 0.03 | (72) | 16.17 ± 0.1 | (72) |
| 2M16360984+4000243 | 249.041036 | +40.00676 | 1331933581137007104 | M5 | (55) | 4 | 11.965 ± 0.022 | -6.97 ± 0.11 | -85.6 ± 0.12 | -85.6 ± 0.12 | (72) | 69.82 ± 0.23 | (72) |
| 2M16402068+6736046 | 250.086172 | +67.601295 | 164848486858988544 | M7 | (44) | 1 | 9.294 ± 0.021 | -273.27 ± 0.29 | 365.31 ± 0.28 | 365.31 ± 0.28 | (72) | 84.01 ± 0.03 | (72) |
| 2M16463154+3434554 | 251.631453 | +34.582073 | 1326893351115617024 | M6 | (51) | 4 | 9.968 ± 0.017 | -383.68 ± 0.03 | -383.5 ± 0.03 | -383.5 ± 0.03 | (72) | 13.37 ± 0.15 | (72) |
| 2M16485878+3005366 | 252.244945 | +30.093517 | 1311338590181283584 | M6 | (63) | 2 | 12.646 ± 0.033 | -136.61 ± 0.16 | -25.5 ± 0.17 | -25.5 ± 0.17 | (72) | 33.39 ± 0.42 | (72) |
| 2M16572919+2448509 | 254.371656 | +24.814152 | 4572719468075516288 | M5 | (71) | 4 | 11.705 ± 0.019 | 71.55 ± 0.33 | 387.0 ± 0.46 | 387.0 ± 0.46 | (72) | 6.59 ± 0.19 | (72) |
| 2M19005974+5647109 | 285.248946 | -36.786385 | 6731215545363943296 | M4 | (37) | 2 | 13.333 ± 0.035 | 3.86 ± 0.21 | -28.94 ± 0.17 | -28.94 ± 0.17 | (72) | 94.07 ± 0.02 | (72) |
| 2M19241634+7533121 | 291.068089 | +75.553368 | 2289304297045579456 | M6 | (59) | 2 | 9.28 ± 0.026 | 369.42 ± 0.02 | 592.28 ± 0.03 | 592.28 ± 0.03 | (72) | 49.91 ± 0.1 | (72) |
| 2M19544358+1801581 | 298.681615 | +18.032827 | 1821315795663331456 | M8 | (53) | 6 | 11.517 ± 0.024 | -40.2 ± 0.08 | -454.0 ± 0.08 | -454.0 ± 0.08 | (72) | 9.23 ± 0.08 | (72) |
| 2M20035317-0608285 | 308.896554 | -6.141258 | 6908281142715616640 | M7 | (76) | 3 | 12.596 ± 0.035 | 23.61 ± 0.09 | 18.2 ± 0.07 | 18.2 ± 0.07 | (72) | 42.84 ± 0.04 | (72) |
| 2M2004913764+3216514 | 312.307335 | +32.28096 | 1859954695858413184 | M6 | (45) | 3 | 11.179 ± 0.021 | -158.69 ± 0.03 | -268.41 ± 0.04 | -268.41 ± 0.04 | (72) | 57.55 ± 0.06 | (72) |
| 2M21272531+5553150 | 321.855489 | +55.887512 | 217787452238519104 | M8 | (73) | 3 | 11.327 ± 0.018 | 308.52 ± 0.08 | 264.0 ± 0.06 | 264.0 ± 0.06 | (72) | 55.01 ± 0.05 | (72) |
| 2M21381698+5257188 | 324.57076 | +52.955242 | 2173367633501430272 | M7.5 ^a | (59, 71) | 3 | 11.169 ± 0.028 | 218.43 ± 0.05 | 26.9 ± 0.05 | 26.9 ± 0.05 | (72) | 35.98 ± 0.08 | (72) |
| 2M22021125-1109461 | 330.546894 | -11.162809 | 2613754712222934656 | M6/6.5e | (18) | 3 | 11.713 ± 0.022 | 130.75 ± 0.09 | -188.45 ± 0.08 | -188.45 ± 0.08 | (72) | 29.1 ± 0.09 | (72) |
| 2M224001444+0532162 | 340.006039 | +5.537857 | 2706200898267171328 | M6pec | (54) | 3 | 11.087 ± 0.022 | 113.85 ± 0.12 | -130.01 ± 0.09 | -130.01 ± 0.09 | (72) | 11.74 ± 0.1 | (72) |
| 2M22551142+1442456 | 343.79761 | +14.712685 | 281627060214179760 | M6 | (76) | 5 | 12.587 ± 0.023 | 45.14 ± 0.12 | -25.8 ± 0.09 | -25.8 ± 0.09 | (72) | 37.41 ± 0.09 | (72) |
| 2M23200703+1150071 | 350.029308 | +11.835315 | 281094580476773440 | M6.5e | (20) | 3 | 11.815 ± 0.024 | 406.67 ± 0.13 | -433.83 ± 0.09 | -433.83 ± 0.09 | (72) | | (72) |

^a Lick/KASf spectra were obtained on 2020 August 15 with a low signal-to-noise ratio, giving a spectral type of M5.

References: (1) Stephenson (1986); (2) Kirkpatrick et al. (1991); (3) Arctia et al. (2000); (4) Gizis et al. (2000); (5) Jahreiß et al. (2001); (6) McCaughrean et al. (2002); (7) Henry et al. (2002); (8) Preibisch et al. (2002); (9) Gizis (2002); (10) Briceño et al. (2002); (11) Monet et al. (2003); (12) Lépine et al. (2003); (13) Cruz et al. (2003); (14) Reid et al. (2003); (15) Martin et al. (2004); (16) Henry et al. (2004); (17) Luhman (2004); (18) Crifo et al. (2005); (19) Meese & McCaughrean (2005); (20) Reid & Gizis (2005); (21) Slesnick et al. (2006); (22) Law et al. (2006); (23) Menten et al. (2007); (24) Cruz et al. (2007); (25) Schmidt et al. (2007); (26) Kraus & Hillenbrand (2007); (27) Close et al. (2007); (28) Reid et al. (2008); (29) Slesnick et al. (2008); (30) Phan-Bao et al. (2008); (31) Cruz et al. (2009); (32) Konopacki et al. (2010); (33) Lodieu et al. (2011); (34) Fabry et al. (2011); (35) West et al. (2011); (36) Becker et al. (2011); (37) Sicilia-Aguilar et al. (2011); (38) Kirkpatrick et al. (2011); (39) Melnikov & Eisloffel (2012); (40) Deshpande et al. (2012); (41) Scholz et al. (2012); (42) Zacharias et al. (2012); (43) Aller et al. (2013); (44) Newton et al. (2014); (45) Mann et al. (2014); (46) Esplin et al. (2014); (47) Bardalez Gagliuffi et al. (2014); (48) Dittmann et al. (2014); (49) Schmidt et al. (2014); (50) Curi et al. (2015); (51) Alonso-Fornari et al. (2015); (52) Gagne et al. (2015); (53) West et al. (2015); (54) Gagne et al. (2015b); (55) Cook et al. (2016); (56) Theissen et al. (2017); (57) Esplin & Luhman (2017); (58) Dupuy & Liu (2017); (59) Reyle (2018); (60) Luhman et al. (2018); (61) Zhang et al. (2018); (62) Theissen (2018); (63) Bar et al. (2018); (64) Ahmed & Warren (2019); (65) Kiman et al. (2019); (66) Lu et al. (2019); (67) Zhong et al. (2019); (68) Cabello et al. (2019); (69) Tian et al. (2020); (70) Best et al. (2021); (71) Sebastian et al. (2021); (72) Gaia Collaboration et al. (2021); (73) this work.

3.2 APOGEE Spectral Analysis

3.2.1 Spectral Data

My APOGEE spectra were selected from APOGEE single epoch, individual visit spectra (apVisit) files (Abdurro'uf et al. 2022), covering chip a (1.657–1.696 μm), chip b (1.585–1.644 μm), and chip c (1.514–1.581 μm).

The data reduction has been described in detail in Nidever et al. (2015); Holtzman et al. (2018); Jönsson et al. (2020); Abdurro'uf et al. (2022). Each apVisit spectrum underwent dark, flat-field, cosmic ray, flux, sky and telluric corrections, as well as wavelength calibrations. In particular, the wavelength solutions were derived from a combination of sky lines and ThArNe and UNe hollow-cathode lamps (Nidever et al. 2015). Each spectrum was applied with pixel to wavelength solution (HDU4), flux (HDU1), and noise (HDU2). Bad pixels were masked out using the bit mask from HDU3 for each chip, including the “0” (BADPIX; bad pixel mask or pixels from strong persistence jump), “1” (CRPIX; cosmic ray contaminated pixel), “2” (SATPIX; saturated pixel), “3” (UNFIXABLE; unfixable pixel), “4” in (BADDARK; bad pixels from dark frames), “5” (BADFLAT bad pixels from flat-field lamp frames), “6” (BADERR; pixels with high error), “12” (SIG_SKYLINE; pixels near the large flux from sky lines), “14” (NOT_ENOUGH_PSF; less than 50% of point-spread function in good pixels). In order to simultaneously calibrate the wavelength solution imprinted in the spectra, the earth telluric absorption profile has been included in each reduced apVisit spectrum (HDU7). I fit each apVisit spectrum using a forward-modeling method which models the stellar and telluric features simultaneously (see Section 3.2.2).

3.2.2 Forward Modeling

To infer the physical properties of my sources—effective temperature (T_{eff}), surface gravity ($\log g$), radial velocity (RV), and rotational velocity ($v \sin i$)—I employed a Markov chain Monte Carlo (MCMC) forward-modeling technique that simultaneously models the telluric and stellar absorption present in the APOGEE data. I used the Spectral Modeling Analysis and RV Tool (SMART; Hsu et al. 2021), which follows methods previously described in Blake et al. (2010); Burgasser et al. (2016); Theissen et al. (2021); and Hsu et al. (2021).

Each APOGEE spectrum is forward-modeled using the following model:

$$D[p] = \left(C[p] \times \left[\left(M \left[p^* \left(\lambda \left[1 + \frac{RV^*}{c} \right] \right), T_{\text{eff}}, \log g \right] * \kappa_D(v_{\text{micro}}) * \kappa_R(v \sin i) \right) \times T \left[p^*(\lambda, \text{AM}, \text{PWV}) \right] * \kappa_G(\Delta v_{\text{inst}}) \right] \right) + C_{\text{flux}}, \quad (3.1)$$

Here, $D[p]$ is the data model as a function of pixel p ; $C[p]$ is a fifth-order polynomial representing the continuum emission; $M[p]$ is the stellar solar-metallicity atmosphere model parameterized by T_{eff} and $\log g$; $p^*(\lambda)$ is a wavelength-to-pixel conversion function, initially provided by the APOGEE reduction pipeline with an additional constant offset parameter $C_{\Delta\lambda}$ to adjust for chip-to-chip variations; $RV^* = RV + v_{\text{bary}}$ is the radial velocity of the source plus barycentric motion of the Earth at the observed epoch; c is the speed of light; κ_D is a Gaussian convolution kernel that applies a microturbulence velocity broadening v_{micro} , modeled as $2.478 - 0.325 \times \log g \text{ km s}^{-1}$ (Zamora et al. 2015); κ_R is a rotational line broadening convolution kernel based, with the limb-darkening coefficient ε of 0.6 (Gray 1992) for projected rotational velocity $v \sin i$ is projected rotational velocity; $T[p]$ is the telluric absorption model based on the model grid of Moehler et al. (2014) and parameterized by airmass (AM) and precipitable water vapor (PWV); κ_G

is a Gauss-Hermite convolution kernel used to account for the instrumental line spread function (LSF), with the width v_{inst} obtained from the APOGEE pipeline (Nidever et al. 2015; Bovy 2016); and C_{flux} is a constant additive flux offset.

The log-likelihood function of my model fit was defined as

$$\ln \mathcal{L} = -0.5 \times \left[\sum \chi^2 / C_{\text{noise}}^2 + \sum \ln(2\pi(C_{\text{noise}}\sigma)^2) \right], \quad (3.2)$$

where the statistic

$$\chi^2 = \sum_{i=1}^N \frac{(S[p] - \alpha D[p])^2}{\sigma[p]^2} \quad (3.3)$$

compares the observed spectrum $S[p]$ and uncertainty $\sigma[p]$ to the scaled forward model $D[p]$, with the scale factor α determined to minimize χ^2 . I include the constant scaling factor C_{noise} to account for under- or overestimation of observational noise, as well as systematic errors such as missing line features. With the 18 continuum parameters, LSF broadening v_{micro} , and v_{bary} computed outside the MCMC loop, there are 13 parameters fit by the forward-modeling routine. These parameters are summarized in Table 3.3, including the assumed parameter prior and bound ranges. All priors were assumed to be uniformly distributed between state ranges, which were chosen to match the expected values for late-M and L dwarfs.

Cool dwarfs have abundant molecular absorption lines in their infrared spectra, and hence careful consideration must be made for the choice of stellar model. I explored for my APOGEE sample stellar and substellar synthetic model grids from Baraffe et al. (2015, BT-Settl models), Husser et al. (2013, ACES models), Mészáros et al. (2012, MARCS models), and Marley et al. (2018, Sonora models). For the lowest-temperature dwarfs (L dwarfs), I found that the Sonora models outperform other model sets, particular redward of $1.58 \mu\text{m}$ where FeH absorption is an important source of opacity (Cushing et al. 2003; Souto et al. 2017), although there are still some missing

features in chip c. Figures 3.5, 3.6 and 3.7 show the best-fit models using Sonora and BT-Settl models for L2 β 2MASS J00452143+1634446, M9 2MASS J08440350+0434356, and M7+M9.5 2MASS J04214955+1929086. The best-fit model with Sonora models clearly outperforms (from the spectral fit, residual, and χ^2) the rest models even though the best-fit T_{eff} reaches the T_{eff} ceiling of the Sonora model grid. The best-fit models of the BT-Settl, ACES, and MARCS models give similar results, with missing opacities of FeH redder than 1.58 μm . Compared to Sonora models, the other three models give lower $\log g$ and high $v \sin i$, which can be interpreted as compensation of missing opacities. Such effect has been also found in Keck/NIRSPEC J -band spectra of T dwarfs (Hsu et al. 2021). For warmer sources (late-M dwarfs) the BT-Settl models provided superior fits to Sonora and other models, although telluric absorption strengths are higher for these model fits, suggesting compensation for missing opacity. I therefore focused my analysis on these two model sets, with an “optimal model” transition around 2700 K $\lesssim T_{\text{eff}} \lesssim$ 3000 K of BT-Settl models. Among these transition temperatures, the Sonora models can give a better fit (based on χ^2 and visual inspection) with its $T_{\text{eff}} \leq$ 2400 K.

For each source and model set, I fit all three chips simultaneously, with the nuisance parameters C_{flux} , $C_{\Delta\lambda}$, and continuum parameters modeled separately for each chip. I used the `emcee` code (Foreman-Mackey et al. 2013) to run the MCMC with a kernel-density estimator (KDE) for step size determination, and deployed 100 chains of 1,000 steps each, with the first 800 steps removed for “burn-in”. I also used a 3-sigma-clipping mask at the step of 600 to remove outliers. Chains were visually inspected to ensure convergence, and the typical integrated auto-correlation range was \sim 17 steps. An illustrative fit to data for the L2 β 2MASS J00452143+1634446 and M7 2MASS J15512179+2931062 (G 168-14) using the Sonora and BT-Settl models are shown in Figures 3.8 and 3.9, respectively.

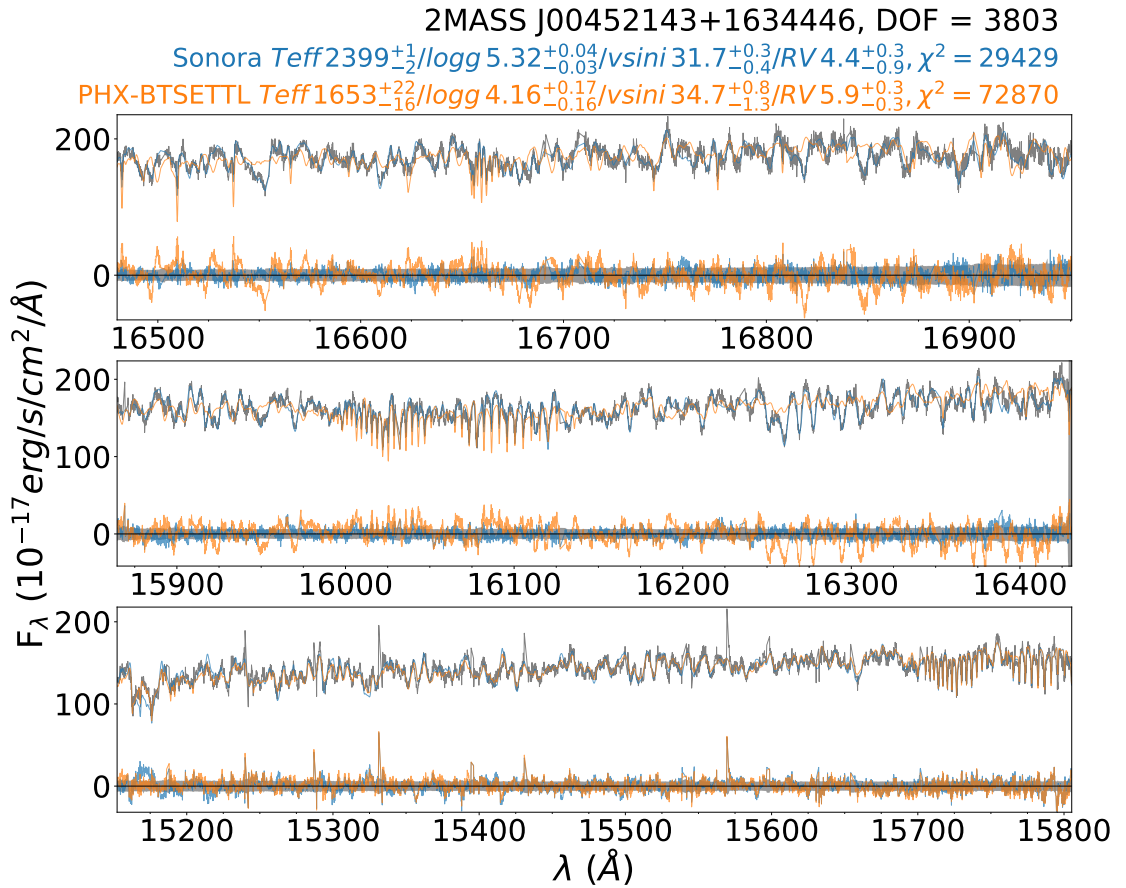


Figure 3.5: Spectrum and best-fit forward models for L2 β 2MASS J00452143+1634446, observed on JD of 2456587.736. The APOGEE data are labeled in grey, and the best-fit forward models with Sonora and BT-Settl models are labeled in blue and orange, respectively. The noise and residual (data–model) are depicted in grey-shaded regions and colored lines corresponding to the models, respectively.

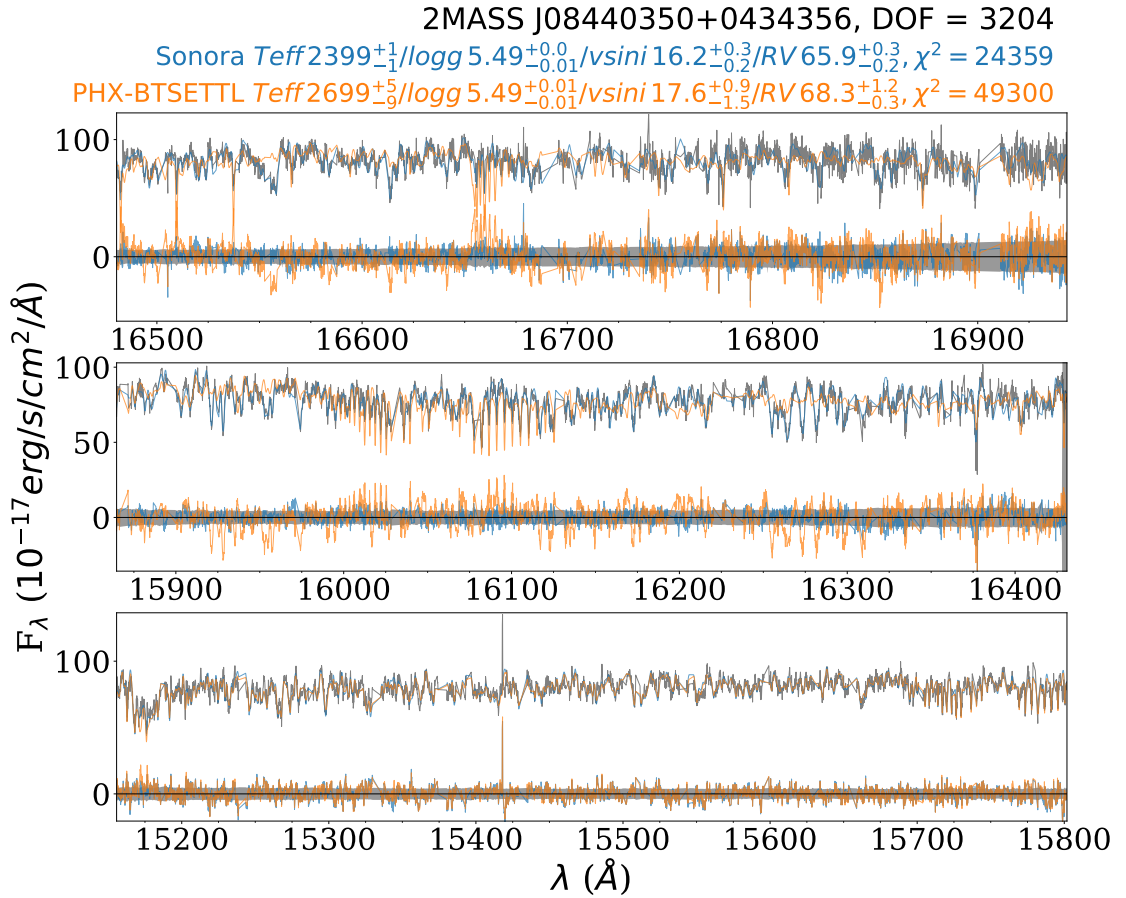


Figure 3.6: Spectrum and best-fit forward models for M9 2MASS J08440350+0434356, observed on JD of 2458198.659. The APOGEE data are labeled in grey, and the best-fit forward models with Sonora and BT-Settl models are labeled in blue and orange, respectively. The noise and residual (data–model) are depicted in grey-shaded regions and colored lines corresponding to the models, respectively.

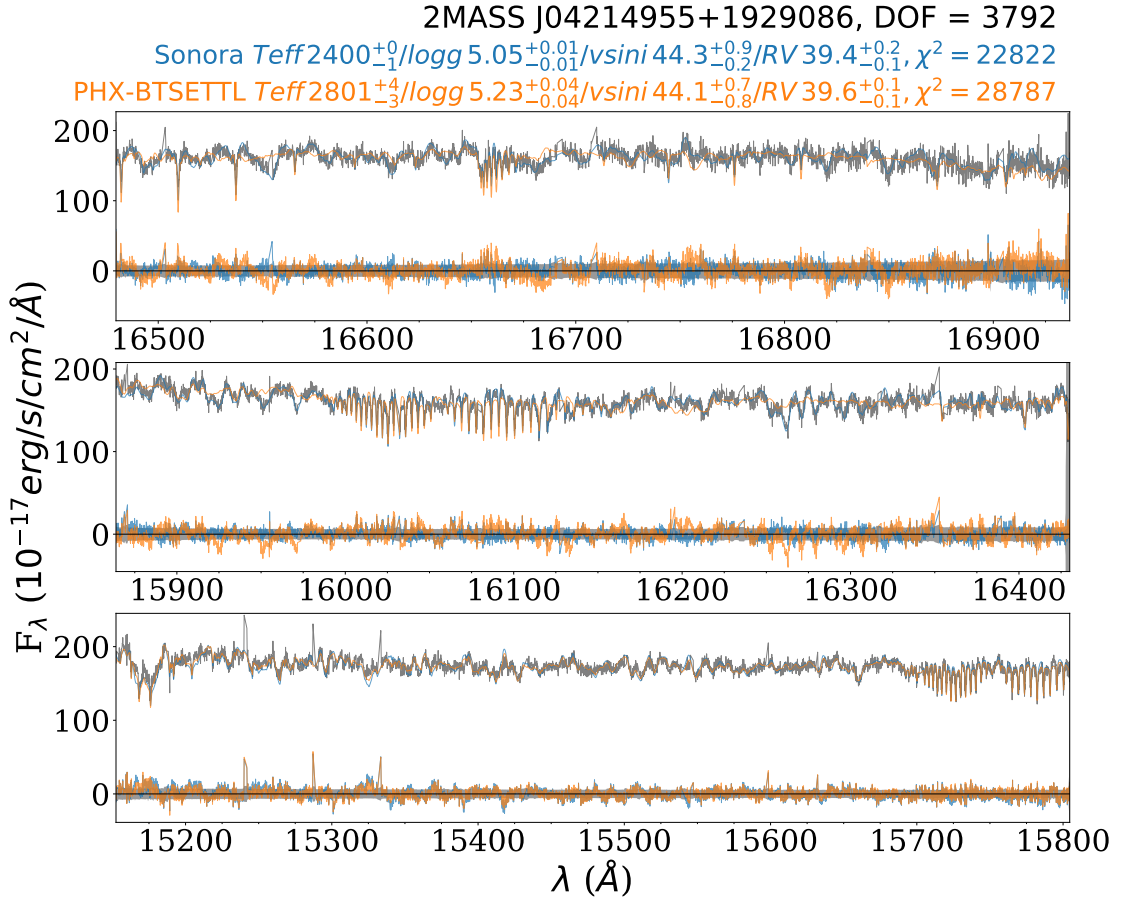


Figure 3.7: Spectrum and best-fit forward models for M7+M9.5 2MASS J04214955+1929086, observed on JD of 2458820.725. The APOGEE data are labeled in grey, and the best-fit forward models with Sonora and BT-Settl models are labeled in blue and orange, respectively. The noise and residual (data–model) are depicted in grey-shaded regions and colored lines corresponding to the models, respectively.

Table 3.3: Modeling Parameter Ranges

| Description | Symbol (unit) | Priors ^a | Bounds |
|--------------------------|--------------------------------------|-----------------------------|--|
| Effective Temp. | T_{eff} (K) | (1800, 4000) ^b | (1200, 7000) ^b |
| ... | ... | (1,500, 2,400) ^c | (200, 2400) ^c |
| Surface Grav. | $\log g$ (cm s^{-2}) | (3.5, 5.5) | (3.5, 5.5) |
| Rot. Vel. | $v \sin i$ (km s^{-1}) | (0, 50) | (0, 100) |
| Radial Vel. | RV (km s^{-1}) | (-100, +200) | (-100, +200) |
| Flux Offset ^d | C_{flux} | (-0.01, +0.01) | (-10 ⁴ , +10 ⁴) |
| Wave Offset ^d | $C_{\Delta\lambda}$ (\AA) | (-0.1, +0.1) | (-0.5, +0.5) |
| Airmass | AM | (1.0, 3.0) | (1.0, 3.0) |
| Water Vapor | PWV (mm) | (0.5, 20.0) | (0.5, 20.0) |
| Noise Factor | C_{noise} | (1.0, 5.0) | (1.0, 10.0) |

^a All priors assume a uniform distribution over range specified

^b T_{eff} range for BT-Settl (Phoenix) models

^c T_{eff} range for Sonora models

^d Three chips are fitted individually.

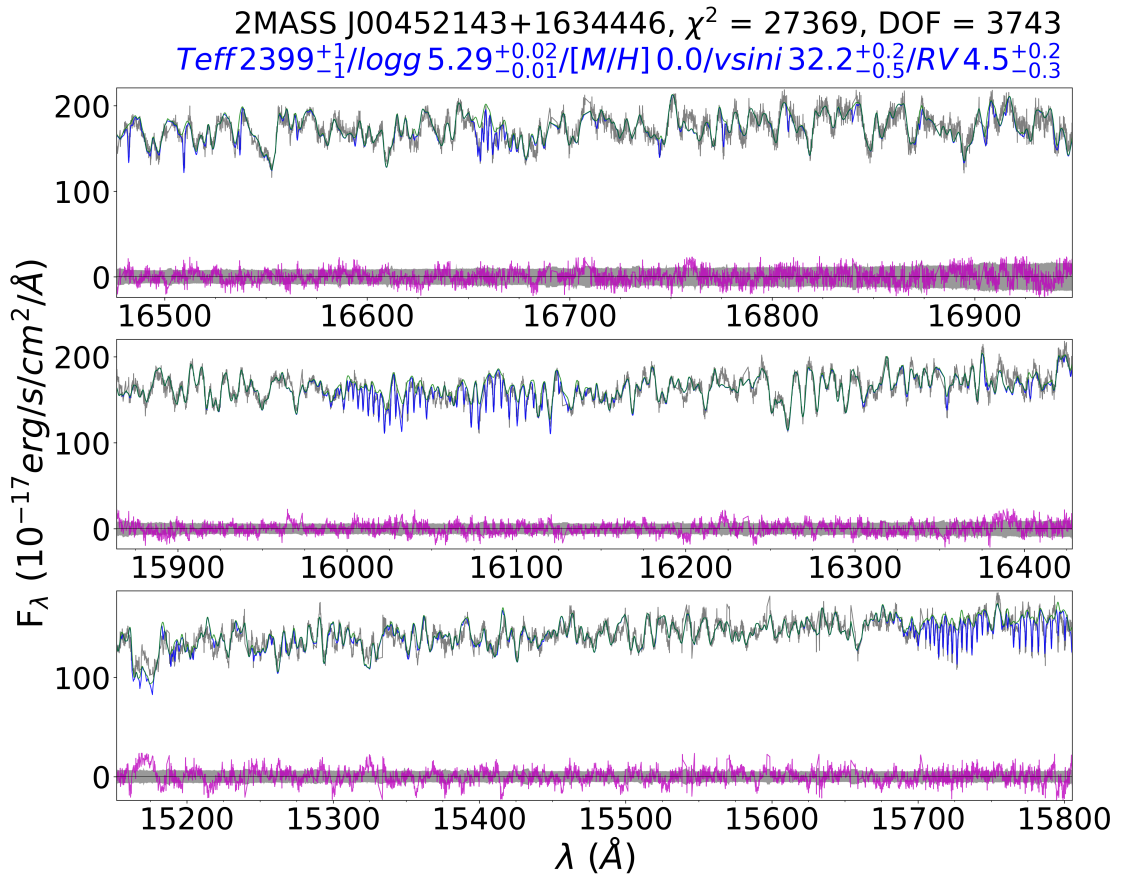


Figure 3.8: Spectrum and best-fit forward model for L2 β 2MASS J00452143+1634446, observed on JD of 2456587.736. The APOGEE data, and the best-fit forward model with/without telluric absorption are labeled in grey, blue, and green, respectively. The noise and residual (data–model) are depicted in grey-shaded regions and magenta lines, respectively. The residual highlights some missing molecular opacities, including H₂O and FeH.

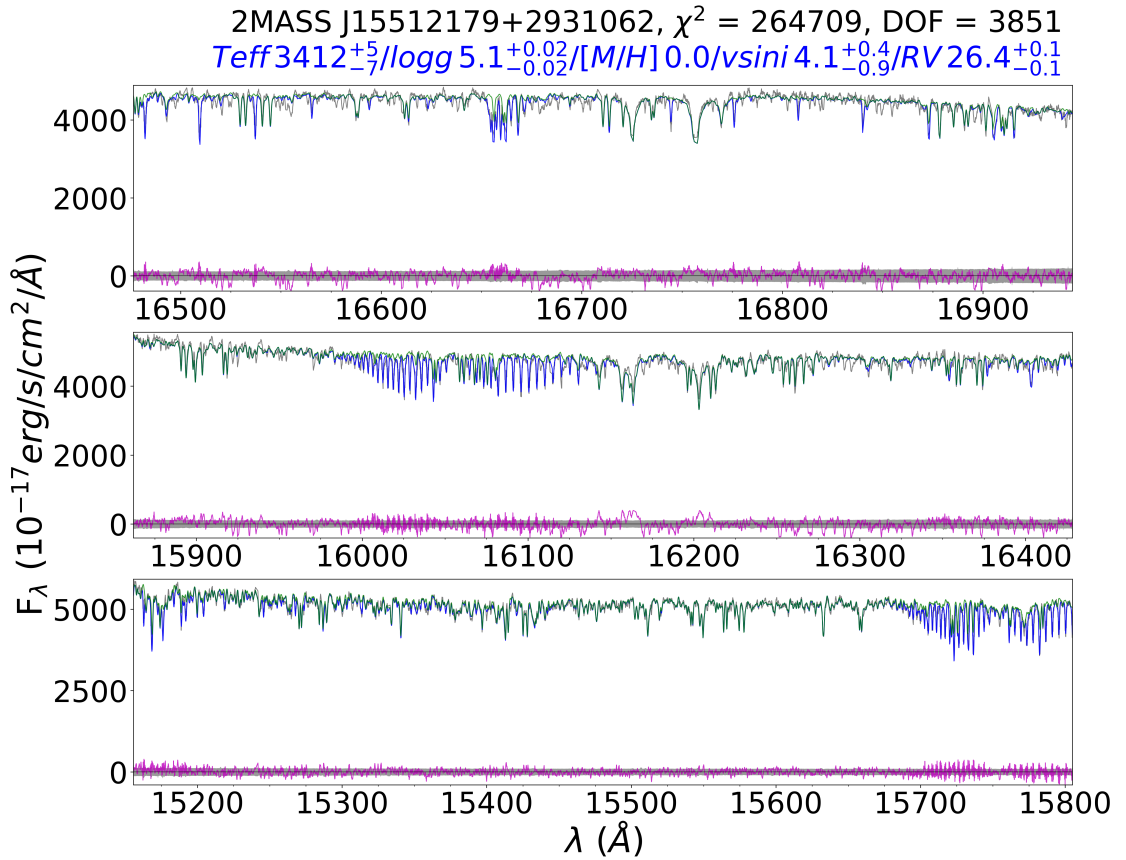


Figure 3.9: Spectrum and best-fit forward model for M7 2MASS J15512179+2931062 (G 168-14), observed on JD of 2458258.85130. The APOGEE data, and the best-fit forward model with/without telluric absorption are labeled in grey, blue, and green, respectively. The noise and residual (data–model) are depicted in grey-shaded regions and magenta lines, respectively. The residual highlights some missing molecular opacities, including H₂O and FeH.

3.3 Results of APOGEE M and L Dwarfs

In this section, I review my RV, $v \sin i$, T_{eff} , and $\log g$ measurements, all of which are compiled in Table 3.4.

3.3.1 Radial Velocities

My RV measurements span the range -61.43 km s^{-1} to $+66.68 \text{ km s}^{-1}$ with a median value of -2.1 km s^{-1} and a median measurement uncertainty of 23 km s^{-1} . To assess sources of systematic uncertainty, I evaluated the scatter in measurements inferred from 13 epochs of observations of the M2 2MASS J16495034+4745402, one of the RV standards in the Deshpande et al. (2013) APOGEE sample. I compared fits based on MARCS, BT-Settl, and ACES models, which had internal per-epoch scatter of 0.18 km s^{-1} , 0.19 km s^{-1} , and 0.16 km s^{-1} , respectively; and an overall scatter between models of 0.18 km s^{-1} . I therefore conservatively assume an overall systematic RV uncertainty of 0.19 km s^{-1} , which has been added to the reported RV measurements for all sources, resulting in a final median RV precision of 0.3 km s^{-1} .

I explored whether this precision could be improved by modeling restricted wavelength regions where strong telluric absorption can be used to improve the wavelength calibration. This was motivated by higher fitting scatter in these regions caused by slight mismatches between the observed and modeled spectra, which may be due to offsets in the wavelength calibrations derived from arc lamp lines. I explored fitting individual regions of strong telluric absorption of $16560\text{--}16700 \text{ \AA}$ on chip a, $15980\text{--}16160 \text{ \AA}$ on chip b, and $15100\text{--}15500 \text{ \AA}$ and $15500\text{--}16800 \text{ \AA}$ on chip c (see Figure 3.8), and included an additional pixel-to-wavelength zero-point offset term in my model. Unfortunately, the variance in RV measurements between the regions ($0.23\text{--}0.56 \text{ km s}^{-1}$) was worse than fitting all three chips simultaneously, likely due to the lack of stellar lines. I conjecture

that slight improvements in the APOGEE pipeline wavelength calibration could be realized by combining arc lines, sky emission lines, and telluric absorption lines to compute the overall wavelength calibration.

I quantified the validity of my RV measurements by comparing my measured RVs with those reported in the literature, summarized in Table 3.5. A total of 59 sources in my sample have reported RVs in the literature, 43 of which include RV uncertainties. Figure 3.10 compares these values. 77% of these sources have consistent RVs to within 3σ deviation, while ten sources are significant outliers. Three of these outliers, 2MASS J08294949+2646348 ($\Delta RV = 5.5 \text{ km s}^{-1}$), 2MASS J15512179+2931062 ($\Delta RV = 8.7 \text{ km s}^{-1}$), and 2MASS J16311879+4051516 ($\Delta RV = 4.4 \text{ km s}^{-1}$), are based on measurements made with lower-resolution data ($\lambda/\Delta\lambda \approx 2000$) reported in Terrien et al. (2015), and may reflect underestimated uncertainties. Three other outliers, 2MASS J04262939+2624137, 2MASS J04294568+2630468, and 2MASS J04330945+2246487 are all members of the Taurus Complex star-forming region and have prior APOGEE measurements reported by Kounkel et al. (2019) that are $2\text{--}3 \text{ km s}^{-1}$ offset lower than my measurements. Both Cook et al. (2014) and Kounkel et al. (2019) report a systematic red-shift in RV measurements among the lowest temperature sources in their samples ($T_{\text{eff}} \leq 3,400 \text{ K}$) compared to the higher-mass stars in clusters, and the latter study proposes a systematic correction of $\Delta RV = 12.84 - 0.0038 \times T_{\text{eff}}$. Accounting for this offset brings my measurements fully in line with RVs reported in Kounkel et al. (2019). Two of the outliers, 2MASS J03505737+1818069 (LP 413–53) and 2MASS J08501918+1056436 appear to be RV-variable binaries based on the high scatter of individual epoch measurements; these are discussed in further detail in Section 3.4.5. Of the remaining two outliers, the M8 2MASS J07140394+3702459 appears to be poorly fit by BT-Settl models due to a lack of FeH opacities, whereas the Sonora models provide a much better fit, resulting in a shift of $2\text{--}4 \text{ km s}^{-1}$ (depending on the epoch) and bringing

my measurement in line with that from the APOGEE pipeline. As the literature measurement from Deshpande et al. (2013) utilized BT-Settl models, I attribute this difference to modeling systematics. Finally, the M6 2MASS J16093019–2059536, a reported member of the Upper Scorpius Association (Slesnick et al. 2006), has a significantly different RV from my measurements ($RV = -1.3 \pm 0.6 \text{ km s}^{-1}$) compared to that reported in Dahm et al. (2012) ($RV = -5.1 \pm 0.6 \text{ km s}^{-1}$). The latter is based on Keck/HIRES optical high-resolution spectra and cross-correlation with the M8 standard VB 10. On the other hand, my measurement is fully consistent with that reported in Jönsson et al. (2020, $-0.98 \pm 0.09 \text{ km s}^{-1}$), using the cross-correlation method with the DR16 APOGEE spectra. The variance between these measurements could be due to the same RV offset found for Taurus members in near-infrared spectra noted above, or variability induced by a binary (only one epoch of APOGEE data was available for this source).

For completeness, I also compared my measured RVs with those provided by the APOGEE DR17 pipeline `Doppler` (Nidever 2021), which uses cross-correlation with The Cannon models (Ness et al. 2015). While performing well for warmer stars, the pipeline is known to have systematic issues with M dwarfs with $T_{\text{eff}} \lesssim 3,500 \text{ K}$ (Abdurro’uf et al. 2022). Indeed, roughly half of the sources in my sample with literature measurements show a $>3\sigma$ discrepancy with APOGEE pipeline RVs, and 16 sources in my sample have pipeline RVs $> 250 \text{ km s}^{-1}$. In general, I thus consider APOGEE pipeline RVs to be unreliable for these low-temperature objects. While all of my APOGEE sources have radial velocities from the APOGEE DR17 pipeline (182 sources), there are 121 sources as more than $3\text{-}\sigma$ outliers (66% of the sample) compared to my RV measurements.

In summary, all of the significant outliers between my and literature measurements can be explained by methodological or astrophysical causes, and I conclude that my RV measurements are robust to a precision of 0.3 km s^{-1} .

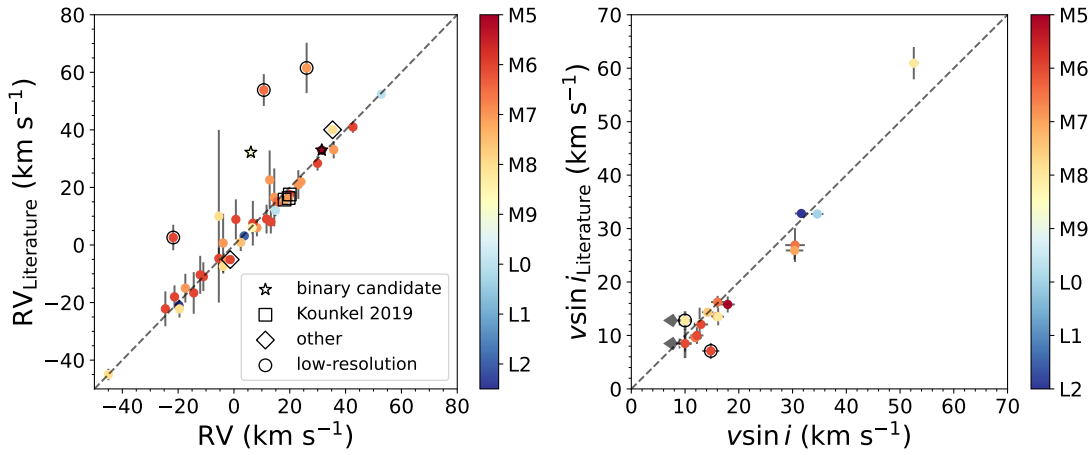


Figure 3.10: Comparison of RV (left) and $v \sin i$ (right) measurements from my APOGEE data to previous values reported in the literature (see Table 3.5). The black dashed line delineates perfect agreement. Sources are color-coded by spectral types. RV outliers are labeled with large symbols indicating binary candidates (stars), young sources with systematic RV offsets (Kounkel et al. 2019; squares), measurements based on low-resolution SpeX spectra (Terrien et al. 2015, circles), and other issues (diamonds). $v \sin i$ outliers are also highlighted by larger symbols, and are largely attributed to the systematic differences between Sonora and BT-Settl models.

3.3.2 Projected Rotational Velocities

Measured $v \sin i$ values for my sample range from 0.4 km s^{-1} to 96.1 km s^{-1} , with a median value of 16 km s^{-1} . The distribution of my measurements is shown in Figure 3.11. To determine my $v \sin i$ detection limit, I compared the distribution of all of my $v \sin i$ for both the Sonora and BT-Settl models and determined my $v \sin i$ detection limit as 10 km s^{-1} , which is more conservative than the $v \sin i = 8 \text{ km s}^{-1}$ floor in Gilhool et al. (2018) and $v \sin i = 5 \text{ km s}^{-1}$ floor in Deshpande et al. 2013), and I set my weighted average $\langle v \sin i \rangle = 10 \text{ km s}^{-1}$ for sources with $\langle v \sin i \rangle < 10 \text{ km s}^{-1}$. My median $v \sin i$ measurement precision is 1.0 km s^{-1} . In addition to MCMC uncertainty for $v \sin i$, I compared multi-epoch measurements ($N_{\text{obs}} \geq 3$) for all of my non-binary sources, and I found that the median scatter (STD) distribution for these sources to be 0.95 km s^{-1} , which I determined as my systematic $v \sin i$ uncertainty and therefore conservatively

added 0.95 km s^{-1} to all of my weighted average $v \sin i$ measurements.

Again, I assess the reliability of my $v \sin i$ measurements being compared to literature values (Figure 3.10). There are 17 sources with literature measurements, two of which are identified as $>3\sigma$ outliers: 2MASS J07140394+3702459 ($< 10 \text{ km s}^{-1}$; best-fit $v \sin i = 7.3 \pm 1.1 \text{ km s}^{-1}$ vs. $12.8 \pm 0.5 \text{ km s}^{-1}$ in Deshpande et al. 2013) and 2MASS J16311879+4051516 ($14.8 \pm 1.6 \text{ km s}^{-1}$ vs. $7.1 \pm 1.5 \text{ km s}^{-1}$ in Reiners et al. 2018). In these two cases, I find that Sonora models provide a better fit to the APOGEE data, whereas the literature values are based on comparisons to BT-Settl models. I therefore attribute these deviations to systematics associated with model choice, and conjecture that my measured $v \sin i$ values are robust.

The distribution of $v \sin i$ measurements of my sample as a function of spectral type is shown in Figure 3.12. Median values are approximately constant over the M6–L2 range of $16_{-7}^{+17} \text{ km s}^{-1}$ (uncertainties computed from the 84th and 16th percentiles), which is consistent with trends previously reported in the literature (Crossfield 2014; Tannock et al. 2021; Hsu et al. 2021; Figure 3.13). Median $v \sin i$ values for the full APOGEE plus literature sample are $14_{-6}^{+16} \text{ km s}^{-1}$ for M5–L0 dwarfs, $19_{-8}^{+19} \text{ km s}^{-1}$ for L0–L5 dwarfs, $22_{-4}^{+11} \text{ km s}^{-1}$ for L5–T0 dwarfs, and $28_{-17}^{+15} \text{ km s}^{-1}$ for T0–T9 dwarfs, consistent with previous findings showing reduced angular momentum loss toward lower temperature stars and brown dwarfs (Mohanty & Basri 2003; Reiners & Basri 2010; Irwin et al. 2011). It should be noted that my sample and the literature sample are both biased toward young sources, particularly for late M and L dwarfs; and the young cluster members in my sample do show a statistically consistent median $v \sin i = 20_{-6}^{+25} \text{ km s}^{-1}$ (uncertainties computed from the 84th and 16th percentiles). While the majority of my sources have $v \sin i < 40 \text{ km s}^{-1}$, there are six sources with $v \sin i > 60 \text{ km s}^{-1}$. Four sources identified as young sources have likely not had time to lose angular momentum. These include three sources previously identified as members of the 10 Myr Upper

Scorpius moving group (M7 2MASS J15560497–2106461, M6 2M16003023–2334457, and M8 2MASS J16045199–2224108; Pecaut & Mamajek 2016). The fourth source appears to be a member of the Orion Nebular Cluster (L0 2MASS J05350162–0521489; Meeus & McCaughrean 2005). The other two sources are likely binaries. The M5 2MASS J09381783+0132490 is spatially resolved binary ($1''.7$) in both PanSTARRS and *Gaia* data, with both components having a common parallax and proper motion. 2MASS J15010818+2250020 (aka TVLM 513-46546) is a source with known periodic radio variability (Hallinan et al. 2006) and a potential giant planet companion identified by radio astrometry (Curiel et al. 2020), which I also identify as an RV variable in my sample ($\Delta RV_{\max} \sim 2 \text{ km s}^{-1}$). This source is discussed in further detail below.

3.3.3 Effective Temperatures and Surface Gravities

I examined the modeled effective temperatures and surface gravities for my APOGEE sample. Of the 180 spectra modeled, 160 were best-fit by the Sonora models while 20 were best-fit by the BT-Settl models. The Sonora grid has a T_{eff} ceiling of 2,400 K, which corresponds to a spectral type of approximately M9 (Filippazzo et al. 2015). As this encompasses the majority of my sample, all of the inferred best-fit temperatures were close to the maximum limit, making any inference of T_{eff} trends impossible. On the other hand, T_{eff} s inferred from BT-Settl models ranged between 2798 K and 3644 K, with a median of 3162 K. Figure 3.14 shows the T_{eff} trend as a function of spectral type. While the best-fit T_{eff} s from the Sonora models almost all reach the T_{eff} ceiling, the best-fit T_{eff} s from the BT-Settl models show a general decreasing trend toward later spectral types from M4 to M7. The two outliers in this trend are the binary M7 2M15512179+2931062 (G 168-14; $T_{\text{eff}} = 3426 \pm 9 \text{ K}$; *Gaia* RUWE = 1.521) and the young source L0 2MASS J05350162–0521489 (V V2113 Ori; $T_{\text{eff}} = 3162 \pm 13 \text{ K}$). Comparing to empirical spectral type to T_{eff} relations from Pecaut & Mamajek (2013)

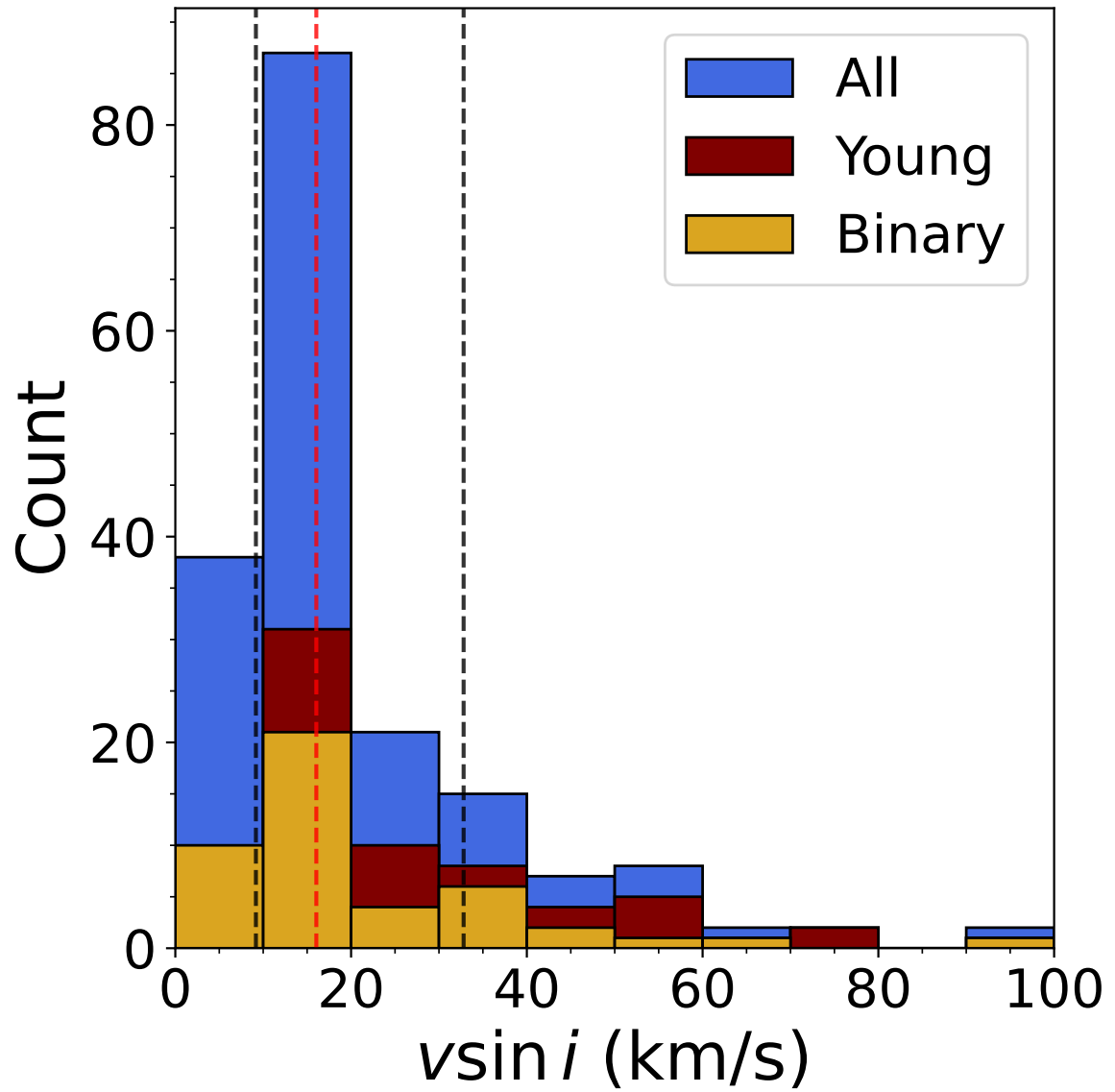


Figure 3.11: Histogram of $v \sin i$ measurements. The median and 16%/84% quantiles are indicated by vertical dashed lines, respectively. Binaries, young cluster members, and overall sample are indicated by stacked yellow, red and blue histograms, respectively.

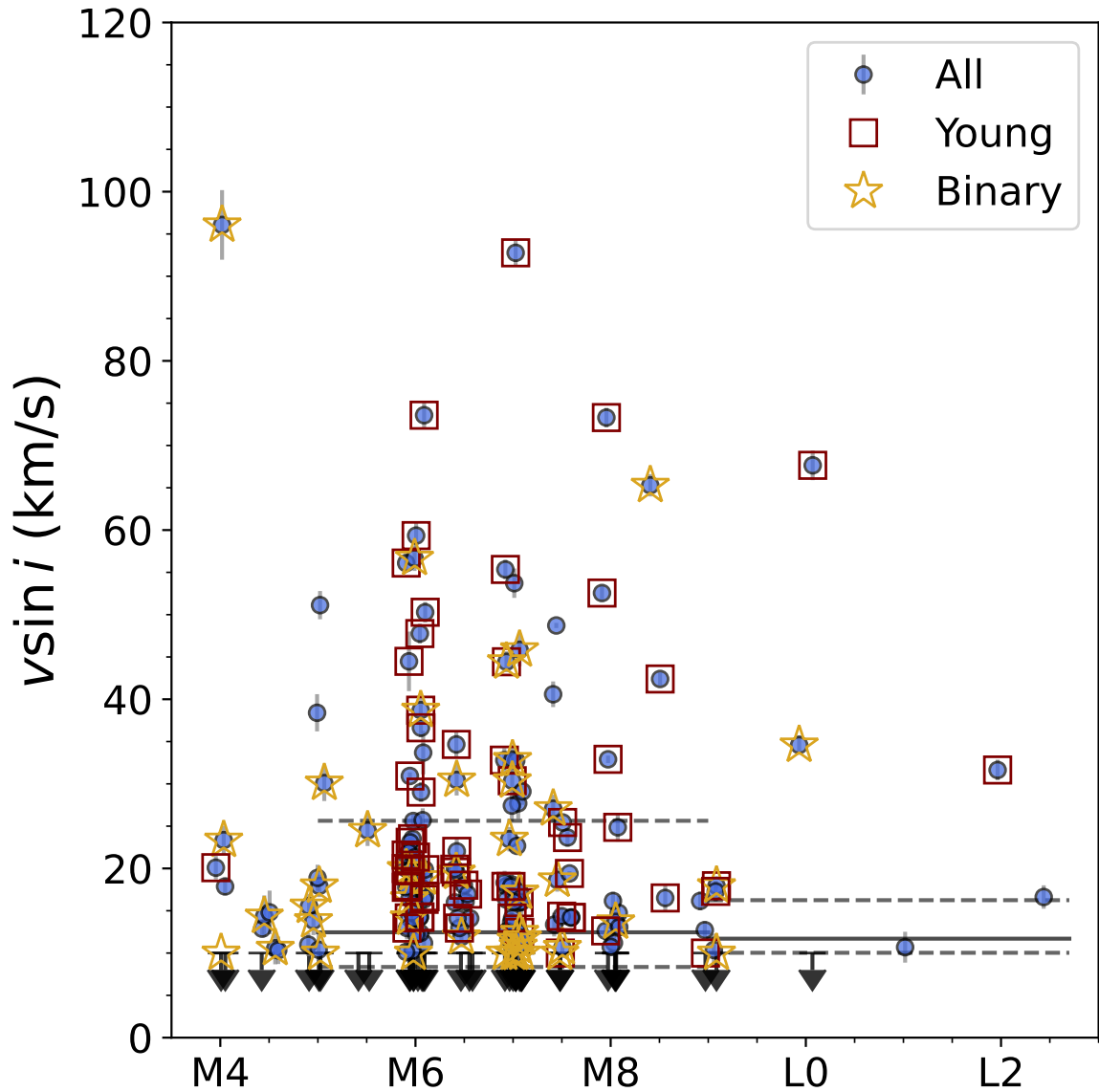


Figure 3.12: Distribution of $v \sin i$ measurements as a function of spectral type. The overall sample are indicated by blue dots, the binary candidates are indicated by yellow stars, and young sources are indicated by red squares. Sources with $v \sin i \leq 10 \text{ km s}^{-1}$ (below my measurement limit) are indicated by downward black arrows. The median and the 84th/16th percentiles are labeled in solid and dashed grey lines for M5–M8 and M9–L2 subtypes, respectively.

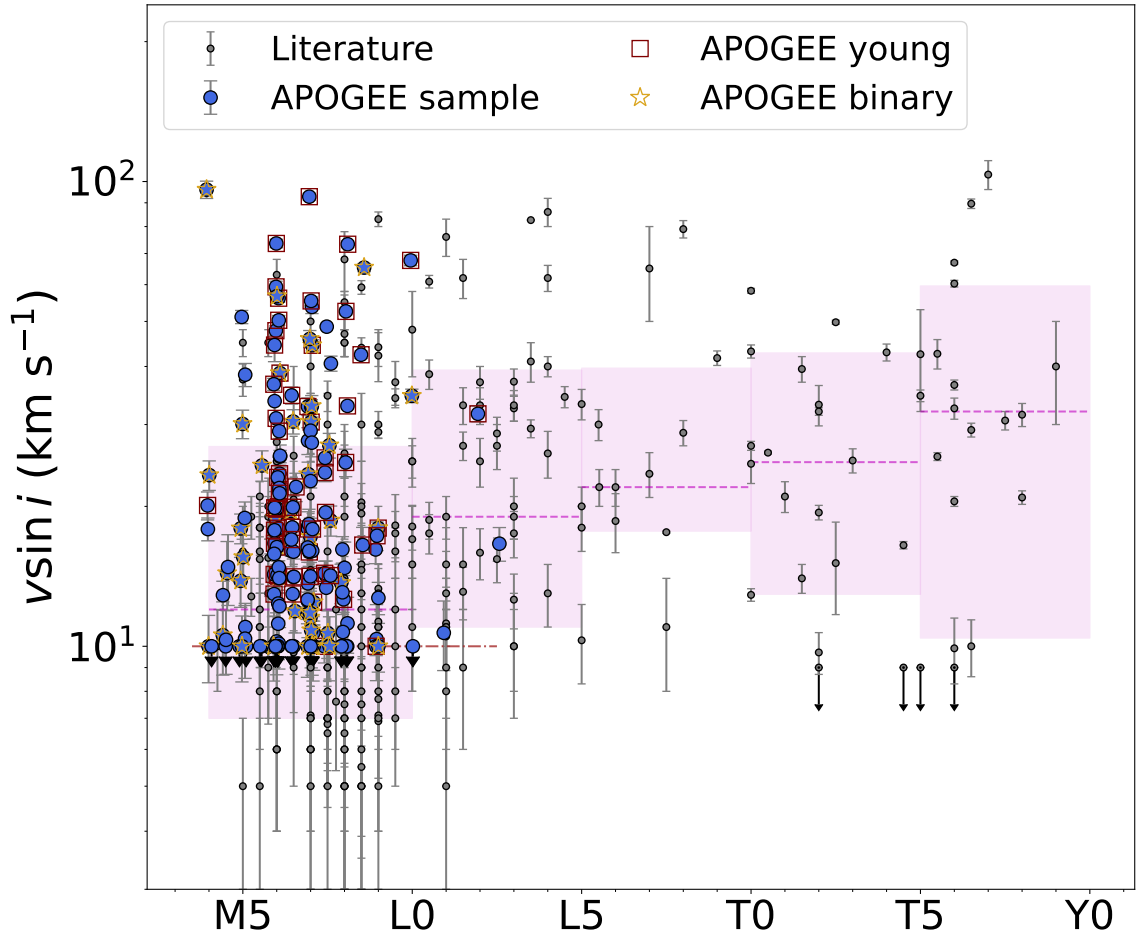


Figure 3.13: Comparison of APOGEE $v \sin i$ measurements (blue large dots) to reported literature measurements (grey small dots) as a function of spectral type. The binary candidates and known young sources are denoted in yellow stars and red squares, respectively. Median values and 16%/84% quantiles in 5-subtype bins are indicated by horizontal magenta bands. The minimum $v \sin i$ limit for my APOGEE sample is indicated by the yellow dashed line, and sources with measurements below this limit are denoted by downward black arrows. The median $v \sin i$ s are 12^{+15}_{-5} km s⁻¹, 19^{+20}_{-8} km s⁻¹, 22^{+18}_{-4} km s⁻¹, 25^{+18}_{-12} km s⁻¹, and 32^{+28}_{-22} km s⁻¹ in the bins of M4–L0, L0–L5, L5–T0, T0–T5, and T5–Y0, respectively.

and Filippazzo et al. (2015), my best-fit T_{eff} s with BT-Settl are higher than the empirical T_{eff} s, which can be attributed to the model discrepancy in H -band and/or young sources and binaries in my sample. Surface gravities from the Sonora model fits scatter across the full model parameter range of $3.5 \leq \log g \leq 5.5$, with members of young clusters typically having $\log g$ values closer to the minimum. Surface gravities from the BT-Settl model fits have the narrower range of $4.4 \leq \log g \leq 5.5$, with the young cluster members again having values in the bottom half of this range. These can be shown in Figure 3.15. Finally, I compare the distribution between T_{eff} and $\log g$ between Sonora and BT-Settl models, shown in Figure 3.16. As expected, T_{eff} s from the Sonora models are stacked at $T_{\text{eff}} = 2400$ K with $\log g$ spanning across the whole parameter space of $\log g$, while T_{eff} s from the BT-Settl models span from 2798 K to 3644 K with narrower $\log g$ s. The young sources with the BT-Settl models locate at the lower end of the $\log g$ distribution. Given the limited temperature fit range for the Sonora models and large scatter in inferred surface gravities for both models, I do not regard these values as realistic estimates, and do not further investigate their trends. However, I verified that variations in T_{eff} and $\log g$ about the optimal values had minimal influence on derived RV and $v \sin i$ values, as did the choice of model. I focus the remainder of my analysis on these velocities.

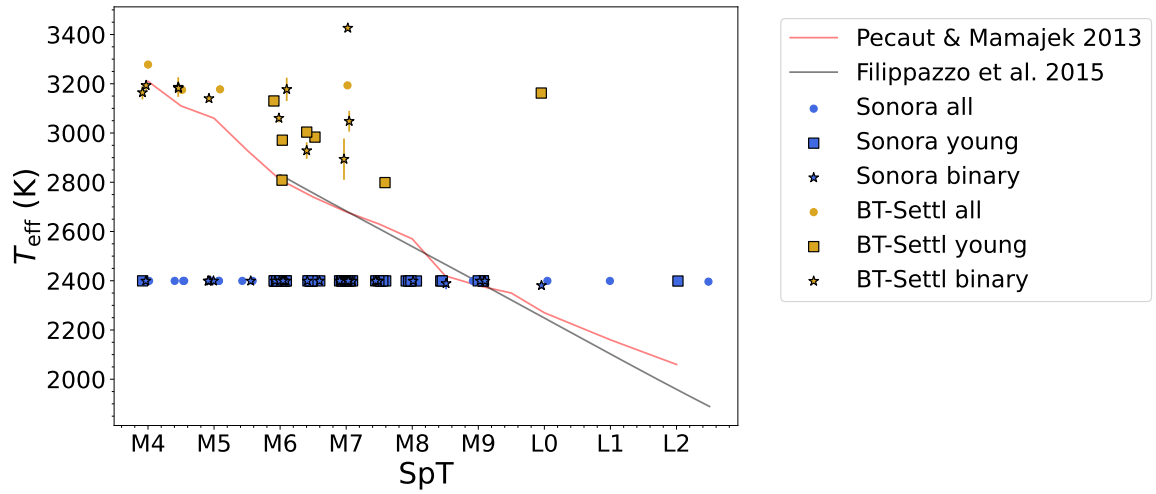


Figure 3.14: Comparison of my best-fit T_{eff} s as a function of spectral type between the Sonora (blue) and BT-Settl (yellow) models. The young sources and binaries are depicted in square boxes and stars, respectively. Over-plotted is empirical T_{eff} -spectral type relations from Pecaut & Mamajek (2013, red line) and Filippazzo et al. (2015, black line). The uncertainty of the Filippazzo et al. (2015) relation is 113 K.

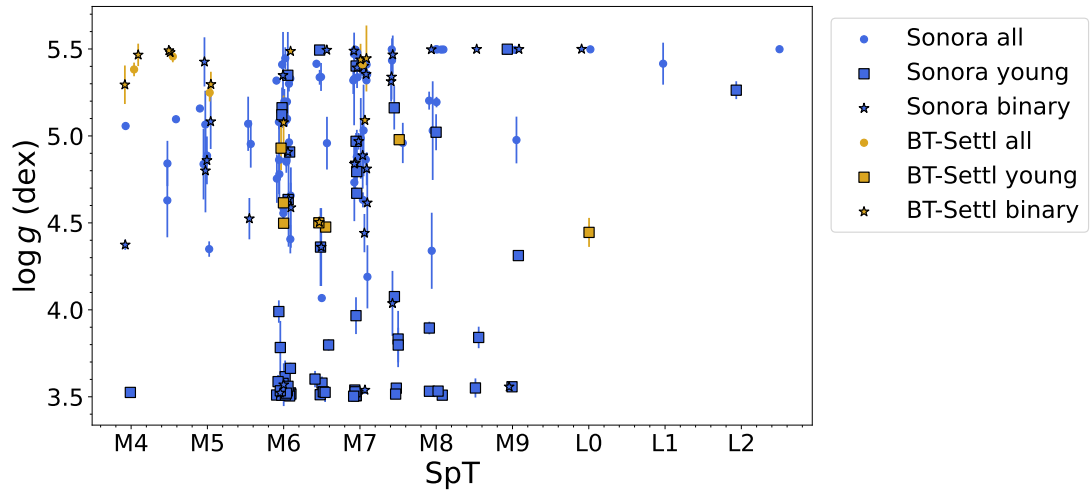


Figure 3.15: Comparison of my best-fit $\log g$ s as a function of spectral type between the Sonora (blue) and BT-Settl (yellow) models. The young sources and binaries are depicted in square boxes and stars, respectively.

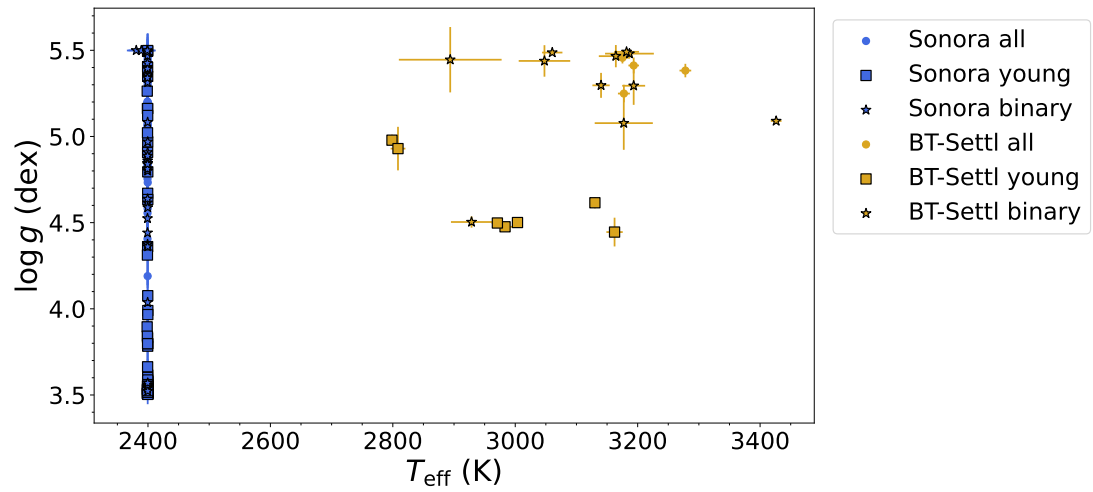


Figure 3.16: Comparison of my best-fit T_{eff} s and $\log g$ s between the Sonora (blue) and BT-Settl (yellow) models. The young sources and binaries are depicted in square boxes and stars, respectively.

Table 3.4: Spectral Model Fit Parameters

| APOGEE ID | Plate ID | Loc. ID | Fiber ID | JD (day) | bary ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | v sin i (km s ⁻¹) | (v sin i) ^{b,c} (km s ⁻¹) | T _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M _d ^d |
|--------------------|----------|---------|----------|-------------|---|------|---------------------------------------|---|--------------------------------------|--|--|--|--|--|-----------------------------|
| 2M00312793+6139333 | 6228 | 4243 | 131 | 2456171.848 | 16.15 | 29.4 | -34.5 ^{+0.1} _{-0.2} | -34.4 ^{+0.2} _{-0.2} | 9.0 ^{+0.4} _{-0.4} | < 10 | 2399.6 ^{+0.3} _{-0.3} | 2399.6 ^{+0.3} _{-0.2} | 4.81 ^{+0.02} _{-0.02} | 4.73 ^{+0.02} _{-0.22} | S |
| ... | 6229 | 4243 | 134 | 2456172.852 | 15.99 | 27.9 | -34.3 ^{+0.2} _{-0.3} | -34.3 ^{+0.2} _{-0.3} | 10.3 ^{+0.7} _{-0.7} | ... | 2399.7 ^{+0.6} _{-0.6} | ... | 4.67 ^{+0.04} _{-0.04} | ... | S |
| ... | 6228 | 4243 | 122 | 2456177.838 | 15.18 | 32.4 | -34.6 ^{+0.2} _{-0.2} | -34.6 ^{+0.2} _{-0.2} | 3.5 ^{+0.9} _{-0.9} | ... | 2399.3 ^{+0.5} _{-0.5} | ... | 5.12 ^{+0.03} _{-0.03} | ... | S |
| ... | 6228 | 4243 | 125 | 2456202.709 | 9.62 | 28.1 | -34.0 ^{+0.3} _{-0.3} | -34.0 ^{+0.3} _{-0.3} | 8.6 ^{+0.2} _{-0.2} | ... | 2399.5 ^{+0.6} _{-0.6} | ... | 4.68 ^{+0.02} _{-0.02} | ... | S |
| ... | 6229 | 4243 | 137 | 2456203.752 | 9.28 | 33.7 | -34.6 ^{+0.2} _{-0.2} | -34.6 ^{+0.2} _{-0.2} | 7.9 ^{+0.9} _{-0.9} | ... | 2399.5 ^{+0.4} _{-0.4} | ... | 4.83 ^{+0.03} _{-0.03} | ... | S |
| ... | 6229 | 4243 | 137 | 2456223.734 | 3.27 | 26.6 | -34.8 ^{+0.4} _{-0.4} | -34.8 ^{+0.4} _{-0.4} | 10.6 ^{+0.2} _{-0.2} | ... | 2399.7 ^{+0.5} _{-0.5} | ... | 4.38 ^{+0.03} _{-0.03} | ... | S |
| 2M00452143+1634446 | 6561 | 4476 | 131 | 2456587.756 | -6.46 | 34.1 | 4.5 ^{+0.2} _{-0.2} | 3.7 ^{+0.4} _{-0.6} | 32.2 ^{+0.5} _{-0.5} | 31.6 ^{+1.1} _{-1.2} | 2399.0 ^{+1.4} _{-1.4} | 2398.8 ^{+1.1} _{-0.6} | 5.29 ^{+0.01} _{-0.01} | 5.26 ^{+0.05} _{-0.05} | S |
| ... | 6561 | 4476 | 125 | 2456607.662 | -15.84 | 33.8 | 3.4 ^{+0.2} _{-0.2} | ... | 31.2 ^{+0.5} _{-0.5} | ... | 2398.8 ^{+1.0} _{-1.0} | ... | 5.32 ^{+0.01} _{-0.01} | ... | S |
| ... | 6561 | 4476 | 131 | 2456616.665 | -19.61 | 35.9 | 3.6 ^{+0.3} _{-0.3} | ... | 31.2 ^{+0.5} _{-0.5} | ... | 2398.2 ^{+2.3} _{-2.3} | ... | 5.2 ^{+0.02} _{-0.02} | ... | S |
| 2M01120002+1502170 | 12094 | 2778 | 200 | 2458814.659 | -20.29 | 42.9 | -44.6 ^{+0.2} _{-0.2} | -44.3 ^{+0.3} _{-0.3} | 7.4 ^{+0.4} _{-0.4} | < 10 | 2399.5 ^{+0.4} _{-0.4} | 2399.4 ^{+0.6} _{-0.3} | 5.08 ^{+0.02} _{-0.02} | 4.95 ^{+0.13} _{-0.14} | S |
| ... | 12094 | 2778 | 200 | 2458819.652 | -22.17 | 32.5 | -44.1 ^{+0.3} _{-0.3} | ... | 8.2 ^{+0.4} _{-0.4} | ... | 2399.3 ^{+0.8} _{-0.8} | ... | 4.99 ^{+0.04} _{-0.04} | ... | S |
| ... | 12094 | 2778 | 158 | 2458868.575 | -30.01 | 20.3 | -44.1 ^{+0.3} _{-0.3} | ... | 10.4 ^{+0.6} _{-0.6} | ... | 2399.3 ^{+0.5} _{-0.5} | ... | 4.8 ^{+0.02} _{-0.02} | ... | S |
| 2M01154176+0059317 | 12075 | 2759 | 277 | 2458779.803 | -6.49 | 22.2 | 11.4 ^{+0.3} _{-0.3} | 10.8 ^{+0.8} _{-1.2} | 33.3 ^{+0.4} _{-0.4} | 33.7 ^{+2.2} _{-2.6} | 2399.3 ^{+1.0} _{-1.0} | 2399.2 ^{+0.8} _{-0.5} | 4.68 ^{+0.09} _{-0.09} | 4.56 ^{+0.08} _{-0.04} | S |
| ... | 12075 | 2759 | 277 | 2458780.716 | -6.74 | 20.7 | 9.1 ^{+0.3} _{-0.3} | 10.3 ^{+0.1} _{-0.1} | 42.2 ^{+0.9} _{-0.9} | < 10 | 2399.2 ^{+0.5} _{-0.5} | 2399.2 ^{+0.5} _{-0.5} | 5.4 ^{+0.06} _{-0.06} | 5.34 ^{+0.04} _{-0.04} | S |
| ... | 12075 | 2759 | 258 | 2458780.716 | -5.98 | 28.1 | 10.2 ^{+0.1} _{-0.1} | -3.9 ^{+0.2} _{-0.2} | 9.7 ^{+1.1} _{-1.1} | ... | 2399.0 ^{+1.5} _{-1.5} | ... | 5.32 ^{+0.02} _{-0.02} | ... | S |
| ... | 12075 | 2759 | 77 | 2458779.803 | -5.68 | 48.8 | -3.8 ^{+0.1} _{-0.1} | ... | 27.4 ^{+1.3} _{-1.3} | 27.7 ^{+1.1} _{-1.1} | 2399.5 ^{+0.7} _{-0.7} | 2399.5 ^{+0.5} _{-0.2} | 5.47 ^{+0.02} _{-0.02} | 5.46 ^{+0.02} _{-0.02} | S |
| 2M01243124-0027556 | 12075 | 2759 | 77 | 2458780.716 | -5.93 | 44.8 | -4.0 ^{+0.2} _{-0.2} | ... | 30.4 ^{+1.1} _{-1.1} | ... | 2399.6 ^{+0.8} _{-0.8} | 2399.6 ^{+0.6} _{-0.6} | 5.46 ^{+0.02} _{-0.02} | 5.46 ^{+0.02} _{-0.02} | S |
| ... | 12078 | 2762 | 283 | 2458837.620 | -26.23 | 12.4 | 13.5 ^{+0.4} _{-0.4} | 14.4 ^{+0.6} _{-0.6} | 19.7 ^{+0.4} _{-0.4} | 18.1 ^{+1.0} _{-1.0} | 2399.2 ^{+1.0} _{-1.0} | 2399.3 ^{+0.6} _{-0.6} | 4.93 ^{+0.03} _{-0.03} | 4.83 ^{+0.11} _{-0.11} | S |
| ... | 12078 | 2762 | 283 | 2458838.668 | -26.61 | 11.7 | 15.0 ^{+0.2} _{-0.2} | ... | 18.0 ^{+0.4} _{-0.4} | ... | 2399.3 ^{+1.5} _{-1.5} | 2399.3 ^{+1.5} _{-1.5} | 4.83 ^{+0.02} _{-0.02} | ... | S |
| ... | 12078 | 2762 | 283 | 2458840.666 | -27.09 | 10.2 | 14.2 ^{+0.3} _{-0.3} | ... | 17.9 ^{+0.1} _{-0.1} | ... | 2399.4 ^{+1.3} _{-1.3} | 2399.4 ^{+1.3} _{-1.3} | 4.58 ^{+0.04} _{-0.04} | ... | S |
| ... | 10222 | 2475 | 19 | 2458861.574 | -26.73 | 15.7 | 26.3 ^{+0.3} _{-0.3} | 25.6 ^{+0.7} _{-0.7} | 11.1 ^{+0.9} _{-0.9} | < 10 | 2399.4 ^{+0.4} _{-0.4} | 2399.4 ^{+0.4} _{-0.4} | 4.78 ^{+0.05} _{-0.05} | 5.07 ^{+0.13} _{-0.16} | S |
| ... | 10222 | 2475 | 19 | 2458862.596 | -26.92 | 29.7 | 25.1 ^{+0.3} _{-0.3} | ... | 7.1 ^{+1.1} _{-1.1} | ... | 2399.2 ^{+1.1} _{-1.1} | 2399.2 ^{+1.1} _{-1.1} | 5.14 ^{+0.03} _{-0.03} | ... | S |
| 2M03040207+0045512 | 9193 | 2394 | 295 | 2457691.823 | 2.91 | 42.2 | 29.6 ^{+0.2} _{-0.2} | 29.9 ^{+0.3} _{-0.3} | 16.2 ^{+0.8} _{-0.8} | 20.0 ^{+2.4} _{-1.7} | 2399.3 ^{+1.0} _{-1.0} | 2399.5 ^{+0.2} _{-0.2} | 5.49 ^{+0.01} _{-0.01} | 5.35 ^{+0.25} _{-0.21} | S |
| ... | 9193 | 2394 | 295 | 2457692.844 | 2.34 | 25.6 | 30.3 ^{+0.2} _{-0.2} | ... | 19.8 ^{+0.1} _{-0.1} | ... | 2399.4 ^{+0.8} _{-0.8} | 2399.4 ^{+0.8} _{-0.8} | 4.96 ^{+0.02} _{-0.02} | ... | S |
| ... | 9193 | 2394 | 295 | 2457693.850 | 1.82 | 57.0 | 30.0 ^{+0.2} _{-0.2} | ... | 16.0 ^{+0.1} _{-0.1} | ... | 2399.4 ^{+0.9} _{-0.9} | 2399.4 ^{+0.9} _{-0.9} | 5.47 ^{+0.02} _{-0.02} | ... | S |
| ... | 9193 | 2394 | 246 | 2457776.624 | -28.66 | 32.6 | 30.5 ^{+0.2} _{-0.2} | ... | 19.7 ^{+0.2} _{-0.2} | ... | 2399.2 ^{+1.6} _{-1.6} | 2399.2 ^{+1.6} _{-1.6} | 5.2 ^{+0.13} _{-0.13} | ... | S |
| ... | 9193 | 2394 | 246 | 2457778.616 | -28.83 | 28.8 | 30.1 ^{+0.2} _{-0.2} | ... | 20.0 ^{+0.3} _{-0.3} | ... | 2399.4 ^{+0.8} _{-0.8} | 2399.4 ^{+0.8} _{-0.8} | 4.88 ^{+0.06} _{-0.06} | ... | S |
| ... | 9193 | 2394 | 246 | 2457779.581 | -28.82 | 37.6 | 29.9 ^{+0.3} _{-0.3} | ... | 20.2 ^{+0.5} _{-0.5} | ... | 2399.5 ^{+0.5} _{-0.5} | 2399.5 ^{+0.5} _{-0.5} | 5.39 ^{+0.06} _{-0.06} | ... | S |
| ... | 9194 | 2395 | 289 | 2457779.629 | -28.94 | 37.4 | 30.2 ^{+0.1} _{-0.1} | ... | 19.7 ^{+0.1} _{-0.1} | ... | 2399.7 ^{+0.4} _{-0.4} | 2399.7 ^{+0.4} _{-0.4} | 4.92 ^{+0.02} _{-0.02} | ... | S |
| ... | 9193 | 2394 | 246 | 2457780.576 | -28.88 | 24.0 | 30.3 ^{+0.4} _{-0.4} | ... | 25.5 ^{+0.2} _{-0.2} | ... | 2399.5 ^{+0.4} _{-0.4} | 2399.5 ^{+0.4} _{-0.4} | 4.81 ^{+0.04} _{-0.04} | ... | S |
| ... | 9194 | 2395 | 289 | 2457780.615 | -28.98 | 40.8 | 30.4 ^{+0.2} _{-0.2} | ... | 18.0 ^{+0.7} _{-0.7} | ... | 2399.4 ^{+0.8} _{-0.8} | 2399.4 ^{+0.8} _{-0.8} | 5.17 ^{+0.02} _{-0.02} | ... | S |
| ... | 9194 | 2395 | 289 | 2457782.614 | -29.09 | 37.7 | 29.6 ^{+0.2} _{-0.2} | ... | 23.5 ^{+0.1} _{-0.1} | ... | 2399.6 ^{+0.5} _{-0.5} | 2399.6 ^{+0.5} _{-0.5} | 4.84 ^{+0.02} _{-0.02} | ... | S |
| ... | 9194 | 2395 | 289 | 2457783.614 | -29.13 | 37.9 | 29.9 ^{+0.1} _{-0.1} | ... | 19.7 ^{+0.1} _{-0.1} | ... | 2399.5 ^{+0.4} _{-0.4} | 2399.5 ^{+0.4} _{-0.4} | 5.01 ^{+0.08} _{-0.08} | ... | S |
| ... | 9192 | 2393 | 180 | 2457785.587 | -29.12 | 41.1 | 29.6 ^{+0.1} _{-0.1} | ... | 17.9 ^{+0.1} _{-0.1} | ... | 2399.4 ^{+1.2} _{-1.2} | 2399.4 ^{+1.2} _{-1.2} | 5.46 ^{+0.02} _{-0.02} | ... | S |
| ... | 9192 | 2393 | 180 | 2457786.587 | -29.13 | 40.3 | 30.1 ^{+0.1} _{-0.1} | ... | 17.9 ^{+0.2} _{-0.2} | ... | 2399.2 ^{+0.9} _{-0.9} | 2399.2 ^{+0.9} _{-0.9} | 5.39 ^{+0.03} _{-0.03} | ... | S |
| ... | 9192 | 2393 | 180 | 2457787.588 | -29.14 | 26.7 | 29.6 ^{+0.3} _{-0.3} | ... | 19.7 ^{+0.1} _{-0.1} | ... | 2399.6 ^{+0.7} _{-0.7} | 2399.6 ^{+0.7} _{-0.7} | 4.85 ^{+0.03} _{-0.03} | ... | S |
| ... | 9192 | 2393 | 259 | 2458014.929 | 21.00 | 82.3 | 29.5 ^{+0.2} _{-0.2} | ... | 16.0 ^{+0.7} _{-0.7} | ... | 2399.2 ^{+1.1} _{-1.1} | 2399.2 ^{+1.1} _{-1.1} | 5.39 ^{+0.02} _{-0.02} | ... | S |
| ... | 9192 | 2393 | 259 | 2458015.960 | 20.58 | 28.8 | 29.5 ^{+0.2} _{-0.2} | ... | 15.9 ^{+0.5} _{-0.5} | ... | 2399.2 ^{+0.6} _{-0.6} | 2399.2 ^{+0.6} _{-0.6} | 5.39 ^{+0.04} _{-0.04} | ... | S |
| ... | 6225 | 4587 | 55 | 2456236.727 | 7.15 | 10.5 | 15.9 ^{+0.3} _{-0.3} | 15.4 ^{+0.8} _{-0.9} | 34.4 ^{+0.8} _{-0.8} | 30.5 ^{+2.5} _{-1.8} | 2837.0 ^{+18.0} _{-18.0} | 2928.6 ^{+33.6} _{-33.6} | 4.18 ^{+0.1} _{-0.1} | 4.5 ^{+0.03} _{-0.03} | B |
| ... | 6226 | 4587 | 234 | 2456315.637 | -26.94 | 12.4 | 14.3 ^{+0.2} _{-0.2} | ... | 32.9 ^{+1.8} _{-1.8} | ... | 2964.2 ^{+14.0} _{-14.0} | 2964.2 ^{+14.0} _{-14.0} | 4.51 ^{+0.03} _{-0.03} | ... | B |
| ... | 6224 | 4587 | 222 | 2456561.814 | 23.56 | 10.1 | 15.7 ^{+0.3} _{-0.3} | ... | 31.3 ^{+0.9} _{-0.9} | ... | 2925.3 ^{+17.4} _{-17.4} | 2925.3 ^{+17.4} _{-17.4} | 4.56 ^{+0.06} _{-0.06} | ... | B |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate | Loc. ID | Fiber ID | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | vsin <i>i</i> (km s ⁻¹) | (v sin <i>i</i>) ^{b,c} (km s ⁻¹) | <i>T</i> _{eff} (K) | (<i>T</i> _{eff}) ^b (K) | log <i>g</i> (cm s ⁻²) | (log <i>g</i>) ^b (cm s ⁻²) | Mdl ^d |
|--------------------|-------|---------|----------|-------------|--|------|---------------------------------------|---|--------------------------------------|--|--|--|--|--|------------------|
| ... | 11425 | 5925 | 234 | 2458447.665 | -2.69 | 10.4 | 16.8 ^{+0.9} _{-0.3} | ... | 31.9 ^{+1.0} _{-0.0} | ... | 2922.9 ^{+13.8} _{-13.8} | ... | 4.52 ^{+0.03} _{-0.04} | ... | B |
| ... | 11425 | 5925 | 228 | 2458527.600 | -29.54 | 13.1 | 14.9 ^{+0.2} _{-0.2} | ... | 28.4 ^{+0.8} _{-0.8} | ... | 2980.5 ^{+12.9} _{-12.9} | ... | 4.49 ^{+0.03} _{-0.03} | ... | B |
| ... | 11425 | 5925 | 234 | 2458744.878 | 25.67 | 13.7 | 15.9 ^{+0.3} _{-0.3} | ... | 30.9 ^{+1.4} _{-1.4} | ... | 2916.4 ^{+17.5} _{-17.5} | ... | 4.51 ^{+0.02} _{-0.04} | ... | B |
| ... | 11425 | 5925 | 234 | 2458773.830 | 16.09 | 12.1 | 15.3 ^{+0.3} _{-0.3} | ... | 26.7 ^{+0.8} _{-0.8} | ... | 2944.3 ^{+9.4} _{-9.4} | ... | 4.49 ^{+0.02} _{-0.02} | ... | B |
| ... | 11425 | 5925 | 234 | 2458796.752 | 5.45 | 10.2 | 16.0 ^{+0.3} _{-0.3} | ... | 30.3 ^{+1.2} _{-1.2} | ... | 2924.4 ^{+12.9} _{-12.9} | ... | 4.45 ^{+0.02} _{-0.02} | ... | B |
| ... | 11425 | 5925 | 240 | 2458803.745 | 1.90 | 13.7 | 16.4 ^{+0.2} _{-0.2} | ... | 28.7 ^{+0.7} _{-0.7} | ... | 2894.3 ^{+11.7} _{-11.7} | ... | 4.5 ^{+0.03} _{-0.03} | ... | B |
| ... | 11425 | 5925 | 234 | 2458820.666 | -6.70 | 10.8 | 15.1 ^{+0.3} _{-0.3} | ... | 32.9 ^{+1.1} _{-1.1} | ... | 2945.4 ^{+13.3} _{-13.3} | ... | 4.52 ^{+0.02} _{-0.02} | ... | B |
| 2M03293053+3127280 | 7070 | 4587 | 293 | 2456671.555 | -24.26 | 18.7 | 16.7 ^{+0.4} _{-0.4} | 15.8 ^{+0.5} _{-0.5} | 15.3 ^{+0.6} _{-0.6} | 16.0 ^{+1.0} _{-1.0} | 2992.4 ^{+7.9} _{-7.9} | 2983.3 ^{+11.4} _{-10.5} | 4.49 ^{+0.03} _{-0.02} | 4.48 ^{+0.02} _{-0.02} | B |
| ... | 7071 | 4587 | 230 | 2456674.559 | -25.12 | 21.6 | 15.5 ^{+0.4} _{-0.4} | ... | 16.1 ^{+0.5} _{-0.5} | ... | 2972.4 ^{+6.1} _{-6.1} | ... | 4.47 ^{+0.02} _{-0.02} | ... | B |
| ... | 12138 | 6179 | 19 | 2459159.856 | 7.51 | 26.2 | 6.0 ^{+0.2} _{-0.1} | 6.0 ^{+0.2} _{-0.1} | 12.7 ^{+0.4} _{-0.4} | 12.7 ^{+0.4} _{-0.4} | 2399.3 ^{+0.8} _{-0.8} | 2399.3 ^{+0.8} _{-0.8} | 5.49 ^{+0.01} _{-0.01} | 5.49 ^{+0.01} _{-0.01} | S |
| 2M03505737+1818069 | 12146 | 6187 | 121 | 2458793.799 | 9.82 | 23.9 | 39.4 ^{+0.2} _{-0.2} | 39.3 ^{+0.2} _{-0.2} | 14.2 ^{+0.1} _{-0.1} | 14.2 ^{+0.1} _{-0.1} | 2399.4 ^{+0.5} _{-0.5} | 2399.4 ^{+0.5} _{-0.5} | 4.88 ^{+0.02} _{-0.02} | 4.91 ^{+0.02} _{-0.02} | S |
| 2M04110642+1247481 | 12146 | 6187 | 121 | 2458796.862 | 8.15 | 32.1 | 39.0 ^{+0.3} _{-0.3} | ... | 13.9 ^{+0.4} _{-0.4} | ... | 2399.4 ^{+0.7} _{-0.7} | ... | 5.0 ^{+0.03} _{-0.03} | ... | S |
| ... | 11592 | 5962 | 31 | 2458744.995 | 27.93 | 16.4 | 21.1 ^{+0.2} _{-0.2} | 21.1 ^{+0.2} _{-0.2} | 9.2 ^{+0.6} _{-0.6} | < 10 | 2798.6 ^{+4.3} _{-4.3} | 2798.6 ^{+4.3} _{-4.3} | 4.98 ^{+0.03} _{-0.03} | 4.98 ^{+0.03} _{-0.03} | B |
| ... | 6238 | 4153 | 293 | 2456170.993 | 24.33 | 10.3 | -29.5 ^{+0.3} _{-0.3} | -29.5 ^{+0.3} _{-0.3} | 16.0 ^{+1.8} _{-1.8} | 14.7 ^{+2.7} _{-2.0} | 2399.5 ^{+0.7} _{-0.7} | 2399.5 ^{+0.7} _{-0.7} | 4.63 ^{+0.03} _{-0.03} | 5.03 ^{+0.28} _{-0.28} | S |
| 2M04204796+5624202 | 6238 | 4153 | 293 | 2456173.956 | 24.45 | 12.5 | -29.8 ^{+0.2} _{-0.2} | ... | 14.1 ^{+0.3} _{-0.3} | ... | 2399.5 ^{+0.9} _{-0.9} | ... | 4.69 ^{+0.05} _{-0.05} | ... | S |
| ... | 6239 | 4153 | 193 | 2456175.987 | 24.43 | 22.4 | -29.4 ^{+0.2} _{-0.2} | ... | 4.0 ^{+0.5} _{-0.5} | ... | 2399.1 ^{+0.7} _{-0.7} | ... | 5.37 ^{+0.02} _{-0.02} | ... | S |
| ... | 6238 | 4153 | 293 | 2456203.871 | 21.86 | 22.6 | -29.3 ^{+0.2} _{-0.2} | ... | 9.0 ^{+0.4} _{-0.4} | ... | 2399.5 ^{+0.7} _{-0.7} | ... | 5.07 ^{+0.02} _{-0.02} | ... | S |
| ... | 6238 | 4153 | 293 | 2456227.799 | 15.56 | 20.9 | -29.5 ^{+0.2} _{-0.2} | ... | 12.5 ^{+1.5} _{-1.5} | ... | 2399.6 ^{+0.2} _{-0.2} | ... | 4.84 ^{+0.03} _{-0.03} | ... | S |
| ... | 6239 | 4153 | 198 | 2456228.805 | 15.22 | 28.6 | -29.9 ^{+0.2} _{-0.2} | ... | 14.2 ^{+1.2} _{-1.2} | ... | 2399.1 ^{+1.3} _{-1.3} | ... | 5.34 ^{+0.04} _{-0.04} | ... | S |
| ... | 6239 | 4153 | 252 | 2456232.789 | 13.86 | 26.9 | -29.4 ^{+0.2} _{-0.2} | ... | 7.1 ^{+0.8} _{-0.8} | ... | 2399.3 ^{+0.5} _{-0.5} | ... | 5.16 ^{+0.05} _{-0.05} | ... | S |
| 2M04214435+2024105 | 12148 | 6189 | 91 | 2458797.847 | 9.72 | 13.3 | 41.0 ^{+0.2} _{-0.2} | 40.8 ^{+0.4} _{-0.4} | 32.8 ^{+1.5} _{-1.5} | 32.8 ^{+1.5} _{-1.5} | 2399.2 ^{+0.6} _{-0.6} | 2399.5 ^{+0.7} _{-0.7} | 4.66 ^{+0.03} _{-0.03} | 4.67 ^{+0.03} _{-0.03} | S |
| ... | 12148 | 6189 | 60 | 2458802.840 | 7.22 | 16.9 | 40.1 ^{+0.4} _{-0.4} | ... | 32.8 ^{+1.7} _{-1.7} | ... | 2399.6 ^{+0.8} _{-0.8} | ... | 4.69 ^{+0.06} _{-0.06} | ... | S |
| ... | 12143 | 6184 | 294 | 2458820.725 | -2.02 | 31.4 | 39.4 ^{+0.2} _{-0.2} | 39.4 ^{+0.2} _{-0.2} | 44.4 ^{+0.3} _{-0.3} | 44.4 ^{+0.3} _{-0.3} | 2399.6 ^{+0.2} _{-0.2} | 2399.6 ^{+0.2} _{-0.2} | 4.97 ^{+0.02} _{-0.02} | 4.97 ^{+0.02} _{-0.02} | S |
| 2M04262939+2624137 | 9287 | 5223 | 233 | 2457710.833 | 6.36 | 20.6 | 20.7 ^{+0.2} _{-0.2} | 20.0 ^{+0.4} _{-0.4} | 14.2 ^{+0.2} _{-0.2} | 13.0 ^{+1.3} _{-1.3} | 2399.6 ^{+0.6} _{-0.6} | 2399.6 ^{+0.6} _{-0.6} | 3.6 ^{+0.02} _{-0.02} | 3.78 ^{+0.12} _{-0.15} | S |
| ... | 9287 | 5223 | 185 | 2457737.680 | -7.44 | 33.8 | 20.0 ^{+0.2} _{-0.2} | ... | 12.3 ^{+0.1} _{-0.1} | ... | 2399.6 ^{+0.8} _{-0.8} | ... | 3.86 ^{+0.01} _{-0.01} | ... | S |
| ... | 9287 | 5223 | 188 | 2457761.707 | -18.91 | 42.4 | 19.7 ^{+0.1} _{-0.1} | ... | 12.4 ^{+0.2} _{-0.2} | ... | 2399.6 ^{+0.3} _{-0.3} | ... | 3.93 ^{+0.03} _{-0.03} | ... | S |
| ... | 9287 | 5223 | 199 | 2457710.833 | 6.74 | 37.1 | 17.7 ^{+0.2} _{-0.2} | 18.1 ^{+0.2} _{-0.2} | 14.2 ^{+0.2} _{-0.2} | 14.2 ^{+1.0} _{-1.0} | 2399.6 ^{+0.6} _{-0.6} | 2399.6 ^{+0.6} _{-0.6} | 4.07 ^{+0.01} _{-0.01} | 4.08 ^{+0.01} _{-0.01} | S |
| ... | 9287 | 5223 | 253 | 2457737.680 | -7.06 | 52.7 | 18.3 ^{+0.1} _{-0.1} | ... | 14.3 ^{+0.4} _{-0.4} | ... | 2399.6 ^{+0.2} _{-0.2} | ... | 4.08 ^{+0.03} _{-0.03} | ... | S |
| ... | 9287 | 5223 | 199 | 2457761.707 | -18.60 | 57.4 | 18.1 ^{+0.1} _{-0.1} | ... | 14.2 ^{+0.1} _{-0.1} | ... | 2399.7 ^{+0.5} _{-0.5} | ... | 4.08 ^{+0.02} _{-0.02} | ... | S |
| ... | 9259 | 5222 | 102 | 2457683.865 | 19.33 | 42.9 | 19.5 ^{+0.2} _{-0.2} | 19.6 ^{+0.4} _{-0.4} | 16.0 ^{+1.0} _{-1.0} | 16.0 ^{+1.0} _{-1.0} | 2399.7 ^{+0.2} _{-0.2} | 2399.6 ^{+0.3} _{-0.3} | 3.5 ^{+0.01} _{-0.01} | 3.51 ^{+0.01} _{-0.01} | S |
| ... | 9259 | 5222 | 91 | 2457712.842 | 5.82 | 38.8 | 20.0 ^{+0.2} _{-0.2} | ... | 14.4 ^{+0.3} _{-0.3} | ... | 2399.5 ^{+0.7} _{-0.7} | ... | 3.52 ^{+0.01} _{-0.01} | ... | S |
| ... | 9259 | 5222 | 91 | 2458010.981 | 28.98 | 40.7 | 19.1 ^{+0.2} _{-0.2} | ... | 16.1 ^{+0.1} _{-0.1} | ... | 2399.6 ^{+0.6} _{-0.6} | ... | 3.51 ^{+0.01} _{-0.01} | ... | S |
| ... | 12152 | 6193 | 217 | 2458853.674 | -16.81 | 20.2 | 39.9 ^{+0.2} _{-0.2} | 40.0 ^{+0.3} _{-0.3} | 23.6 ^{+0.2} _{-0.2} | 23.7 ^{+1.0} _{-1.0} | 2398.9 ^{+0.8} _{-0.8} | 2399.1 ^{+0.8} _{-0.8} | 5.2 ^{+0.02} _{-0.02} | 5.16 ^{+0.07} _{-0.07} | S |
| ... | 12152 | 6193 | 222 | 2458880.638 | -26.43 | 10.6 | 40.1 ^{+0.3} _{-0.3} | ... | 23.3 ^{+0.4} _{-0.4} | ... | 2399.2 ^{+1.1} _{-1.1} | ... | 4.95 ^{+0.03} _{-0.03} | ... | S |
| ... | 12155 | 6196 | 139 | 2458886.664 | -27.41 | 10.1 | 21.9 ^{+0.3} _{-0.3} | 21.8 ^{+0.2} _{-0.2} | 14.4 ^{+1.1} _{-1.1} | 14.3 ^{+1.2} _{-1.2} | 2822.9 ^{+15.3} _{-15.3} | 2808.5 ^{+12.1} _{-12.1} | 4.99 ^{+0.04} _{-0.04} | 4.93 ^{+0.12} _{-0.13} | B |
| 2M0440164+1621324 | 12155 | 6196 | 144 | 2458915.585 | -29.89 | 10.3 | 21.8 ^{+0.3} _{-0.3} | ... | 14.1 ^{+1.1} _{-1.1} | ... | 2803.6 ^{+2.0} _{-2.0} | ... | 4.73 ^{+0.07} _{-0.07} | ... | B |
| ... | 12150 | 6191 | 254 | 2458854.651 | -15.74 | 30.0 | 42.2 ^{+0.3} _{-0.3} | 42.2 ^{+0.3} _{-0.3} | 17.9 ^{+0.1} _{-0.1} | 17.9 ^{+0.1} _{-0.1} | 2399.7 ^{+0.4} _{-0.4} | 2399.7 ^{+0.4} _{-0.4} | 4.79 ^{+0.04} _{-0.04} | 4.79 ^{+0.04} _{-0.04} | S |
| ... | 11426 | 5926 | 42 | 2458417.855 | 20.15 | 33.8 | 17.4 ^{+0.2} _{-0.2} | 17.5 ^{+0.2} _{-0.2} | 14.2 ^{+1.0} _{-1.0} | 14.2 ^{+1.0} _{-1.0} | 2399.6 ^{+0.3} _{-0.3} | 2399.6 ^{+0.3} _{-0.3} | 3.78 ^{+0.04} _{-0.04} | 3.62 ^{+0.09} _{-0.09} | S |
| ... | 11427 | 5926 | 60 | 2458438.787 | 11.14 | 26.0 | 16.9 ^{+0.3} _{-0.3} | ... | 14.2 ^{+0.1} _{-0.1} | ... | 2399.6 ^{+0.5} _{-0.5} | ... | 3.64 ^{+0.03} _{-0.03} | ... | S |
| ... | 11427 | 5926 | 60 | 2458439.758 | 10.72 | 25.1 | 17.6 ^{+0.1} _{-0.1} | ... | 14.4 ^{+0.8} _{-0.8} | ... | 2399.6 ^{+0.3} _{-0.3} | ... | 3.57 ^{+0.02} _{-0.02} | ... | S |
| ... | 11428 | 5926 | 47 | 2458444.753 | 8.25 | 36.0 | 17.4 ^{+0.1} _{-0.1} | ... | 14.2 ^{+0.2} _{-0.2} | ... | 2399.6 ^{+0.4} _{-0.4} | ... | 3.55 ^{+0.02} _{-0.02} | ... | S |
| ... | 11426 | 5926 | 96 | 2458417.855 | 20.28 | 20.9 | 17.1 ^{+0.2} _{-0.2} | 17.9 ^{+0.4} _{-0.4} | 12.1 ^{+0.6} _{-0.6} | 12.4 ^{+1.0} _{-1.0} | 2399.5 ^{+0.7} _{-0.7} | 2399.4 ^{+0.4} _{-0.4} | 3.53 ^{+0.02} _{-0.02} | 3.54 ^{+0.02} _{-0.02} | S |
| ... | 11427 | 5926 | 98 | 2458438.787 | 11.27 | 14.6 | 18.3 ^{+0.1} _{-0.1} | ... | 12.5 ^{+0.1} _{-0.1} | ... | 2399.2 ^{+1.1} _{-1.1} | ... | 3.57 ^{+0.02} _{-0.02} | ... | S |
| ... | 11427 | 5926 | 98 | 2458439.758 | 10.85 | 13.7 | 17.9 ^{+0.2} _{-0.2} | ... | 12.8 ^{+0.3} _{-0.3} | ... | 2399.3 ^{+0.5} _{-0.5} | ... | 3.52 ^{+0.02} _{-0.02} | ... | S |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate | Loc. ID | Fiber | JD (day) | bary ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | vsin <i>i</i> | (v sin <i>i</i>) ^{b,c} (km s ⁻¹) | <i>T</i> _{eff} (K) | log <i>g</i> (cm s ⁻²) | Mdl ^d |
|--------------------|-------|---------|-------------|-------------|---|-------|--------------------------|---|----------------------|--|-----------------------------|------------------------------------|------------------|
| ... | 11428 | 5926 | 91 | 2458444.753 | 8.39 | 23.2 | 17.9 ^{+0.2} | ... | 12.5 ^{+0.2} | ... | ... | ... | S |
| 2M05350162-0521489 | 12274 | 7043 | 201 | 2458882.634 | -20.28 | 34.0 | 25.0 ^{+0.1} | 25.1 ^{+0.3} | 66.7 ^{+0.4} | 67.7 ^{+2.4} | 3162.3 ^{+13.8} | 3.53 ^{+0.02} | B |
| ... | 12274 | 7043 | 201 | 2458883.686 | -20.72 | 24.7 | 23.2 ^{+0.7} | 0.6 | 70.8 ^{+1.5} | ... | ... | 4.39 ^{+0.03} | B |
| 2M05392474+4038437 | 6541 | 4559 | 164 | 2456257.734 | 10.58 | 65.6 | -5.6 ^{+0.1} | -5.4 ^{+0.2} | ... | < 10 | 2399.3 ^{+0.5} | 4.55 ^{+0.05} | S |
| ... | 6541 | 4559 | 164 | 2456261.793 | 8.55 | 55.3 | -5.1 ^{+0.2} | ... | ... | ... | 2399.2 ^{+0.1} | 5.5 ^{+0.0} | S |
| ... | 6541 | 4559 | 164 | 2456313.573 | -16.28 | 57.8 | -5.4 ^{+0.1} | ... | ... | ... | ... | 5.49 ^{+0.01} | S |
| 2M05402570+2448090 | 6761 | 4564 | 250 | 2456291.683 | -6.75 | 92.3 | 25.8 ^{+0.9} | 23.1 ^{+0.6} | 30.4 ^{+2.0} | 30.4 ^{+2.0} | 2399.4 ^{+0.4} | 5.5 ^{+0.0} | S |
| ... | 6761 | 4564 | 249 | 2456582.932 | 29.54 | 208.8 | 23.8 ^{+0.2} | ... | 29.3 ^{+0.2} | ... | ... | 5.41 ^{+0.04} | S |
| ... | 6761 | 4564 | 249 | 2456586.926 | 25.04 | 193.0 | 23.1 ^{+0.1} | ... | 32.1 ^{+0.8} | ... | ... | 5.41 ^{+0.02} | S |
| 2M06154934-0100415 | 6358 | 4123 | 181 | 2456202.997 | 27.01 | 18.0 | -19.5 ^{+0.2} | -19.7 ^{+0.2} | 33.0 ^{+0.1} | ... | ... | 5.38 ^{+0.02} | S |
| ... | 6358 | 4123 | 57 | 2456206.003 | 26.81 | 11.3 | -19.6 ^{+0.4} | ... | 16.3 ^{+0.2} | 16.6 ^{+1.4} | 2335.6 ^{+18.5} | 5.5 ^{+0.0} | S |
| ... | 6358 | 4123 | 288 | 2456206.993 | 26.77 | 17.1 | -19.8 ^{+0.1} | ... | 17.3 ^{+0.3} | ... | 2396.4 ^{+6.5} | 5.5 ^{+0.0} | S |
| ... | 6358 | 4123 | 58 | 2456209.985 | 26.52 | 17.7 | -19.8 ^{+0.2} | ... | 16.3 ^{+0.3} | ... | ... | 5.5 ^{+0.0} | S |
| ... | 6358 | 4123 | 186 | 2456233.931 | 21.93 | 28.4 | -19.5 ^{+0.2} | ... | 15.8 ^{+0.4} | ... | ... | 5.5 ^{+0.0} | S |
| 2M06521977-2534505 | 6333 | 4292 | 73 | 2456235.942 | 21.32 | 26.3 | -19.9 ^{+0.2} | 14.9 ^{+0.2} | 16.5 ^{+0.9} | < 10 | 2399.5 ^{+0.8} | 5.5 ^{+0.0} | S |
| ... | 6333 | 4292 | 73 | 2456228.989 | 18.93 | 30.9 | 14.8 ^{+0.1} | ... | 8.0 ^{+1.2} | ... | 2399.4 ^{+0.5} | 5.5 ^{+0.0} | S |
| ... | 6333 | 4292 | 73 | 2456232.983 | 18.46 | 42.1 | 14.8 ^{+0.1} | ... | 7.8 ^{+0.4} | ... | ... | 5.5 ^{+0.0} | S |
| ... | 6333 | 4292 | 73 | 2456264.875 | 11.83 | 25.7 | 15.2 ^{+0.1} | ... | 9.2 ^{+0.3} | ... | ... | 5.5 ^{+0.0} | S |
| 2M07025026-6102482 | 12298 | 7067 | 179 | 2458884.720 | 1.09 | 84.5 | 21.3 ^{+0.1} | 21.3 ^{+0.1} | 16.0 ^{+0.1} | 16.0 ^{+0.1} | 2399.8 ^{+0.3} | 4.07 ^{+0.02} | S |
| 2M07140394+3702459 | 5586 | 4221 | 62 | 2455881.005 | 22.79 | 64.0 | 35.3 ^{+0.1} | 35.3 ^{+0.2} | ... | < 10 | 2399.6 ^{+0.3} | 5.5 ^{+0.0} | S |
| ... | 5586 | 4221 | 62 | 2455939.845 | -3.70 | 39.7 | 35.2 ^{+0.1} | ... | 7.4 ^{+0.2} | ... | 2399.5 ^{+0.2} | 5.5 ^{+0.0} | S |
| ... | 5586 | 4221 | 62 | 2455960.754 | -13.78 | 54.4 | 35.8 ^{+0.2} | ... | ... | ... | ... | 5.5 ^{+0.0} | S |
| 2M07464256+2000321 | 9492 | 2406 | 290 | 2457783.744 | -7.73 | 85.4 | 52.7 ^{+0.2} | 52.8 ^{+0.1} | 34.7 ^{+1.0} | 34.6 ^{+1.0} | 2380.9 ^{+12.8} | 5.5 ^{+0.0} | S |
| ... | 9497 | 2411 | 113 | 2457786.730 | -9.23 | 86.7 | 52.8 ^{+0.1} | 7.4 ^{+0.7} | 33.0 ^{+0.2} | ... | 2368.4 ^{+7.1} | 5.5 ^{+0.0} | S |
| 2M07474757+6653337 | 9515 | 5246 | 246 | 2457735.959 | 8.18 | 15.7 | 8.2 ^{+0.2} | ... | 44.2 ^{+0.5} | ... | 2399.1 ^{+0.1} | 4.62 ^{+0.02} | S |
| ... | 9515 | 5246 | 294 | 2457742.880 | 5.80 | 17.2 | 7.2 ^{+0.4} | ... | 46.0 ^{+1.1} | ... | ... | 4.75 ^{+0.04} | S |
| ... | 9539 | 5246 | 210 | 2457761.839 | -1.28 | 11.9 | 4.7 ^{+0.6} | ... | 49.9 ^{+3.3} | ... | 2399.3 ^{+0.5} | 4.68 ^{+0.02} | S |
| ... | 9515 | 5246 | 246 | 2457789.758 | -11.15 | 22.3 | 7.2 ^{+0.3} | ... | 40.8 ^{+0.5} | ... | ... | 4.46 ^{+0.04} | S |
| ... | 9515 | 5246 | 205 | 2457793.801 | -12.45 | 10.1 | 7.6 ^{+0.7} | ... | 40.8 ^{+0.5} | ... | ... | 4.82 ^{+0.02} | S |
| ... | 9539 | 5246 | 204 | 2457708.002 | 16.46 | 12.2 | 8.6 ^{+0.1} | 7.4 ^{+0.7} | 57.3 ^{+1.7} | ... | 2398.9 ^{+1.2} | 3.57 ^{+0.05} | S |
| ... | 9539 | 5246 | 204 | 2457795.722 | -12.95 | 13.5 | 6.6 ^{+0.3} | ... | 45.3 ^{+0.8} | ... | ... | 4.58 ^{+0.02} | S |
| ... | 9539 | 5246 | 210 | 2457821.654 | -18.96 | 14.4 | 8.7 ^{+0.4} | ... | 43.7 ^{+0.7} | ... | ... | 4.66 ^{+0.03} | S |
| ... | 9539 | 5246 | 162 | 2457825.630 | -19.54 | 22.7 | 8.1 ^{+0.9} | ... | 44.2 ^{+0.5} | ... | ... | 4.87 ^{+0.05} | S |
| 9666 | 5246 | 245 | 2457827.608 | -19.79 | 18.5 | 17.2 | 7.7 ^{+0.3} | ... | 44.6 ^{+0.2} | ... | ... | 4.76 ^{+0.02} | S |
| 9666 | 5246 | 205 | 2457878.628 | -18.37 | 16.7 | 16.7 | 8.0 ^{+0.9} | ... | 46.8 ^{+0.8} | ... | ... | 4.64 ^{+0.02} | S |
| ... | 9666 | 5246 | 245 | 2458054.982 | 19.85 | 14.0 | 7.1 ^{+0.6} | ... | 44.2 ^{+0.8} | ... | ... | 4.57 ^{+0.07} | S |
| ... | 9666 | 5246 | 242 | 2458067.965 | 17.67 | 17.4 | 8.1 ^{+0.3} | ... | 43.9 ^{+1.2} | ... | ... | 4.69 ^{+0.04} | S |
| ... | 9666 | 5246 | 199 | 2458097.019 | 9.57 | 18.1 | 6.0 ^{+0.7} | ... | 47.8 ^{+0.6} | ... | ... | 4.66 ^{+0.05} | S |
| ... | 9666 | 5246 | 242 | 2458097.886 | 9.40 | 15.7 | 7.2 ^{+0.2} | ... | 46.4 ^{+0.9} | ... | ... | 4.6 ^{+0.02} | S |
| ... | 9666 | 5246 | 241 | 2458123.962 | -0.19 | 22.4 | 8.0 ^{+0.6} | ... | 44.8 ^{+0.9} | ... | ... | 4.6 ^{+0.02} | S |
| ... | 9726 | 5246 | 241 | 2458126.947 | -1.30 | 15.2 | 7.1 ^{+0.6} | ... | 48.5 ^{+0.6} | ... | ... | 4.37 ^{+0.03} | S |
| 2M07552256+2755318 | 8986 | 2337 | 18 | 2458072.998 | 26.28 | 16.6 | -3.8 ^{+0.2} | -3.9 ^{+0.3} | 10.8 ^{+1.4} | < 10 | 2399.4 ^{+0.5} | 4.78 ^{+0.02} | S |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate | Loc. ID | Fiber | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | v sin i (km s ⁻¹) ^{b,c} | Z _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M _d ^d |
|--------------------|-------|---------|-------|-------------|--|-------|--------------------------------------|---|--|--|--|--|--|-----------------------------|
| ... | 8986 | 2337 | 18 | 2458074.877 | 26.05 | 27.6 | -3.7 ^{+0.2} _{-0.2} | ... | 7.3 ^{+0.6} _{-0.3} | 2399.3 ^{+0.7} _{-0.6} | ... | 4.93 ^{+0.02} _{-0.02} | ... | S |
| ... | 8986 | 2337 | 18 | 2458077.997 | 24.94 | 28.7 | -4.4 ^{+0.2} _{-0.2} | ... | 9.2 ^{+0.3} _{-0.3} | 2399.5 ^{+0.4} _{-0.4} | ... | 4.87 ^{+0.03} _{-0.03} | ... | S |
| 2M07564895+6649595 | 9539 | 5246 | 179 | 2457708.002 | 16.69 | 10.4 | 0.2 ^{+0.4} _{-0.4} | 0.0 ^{+0.4} _{-0.4} | 10.7 ^{+1.0} _{-1.0} | 2399.0 ^{+1.5} _{-1.5} | 2399.4 ^{+0.2} _{-0.2} | 3.64 ^{+0.04} _{-0.06} | 4.04 ^{+0.19} _{-0.15} | S |
| ... | 9515 | 5246 | 176 | 2457735.959 | 8.57 | 15.0 | 0.1 ^{+0.3} _{-0.3} | ... | 10.6 ^{+0.6} _{-0.6} | 2399.3 ^{+0.6} _{-0.6} | ... | 4.08 ^{+0.04} _{-0.04} | ... | S |
| ... | 9515 | 5246 | 155 | 2457742.880 | 6.22 | 17.3 | -0.1 ^{+0.2} _{-0.2} | ... | 10.9 ^{+0.4} _{-0.4} | 2399.5 ^{+0.8} _{-0.8} | ... | 4.12 ^{+0.03} _{-0.03} | ... | S |
| ... | 9539 | 5246 | 260 | 2457761.839 | -0.82 | 12.0 | 0.1 ^{+0.3} _{-0.3} | ... | 10.8 ^{+0.4} _{-0.4} | 2399.3 ^{+1.1} _{-1.1} | ... | 3.6 ^{+0.06} _{-0.06} | ... | S |
| ... | 9515 | 5246 | 176 | 2457789.758 | -10.72 | 22.4 | 0.2 ^{+0.2} _{-0.2} | ... | 10.6 ^{+0.2} _{-0.2} | 2399.6 ^{+0.6} _{-0.6} | ... | 4.09 ^{+0.03} _{-0.03} | ... | S |
| ... | 9539 | 5246 | 179 | 2457795.722 | -12.54 | 13.3 | 0.6 ^{+0.2} _{-0.2} | ... | 10.7 ^{+0.8} _{-0.8} | 2399.4 ^{+0.4} _{-0.4} | ... | 3.91 ^{+0.05} _{-0.05} | ... | S |
| ... | 9539 | 5246 | 161 | 2457821.654 | -18.69 | 13.1 | 0.6 ^{+0.2} _{-0.2} | ... | 12.4 ^{+0.5} _{-0.5} | 2399.3 ^{+0.5} _{-0.5} | ... | 3.56 ^{+0.04} _{-0.04} | ... | S |
| ... | 9539 | 5246 | 266 | 2457825.630 | -19.30 | 20.6 | 0.6 ^{+0.2} _{-0.2} | ... | 10.5 ^{+0.2} _{-0.2} | 2399.5 ^{+0.7} _{-0.7} | ... | 4.11 ^{+0.03} _{-0.03} | ... | S |
| ... | 9666 | 5246 | 259 | 2457827.608 | -19.56 | 18.6 | 1.1 ^{+0.2} _{-0.2} | ... | 11.7 ^{+0.5} _{-0.5} | 2399.5 ^{+0.4} _{-0.4} | ... | 3.93 ^{+0.07} _{-0.07} | ... | S |
| ... | 9726 | 5246 | 163 | 2457878.628 | -18.53 | 15.6 | 0.4 ^{+0.5} _{-0.5} | ... | 10.6 ^{+0.2} _{-0.2} | 2399.5 ^{+0.8} _{-0.8} | ... | 4.05 ^{+0.03} _{-0.03} | ... | S |
| ... | 9666 | 5246 | 270 | 2458054.982 | 19.96 | 13.4 | -0.2 ^{+0.2} _{-0.2} | ... | 10.9 ^{+0.5} _{-0.5} | 2399.0 ^{+1.5} _{-1.5} | ... | 3.88 ^{+0.02} _{-0.02} | ... | S |
| ... | 9666 | 5246 | 175 | 2458059.998 | 19.24 | 14.2 | 0.1 ^{+0.3} _{-0.3} | ... | 10.1 ^{+0.4} _{-0.4} | 2399.3 ^{+0.9} _{-0.9} | ... | 4.1 ^{+0.05} _{-0.05} | ... | S |
| ... | 9666 | 5246 | 175 | 2458067.965 | 17.87 | 19.4 | 0.1 ^{+0.3} _{-0.3} | ... | 9.8 ^{+0.2} _{-0.2} | 2399.2 ^{+0.6} _{-0.6} | ... | 4.18 ^{+0.02} _{-0.02} | ... | S |
| ... | 9726 | 5246 | 175 | 2458097.019 | 9.95 | 14.2 | -0.4 ^{+0.3} _{-0.3} | ... | 10.8 ^{+0.6} _{-0.6} | 2399.3 ^{+0.5} _{-0.5} | ... | 3.74 ^{+0.06} _{-0.06} | ... | S |
| ... | 9666 | 5246 | 259 | 2458097.886 | 9.78 | 20.7 | -0.5 ^{+0.2} _{-0.2} | ... | 10.6 ^{+0.2} _{-0.2} | 2399.6 ^{+0.6} _{-0.6} | ... | 4.11 ^{+0.03} _{-0.03} | ... | S |
| ... | 9726 | 5246 | 180 | 2458123.962 | 0.27 | 22.3 | 0.0 ^{+0.2} _{-0.2} | ... | 10.7 ^{+0.4} _{-0.4} | 2399.6 ^{+0.3} _{-0.3} | ... | 4.12 ^{+0.05} _{-0.05} | ... | S |
| ... | 9726 | 5246 | 180 | 2458126.947 | -0.84 | 15.7 | 0.2 ^{+0.2} _{-0.2} | ... | 9.9 ^{+0.2} _{-0.2} | 2399.3 ^{+1.0} _{-1.0} | ... | 4.09 ^{+0.02} _{-0.02} | ... | S |
| 2M08072607+3213101 | 10220 | 2473 | 43 | 2458130.771 | 2.99 | 32.4 | 34.4 ^{+0.1} _{-0.1} | 34.4 ^{+0.2} _{-0.2} | 12.4 ^{+0.4} _{-0.4} | 2398.4 ^{+2.0} _{-2.0} | 2399.1 ^{+0.6} _{-0.6} | 5.5 ^{+0.0} _{-0.0} | 5.5 ^{+0.0} _{-0.0} | S |
| ... | 10220 | 2473 | 43 | 2458138.702 | -1.05 | 31.4 | 34.4 ^{+0.1} _{-0.1} | ... | 14.3 ^{+0.3} _{-0.3} | 2399.2 ^{+1.2} _{-1.2} | ... | 5.5 ^{+0.01} _{-0.01} | ... | S |
| ... | 10220 | 2473 | 43 | 2458142.686 | -3.10 | 30.3 | 34.2 ^{+0.1} _{-0.1} | ... | 14.2 ^{+0.3} _{-0.3} | 2399.1 ^{+1.0} _{-1.0} | ... | 5.5 ^{+0.0} _{-0.0} | ... | S |
| ... | 10220 | 2473 | 43 | 2458143.869 | -4.07 | 30.5 | 34.8 ^{+0.2} _{-0.2} | ... | 13.5 ^{+0.4} _{-0.4} | 2399.1 ^{+0.6} _{-0.6} | ... | 5.5 ^{+0.0} _{-0.0} | ... | S |
| ... | 10220 | 2473 | 139 | 2458130.771 | 3.09 | 16.3 | 30.2 ^{+0.3} _{-0.3} | 30.6 ^{+0.3} _{-0.3} | 14.0 ^{+1.1} _{-1.1} | 2398.8 ^{+1.8} _{-1.8} | 2399.0 ^{+0.7} _{-0.7} | 5.29 ^{+0.05} _{-0.05} | 5.35 ^{+0.03} _{-0.02} | S |
| ... | 10220 | 2473 | 139 | 2458138.702 | -0.95 | 18.1 | 31.0 ^{+0.1} _{-0.1} | ... | 14.5 ^{+0.3} _{-0.3} | 2398.8 ^{+1.3} _{-1.3} | 2399.0 ^{+0.4} _{-0.4} | 5.34 ^{+0.05} _{-0.05} | ... | S |
| ... | 10220 | 2473 | 139 | 2458142.686 | -3.01 | 16.0 | 30.4 ^{+0.1} _{-0.1} | ... | 12.7 ^{+0.4} _{-0.4} | 2399.0 ^{+1.0} _{-1.0} | ... | 5.36 ^{+0.05} _{-0.05} | ... | S |
| ... | 10220 | 2473 | 139 | 2458143.869 | -3.98 | 17.8 | 30.4 ^{+0.3} _{-0.3} | ... | 11.9 ^{+0.2} _{-0.2} | 2399.2 ^{+0.6} _{-0.6} | ... | 5.36 ^{+0.02} _{-0.02} | ... | S |
| 2M08092892+3235226 | 10220 | 2473 | 31 | 2458130.771 | 3.17 | 14.5 | -7.4 ^{+0.2} _{-0.2} | -6.7 ^{+0.6} _{-0.6} | 23.6 ^{+1.7} _{-1.7} | 2399.3 ^{+0.5} _{-0.5} | 2399.3 ^{+0.3} _{-0.3} | 4.37 ^{+0.04} _{-0.04} | 4.37 ^{+0.03} _{-0.03} | S |
| ... | 10220 | 2473 | 31 | 2458138.702 | -0.86 | 13.8 | -6.1 ^{+0.2} _{-0.2} | ... | 23.5 ^{+1.4} _{-1.4} | 2399.4 ^{+0.9} _{-0.9} | ... | 4.36 ^{+0.03} _{-0.03} | ... | S |
| ... | 10220 | 2473 | 31 | 2458142.686 | -2.91 | 13.3 | -6.5 ^{+0.2} _{-0.2} | ... | 24.9 ^{+0.6} _{-0.6} | 2399.4 ^{+0.4} _{-0.4} | ... | 4.43 ^{+0.01} _{-0.01} | ... | S |
| ... | 10220 | 2473 | 31 | 2458143.869 | -3.88 | 13.2 | -7.0 ^{+0.3} _{-0.3} | ... | 17.6 ^{+0.2} _{-0.2} | 2399.1 ^{+1.3} _{-1.3} | ... | 4.42 ^{+0.08} _{-0.08} | ... | S |
| 2M08144389+4650522 | 10495 | 2469 | 120 | 2458546.687 | -19.74 | 38.4 | 23.7 ^{+0.6} _{-0.6} | 24.4 ^{+0.5} _{-0.5} | 17.9 ^{+1.0} _{-1.0} | 2399.2 ^{+1.5} _{-1.5} | 2399.3 ^{+0.8} _{-0.8} | 5.06 ^{+0.04} _{-0.04} | 5.06 ^{+0.02} _{-0.02} | S |
| ... | 10495 | 2469 | 120 | 2458547.653 | -19.99 | 40.5 | 24.6 ^{+0.6} _{-0.6} | ... | 17.9 ^{+0.1} _{-0.1} | 2399.3 ^{+1.2} _{-1.2} | ... | 5.05 ^{+0.03} _{-0.03} | ... | S |
| 2M08185804+2335322 | 8939 | 2318 | 7 | 2457484.651 | -28.66 | 29.4 | 36.0 ^{+0.1} _{-0.1} | 35.7 ^{+0.3} _{-0.3} | 7.3 ^{+0.6} _{-0.6} | 2399.2 ^{+1.3} _{-1.3} | 2399.2 ^{+0.6} _{-0.6} | 5.42 ^{+0.02} _{-0.02} | 5.39 ^{+0.12} _{-0.12} | S |
| ... | 8939 | 2318 | 7 | 2457485.642 | -28.77 | 25.9 | 36.0 ^{+0.3} _{-0.3} | ... | 8.5 ^{+0.8} _{-0.8} | 2399.7 ^{+1.0} _{-1.0} | ... | 5.36 ^{+0.03} _{-0.03} | ... | S |
| ... | 8939 | 2318 | 7 | 2457488.617 | -29.06 | 22.4 | 35.5 ^{+0.1} _{-0.1} | ... | 10.7 ^{+0.3} _{-0.3} | 2399.3 ^{+0.8} _{-0.8} | ... | 5.23 ^{+0.02} _{-0.02} | ... | S |
| ... | 10219 | 2472 | 300 | 2458107.876 | 16.47 | 30.1 | 36.1 ^{+0.2} _{-0.2} | ... | 7.3 ^{+0.7} _{-0.7} | 2399.2 ^{+0.6} _{-0.6} | ... | 5.48 ^{+0.01} _{-0.01} | ... | S |
| 2M08211639+5658358 | 10492 | 2466 | 157 | 2458191.636 | -20.71 | 22.1 | 7.1 ^{+0.2} _{-0.2} | 7.2 ^{+0.2} _{-0.2} | 10.7 ^{+0.6} _{-0.6} | 2399.4 ^{+0.9} _{-0.9} | 2399.5 ^{+0.5} _{-0.5} | 5.19 ^{+0.03} _{-0.03} | 4.96 ^{+0.15} _{-0.14} | S |
| ... | 10492 | 2466 | 157 | 2458196.700 | -21.79 | 18.0 | 6.8 ^{+0.3} _{-0.3} | ... | 14.2 ^{+0.1} _{-0.1} | 2399.4 ^{+0.7} _{-0.7} | ... | 4.85 ^{+0.03} _{-0.03} | ... | S |
| ... | 10492 | 2466 | 157 | 2458197.594 | -21.80 | 16.9 | 6.8 ^{+0.3} _{-0.3} | ... | 14.2 ^{+0.2} _{-0.2} | 2399.6 ^{+0.3} _{-0.3} | ... | 4.96 ^{+0.04} _{-0.04} | ... | S |
| 2M08294949+2646348 | 9507 | 2421 | 226 | 2457830.640 | -23.73 | 126.8 | 10.8 ^{+0.1} _{-0.1} | 10.7 ^{+0.3} _{-0.3} | 10.6 ^{+0.2} _{-0.2} | 2399.1 ^{+1.3} _{-1.3} | 2399.4 ^{+0.3} _{-0.3} | 5.5 ^{+0.0} _{-0.0} | 5.49 ^{+0.02} _{-0.01} | S |
| ... | 9508 | 2422 | 154 | 2457833.643 | -24.63 | 144.0 | 10.6 ^{+0.1} _{-0.1} | ... | 12.1 ^{+0.1} _{-0.1} | 2399.5 ^{+0.6} _{-0.6} | ... | 5.48 ^{+0.01} _{-0.01} | ... | S |
| ... | 9508 | 2422 | 154 | 2457834.610 | -24.83 | 115.4 | 10.4 ^{+0.1} _{-0.1} | ... | 11.7 ^{+0.1} _{-0.1} | 2399.4 ^{+0.4} _{-0.4} | ... | 5.49 ^{+0.03} _{-0.01} | ... | S |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate ID | Loc. ID | Fiber ID | JD (day) | bury ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | v sin i (km s ⁻¹) | (v sin i) ^{b,c} (km s ⁻¹) | Z _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M _d ^d |
|--------------------|----------|---------|----------|-------------|---|-------|--------------------------|---|-------------------------------|--|-------------------------|--------------------------------------|-----------------------------|--|-----------------------------|
| ... | 9510 | 2424 | 141 | 2457860.640 | -29.30 | 30.0 | 11.1 ^{+0.1} | ... | 10.9 ^{+0.5} | ... | 2399.1 ^{+1.4} | ... | 5.43 ^{+0.02} | ... | S |
| ... | 9510 | 2424 | 141 | 2457861.640 | -29.36 | 29.1 | 11.2 ^{+0.2} | ... | 12.4 ^{+0.6} | ... | 2398.9 ^{+1.7} | ... | 5.42 ^{+0.04} | ... | S |
| 2M08440350+0434356 | 10511 | 2485 | 276 | 2458198.659 | -21.33 | 23.9 | 66.0 ^{+0.3} | 66.7 ^{+0.5} | 16.1 ^{+0.2} | 16.2 ^{+1.0} | 2399.0 ^{+0.8} | 2399.0 ^{+0.8} | 5.49 ^{+0.01} | 5.49 ^{+0.01} | S |
| ... | 10511 | 2485 | 276 | 2458211.626 | -20.58 | 12.6 | 67.0 ^{+0.2} | ... | 16.3 ^{+0.7} | ... | 2399.2 ^{+1.6} | ... | 5.49 ^{+0.01} | ... | S |
| 2M08490052+0220155 | 10511 | 2485 | 150 | 2458198.659 | -25.01 | 31.3 | 22.5 ^{+0.2} | 22.4 ^{+0.4} | 53.3 ^{+0.6} | 53.7 ^{+1.7} | 2399.2 ^{+1.2} | 2399.2 ^{+1.2} | 5.07 ^{+0.02} | 4.99 ^{+0.23} | S |
| ... | 10511 | 2485 | 150 | 2458200.654 | -21.18 | 10.6 | 21.4 ^{+1.6} | ... | 64.6 ^{+1.7} | ... | 2398.9 ^{+1.6} | ... | 3.6 ^{+0.09} | ... | S |
| ... | 10511 | 2485 | 145 | 2458211.626 | -24.40 | 18.4 | 22.8 ^{+0.2} | ... | 56.8 ^{+3.0} | ... | 2398.8 ^{+1.4} | ... | 4.9 ^{+0.04} | ... | S |
| ... | 10839 | 2497 | 276 | 2458572.628 | -23.24 | 26.3 | 23.5 ^{+0.3} | ... | 53.5 ^{+0.8} | ... | 2399.2 ^{+1.3} | ... | 5.13 ^{+0.02} | ... | S |
| ... | 10839 | 2497 | 276 | 2458573.625 | -23.52 | 15.0 | 21.3 ^{+0.4} | ... | 55.7 ^{+1.3} | ... | 2398.9 ^{+1.5} | ... | 4.83 ^{+0.03} | ... | S |
| ... | 10839 | 2497 | 276 | 2458575.639 | -24.12 | 28.0 | 22.2 ^{+0.4} | ... | 50.9 ^{+0.9} | ... | 2399.4 ^{+0.9} | ... | 5.08 ^{+0.02} | ... | S |
| ... | 10839 | 2497 | 276 | 2458576.685 | -24.51 | 19.5 | 22.2 ^{+0.2} | ... | 54.0 ^{+0.9} | ... | 2399.2 ^{+1.6} | ... | 5.1 ^{+0.03} | ... | S |
| ... | 10839 | 2497 | 276 | 2458577.670 | -24.73 | 17.6 | 22.3 ^{+0.2} | ... | 55.4 ^{+1.3} | ... | 2399.1 ^{+1.5} | ... | 4.85 ^{+0.02} | ... | S |
| ... | 10839 | 2497 | 276 | 2458578.678 | -25.01 | 21.9 | 21.5 ^{+0.3} | ... | 51.8 ^{+1.1} | ... | 2399.3 ^{+1.0} | ... | 5.1 ^{+0.05} | ... | S |
| 2M08501918+1056436 | 5564 | 4162 | 105 | 2455903.978 | 24.72 | 81.8 | 31.5 ^{+0.2} | 31.4 ^{+0.4} | 19.8 ^{+0.3} | 17.9 ^{+1.1} | 3140.2 ^{+14.0} | 3140.2 ^{+14.0} | 5.43 ^{+0.02} | 5.3 ^{+0.07} | B |
| ... | 5564 | 4162 | 94 | 2455930.889 | 14.41 | 73.1 | 32.3 ^{+0.1} | ... | 17.2 ^{+0.9} | ... | 3128.3 ^{+4.6} | ... | 5.36 ^{+0.02} | ... | B |
| ... | 5564 | 4162 | 99 | 2455934.880 | 12.53 | 93.4 | 32.2 ^{+0.1} | ... | 18.1 ^{+0.8} | ... | 3115.9 ^{+2.8} | ... | 5.42 ^{+0.02} | ... | B |
| ... | 7269 | 4162 | 93 | 2456650.992 | 18.80 | 110.6 | 31.3 ^{+0.1} | ... | 17.8 ^{+0.4} | ... | 3153.4 ^{+6.4} | ... | 5.36 ^{+0.02} | ... | B |
| ... | 7270 | 4162 | 93 | 2456652.000 | 18.37 | 98.9 | 30.9 ^{+0.2} | ... | 18.1 ^{+0.6} | ... | 3147.3 ^{+6.4} | ... | 5.34 ^{+0.03} | ... | B |
| ... | 7267 | 4162 | 106 | 2456654.922 | 17.30 | 89.9 | 31.6 ^{+0.1} | ... | 18.0 ^{+0.2} | ... | 3156.2 ^{+3.7} | ... | 5.34 ^{+0.02} | ... | B |
| ... | 7267 | 4162 | 99 | 2456668.864 | 10.87 | 81.2 | 31.2 ^{+0.2} | ... | 16.3 ^{+0.7} | ... | 3148.2 ^{+1.1} | ... | 5.37 ^{+0.02} | ... | B |
| ... | 7269 | 4162 | 94 | 2456671.924 | 9.20 | 76.4 | 31.0 ^{+0.1} | ... | 18.0 ^{+0.3} | ... | 3149.5 ^{+3.0} | ... | 5.3 ^{+0.02} | ... | B |
| ... | 7268 | 4162 | 142 | 2456672.858 | 8.88 | 77.7 | 30.8 ^{+0.1} | ... | 16.3 ^{+0.3} | ... | 3157.1 ^{+1.7} | ... | 5.34 ^{+0.02} | ... | B |
| ... | 7268 | 4162 | 142 | 2456677.875 | 6.26 | 86.8 | 31.8 ^{+0.1} | ... | 16.2 ^{+0.4} | ... | 3156.1 ^{+3.2} | ... | 5.38 ^{+0.02} | ... | B |
| ... | 7269 | 4162 | 141 | 2456678.898 | 5.68 | 73.3 | 31.4 ^{+0.1} | ... | 18.0 ^{+0.2} | ... | 3131.5 ^{+2.8} | ... | 5.32 ^{+0.01} | ... | B |
| ... | 7267 | 4162 | 94 | 2456698.749 | -4.47 | 51.5 | 30.4 ^{+0.2} | ... | 18.1 ^{+0.4} | ... | 3140.6 ^{+6.2} | ... | 5.36 ^{+0.02} | ... | B |
| ... | 7268 | 4162 | 100 | 2456700.761 | -5.54 | 74.9 | 30.9 ^{+0.1} | ... | 18.2 ^{+0.3} | ... | 3130.9 ^{+6.5} | ... | 5.23 ^{+0.01} | ... | B |
| ... | 7270 | 4162 | 142 | 2456703.818 | -7.25 | 87.9 | 31.1 ^{+0.2} | ... | 17.8 ^{+0.5} | ... | 3148.2 ^{+1.7} | ... | 5.22 ^{+0.02} | ... | B |
| ... | 7269 | 4162 | 94 | 2456707.766 | -9.12 | 68.8 | 31.3 ^{+0.1} | ... | 18.0 ^{+0.3} | ... | 3132.9 ^{+3.0} | ... | 5.2 ^{+0.02} | ... | B |
| ... | 7269 | 4162 | 93 | 2456727.670 | -18.07 | 110.1 | 30.7 ^{+0.1} | ... | 18.0 ^{+0.1} | ... | 3136.4 ^{+3.5} | ... | 5.19 ^{+0.02} | ... | B |
| ... | 7268 | 4162 | 141 | 2456734.662 | -20.76 | 75.8 | 31.4 ^{+0.1} | ... | 18.0 ^{+0.3} | ... | 3157.5 ^{+2.8} | ... | 5.24 ^{+0.02} | ... | B |
| ... | 7269 | 4162 | 141 | 2456759.687 | -27.76 | 60.6 | 31.8 ^{+0.1} | ... | 18.0 ^{+0.2} | ... | 3150.2 ^{+8.6} | ... | 5.21 ^{+0.03} | ... | B |
| ... | 7269 | 4162 | 141 | 2456761.703 | -28.13 | 73.9 | 31.7 ^{+0.1} | ... | 17.9 ^{+0.3} | ... | 3161.1 ^{+3.5} | ... | 5.23 ^{+0.02} | ... | B |
| ... | 7268 | 4162 | 142 | 2456762.633 | -28.12 | 83.5 | 31.6 ^{+0.1} | ... | 17.7 ^{+0.8} | ... | 3153.9 ^{+4.4} | ... | 5.28 ^{+0.02} | ... | B |
| ... | 7269 | 4162 | 93 | 2456765.617 | -28.51 | 74.7 | 31.2 ^{+0.2} | ... | 19.7 ^{+0.5} | ... | 3127.2 ^{+4.8} | ... | 5.23 ^{+0.02} | ... | B |
| ... | 7270 | 4162 | 147 | 2456787.631 | -29.34 | 82.5 | 31.9 ^{+0.1} | ... | 18.2 ^{+0.2} | ... | 3158.6 ^{+3.1} | ... | 5.25 ^{+0.03} | ... | B |
| ... | 10424 | 5653 | 227 | 2458183.562 | -15.64 | 86.0 | 31.4 ^{+0.1} | ... | 17.9 ^{+0.1} | ... | 3155.3 ^{+3.1} | ... | 5.26 ^{+0.02} | ... | B |
| 2M08522464+2540591 | 9500 | 2414 | 258 | 2457831.660 | -22.36 | 83.3 | 29.6 ^{+0.2} | 29.6 ^{+0.2} | 9.2 ^{+0.6} | < 10 | 2399.5 ^{+0.4} | 2399.5 ^{+0.4} | 5.35 ^{+0.03} | 5.35 ^{+0.02} | S |
| 2M09020690+0033195 | 12511 | 2812 | 133 | 2458895.785 | -4.21 | 23.0 | 42.5 ^{+0.3} | 42.6 ^{+0.3} | 9.0 ^{+0.4} | < 10 | 2399.3 ^{+0.8} | 2399.3 ^{+0.8} | 4.91 ^{+0.03} | 4.78 ^{+0.14} | S |
| ... | 12511 | 2812 | 133 | 2458896.700 | -4.48 | 12.2 | 42.8 ^{+0.2} | ... | 13.3 ^{+1.3} | ... | 2399.3 ^{+0.5} | ... | 4.63 ^{+0.02} | ... | S |
| ... | 11749 | 2662 | 115 | 2458866.787 | 7.41 | 16.4 | 52.0 ^{+0.2} | 51.8 ^{+0.6} | 9.3 ^{+0.7} | < 10 | 3076.4 ^{+1.6} | 3047.7 ^{+41.6} | 5.49 ^{+0.02} | 5.44 ^{+0.09} | B |
| ... | 11749 | 2662 | 115 | 2458867.778 | 6.92 | 22.7 | 51.5 ^{+0.2} | ... | 7.6 ^{+0.7} | ... | 3080.5 ^{+6.6} | ... | 5.48 ^{+0.01} | ... | B |
| ... | 11749 | 2662 | 115 | 2458872.787 | 4.34 | 15.3 | 51.9 ^{+0.3} | ... | 10.2 ^{+1.1} | ... | 3068.2 ^{+13.9} | ... | 5.4 ^{+0.04} | ... | B |
| ... | 11748 | 2661 | 217 | 2458874.791 | 3.30 | 11.1 | 51.6 ^{+0.3} | ... | 9.1 ^{+0.7} | ... | 3078.7 ^{+14.6} | ... | 5.46 ^{+0.03} | ... | B |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate | Loc. ID | Fiber ID | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | vsini ⁱ (km s ⁻¹) | (v sin i) ^{b,c} (km s ⁻¹) | T _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M _d ^d |
|--------------------|-------|---------|----------|-------------|--|------|--------------------------|---|--|--|-------------------------|--------------------------------------|-----------------------------|--|-----------------------------|
| ... | 11748 | 2661 | 217 | 2458923.625 | -19.44 | 12.3 | 51.8 ^{+0.2} | ... | 6.5 ^{+1.5} | ... | 3087.5 ^{+16.9} | ... | 5.47 ^{+0.03} | ... | B |
| ... | 12487 | 2788 | 293 | 2458924.631 | -19.83 | 18.8 | 51.1 ^{+0.2} | ... | 9.3 ^{+0.7} | ... | 3075.5 ^{+16.3} | ... | 5.31 ^{+0.03} | ... | B |
| ... | 12487 | 2788 | 293 | 2458925.620 | -20.16 | 22.1 | 52.6 ^{+0.1} | ... | 10.8 ^{+0.4} | ... | 2952.4 ^{+8.7} | ... | 5.28 ^{+0.02} | ... | B |
| ... | 12487 | 2788 | 293 | 2458928.783 | -21.60 | 14.3 | 51.9 ^{+0.2} | ... | 10.8 ^{+0.9} | ... | 3017.1 ^{+11.2} | ... | 5.38 ^{+0.03} | ... | B |
| 2M09373349+5334057 | 8911 | 5179 | 174 | 2457435.783 | -8.43 | 15.9 | 1.3 ^{+0.2} | 0.7 ^{+0.5} | 19.8 ^{+0.1} | 19.4 ^{+2.9} | 2399.3 ^{+1.1} | 2399.4 ^{+0.2} | 4.58 ^{+0.04} | 4.64 ^{+0.26} | S |
| ... | 8911 | 5179 | 151 | 2457444.753 | -11.69 | 17.5 | 0.6 ^{+0.2} | ... | 17.9 ^{+0.2} | ... | 2399.3 ^{+0.5} | ... | 4.89 ^{+0.04} | ... | S |
| ... | 8911 | 5179 | 180 | 2457472.676 | -19.65 | 14.6 | 0.9 ^{+0.4} | ... | 16.0 ^{+1.1} | ... | 2399.3 ^{+1.0} | ... | 4.67 ^{+0.02} | ... | S |
| ... | 8911 | 5179 | 151 | 2457493.620 | -22.65 | 21.1 | 0.4 ^{+0.5} | ... | 15.1 ^{+0.9} | ... | 2399.3 ^{+0.9} | ... | 4.92 ^{+0.07} | ... | S |
| ... | 9540 | 5179 | 38 | 2457707.016 | 22.51 | 10.9 | 4.5 ^{+0.4} | ... | 21.6 ^{+0.8} | ... | 2398.2 ^{+1.3} | ... | 3.94 ^{+0.03} | ... | S |
| ... | 9540 | 5179 | 38 | 2457711.998 | 21.87 | 18.0 | 0.8 ^{+0.2} | ... | 23.5 ^{+1.8} | ... | 2399.5 ^{+0.8} | ... | 3.62 ^{+0.04} | ... | S |
| ... | 9541 | 5179 | 210 | 2457713.013 | 21.69 | 13.1 | 0.7 ^{+0.2} | ... | 19.8 ^{+0.2} | ... | 2399.5 ^{+0.4} | ... | 4.68 ^{+0.02} | ... | S |
| ... | 9540 | 5179 | 41 | 2457742.946 | 14.27 | 17.8 | 1.2 ^{+0.3} | ... | 17.9 ^{+1.3} | ... | 2399.3 ^{+0.7} | ... | 4.55 ^{+0.03} | ... | S |
| ... | 9540 | 5179 | 32 | 2457761.901 | 7.35 | 13.3 | 0.6 ^{+0.3} | ... | 19.6 ^{+0.7} | ... | 2399.6 ^{+0.2} | ... | 4.12 ^{+0.05} | ... | S |
| ... | 9541 | 5179 | 175 | 2457762.941 | 6.88 | 15.9 | 0.8 ^{+0.3} | ... | 16.3 ^{+0.9} | ... | 2399.3 ^{+1.0} | ... | 4.83 ^{+0.04} | ... | S |
| ... | 9540 | 5179 | 32 | 2457765.872 | 5.80 | 11.1 | -0.2 ^{+0.3} | ... | 23.5 ^{+1.6} | ... | 2399.5 ^{+0.7} | ... | 4.36 ^{+0.05} | ... | S |
| ... | 9541 | 5179 | 156 | 2457791.827 | -4.84 | 14.6 | 1.0 ^{+0.3} | ... | 16.1 ^{+0.3} | ... | 2399.2 ^{+1.6} | ... | 4.86 ^{+0.04} | ... | S |
| ... | 9541 | 5179 | 156 | 2457792.826 | -5.24 | 15.2 | -0.4 ^{+0.5} | ... | 21.7 ^{+0.2} | ... | 2399.2 ^{+0.9} | ... | 4.8 ^{+0.06} | ... | S |
| ... | 9541 | 5179 | 210 | 2457795.839 | -6.46 | 16.3 | 0.7 ^{+0.2} | ... | 17.9 ^{+0.3} | ... | 2399.2 ^{+0.9} | ... | 4.83 ^{+0.02} | ... | S |
| ... | 9541 | 5179 | 151 | 2457820.712 | -15.19 | 18.8 | 0.9 ^{+0.2} | ... | 18.0 ^{+0.1} | ... | 2399.5 ^{+1.0} | ... | 4.85 ^{+0.03} | ... | S |
| ... | 9689 | 5179 | 179 | 2457821.716 | -15.50 | 14.6 | 0.4 ^{+0.6} | ... | 25.4 ^{+1.8} | ... | 2399.4 ^{+0.4} | ... | 4.53 ^{+0.05} | ... | S |
| ... | 9689 | 5179 | 152 | 2457825.747 | -16.72 | 12.6 | -0.5 ^{+0.3} | ... | 33.1 ^{+1.4} | ... | 2399.2 ^{+0.2} | ... | 4.33 ^{+0.02} | ... | S |
| ... | 9689 | 5179 | 203 | 2457829.764 | -17.83 | 12.0 | 0.9 ^{+0.5} | ... | 21.7 ^{+0.3} | ... | 2399.3 ^{+0.9} | ... | 4.56 ^{+0.03} | ... | S |
| ... | 9689 | 5179 | 152 | 2457849.608 | -21.62 | 15.8 | 0.8 ^{+0.3} | ... | 23.7 ^{+1.8} | ... | 2399.2 ^{+0.5} | ... | 4.64 ^{+0.06} | ... | S |
| ... | 9689 | 5179 | 161 | 2458098.947 | 17.14 | 13.6 | 0.4 ^{+0.4} | ... | 23.5 ^{+1.8} | ... | 2399.2 ^{+1.1} | ... | 4.61 ^{+0.04} | ... | S |
| 2M09381783+0132490 | 10514 | 2488 | 108 | 2458115.966 | 22.47 | 27.2 | -16.5 ^{+0.8} | -16.8 ^{+1.5} | 61.8 ^{+1.7} | 96.1 ^{+3.5} | 3187.1 ^{+1.5} | 3193.5 ^{+15.6} | 5.32 ^{+0.05} | 5.29 ^{+0.11} | B |
| ... | 10514 | 2488 | 108 | 2458116.935 | 22.21 | 18.9 | -18.7 ^{+1.3} | ... | 99.6 ^{+0.6} | ... | 3172.6 ^{+20.6} | ... | 5.2 ^{+0.08} | ... | B |
| ... | 11752 | 2678 | 180 | 2458839.925 | 24.68 | 15.1 | -16.9 ^{+1.3} | ... | 49.7 ^{+1.4} | ... | 3182.5 ^{+17.2} | ... | 5.44 ^{+0.04} | ... | B |
| ... | 11752 | 2678 | 180 | 2458844.916 | 23.14 | 15.1 | -7.9 ^{+0.1} | ... | 99.3 ^{+0.5} | ... | 3211.8 ^{+18.1} | ... | 5.36 ^{+0.09} | ... | B |
| ... | 11752 | 2678 | 180 | 2458848.897 | 21.80 | 19.2 | -15.9 ^{+1.2} | ... | 97.1 ^{+0.7} | ... | 3167.5 ^{+15.4} | ... | 5.17 ^{+0.08} | ... | B |
| ... | 11759 | 2679 | 228 | 2458898.795 | -1.44 | 27.1 | -15.3 ^{+1.3} | ... | 99.4 ^{+0.5} | ... | 3201.8 ^{+16.5} | ... | 5.2 ^{+0.05} | ... | B |
| ... | 11759 | 2679 | 228 | 2458899.800 | -1.98 | 19.5 | -17.9 ^{+0.6} | ... | 44.0 ^{+1.1} | ... | 3216.9 ^{+13.4} | ... | 5.17 ^{+0.04} | ... | B |
| 2M09442625+3521233 | 11751 | 2660 | 37 | 2458566.610 | -19.84 | 22.5 | 51.1 ^{+0.3} | 51.2 ^{+0.9} | 14.6 ^{+1.4} | 13.8 ^{+1.7} | 2399.5 ^{+0.3} | 2399.6 ^{+0.2} | 4.41 ^{+0.02} | 4.8 ^{+0.24} | S |
| ... | 11751 | 2660 | 37 | 2458567.623 | -20.20 | 28.7 | 50.4 ^{+0.2} | ... | 10.9 ^{+0.5} | ... | 2399.1 ^{+1.1} | ... | 5.08 ^{+0.02} | ... | S |
| ... | 10838 | 2496 | 271 | 2458569.635 | -20.87 | 17.1 | 52.7 ^{+0.2} | ... | 14.3 ^{+0.5} | ... | 2399.1 ^{+1.0} | ... | 4.78 ^{+0.02} | ... | S |
| ... | 10838 | 2496 | 271 | 2458576.619 | -22.91 | 16.4 | 50.6 ^{+0.2} | ... | 15.7 ^{+0.3} | ... | 2399.1 ^{+0.6} | ... | 4.62 ^{+0.05} | ... | S |
| ... | 10838 | 2496 | 271 | 2458577.610 | -23.16 | 21.4 | 51.5 ^{+0.4} | ... | 14.2 ^{+0.3} | ... | 2399.4 ^{+0.9} | ... | 4.86 ^{+0.04} | ... | S |
| ... | 10838 | 2496 | 271 | 2458578.612 | -23.43 | 28.5 | 51.3 ^{+0.2} | ... | 14.4 ^{+0.3} | ... | 2399.7 ^{+0.2} | ... | 4.84 ^{+0.03} | ... | S |
| 2M09453388+5458511 | 8911 | 5179 | 61 | 2457435.783 | -7.79 | 13.4 | -3.4 ^{+0.5} | -3.7 ^{+0.7} | 25.4 ^{+0.7} | 23.5 ^{+1.4} | 2399.2 ^{+1.1} | 2399.2 ^{+0.4} | 4.81 ^{+0.03} | 4.81 ^{+0.08} | S |
| ... | 8911 | 5179 | 67 | 2457444.753 | -11.10 | 13.4 | -3.1 ^{+0.2} | ... | 21.9 ^{+0.3} | ... | 2399.4 ^{+0.5} | ... | 4.77 ^{+0.02} | ... | S |
| ... | 8911 | 5179 | 67 | 2457467.657 | -18.08 | 10.1 | -3.1 ^{+0.9} | ... | 24.6 ^{+1.5} | ... | 2399.0 ^{+1.0} | ... | 4.66 ^{+0.05} | ... | S |
| ... | 8911 | 5179 | 66 | 2457472.676 | -19.29 | 11.1 | -3.5 ^{+0.3} | ... | 23.3 ^{+1.5} | ... | 2398.9 ^{+1.7} | ... | 4.68 ^{+0.03} | ... | S |
| ... | 8911 | 5179 | 61 | 2457493.620 | -22.51 | 12.9 | -4.1 ^{+0.6} | ... | 25.0 ^{+0.6} | ... | 2399.3 ^{+1.0} | ... | 4.79 ^{+0.04} | ... | S |
| ... | 9540 | 5179 | 66 | 2457711.998 | 22.14 | 13.3 | -3.9 ^{+0.3} | ... | 23.8 ^{+1.0} | ... | 2399.4 ^{+0.4} | ... | 4.76 ^{+0.07} | ... | S |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate ID | Loc. ID | Fiber | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | v sin i (km s ⁻¹) ^{b,c} | Z _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M _d ^d |
|--------------------|----------|---------|-------|-------------|--|-------|--------------------------|---|--|------------------------|--------------------------------------|-----------------------------|--|-----------------------------|
| ... | 9540 | 5179 | 66 | 2457742.946 | 14.83 | 11.3 | -3.9 ^{+0.3} | ... | 21.9 ^{+0.4} | 2399.2 ^{+0.9} | ... | 4.85 ^{+0.03} | ... | S |
| ... | 9541 | 5179 | 72 | 2457795.839 | -5.80 | 10.2 | -4.4 ^{+0.4} | ... | 23.8 ^{+0.3} | 2399.1 ^{+1.7} | ... | 4.78 ^{+0.08} | ... | S |
| ... | 9541 | 5179 | 67 | 2457820.712 | -14.68 | 12.5 | -2.9 ^{+0.3} | ... | 23.7 ^{+0.2} | 2399.3 ^{+1.6} | ... | 4.87 ^{+0.03} | ... | S |
| ... | 9689 | 5179 | 78 | 2457821.716 | -15.00 | 10.9 | -4.0 ^{+0.4} | ... | 23.0 ^{+0.7} | 2399.2 ^{+0.6} | ... | 5.03 ^{+0.03} | ... | S |
| 2M09472006-0020093 | 12512 | 2813 | 37 | 2458904.762 | -2.98 | 39.7 | 15.0 ^{+0.1} | 15.0 ^{+0.1} | 9.0 ^{+0.3} | 2399.6 ^{+0.5} | 2399.5 ^{+0.4} | 5.29 ^{+0.01} | 5.32 ^{+0.06} | S |
| ... | 12512 | 2813 | 37 | 2458906.775 | -4.05 | 50.1 | 15.0 ^{+0.2} | ... | 7.4 ^{+0.7} | 2399.4 ^{+0.5} | ... | 5.44 ^{+0.02} | ... | S |
| 2M09474477+0224327 | 11753 | 2681 | 54 | 2458838.943 | 25.61 | 31.1 | 8.9 ^{+0.3} | 8.8 ^{+0.2} | 12.1 ^{+0.2} | 2399.2 ^{+1.4} | 2399.3 ^{+0.9} | 5.11 ^{+0.03} | 5.02 ^{+0.1} | S |
| ... | 11753 | 2681 | 48 | 2458923.716 | -12.69 | 11.3 | 8.5 ^{+0.3} | ... | 14.6 ^{+0.8} | 2399.3 ^{+0.5} | ... | 4.91 ^{+0.03} | 5.37 ^{+0.05} | S |
| 2M09522188-1924319 | 11739 | 6022 | 68 | 2458562.563 | -8.56 | 57.9 | -17.7 ^{+0.1} | -17.1 ^{+0.9} | 16.0 ^{+1.8} | 2399.6 ^{+0.3} | 2399.6 ^{+0.2} | 5.34 ^{+0.01} | 5.37 ^{+0.05} | S |
| ... | 11739 | 6022 | 71 | 2458565.638 | -9.97 | 28.7 | -17.5 ^{+0.1} | ... | 16.0 ^{+0.1} | 2399.6 ^{+0.5} | ... | 5.47 ^{+0.02} | ... | S |
| ... | 11739 | 6022 | 71 | 2458591.535 | -19.01 | 39.8 | -15.4 ^{+0.2} | ... | 16.0 ^{+0.3} | 2399.6 ^{+0.3} | ... | 5.35 ^{+0.02} | ... | S |
| 2M09524622+0620410 | 10515 | 2489 | 247 | 2458824.013 | 28.84 | 15.5 | 12.2 ^{+0.3} | 12.8 ^{+0.4} | 19.8 ^{+0.3} | 2399.3 ^{+1.1} | 2399.3 ^{+0.6} | 4.21 ^{+0.04} | 4.44 ^{+0.09} | S |
| ... | 10515 | 2489 | 247 | 2458824.965 | 28.81 | 15.6 | 12.5 ^{+0.3} | ... | 17.2 ^{+1.7} | 2399.3 ^{+1.1} | 2399.3 ^{+0.3} | 4.21 ^{+0.04} | 4.44 ^{+0.09} | S |
| ... | 10515 | 2489 | 247 | 2458879.845 | 9.27 | 25.3 | 13.2 ^{+0.2} | ... | 18.1 ^{+0.9} | 2399.1 ^{+0.6} | ... | 4.37 ^{+0.03} | ... | S |
| ... | 10515 | 2489 | 247 | 2458880.834 | 8.80 | 21.0 | 13.1 ^{+0.2} | ... | 16.2 ^{+0.2} | 2399.2 ^{+1.1} | ... | 4.61 ^{+0.05} | ... | S |
| 2M09560888+0134128 | 10845 | 2503 | 108 | 2458582.654 | -21.44 | 30.4 | 21.4 ^{+0.2} | 21.1 ^{+0.6} | 30.1 ^{+3.7} | 2399.5 ^{+0.3} | 2399.4 ^{+0.2} | 4.93 ^{+0.02} | 4.86 ^{+0.13} | S |
| ... | 10845 | 2503 | 108 | 2458583.659 | -21.79 | 16.8 | 21.4 ^{+0.2} | ... | 28.3 ^{+0.9} | 2399.3 ^{+1.1} | ... | 4.79 ^{+0.02} | ... | S |
| ... | 11866 | 2683 | 223 | 2458867.863 | 16.03 | 21.8 | 20.8 ^{+0.3} | ... | 29.4 ^{+0.8} | 2399.3 ^{+0.5} | ... | 4.95 ^{+0.02} | ... | S |
| ... | 11866 | 2683 | 223 | 2458872.834 | 13.82 | 12.0 | 18.9 ^{+0.5} | ... | 34.7 ^{+0.4} | 2399.2 ^{+1.3} | ... | 4.56 ^{+0.03} | ... | S |
| 2M10031918-0105079 | 11836 | 2682 | 96 | 2458849.914 | 23.73 | 40.4 | 24.4 ^{+0.3} | 24.0 ^{+0.3} | 33.0 ^{+0.7} | 2399.2 ^{+0.6} | 2399.3 ^{+0.9} | 5.5 ^{+0.0} | 5.5 ^{+0.0} | S |
| ... | 11836 | 2682 | 96 | 2458854.961 | 21.91 | 42.3 | 23.8 ^{+0.2} | ... | 32.3 ^{+0.3} | 2399.3 ^{+1.2} | ... | 5.5 ^{+0.0} | ... | S |
| 2M10134315+0000406 | 10846 | 2504 | 186 | 2458900.805 | 2.19 | 40.3 | 3.7 ^{+0.2} | 3.9 ^{+0.3} | 8.5 ^{+0.6} | 2399.4 ^{+0.1} | 2399.4 ^{+0.7} | 5.01 ^{+0.03} | 4.86 ^{+0.16} | S |
| ... | 10846 | 2504 | 186 | 2458904.828 | 0.03 | 24.2 | 4.3 ^{+0.2} | ... | 10.9 ^{+1.0} | 2399.4 ^{+0.4} | ... | 4.65 ^{+0.05} | ... | S |
| ... | 11838 | 2685 | 203 | 2458873.866 | 16.38 | 14.8 | 30.7 ^{+0.2} | 34.0 ^{+6.0} | 10.8 ^{+0.4} | 2399.2 ^{+1.4} | 2399.2 ^{+0.7} | 5.27 ^{+0.08} | 5.2 ^{+0.04} | S |
| ... | 11838 | 2685 | 203 | 2458874.872 | 15.92 | 14.2 | 46.6 ^{+0.3} | ... | 9.1 ^{+0.9} | 2399.0 ^{+0.7} | ... | 5.21 ^{+0.03} | ... | S |
| 2M10225090+0032169 | 11707 | 6011 | 231 | 2458510.886 | 12.50 | 67.3 | 8.3 ^{+0.2} | 8.2 ^{+0.1} | 4.0 ^{+0.3} | 2399.5 ^{+0.4} | 2399.5 ^{+0.5} | 5.48 ^{+0.01} | 5.48 ^{+0.01} | S |
| ... | 11707 | 6011 | 184 | 2458527.793 | 4.12 | 59.5 | 8.2 ^{+0.1} | ... | 12.6 ^{+0.4} | 2399.3 ^{+1.0} | ... | 5.48 ^{+0.01} | ... | S |
| ... | 11707 | 6011 | 231 | 2458560.787 | -12.66 | 59.2 | 8.2 ^{+0.2} | ... | 5.6 ^{+0.2} | 2399.2 ^{+1.1} | ... | 5.48 ^{+0.01} | ... | S |
| 2M10323297+0630074 | 10520 | 2494 | 242 | 2458580.635 | -18.34 | 114.0 | 13.3 ^{+0.1} | 13.2 ^{+0.1} | 5.1 ^{+0.7} | 2399.2 ^{+0.5} | ... | 5.45 ^{+0.03} | ... | S |
| ... | 10520 | 2494 | 242 | 2458581.665 | -18.82 | 105.5 | 12.9 ^{+0.2} | ... | 10.6 ^{+0.4} | 2399.6 ^{+0.3} | 2399.6 ^{+0.2} | 5.2 ^{+0.02} | 5.2 ^{+0.02} | S |
| ... | 6770 | 4506 | 260 | 2456402.619 | -24.00 | 12.2 | 8.2 ^{+0.3} | 8.0 ^{+0.2} | 14.1 ^{+0.9} | 2399.4 ^{+0.4} | ... | 5.2 ^{+0.02} | ... | S |
| 2M10372897+3011117 | 6770 | 4506 | 158 | 2456407.688 | -25.26 | 13.6 | 7.9 ^{+0.1} | ... | 12.5 ^{+0.3} | 2399.6 ^{+0.7} | ... | 3.52 ^{+0.01} | 3.52 ^{+0.01} | S |
| 2M10541102-8505023 | 9464 | 5231 | 193 | 2458116.869 | 4.00 | 27.9 | -11.3 ^{+0.1} | -10.8 ^{+0.8} | 10.8 ^{+0.3} | 2399.4 ^{+0.8} | 2399.4 ^{+0.5} | 5.5 ^{+0.0} | 5.5 ^{+0.0} | S |
| ... | 9464 | 5231 | 192 | 2458213.609 | 10.23 | 34.4 | -9.1 ^{+0.1} | ... | 10.7 ^{+0.3} | 2399.5 ^{+0.6} | ... | 5.5 ^{+0.0} | ... | S |
| 2M10543366+0503467 | 11828 | 2658 | 270 | 2458877.908 | 17.20 | 30.1 | -20.2 ^{+0.1} | -20.2 ^{+0.1} | 9.0 ^{+0.4} | 2399.3 ^{+1.3} | 2399.2 ^{+1.1} | 5.48 ^{+0.02} | 5.42 ^{+0.12} | S |
| ... | 11828 | 2658 | 270 | 2458880.906 | 15.84 | 11.0 | -20.2 ^{+0.3} | ... | 13.4 ^{+0.5} | 2399.2 ^{+0.6} | ... | 5.19 ^{+0.03} | ... | S |
| 2M10570380+2217203 | 8448 | 2165 | 215 | 2457123.784 | -19.84 | 45.4 | 11.7 ^{+0.1} | 11.7 ^{+0.1} | 9.5 ^{+0.9} | 2399.4 ^{+0.8} | 2399.5 ^{+0.5} | 5.25 ^{+0.03} | 5.3 ^{+0.04} | S |
| ... | 8448 | 2165 | 215 | 2457129.723 | -21.76 | 85.4 | 11.7 ^{+0.2} | ... | 8.9 ^{+0.3} | 2399.6 ^{+0.6} | ... | 5.33 ^{+0.02} | ... | S |
| 2M11194647+0820356 | 7351 | 4510 | 265 | 2456674.908 | 23.45 | 33.0 | -45.1 ^{+0.2} | -45.0 ^{+0.2} | 8.7 ^{+0.1} | 2399.5 ^{+0.9} | 2399.5 ^{+0.5} | 4.56 ^{+0.02} | 4.34 ^{+0.22} | S |
| ... | 7351 | 4510 | 264 | 2456706.842 | 9.71 | 22.5 | -44.8 ^{+0.2} | ... | 10.6 ^{+0.2} | 2399.4 ^{+0.7} | ... | 4.13 ^{+0.02} | ... | S |
| ... | 7351 | 4510 | 270 | 2456726.784 | -0.53 | 17.4 | -45.0 ^{+0.2} | ... | 10.9 ^{+0.2} | 2399.5 ^{+0.4} | ... | 4.11 ^{+0.03} | ... | S |
| 2M11203609+0704135 | 7351 | 4510 | 72 | 2456674.908 | 23.71 | 37.9 | -15.1 ^{+0.2} | -14.4 ^{+0.6} | 9.2 ^{+0.3} | 2399.5 ^{+0.8} | 2399.5 ^{+0.4} | 5.11 ^{+0.02} | 5.1 ^{+0.04} | S |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate ID | Loc. ID | Fiber | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | v sin i (km s ⁻¹) | (v sin i) ^{b,c} (km s ⁻¹) | Z _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M _d ^d |
|--------------------|----------|---------|-------|-------------|--|------|--------------------------|---|-------------------------------|--|-------------------------|--------------------------------------|-----------------------------|--|-----------------------------|
| ... | 7351 | 4510 | 90 | 2456706.842 | 10.06 | 34.3 | -13.8 ^{+0.1} | ... | 5.7 ^{+0.6} | ... | 2399.2 ^{+1.1} | ... | 5.04 ^{+0.04} | ... | S |
| ... | 7351 | 4510 | 67 | 2456726.784 | -0.17 | 33.7 | -14.4 ^{+0.2} | ... | 7.4 ^{+0.6} | ... | 2399.5 ^{+0.3} | ... | 5.14 ^{+0.04} | ... | S |
| 2M11210854+2126274 | 8450 | 2167 | 115 | 2457405.939 | 20.66 | 66.6 | -0.3 ^{+0.2} | -0.3 ^{+0.2} | 12.4 ^{+0.1} | 12.4 ^{+0.1} | 2399.3 ^{+0.7} | 5.09 ^{+0.01} | 5.09 ^{+0.01} | ... | S |
| 2M11232934+0154040 | 9758 | 5306 | 44 | 2457878.500 | -23.18 | 69.4 | -0.9 ^{+0.2} | -0.2 ^{+0.3} | 17.6 ^{+0.1} | 18.3 ^{+1.4} | 2399.0 ^{+0.7} | 5.5 ^{+0.0} | 5.5 ^{+0.0} | ... | S |
| ... | 9850 | 5306 | 53 | 2458243.588 | -23.28 | 56.5 | 0.2 ^{+0.2} | ... | 19.7 ^{+0.8} | ... | 2399.3 ^{+1.0} | 5.49 ^{+0.01} | 5.49 ^{+0.01} | ... | S |
| ... | 9850 | 5306 | 47 | 2458263.529 | -27.78 | 47.6 | 0.4 ^{+0.2} | ... | 17.9 ^{+0.2} | ... | 2399.1 ^{+0.9} | 5.49 ^{+0.03} | 5.49 ^{+0.03} | ... | S |
| ... | 8554 | 2210 | 115 | 2457152.746 | -22.09 | 29.7 | 28.8 ^{+0.2} | 29.2 ^{+0.6} | 10.8 ^{+0.4} | 13.7 ^{+1.7} | 2399.5 ^{+0.6} | 4.88 ^{+0.02} | 4.88 ^{+0.02} | 4.86 ^{+0.03} | S |
| ... | 8554 | 2210 | 115 | 2457159.760 | -23.34 | 18.8 | 30.1 ^{+0.3} | ... | 14.3 ^{+0.4} | ... | 2399.4 ^{+1.0} | 4.82 ^{+0.05} | 4.82 ^{+0.05} | ... | S |
| 2M12153877+5205050 | 11957 | 2719 | 26 | 2458852.980 | 16.22 | 57.2 | -4.8 ^{+0.2} | -4.8 ^{+0.2} | 12.9 ^{+0.9} | 12.9 ^{+0.9} | 2399.5 ^{+0.7} | 5.1 ^{+0.01} | 5.1 ^{+0.01} | ... | S |
| 2M12201166+3315379 | 12483 | 2784 | 1 | 2458928.890 | -4.21 | 16.4 | 11.1 ^{+0.3} | 11.1 ^{+0.3} | 9.1 ^{+0.9} | < 10 | 2399.1 ^{+0.8} | 5.18 ^{+0.04} | 5.18 ^{+0.04} | ... | S |
| ... | 12483 | 2784 | 1 | 2458929.883 | -4.63 | 14.4 | 11.2 ^{+0.3} | ... | 8.9 ^{+1.0} | ... | 2399.1 ^{+0.7} | 5.21 ^{+0.04} | 5.21 ^{+0.04} | ... | S |
| 2M12205439+252568 | 7437 | 4216 | 109 | 2456815.666 | -26.41 | 10.9 | 14.8 ^{+0.2} | 14.8 ^{+0.2} | 25.6 ^{+0.3} | ... | 2399.2 ^{+1.1} | 4.85 ^{+0.03} | 4.85 ^{+0.03} | ... | S |
| 2M12215013+4632447 | 8263 | 2118 | 186 | 2457121.699 | -12.60 | 49.2 | -10.4 ^{+0.3} | -10.4 ^{+0.3} | 29.1 ^{+0.1} | 29.1 ^{+0.1} | 2399.0 ^{+0.5} | 5.43 ^{+0.04} | 5.43 ^{+0.04} | ... | S |
| ... | 8263 | 2118 | 186 | 2457122.753 | -13.01 | 43.5 | -10.7 ^{+0.2} | -10.7 ^{+0.2} | 19.1 ^{+0.2} | 19.1 ^{+0.2} | 2399.2 ^{+1.2} | 4.88 ^{+0.02} | 4.88 ^{+0.02} | ... | S |
| 2M12235346+2534559 | 7435 | 4216 | 109 | 2456761.646 | -12.53 | 10.1 | 7.9 ^{+0.4} | 7.0 ^{+0.8} | 15.3 ^{+1.3} | 16.4 ^{+1.7} | 3045.2 ^{+18.8} | 5.48 ^{+0.01} | 5.48 ^{+0.01} | 5.49 ^{+0.01} | B |
| ... | 7438 | 4216 | 43 | 2456814.643 | -26.15 | 10.3 | -22.2 ^{+3.9} | ... | 97.4 ^{+3.0} | ... | 3062.8 ^{+15.2} | 5.38 ^{+0.01} | 5.38 ^{+0.01} | ... | B |
| ... | 7438 | 4216 | 7 | 2456818.645 | -26.40 | 14.3 | -7.1 ^{+2.6} | ... | 84.7 ^{+3.0} | ... | 2899.6 ^{+20.1} | 4.64 ^{+0.07} | 4.64 ^{+0.07} | ... | B |
| ... | 7437 | 4216 | 49 | 2456824.642 | 6.6 ^{+0.3} | 10.3 | 6.6 ^{+0.3} | ... | 17.5 ^{+1.4} | ... | 3070.7 ^{+15.0} | 5.49 ^{+0.01} | 5.49 ^{+0.01} | ... | B |
| 2M12252076+2517082 | 7435 | 4216 | 31 | 2456756.676 | -10.34 | 16.0 | 7.5 ^{+0.2} | 7.2 ^{+0.7} | 32.9 ^{+0.4} | 32.9 ^{+0.4} | 2399.3 ^{+1.1} | 4.86 ^{+0.04} | 4.86 ^{+0.04} | 4.85 ^{+0.16} | B |
| ... | 7438 | 4216 | 31 | 2456790.632 | -22.04 | 12.7 | 7.1 ^{+0.6} | ... | 34.7 ^{+2.0} | ... | 2399.3 ^{+0.5} | 4.81 ^{+0.01} | 4.81 ^{+0.01} | ... | S |
| ... | 7438 | 4216 | 144 | 2456814.643 | -26.14 | 16.0 | 8.9 ^{+0.3} | ... | 29.3 ^{+0.3} | ... | 2399.1 ^{+1.2} | 5.07 ^{+0.03} | 5.07 ^{+0.03} | ... | S |
| ... | 7437 | 4216 | 43 | 2456815.666 | -26.27 | 12.7 | 6.7 ^{+0.4} | ... | 34.9 ^{+0.2} | ... | 2399.1 ^{+0.7} | 4.65 ^{+0.02} | 4.65 ^{+0.02} | ... | S |
| ... | 7438 | 4216 | 43 | 2456818.645 | -26.40 | 13.9 | 6.7 ^{+0.7} | ... | 32.9 ^{+0.4} | ... | 2399.3 ^{+0.5} | 4.9 ^{+0.02} | 4.9 ^{+0.02} | ... | S |
| ... | 7437 | 4216 | 126 | 2456819.640 | -26.44 | 11.6 | 7.2 ^{+0.2} | ... | 30.1 ^{+1.0} | ... | 2398.6 ^{+2.0} | 4.95 ^{+0.06} | 4.95 ^{+0.06} | ... | S |
| ... | 7437 | 4216 | 37 | 2456824.642 | -26.58 | 15.8 | 5.6 ^{+0.6} | ... | 33.1 ^{+0.3} | ... | 2399.4 ^{+0.4} | 4.83 ^{+0.04} | 4.83 ^{+0.04} | ... | S |
| ... | 7435 | 4216 | 84 | 2456761.646 | -12.21 | 15.6 | 2.3 ^{+0.3} | 2.6 ^{+0.6} | 21.7 ^{+0.2} | 19.6 ^{+2.7} | 2399.5 ^{+0.4} | 4.12 ^{+0.03} | 4.12 ^{+0.03} | 4.36 ^{+0.19} | S |
| ... | 7438 | 4216 | 80 | 2456790.632 | -21.89 | 14.4 | 2.2 ^{+0.9} | ... | 25.4 ^{+1.8} | ... | 2399.3 ^{+0.5} | 4.12 ^{+0.05} | 4.12 ^{+0.05} | ... | S |
| ... | 7438 | 4216 | 89 | 2456814.643 | -26.00 | 19.6 | 3.5 ^{+0.2} | ... | 17.9 ^{+0.1} | ... | 2399.6 ^{+0.6} | 4.35 ^{+0.04} | 4.35 ^{+0.04} | ... | S |
| ... | 7437 | 4216 | 73 | 2456815.666 | -26.13 | 18.1 | 3.0 ^{+0.3} | ... | 19.7 ^{+0.7} | ... | 2399.3 ^{+0.5} | 4.82 ^{+0.03} | 4.82 ^{+0.03} | ... | S |
| ... | 7438 | 4216 | 32 | 2456818.645 | -26.27 | 18.3 | 1.9 ^{+0.6} | ... | 19.7 ^{+0.7} | ... | 2399.4 ^{+0.9} | 4.39 ^{+0.02} | 4.39 ^{+0.02} | ... | S |
| ... | 7437 | 4216 | 36 | 2456824.642 | -26.46 | 16.4 | 2.0 ^{+0.2} | ... | 17.9 ^{+0.2} | ... | 2399.5 ^{+0.4} | 4.38 ^{+0.03} | 4.38 ^{+0.03} | ... | S |
| 2M12315462+5130389 | 11832 | 2668 | 186 | 2458607.681 | -17.29 | 43.9 | 8.9 ^{+0.3} | 8.9 ^{+0.3} | 7.8 ^{+1.0} | < 10 | 2399.3 ^{+0.9} | 5.41 ^{+0.02} | 5.41 ^{+0.02} | 5.41 ^{+0.02} | S |
| 2M12493960+5253540 | 11019 | 2523 | 283 | 2458542.878 | 1.00 | 19.0 | -56.1 ^{+0.2} | -56.8 ^{+0.4} | 10.2 ^{+0.3} | 10.4 ^{+3.0} | 2399.5 ^{+0.4} | 4.92 ^{+0.02} | 4.92 ^{+0.02} | 4.98 ^{+0.13} | S |
| ... | 11019 | 2523 | 283 | 2458543.899 | 0.63 | 15.4 | -57.0 ^{+0.1} | ... | 11.1 ^{+0.2} | ... | 2399.3 ^{+0.5} | 4.9 ^{+0.02} | 4.9 ^{+0.02} | ... | S |
| ... | 11761 | 2670 | 60 | 2458578.766 | -9.92 | 24.9 | -57.0 ^{+0.2} | ... | 3.8 ^{+0.8} | ... | 2399.2 ^{+1.7} | 5.22 ^{+0.03} | 5.22 ^{+0.03} | ... | S |
| 2M12522354+2528469 | 11871 | 2647 | 42 | 2458627.681 | -22.59 | 33.6 | 9.4 ^{+0.3} | 9.4 ^{+0.3} | 12.6 ^{+0.3} | 12.6 ^{+0.3} | 2399.3 ^{+0.5} | 5.41 ^{+0.02} | 5.41 ^{+0.02} | 5.41 ^{+0.02} | S |
| 2M13004379+3557591 | 8323 | 2133 | 217 | 2457888.641 | -19.08 | 18.0 | -24.6 ^{+0.4} | -24.6 ^{+0.4} | 19.7 ^{+1.8} | 17.7 ^{+1.7} | 2399.2 ^{+1.0} | 4.5 ^{+0.04} | 4.5 ^{+0.04} | 4.41 ^{+0.08} | S |
| ... | 8323 | 2133 | 217 | 2457889.742 | -19.51 | 10.6 | -24.6 ^{+0.3} | ... | 16.2 ^{+0.9} | ... | 2399.3 ^{+0.5} | 4.34 ^{+0.03} | 4.34 ^{+0.03} | ... | S |
| ... | 8323 | 2133 | 217 | 2457891.776 | -19.99 | 11.7 | -24.2 ^{+0.6} | ... | 18.1 ^{+0.9} | ... | 2399.9 ^{+0.5} | 4.5 ^{+0.08} | 4.5 ^{+0.08} | ... | S |
| ... | 8323 | 2133 | 217 | 2457892.727 | -20.10 | 15.2 | -24.8 ^{+0.4} | ... | 15.6 ^{+1.3} | ... | 2399.2 ^{+0.8} | 4.4 ^{+0.05} | 4.4 ^{+0.05} | ... | S |
| 2M13022083+3227103 | 12484 | 2785 | 186 | 2458898.897 | 12.47 | 18.0 | 7.2 ^{+0.3} | 6.8 ^{+0.3} | 25.5 ^{+0.9} | 25.7 ^{+1.4} | 2399.4 ^{+0.4} | 4.46 ^{+0.04} | 4.46 ^{+0.04} | 4.58 ^{+0.09} | S |
| ... | 12484 | 2785 | 186 | 2458899.883 | 12.13 | 19.5 | 7.2 ^{+0.3} | ... | 27.1 ^{+0.7} | ... | 2399.3 ^{+0.5} | 4.63 ^{+0.04} | 4.63 ^{+0.04} | ... | S |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate ID | Loc. ID | Fiber ID | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | vsin <i>i</i> (km s ⁻¹) | (v sin <i>i</i>) ^{b,c} (km s ⁻¹) | <i>T</i> _{eff} (K) | (<i>T</i> _{eff}) ^b (K) | log <i>g</i> (cm s ⁻²) | (log <i>g</i>) ^b (cm s ⁻²) | Mdl ^d |
|--------------------|----------|---------|----------|-------------|--|------|--------------------------|---|-------------------------------------|--|-----------------------------|--|------------------------------------|--|------------------|
| ... | 12484 | 2785 | 186 | 2458904.980 | 9.95 | 29.9 | 6.6 ^{+0.2} | ... | 25.4 ^{+0.1} | ... | 2399.6 ^{+0.7} | ... | 4.64 ^{+0.02} | ... | S |
| 2M13034100+2414020 | 11009 | 2513 | 132 | 2458579.871 | -5.02 | 21.7 | -9.5 ^{+0.3} | -9.3 ^{+0.3} | 29.2 ^{+0.2} | 27.4 ^{+1.7} | 2398.8 ^{+0.8} | 2399.1 ^{+0.8} | 5.39 ^{+0.05} | 5.33 ^{+0.21} | S |
| ... | 11009 | 2513 | 132 | 2458580.728 | -5.09 | 29.3 | -9.3 ^{+0.7} | ... | 25.4 ^{+0.1} | ... | 2398.7 ^{+0.3} | ... | 5.47 ^{+0.03} | ... | S |
| ... | 11010 | 2514 | 19 | 2458599.723 | -13.03 | 18.7 | -8.9 ^{+0.2} | ... | 29.1 ^{+0.2} | ... | 2399.4 ^{+0.4} | ... | 4.9 ^{+0.01} | ... | S |
| ... | 11010 | 2514 | 19 | 2458601.759 | -13.90 | 43.9 | -9.5 ^{+0.1} | ... | 21.8 ^{+0.2} | ... | 2397.6 ^{+1.1} | ... | 5.48 ^{+0.02} | ... | S |
| 2M13065141+7056376 | 8913 | 5181 | 29 | 2457445.846 | -4.33 | 12.0 | 15.0 ^{+0.2} | 15.2 ^{+0.3} | 10.8 ^{+0.4} | 11.8 ^{+1.3} | 2399.4 ^{+0.8} | 2399.4 ^{+0.2} | 4.28 ^{+0.06} | 4.19 ^{+0.18} | S |
| ... | 8913 | 5181 | 119 | 2457448.840 | -4.94 | 11.3 | 15.2 ^{+0.2} | ... | 11.7 ^{+0.1} | ... | 2399.3 ^{+1.3} | ... | 4.34 ^{+0.04} | ... | S |
| ... | 8913 | 5181 | 29 | 2457463.788 | -7.77 | 11.3 | 15.1 ^{+0.4} | ... | 10.5 ^{+0.6} | ... | 2399.5 ^{+0.4} | ... | 4.12 ^{+0.05} | ... | S |
| ... | 8913 | 5181 | 26 | 2457493.689 | -11.60 | 11.2 | 15.4 ^{+0.3} | ... | 11.3 ^{+0.1} | ... | 2399.4 ^{+0.4} | ... | 3.87 ^{+0.05} | ... | S |
| ... | 9012 | 5181 | 26 | 2457497.758 | -11.96 | 12.4 | 15.0 ^{+0.3} | ... | 10.9 ^{+0.4} | ... | 2399.4 ^{+0.9} | ... | 4.37 ^{+0.06} | ... | S |
| ... | 9012 | 5181 | 113 | 2457503.703 | -12.26 | 11.0 | 14.6 ^{+0.4} | ... | 12.7 ^{+0.8} | ... | 2399.2 ^{+0.6} | ... | 3.68 ^{+0.11} | ... | S |
| ... | 9012 | 5181 | 113 | 2457522.629 | -12.44 | 11.4 | 14.9 ^{+0.3} | ... | 12.3 ^{+0.8} | ... | 2399.3 ^{+1.0} | ... | 4.17 ^{+0.04} | ... | S |
| ... | 9067 | 5181 | 113 | 2457795.965 | -1.10 | 14.2 | 15.3 ^{+0.2} | ... | 12.4 ^{+0.2} | ... | 2399.5 ^{+0.8} | ... | 4.28 ^{+0.05} | ... | S |
| ... | 9067 | 5181 | 113 | 2457801.949 | -2.42 | 14.5 | 15.6 ^{+0.2} | ... | 10.8 ^{+0.3} | ... | 2399.5 ^{+0.4} | ... | 4.16 ^{+0.03} | ... | S |
| ... | 9068 | 5181 | 29 | 2457820.885 | -6.34 | 13.2 | 15.3 ^{+0.2} | ... | 10.9 ^{+0.6} | ... | 2399.4 ^{+0.7} | ... | 4.24 ^{+0.03} | ... | S |
| ... | 9068 | 5181 | 26 | 2457827.854 | -7.60 | 11.2 | 15.5 ^{+0.2} | ... | 10.8 ^{+0.6} | ... | 2399.6 ^{+0.3} | ... | 4.11 ^{+0.06} | ... | S |
| ... | 9068 | 5181 | 26 | 2457831.885 | -8.32 | 10.2 | 16.5 ^{+1.2} | ... | 12.5 ^{+0.3} | ... | 2399.2 ^{+1.0} | ... | 3.67 ^{+0.09} | ... | S |
| 2M13192677+1301119 | 6777 | 4492 | 139 | 2456324.014 | 25.04 | 48.0 | 6.3 ^{+0.2} | 6.3 ^{+0.1} | 8.9 ^{+0.8} | < 10 | 2399.4 ^{+0.5} | 2399.4 ^{+0.5} | 5.06 ^{+0.01} | 4.84 ^{+0.2} | S |
| ... | 6777 | 4492 | 42 | 2456346.961 | 17.75 | 15.3 | 6.2 ^{+0.2} | ... | 8.9 ^{+0.3} | ... | 2399.3 ^{+1.2} | ... | 4.63 ^{+0.01} | ... | S |
| ... | 6777 | 4492 | 138 | 2456351.896 | 15.92 | 39.3 | 6.3 ^{+0.1} | ... | 7.3 ^{+0.9} | ... | 2399.5 ^{+0.6} | ... | 4.96 ^{+0.01} | ... | S |
| 2M13202007+7213140 | 9067 | 5181 | 195 | 2457771.026 | 3.84 | 16.6 | -28.1 ^{+0.4} | -27.3 ^{+0.5} | 18.0 ^{+0.4} | 18.6 ^{+1.4} | 2399.4 ^{+0.4} | 2399.3 ^{+0.2} | 5.3 ^{+0.03} | 5.31 ^{+0.12} | S |
| ... | 9067 | 5181 | 195 | 2457795.965 | -1.40 | 21.3 | -27.8 ^{+0.2} | ... | 18.0 ^{+0.2} | ... | 2399.3 ^{+0.5} | ... | 5.38 ^{+0.03} | ... | S |
| ... | 9067 | 5181 | 196 | 2457801.949 | -2.64 | 21.0 | -27.8 ^{+0.2} | ... | 17.4 ^{+0.5} | ... | 2399.2 ^{+0.5} | ... | 5.4 ^{+0.04} | ... | S |
| ... | 9067 | 5181 | 195 | 2457819.881 | -6.11 | 22.1 | -27.0 ^{+0.2} | ... | 19.8 ^{+0.1} | ... | 2399.4 ^{+0.8} | ... | 5.12 ^{+0.03} | ... | S |
| ... | 9068 | 5181 | 190 | 2457820.885 | -6.30 | 25.6 | -27.1 ^{+0.1} | ... | 16.3 ^{+0.3} | ... | 2399.5 ^{+0.8} | ... | 5.44 ^{+0.03} | ... | S |
| ... | 9067 | 5181 | 195 | 2457820.927 | -6.34 | 17.0 | -27.0 ^{+0.2} | ... | 17.4 ^{+0.9} | ... | 2399.3 ^{+0.9} | ... | 5.37 ^{+0.02} | ... | S |
| ... | 9067 | 5181 | 201 | 2457824.915 | -7.02 | 12.0 | -28.0 ^{+0.3} | ... | 19.1 ^{+0.7} | ... | 2399.1 ^{+0.6} | ... | 5.18 ^{+0.02} | ... | S |
| ... | 9068 | 5181 | 189 | 2457827.854 | -7.46 | 25.2 | -27.9 ^{+0.4} | ... | 18.0 ^{+0.2} | ... | 2399.5 ^{+0.4} | ... | 5.4 ^{+0.03} | ... | S |
| ... | 9068 | 5181 | 202 | 2457831.885 | -8.12 | 19.0 | -27.3 ^{+0.3} | ... | 17.8 ^{+0.5} | ... | 2399.3 ^{+1.1} | ... | 5.31 ^{+0.05} | ... | S |
| ... | 9068 | 5181 | 190 | 2457848.828 | -10.29 | 10.1 | -27.5 ^{+0.4} | ... | 20.2 ^{+1.0} | ... | 2398.7 ^{+0.9} | ... | 5.28 ^{+0.05} | ... | S |
| ... | 9068 | 5181 | 196 | 2457851.792 | -10.56 | 12.7 | -28.3 ^{+0.6} | ... | 18.1 ^{+0.4} | ... | 2399.0 ^{+1.4} | ... | 5.16 ^{+0.02} | ... | S |
| ... | 9068 | 5181 | 189 | 2457854.797 | -10.83 | 10.3 | -26.2 ^{+0.2} | ... | 19.8 ^{+0.3} | ... | 2399.0 ^{+1.3} | ... | 5.39 ^{+0.05} | ... | S |
| 2M13232423+5132272 | 11017 | 2521 | 284 | 2458547.967 | 1.76 | 37.6 | -5.5 ^{+0.3} | -5.4 ^{+0.5} | 16.0 ^{+0.1} | 18.9 ^{+1.9} | 2399.6 ^{+0.2} | 2399.6 ^{+0.2} | 4.55 ^{+0.01} | 4.59 ^{+0.18} | S |
| ... | 11017 | 2521 | 284 | 2458548.911 | 1.54 | 25.0 | -4.6 ^{+0.2} | ... | 14.4 ^{+0.3} | ... | 2399.5 ^{+0.8} | ... | 4.62 ^{+0.02} | ... | S |
| ... | 11017 | 2521 | 284 | 2458549.947 | 1.17 | 13.7 | -5.9 ^{+0.2} | ... | 16.4 ^{+0.7} | ... | 2399.2 ^{+0.7} | ... | 4.38 ^{+0.05} | ... | S |
| ... | 11017 | 2521 | 296 | 2458568.777 | -4.35 | 36.7 | -5.7 ^{+0.2} | ... | 19.7 ^{+0.1} | ... | 2399.7 ^{+0.4} | ... | 4.38 ^{+0.03} | ... | S |
| ... | 11017 | 2521 | 296 | 2458572.885 | -5.72 | 30.9 | -5.5 ^{+0.2} | ... | 16.0 ^{+0.2} | ... | 2399.6 ^{+0.3} | ... | 4.38 ^{+0.02} | ... | S |
| ... | 11017 | 2521 | 296 | 2458575.838 | -6.51 | 34.8 | -6.3 ^{+0.2} | ... | 19.7 ^{+0.1} | ... | 2399.6 ^{+0.4} | ... | 4.34 ^{+0.04} | ... | S |
| ... | 11758 | 2666 | 119 | 2458605.755 | -13.59 | 64.3 | -5.3 ^{+0.1} | ... | 9.3 ^{+0.6} | ... | 2399.4 ^{+1.1} | ... | 4.95 ^{+0.02} | ... | S |
| 2M13342918+3303043 | 8444 | 2161 | 163 | 2457863.729 | -8.61 | 19.2 | -18.0 ^{+0.3} | -18.0 ^{+0.3} | 10.7 ^{+0.3} | 10.7 ^{+0.3} | 2399.3 ^{+0.5} | 2399.3 ^{+1.0} | 4.63 ^{+0.04} | 4.63 ^{+0.04} | S |
| 2M13430646+0038442 | 8266 | 5121 | 294 | 2457058.007 | 27.68 | 13.7 | -12.4 ^{+0.3} | -11.9 ^{+0.7} | 9.6 ^{+0.9} | < 10 | 3157.5 ^{+9.5} | 3164.4 ^{+27.8} | 5.44 ^{+0.03} | 5.47 ^{+0.06} | B |
| ... | 8266 | 5121 | 187 | 2457060.971 | 27.15 | 13.4 | -12.4 ^{+0.3} | ... | 8.1 ^{+1.0} | ... | 3152.1 ^{+10.1} | ... | 5.47 ^{+0.03} | ... | B |
| ... | 8266 | 5121 | 187 | 2457092.891 | 16.61 | 14.9 | -13.3 ^{+0.2} | ... | 9.9 ^{+1.6} | ... | 3142.9 ^{+19.2} | ... | 5.45 ^{+0.04} | ... | B |
| ... | 8267 | 5121 | 187 | 2457093.913 | 16.12 | 13.5 | -13.2 ^{+0.3} | ... | 9.8 ^{+1.2} | ... | 3121.9 ^{+16.6} | ... | 5.22 ^{+0.03} | ... | B |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate | Loc. ID | Fiber ID | JD (day) | JD (day) | RV (km s ⁻¹) | RV (km s ⁻¹) | vsin i (km s ⁻¹) | (v sin i) ^{b,c} (km s ⁻¹) | Z _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | Mdl ^d |
|-----------|-------|---------|----------|-------------|----------|--------------------------|--------------------------|------------------------------|--|-------------------------|--------------------------------------|-----------------------------|--|------------------|
| ... | 8266 | 5121 | 192 | 2457110.844 | 8.32 | 13.7 | -11.7 ^{+0.4} | 9.6 ^{+0.9} | ... | 3152.8 ^{+14.8} | ... | 5.43 ^{+0.04} | ... | B |
| ... | 8266 | 5121 | 181 | 2457113.869 | 6.76 | 11.0 | -12.8 ^{+0.4} | 9.3 ^{+0.8} | ... | 3176.9 ^{+8.4} | ... | 5.47 ^{+0.02} | ... | B |
| ... | 8267 | 5121 | 271 | 2457114.854 | 6.31 | 13.0 | -12.2 ^{+0.3} | 11.8 ^{+1.3} | ... | 3171.1 ^{+16.4} | ... | 5.49 ^{+0.01} | ... | B |
| ... | 8267 | 5121 | 198 | 2457123.840 | 1.82 | 12.6 | -11.5 ^{+0.2} | 9.1 ^{+1.1} | ... | 3186.4 ^{+11.7} | ... | 5.31 ^{+0.05} | ... | B |
| ... | 8581 | 5121 | 235 | 2457142.796 | -7.57 | 12.4 | -11.2 ^{+0.2} | 13.3 ^{+1.6} | ... | 3107.2 ^{+8.0} | ... | 5.25 ^{+0.04} | ... | B |
| ... | 9684 | 5121 | 295 | 2457794.010 | 26.47 | 11.1 | -12.6 ^{+0.3} | 8.3 ^{+1.6} | ... | 3205.6 ^{+18.7} | ... | 5.48 ^{+0.02} | ... | B |
| ... | 9684 | 5121 | 192 | 2457802.011 | 24.31 | 12.7 | -11.6 ^{+0.6} | 12.8 ^{+0.7} | ... | 3143.0 ^{+10.8} | ... | 5.44 ^{+0.05} | ... | B |
| ... | 9685 | 5121 | 239 | 2457849.892 | 3.95 | 14.3 | -12.2 ^{+0.6} | 9.1 ^{+1.0} | ... | 3183.9 ^{+9.5} | ... | 5.38 ^{+0.04} | ... | B |
| ... | 9685 | 5121 | 239 | 2457857.896 | -0.10 | 12.9 | -11.5 ^{+0.2} | 7.4 ^{+0.7} | ... | 3178.9 ^{+7.5} | ... | 5.45 ^{+0.02} | ... | B |
| ... | 9684 | 5121 | 289 | 2458150.014 | 28.36 | 12.8 | -12.8 ^{+0.3} | 8.9 ^{+1.6} | ... | 3210.0 ^{+9.6} | ... | 5.49 ^{+0.01} | ... | B |
| ... | 9684 | 5121 | 289 | 2458176.962 | 21.14 | 14.2 | -11.4 ^{+0.2} | 8.9 ^{+1.0} | ... | 3166.4 ^{+9.8} | ... | 5.38 ^{+0.04} | ... | B |
| ... | 8912 | 5180 | 216 | 2457499.666 | -7.57 | 12.8 | -4.7 ^{+0.1} | 12.6 ^{+0.8} | 14.4 ^{+5.1} | 3146.9 ^{+17.9} | 3186.6 ^{+39.4} | 5.49 ^{+0.02} | 5.48 ^{+0.03} | B |
| ... | 9778 | 5180 | 223 | 2457856.849 | -4.91 | 10.7 | -11.6 ^{+1.7} | 28.0 ^{+3.8} | ... | 3154.9 ^{+16.3} | ... | 5.45 ^{+0.03} | ... | B |
| ... | 9665 | 5180 | 222 | 2457858.851 | -5.67 | 13.8 | -21.9 ^{+0.2} | 20.9 ^{+1.2} | ... | 3220.4 ^{+10.0} | ... | 5.46 ^{+0.04} | ... | B |
| ... | 9683 | 5180 | 216 | 2457859.838 | -6.01 | 12.8 | -20.8 ^{+0.8} | 11.8 ^{+1.1} | ... | 3172.9 ^{+14.7} | ... | 5.49 ^{+0.01} | ... | B |
| ... | 9778 | 5180 | 222 | 2457860.873 | -6.47 | 11.9 | -17.2 ^{+0.4} | 14.2 ^{+1.0} | ... | 3217.1 ^{+15.0} | ... | 5.47 ^{+0.02} | ... | B |
| ... | 9778 | 5180 | 228 | 2457878.798 | -12.56 | 11.8 | -15.0 ^{+0.4} | 12.4 ^{+2.0} | ... | 3201.8 ^{+24.2} | ... | 5.43 ^{+0.07} | ... | B |
| ... | 9777 | 5180 | 222 | 2457886.711 | -14.76 | 10.2 | -14.8 ^{+3.7} | 63.2 ^{+5.6} | ... | 3098.5 ^{+17.3} | ... | 5.2 ^{+0.09} | ... | B |
| ... | 8912 | 5180 | 118 | 2457499.666 | -7.24 | 19.1 | -5.8 ^{+0.2} | 10.6 ^{+2.9} | 10.6 ^{+2.9} | 3158.3 ^{+10.4} | 3181.8 ^{+19.5} | 5.49 ^{+0.02} | 5.49 ^{+0.01} | B |
| ... | 9544 | 5180 | 112 | 2457743.012 | 22.87 | 11.7 | -6.7 ^{+0.3} | 10.1 ^{+1.3} | ... | 3183.8 ^{+14.3} | 3181.8 ^{+20.3} | 5.48 ^{+0.02} | 5.48 ^{+0.01} | B |
| ... | 9544 | 5180 | 117 | 2457823.794 | 8.55 | 10.8 | -4.7 ^{+0.3} | 12.9 ^{+1.3} | ... | 3181.7 ^{+25.3} | ... | 5.48 ^{+0.02} | ... | B |
| ... | 9665 | 5180 | 27 | 2457852.871 | -3.03 | 12.2 | -5.2 ^{+0.6} | 13.2 ^{+1.6} | ... | 3233.2 ^{+13.2} | ... | 5.47 ^{+0.02} | ... | B |
| ... | 9778 | 5180 | 111 | 2457856.849 | -4.53 | 11.5 | -5.7 ^{+0.2} | 5.9 ^{+1.2} | ... | 3179.2 ^{+18.9} | ... | 5.48 ^{+0.02} | ... | B |
| ... | 8912 | 5180 | 112 | 2457857.710 | -4.58 | 11.4 | -6.6 ^{+0.3} | 10.8 ^{+1.9} | ... | 3159.9 ^{+12.9} | ... | 5.48 ^{+0.01} | ... | B |
| ... | 9665 | 5180 | 27 | 2457858.851 | -5.30 | 12.4 | -4.6 ^{+0.4} | 13.5 ^{+1.1} | ... | 3174.2 ^{+9.3} | ... | 5.49 ^{+0.01} | ... | B |
| ... | 9777 | 5180 | 28 | 2457859.770 | -5.48 | 17.5 | -6.4 ^{+0.4} | 10.1 ^{+1.1} | ... | 3171.1 ^{+15.8} | ... | 5.46 ^{+0.04} | ... | B |
| ... | 9683 | 5180 | 27 | 2457859.838 | -5.65 | 12.9 | -4.6 ^{+0.2} | 9.5 ^{+1.0} | ... | 3173.8 ^{+7.9} | ... | 5.45 ^{+0.03} | ... | B |
| ... | 9778 | 5180 | 112 | 2457860.873 | -6.11 | 13.9 | -5.8 ^{+0.3} | 6.1 ^{+1.4} | ... | 3183.6 ^{+9.0} | ... | 5.5 ^{+0.01} | ... | B |
| ... | 9665 | 5180 | 27 | 2457876.710 | -11.48 | 10.9 | -5.5 ^{+0.5} | 8.2 ^{+1.2} | ... | 3251.2 ^{+9.4} | ... | 5.49 ^{+0.02} | ... | B |
| ... | 9778 | 5180 | 10 | 2457878.798 | -12.35 | 11.0 | -6.1 ^{+0.4} | 6.1 ^{+1.3} | ... | 3176.1 ^{+10.9} | ... | 5.49 ^{+0.01} | ... | B |
| ... | 9730 | 5180 | 28 | 2457879.689 | -12.41 | 18.3 | -4.8 ^{+0.3} | 7.2 ^{+1.7} | ... | 3201.1 ^{+11.2} | ... | 5.48 ^{+0.01} | ... | B |
| ... | 9725 | 5180 | 112 | 2457884.700 | -13.99 | 11.8 | -6.7 ^{+0.4} | 11.7 ^{+1.2} | ... | 3157.4 ^{+10.4} | ... | 5.49 ^{+0.01} | ... | B |
| ... | 9777 | 5180 | 27 | 2457886.711 | -14.61 | 12.2 | -6.1 ^{+0.1} | 10.4 ^{+1.2} | ... | 3220.3 ^{+16.9} | ... | 5.48 ^{+0.02} | ... | B |
| ... | 5732 | 4233 | 259 | 2455999.860 | 4.11 | 66.0 | -19.7 ^{+0.2} | 16.2 ^{+1.0} | 16.2 ^{+1.0} | 2399.0 ^{+1.0} | 2399.0 ^{+0.7} | 5.5 ^{+0.0} | 5.5 ^{+0.0} | S |
| ... | 5732 | 4233 | 199 | 2456018.858 | -2.16 | 95.1 | -20.2 ^{+0.2} | 16.2 ^{+0.3} | ... | 2399.1 ^{+1.6} | ... | 5.5 ^{+0.0} | ... | S |
| ... | 5732 | 4233 | 205 | 2456345.942 | 9.92 | 44.8 | -18.8 ^{+0.2} | 16.2 ^{+0.2} | ... | 2398.8 ^{+2.0} | ... | 5.5 ^{+0.0} | ... | S |
| ... | 11013 | 2517 | 121 | 2458581.869 | -6.16 | 12.6 | -40.2 ^{+0.3} | 36.6 ^{+0.8} | ... | 2399.2 ^{+0.5} | 2399.4 ^{+0.6} | 4.4 ^{+0.03} | 4.35 ^{+0.04} | S |
| ... | 11013 | 2517 | 121 | 2458582.854 | -6.38 | 21.7 | -43.5 ^{+0.3} | 44.2 ^{+0.6} | ... | 2399.5 ^{+0.7} | ... | 4.32 ^{+0.02} | ... | S |
| ... | 8912 | 5180 | 77 | 2457499.666 | -6.15 | 16.6 | -18.1 ^{+0.3} | 7.7 ^{+1.0} | ... | 2946.4 ^{+14.6} | 2893.8 ^{+82.0} | 5.29 ^{+0.04} | 5.45 ^{+0.19} | B |
| ... | 9544 | 5180 | 71 | 2457743.012 | 22.20 | 12.4 | -18.4 ^{+0.3} | 10.3 ^{+1.0} | 11.5 ^{+2.3} | 2917.7 ^{+12.8} | ... | 5.48 ^{+0.01} | ... | B |
| ... | 9665 | 5180 | 77 | 2457852.871 | -1.98 | 12.2 | -18.1 ^{+0.3} | 9.5 ^{+0.8} | ... | 2937.9 ^{+23.3} | ... | 5.1 ^{+0.05} | ... | B |
| ... | 9778 | 5180 | 76 | 2457853.901 | -2.44 | 11.6 | -18.9 ^{+0.3} | 15.4 ^{+1.0} | ... | 2931.9 ^{+13.9} | ... | 5.48 ^{+0.01} | ... | B |
| ... | 9778 | 5180 | 76 | 2457856.849 | -3.46 | 17.0 | -18.4 ^{+0.2} | 12.4 ^{+1.1} | ... | 2930.5 ^{+7.9} | ... | 5.49 ^{+0.01} | ... | B |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate ID | Loc. ID | Fiber ID | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | vsin <i>i</i> (km s ⁻¹) | (v sin <i>i</i>) ^{b,c} (km s ⁻¹) | Z _{eff} (K) | (T _{eff}) ^b (K) | log <i>g</i> (cm s ⁻²) | (log <i>g</i>) ^b (cm s ⁻²) | M _d ^d |
|--------------------|----------|---------|----------|-------------|--|-------|--------------------------|---|-------------------------------------|--|-------------------------|--------------------------------------|------------------------------------|--|-----------------------------|
| ... | 9665 | 5180 | 68 | 2457858.851 | -4.22 | 11.8 | -18.1 ^{+0.4} | ... | 10.1 ^{+1.3} | ... | 2848.1 ^{+14.8} | ... | 4.97 ^{+0.06} | ... | B |
| ... | 9771 | 5180 | 75 | 2457859.770 | -4.40 | 18.5 | -18.4 ^{+0.2} | ... | 14.4 ^{+1.4} | ... | 2878.1 ^{+23.9} | ... | 4.79 ^{+0.12} | ... | B |
| ... | 9683 | 5180 | 75 | 2457859.838 | -4.57 | 13.1 | -17.9 ^{+0.2} | ... | 10.7 ^{+0.8} | ... | 2815.9 ^{+10.1} | ... | 4.99 ^{+0.03} | ... | B |
| ... | 9778 | 5180 | 75 | 2457860.873 | -5.03 | 18.1 | -18.7 ^{+0.3} | ... | 10.8 ^{+0.9} | ... | 2946.3 ^{+18.5} | ... | 5.45 ^{+0.03} | ... | B |
| ... | 9665 | 5180 | 71 | 2457876.710 | -10.39 | 11.5 | -17.2 ^{+0.3} | ... | 9.4 ^{+0.8} | ... | 2896.9 ^{+20.6} | ... | 5.21 ^{+0.09} | ... | B |
| ... | 9778 | 5180 | 76 | 2457878.798 | -11.26 | 13.1 | -16.1 ^{+0.3} | ... | 10.7 ^{+1.3} | ... | 3068.3 ^{+15.8} | ... | 5.49 ^{+0.02} | ... | B |
| ... | 9730 | 5180 | 128 | 2457879.689 | -11.33 | 11.5 | -18.2 ^{+0.3} | ... | 6.9 ^{+1.7} | ... | 2968.0 ^{+20.3} | ... | 5.47 ^{+0.05} | ... | B |
| ... | 9725 | 5180 | 76 | 2457884.700 | -13.55 | 14.3 | -17.9 ^{+0.4} | ... | 11.0 ^{+0.9} | ... | 2892.5 ^{+17.9} | ... | 5.25 ^{+0.04} | ... | B |
| ... | 9725 | 5180 | 64 | 2457909.698 | -19.19 | 10.7 | -17.5 ^{+0.3} | ... | 10.5 ^{+0.9} | ... | 2806.6 ^{+12.2} | ... | 4.99 ^{+0.04} | ... | B |
| ... | 9683 | 5180 | 76 | 2457915.628 | -20.05 | 10.4 | -16.1 ^{+0.3} | ... | 15.1 ^{+1.1} | ... | 2807.2 ^{+6.9} | ... | 5.08 ^{+0.05} | ... | B |
| ... | 6857 | 4499 | 43 | 2456376.906 | -1.67 | 32.9 | -43.7 ^{+0.2} | ... | 15.1 ^{+0.6} | ... | 3056.2 ^{+18.4} | ... | 5.49 ^{+0.01} | ... | B |
| ... | 6857 | 4499 | 91 | 2456383.847 | -3.40 | 37.6 | -43.5 ^{+0.2} | ... | 3.8 ^{+1.4} | ... | 3184.8 ^{+7.1} | ... | 5.41 ^{+0.03} | ... | B |
| ... | 8334 | 2144 | 296 | 2458253.726 | -13.09 | 77.0 | -11.0 ^{+0.2} | ... | 19.7 ^{+0.1} | ... | 3159.2 ^{+14.4} | ... | 5.45 ^{+0.02} | ... | B |
| 2M14081562+5236281 | 6857 | 4499 | 91 | 2456439.692 | -14.57 | 135.2 | -21.2 ^{+0.1} | -43.5 ^{+0.1} | 9.2 ^{+0.6} | 19.7 ^{+0.1} | 2399.7 ^{+0.5} | 3175.2 ^{+11.3} | 5.48 ^{+0.02} | 5.46 ^{+0.03} | B |
| ... | 5672 | 4436 | 89 | 2456461.665 | -21.97 | 135.0 | -21.4 ^{+0.1} | -21.3 ^{+0.1} | 9.1 ^{+0.5} | < 10 | 2399.5 ^{+0.4} | ... | 5.41 ^{+0.03} | ... | B |
| ... | 5672 | 4436 | 41 | 2456468.649 | -23.69 | 137.6 | -21.3 ^{+0.2} | ... | 7.4 ^{+0.8} | ... | 2399.5 ^{+0.9} | ... | 5.45 ^{+0.02} | ... | B |
| ... | 9005 | 5186 | 206 | 2457498.739 | -5.69 | 26.9 | -6.5 ^{+0.2} | -6.4 ^{+0.3} | 16.0 ^{+1.1} | 16.3 ^{+1.6} | 2399.5 ^{+0.7} | 2399.3 ^{+0.3} | 4.92 ^{+0.02} | 4.88 ^{+0.15} | S |
| ... | 9006 | 5186 | 158 | 2457499.883 | -6.18 | 22.3 | -6.3 ^{+0.2} | ... | 16.1 ^{+0.2} | ... | 2399.3 ^{+0.4} | ... | 4.93 ^{+0.02} | ... | S |
| ... | 9006 | 5186 | 158 | 2457522.738 | -10.66 | 17.3 | -6.8 ^{+0.3} | ... | 16.1 ^{+0.3} | ... | 2398.9 ^{+0.8} | ... | 4.87 ^{+0.02} | ... | S |
| ... | 9005 | 5186 | 206 | 2457524.644 | -10.85 | 17.1 | -6.4 ^{+0.2} | ... | 16.1 ^{+0.3} | ... | 2399.3 ^{+0.8} | ... | 4.69 ^{+0.02} | ... | S |
| ... | 9005 | 5186 | 206 | 2457528.725 | -11.62 | 15.9 | -6.0 ^{+0.2} | ... | 16.3 ^{+0.3} | ... | 2399.4 ^{+0.5} | ... | 4.78 ^{+0.05} | ... | S |
| ... | 9006 | 5186 | 206 | 2457529.774 | -11.85 | 29.7 | -6.3 ^{+0.2} | ... | 14.1 ^{+1.2} | ... | 2399.2 ^{+1.0} | ... | 5.01 ^{+0.07} | ... | S |
| ... | 9006 | 5186 | 254 | 2457532.698 | -12.16 | 27.1 | -6.0 ^{+0.2} | ... | 12.6 ^{+0.8} | ... | 2399.1 ^{+0.7} | ... | 5.19 ^{+0.02} | ... | S |
| ... | 9006 | 5186 | 206 | 2457553.647 | -14.20 | 23.4 | -6.6 ^{+0.3} | ... | 16.1 ^{+0.8} | ... | 2399.3 ^{+1.0} | ... | 4.81 ^{+0.02} | ... | S |
| ... | 9006 | 5186 | 161 | 2457556.694 | -14.43 | 13.4 | -6.9 ^{+0.3} | ... | 19.8 ^{+0.3} | ... | 2399.2 ^{+0.6} | ... | 4.63 ^{+0.04} | ... | S |
| 2M14402293+1339230 | 6842 | 4493 | 272 | 2456469.649 | -22.80 | 45.7 | -3.3 ^{+0.2} | -3.5 ^{+0.2} | 4.2 ^{+0.4} | < 10 | 2399.1 ^{+0.6} | 2399.1 ^{+0.7} | 5.49 ^{+0.01} | 5.47 ^{+0.03} | S |
| ... | 6842 | 4493 | 278 | 2456701.025 | 25.03 | 27.3 | -3.7 ^{+0.2} | ... | 5.9 ^{+0.7} | ... | 2398.6 ^{+1.2} | ... | 5.41 ^{+0.06} | ... | S |
| ... | 6842 | 4493 | 224 | 2456709.004 | 23.50 | 34.7 | -3.7 ^{+0.2} | ... | 3.9 ^{+0.9} | ... | 2399.3 ^{+1.0} | ... | 5.44 ^{+0.03} | ... | S |
| 2M14432796+0316543 | 11835 | 2675 | 155 | 2458629.742 | -12.45 | 22.2 | -38.4 ^{+0.3} | -38.4 ^{+0.3} | 22.7 ^{+0.8} | 22.7 ^{+0.8} | 2399.2 ^{+1.3} | 2399.2 ^{+1.3} | 5.34 ^{+0.02} | 5.34 ^{+0.02} | S |
| 2M14553384+1545593 | 6844 | 4494 | 150 | 2456432.761 | -9.70 | 17.4 | 19.4 ^{+0.2} | 19.3 ^{+0.2} | 12.4 ^{+0.2} | 14.8 ^{+2.6} | 2399.2 ^{+0.9} | 2399.2 ^{+0.9} | 4.85 ^{+0.04} | 4.63 ^{+0.15} | S |
| ... | 6844 | 4494 | 102 | 2456470.651 | -21.60 | 16.2 | 19.2 ^{+0.2} | ... | 13.8 ^{+1.3} | ... | 2399.2 ^{+0.6} | ... | 4.67 ^{+0.03} | ... | S |
| ... | 6844 | 4494 | 150 | 2456703.995 | 24.34 | 12.2 | 19.2 ^{+0.3} | ... | 21.7 ^{+1.5} | ... | 2399.2 ^{+0.3} | ... | 4.34 ^{+0.08} | ... | S |
| ... | 11824 | 2673 | 119 | 2458634.771 | -13.24 | 60.5 | -39.9 ^{+0.1} | -39.9 ^{+0.1} | < 10 | < 10 | 2399.5 ^{+0.4} | 2399.5 ^{+0.4} | 4.87 ^{+0.02} | 4.89 ^{+0.02} | S |
| ... | 11824 | 2673 | 119 | 2458635.775 | -13.68 | 56.2 | -39.9 ^{+0.2} | ... | 7.6 ^{+0.9} | ... | 2399.5 ^{+0.6} | ... | 4.89 ^{+0.01} | ... | S |
| 2M15010818+2250020 | 5673 | 4437 | 293 | 2456702.002 | 22.44 | 60.2 | 7.6 ^{+0.1} | 6.5 ^{+0.7} | 65.9 ^{+0.4} | 65.3 ^{+1.2} | 2395.6 ^{+3.0} | 2389.1 ^{+23.6} | 5.5 ^{+0.0} | 5.5 ^{+0.0} | S |
| ... | 5673 | 4437 | 284 | 2456706.009 | 21.78 | 48.6 | 6.8 ^{+0.1} | ... | 65.0 ^{+0.3} | ... | 2387.4 ^{+3.9} | ... | 5.5 ^{+0.0} | ... | S |
| ... | 5673 | 4437 | 239 | 2456727.907 | 16.74 | 51.8 | 7.1 ^{+0.1} | ... | 64.0 ^{+0.7} | ... | 2341.1 ^{+3.3} | ... | 5.5 ^{+0.0} | ... | S |
| ... | 5673 | 4437 | 191 | 2456733.940 | 14.78 | 69.8 | 5.7 ^{+0.1} | ... | 64.1 ^{+0.8} | ... | 2309.6 ^{+1.0} | ... | 5.5 ^{+0.0} | ... | S |
| ... | 5673 | 4437 | 293 | 2456780.843 | -3.03 | 73.1 | 6.3 ^{+0.1} | ... | 66.3 ^{+0.4} | ... | 2396.1 ^{+4.6} | ... | 5.5 ^{+0.0} | ... | S |
| 2M15041028+0923232 | 11970 | 2732 | 132 | 2458928.974 | 17.25 | 15.9 | -53.5 ^{+0.2} | -53.3 ^{+0.3} | 15.0 ^{+0.8} | 13.4 ^{+1.4} | 2399.3 ^{+0.6} | 2399.2 ^{+0.4} | 4.85 ^{+0.02} | 4.96 ^{+0.11} | S |
| ... | 11970 | 2732 | 132 | 2458930.898 | 17.25 | 14.9 | -53.5 ^{+0.2} | ... | 12.7 ^{+0.4} | ... | 2399.1 ^{+1.2} | ... | 5.08 ^{+0.02} | ... | S |
| ... | 11962 | 2724 | 247 | 2458932.911 | 16.47 | 16.5 | -52.9 ^{+0.3} | ... | 14.1 ^{+0.7} | ... | 2399.2 ^{+0.6} | ... | 5.07 ^{+0.04} | ... | S |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate ID | Loc. ID | Fiber ID | JD (day) | bar _y . ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | vsin <i>i</i> | (v sin <i>i</i>) ^{b,c} (km s ⁻¹) | T _{eff} (K) | (T _{eff}) ^b (K) | log <i>g</i> (cm s ⁻²) | (log <i>g</i>) ^b (cm s ⁻²) | M _d ^d |
|--------------------|----------|---------|----------|-------------|---|-------|--------------------------|---|----------------------|--|-------------------------|--------------------------------------|------------------------------------|--|-----------------------------|
| 2M15042797-0942464 | 11970 | 2732 | 73 | 2458928.974 | 17.72 | 22.6 | -35.6 ^{+1.3} | -35.6 ^{+1.3} | 51.1 ^{+1.1} | 51.1 ^{+1.1} | 3177.5 ^{+7.8} | 5.25 ^{+0.05} | 5.25 ^{+0.05} | B | |
| 6848 | 4496 | 127 | 18.4 | 2456411.747 | -1.39 | 19.9 | -61.4 ^{+0.2} | -61.4 ^{+0.2} | 18.9 ^{+1.7} | 18.9 ^{+1.7} | 2399.3 ^{+0.7} | 4.89 ^{+0.04} | 4.88 ^{+0.02} | S | |
| 6848 | 4496 | 150 | 20.9 | 2456433.710 | -8.76 | 19.4 | -61.5 ^{+0.2} | -61.5 ^{+0.2} | 20.9 ^{+1.1} | 20.9 ^{+1.1} | 2399.4 ^{+0.8} | 4.87 ^{+0.03} | 4.87 ^{+0.03} | S | |
| 2M15175638-0656388 | 11968 | 2730 | 78 | 2459010.740 | -15.06 | 30.0 | -20.0 ^{+0.1} | -19.8 ^{+0.3} | < 10 | < 10 | 3292.9 ^{+11.5} | 5.43 ^{+0.03} | 5.38 ^{+0.04} | B | |
| 2M15210103-5053230 | 8596 | 2226 | 294 | 2458607.834 | -5.09 | 58.5 | 2.4 ^{+0.1} | 2.4 ^{+0.2} | 48.7 ^{+0.3} | 48.7 ^{+0.3} | 2399.2 ^{+1.1} | 5.5 ^{+0.0} | 5.5 ^{+0.0} | S | |
| 9044 | 2375 | 131 | 131 | 2457861.767 | 4.02 | 40.6 | -14.8 ^{+0.1} | -15.2 ^{+0.0} | 7.3 ^{+0.3} | 7.3 ^{+0.3} | 2399.2 ^{+1.1} | 5.46 ^{+0.01} | 5.47 ^{+0.01} | S | |
| 9044 | 2375 | 131 | 131 | 2457862.790 | 3.62 | 61.3 | -15.1 ^{+0.1} | -15.2 ^{+0.1} | 6.4 ^{+1.1} | 6.4 ^{+1.1} | 2399.4 ^{+0.8} | 5.48 ^{+0.01} | 5.48 ^{+0.01} | S | |
| 9043 | 2374 | 245 | 245 | 2457921.713 | -15.07 | 46.9 | -15.0 ^{+0.1} | -15.2 ^{+0.0} | 7.3 ^{+0.7} | 7.3 ^{+0.7} | 2399.2 ^{+1.0} | 5.49 ^{+0.01} | 5.49 ^{+0.01} | S | |
| 9887 | 2458 | 285 | 285 | 2457922.650 | -15.15 | 21.6 | -15.2 ^{+0.0} | -15.2 ^{+0.0} | 10.5 ^{+0.4} | 10.5 ^{+0.4} | 2399.3 ^{+1.2} | 5.14 ^{+0.02} | 5.14 ^{+0.02} | S | |
| 9887 | 2458 | 238 | 238 | 2458271.707 | -4.32 | 196.6 | 26.4 ^{+0.1} | 26.0 ^{+0.2} | 4.1 ^{+0.4} | 4.1 ^{+0.4} | 3428.7 ^{+6.4} | 5.1 ^{+0.02} | 5.09 ^{+0.01} | B | |
| 9887 | 2458 | 238 | 238 | 2458277.835 | -10.20 | 165.0 | 26.0 ^{+0.1} | 26.0 ^{+0.1} | 3.9 ^{+0.6} | 3.9 ^{+0.6} | 3418.8 ^{+4.3} | 5.07 ^{+0.02} | 5.07 ^{+0.02} | B | |
| 9851 | 5371 | 294 | 294 | 2458176.820 | 30.22 | 37.2 | -3.7 ^{+0.2} | -4.1 ^{+0.5} | 19.9 ^{+1.0} | 19.9 ^{+1.0} | 3007.7 ^{+8.4} | 5.09 ^{+0.01} | 5.09 ^{+0.01} | B | |
| 9851 | 5371 | 289 | 289 | 2458243.639 | 9.32 | 30.0 | -4.7 ^{+0.2} | -4.7 ^{+0.2} | 20.1 ^{+0.8} | 20.1 ^{+0.8} | 2992.6 ^{+3.7} | 4.51 ^{+0.02} | 4.51 ^{+0.02} | B | |
| 10944 | 5785 | 264 | 264 | 2458350.477 | -29.14 | 15.4 | 1.5 ^{+0.3} | 1.5 ^{+0.3} | 13.0 ^{+0.6} | 13.0 ^{+0.6} | 2399.4 ^{+0.8} | 3.58 ^{+0.04} | 3.58 ^{+0.04} | S | |
| 9851 | 5371 | 283 | 283 | 2458243.639 | 30.23 | 19.6 | -3.5 ^{+0.2} | -4.1 ^{+0.6} | 92.8 ^{+1.5} | 92.8 ^{+1.5} | 2399.1 ^{+0.7} | 3.51 ^{+0.01} | 3.51 ^{+0.01} | S | |
| 9851 | 5371 | 283 | 283 | 2458258.851 | -3.65 | 32.8 | 1.1 ^{+0.2} | 1.1 ^{+0.2} | 10.3 ^{+1.6} | 10.3 ^{+1.6} | 2399.5 ^{+0.3} | 4.89 ^{+0.02} | 4.84 ^{+0.13} | S | |
| 9887 | 2458 | 176 | 176 | 2458271.707 | -7.42 | 23.6 | 0.9 ^{+0.2} | 0.9 ^{+0.2} | 14.8 ^{+0.7} | 14.8 ^{+0.7} | 2399.5 ^{+0.3} | 4.6 ^{+0.02} | 4.6 ^{+0.02} | S | |
| 9887 | 2458 | 176 | 176 | 2458277.835 | -9.52 | 28.2 | 1.3 ^{+0.2} | 1.3 ^{+0.2} | 9.1 ^{+0.3} | 9.1 ^{+0.3} | 2399.2 ^{+1.1} | 4.89 ^{+0.01} | 4.89 ^{+0.01} | S | |
| 9887 | 2458 | 176 | 176 | 2458280.655 | -9.96 | 35.7 | 0.9 ^{+0.4} | 0.9 ^{+0.4} | 10.9 ^{+1.0} | 10.9 ^{+1.0} | 2399.4 ^{+0.4} | 4.95 ^{+0.05} | 4.95 ^{+0.05} | S | |
| 2M15592591-2305081 | 9781 | 5331 | 186 | 2458177.782 | 30.22 | 60.1 | -3.3 ^{+0.1} | -3.3 ^{+0.1} | 23.5 ^{+1.0} | 23.5 ^{+1.0} | 2399.7 ^{+0.4} | 4.06 ^{+0.03} | 3.99 ^{+0.06} | S | |
| 9781 | 5331 | 186 | 186 | 2458261.573 | 1.09 | 56.3 | -3.4 ^{+0.2} | -3.4 ^{+0.2} | 23.5 ^{+0.2} | 23.5 ^{+0.2} | 2399.7 ^{+0.2} | 3.94 ^{+0.03} | 3.94 ^{+0.03} | S | |
| 2M15594439-1928191 | 11629 | 6001 | 229 | 2458913.801 | 29.70 | 13.9 | -2.6 ^{+0.4} | -2.6 ^{+0.4} | 14.4 ^{+0.2} | 14.4 ^{+0.2} | 2399.4 ^{+0.7} | 3.83 ^{+0.16} | 3.83 ^{+0.16} | S | |
| 2M16001944-2256287 | 9781 | 5331 | 48 | 2458177.782 | 30.23 | 10.9 | -3.1 ^{+0.4} | -4.3 ^{+0.5} | 23.0 ^{+0.2} | 23.0 ^{+0.2} | 2399.3 ^{+0.5} | 3.54 ^{+0.02} | 3.53 ^{+0.02} | S | |
| 9781 | 5331 | 49 | 49 | 2458261.573 | 1.18 | 12.4 | -4.6 ^{+0.3} | -4.6 ^{+0.3} | 27.7 ^{+0.5} | 27.7 ^{+0.5} | 2399.2 ^{+0.5} | 3.53 ^{+0.04} | 3.53 ^{+0.04} | S | |
| 2M16002844-2209228 | 9781 | 5331 | 67 | 2458177.782 | 30.24 | 17.2 | -3.7 ^{+0.7} | -3.7 ^{+0.7} | 9.1 ^{+0.7} | 9.1 ^{+0.7} | 3177.3 ^{+7.5} | 5.06 ^{+0.12} | 5.08 ^{+0.15} | B | |
| 9781 | 5331 | 90 | 90 | 2458261.573 | 1.12 | 12.7 | -4.7 ^{+0.2} | -4.7 ^{+0.2} | 6.3 ^{+1.2} | 6.3 ^{+1.2} | 3171.8 ^{+20.3} | 5.18 ^{+0.08} | 5.18 ^{+0.08} | B | |
| 11627 | 5999 | 224 | 224 | 2458565.809 | 26.51 | 13.2 | -3.4 ^{+0.2} | -3.4 ^{+0.2} | 10.6 ^{+1.0} | 10.6 ^{+1.0} | 3117.4 ^{+22.3} | 4.87 ^{+0.06} | 4.87 ^{+0.06} | B | |
| 9781 | 5331 | 211 | 211 | 2458177.782 | 30.22 | 24.6 | -3.6 ^{+0.5} | -3.7 ^{+0.5} | 75.8 ^{+1.8} | 75.8 ^{+1.8} | 2399.5 ^{+0.4} | 3.51 ^{+0.01} | 3.51 ^{+0.01} | S | |
| 9781 | 5331 | 211 | 211 | 2458261.573 | 1.26 | 36.1 | -4.5 ^{+0.3} | -4.5 ^{+0.3} | 73.4 ^{+1.1} | 73.4 ^{+1.1} | 2399.5 ^{+0.6} | 3.52 ^{+0.01} | 3.52 ^{+0.01} | S | |
| 10944 | 5785 | 85 | 85 | 2458350.477 | -29.09 | 38.6 | -3.5 ^{+0.2} | -3.5 ^{+0.2} | 72.5 ^{+0.9} | 72.5 ^{+0.9} | 2399.6 ^{+0.7} | 3.51 ^{+0.01} | 3.51 ^{+0.01} | S | |
| 2M16014955-2351082 | 10944 | 5785 | 139 | 2458350.477 | -29.07 | 35.0 | -3.5 ^{+0.1} | -3.5 ^{+0.1} | 38.7 ^{+0.3} | 38.7 ^{+0.3} | 2399.6 ^{+0.3} | 3.52 ^{+0.02} | 3.52 ^{+0.02} | S | |
| 2M16022585-2414081 | 10944 | 5785 | 103 | 2458350.477 | -29.05 | 16.6 | -2.1 ^{+0.4} | -2.1 ^{+0.4} | 17.9 ^{+0.2} | 17.9 ^{+0.2} | 2399.4 ^{+1.0} | 3.53 ^{+0.02} | 3.53 ^{+0.02} | S | |
| 2M16044026-2254323 | 10945 | 5786 | 246 | 2458320.473 | -23.56 | 13.2 | -1.2 ^{+0.5} | -1.2 ^{+0.5} | 19.8 ^{+0.7} | 19.8 ^{+0.7} | 2399.4 ^{+1.1} | 3.66 ^{+0.03} | 3.66 ^{+0.03} | S | |
| 2M16045199-2224108 | 10945 | 5786 | 157 | 2458320.473 | -23.58 | 17.9 | -1.1 ^{+0.8} | -1.1 ^{+0.8} | 73.3 ^{+1.1} | 73.3 ^{+1.1} | 2399.1 ^{+1.2} | 3.51 ^{+0.01} | 3.51 ^{+0.01} | S | |
| 2M16055178-2206212 | 10945 | 5786 | 170 | 2458320.473 | -23.53 | 15.5 | -3.8 ^{+0.3} | -3.8 ^{+0.3} | 21.6 ^{+0.3} | 21.6 ^{+0.3} | 2399.3 ^{+0.9} | 3.52 ^{+0.02} | 3.52 ^{+0.02} | S | |
| 2M16055380-2303058 | 8969 | 5125 | 23 | 2457468.950 | 17.52 | 30.5 | -40.7 ^{+0.2} | -40.3 ^{+0.4} | 10.8 ^{+1.8} | 10.8 ^{+1.8} | 2399.4 ^{+0.4} | 5.12 ^{+0.04} | 4.89 ^{+0.19} | S | |
| 8969 | 5125 | 23 | 23 | 2457474.939 | 16.04 | 24.1 | -40.5 ^{+0.1} | -40.5 ^{+0.1} | 10.9 ^{+0.5} | 10.9 ^{+0.5} | 2399.3 ^{+1.0} | 4.91 ^{+0.02} | 4.91 ^{+0.02} | S | |
| 8969 | 5125 | 26 | 26 | 2457500.888 | 7.96 | 23.1 | -40.9 ^{+0.2} | -40.9 ^{+0.2} | 7.7 ^{+0.4} | 7.7 ^{+0.4} | 2399.3 ^{+0.5} | 5.1 ^{+0.01} | 5.1 ^{+0.01} | S | |
| 8969 | 5125 | 23 | 23 | 2457506.874 | 5.85 | 18.4 | -40.5 ^{+0.2} | -40.5 ^{+0.2} | 12.4 ^{+1.3} | 12.4 ^{+1.3} | 2399.4 ^{+1.0} | 4.67 ^{+0.03} | 4.67 ^{+0.03} | S | |
| 8969 | 5125 | 20 | 20 | 2457524.785 | -0.61 | 15.2 | -40.2 ^{+0.3} | -40.2 ^{+0.3} | 11.6 ^{+0.5} | 11.6 ^{+0.5} | 2399.3 ^{+0.5} | 4.71 ^{+0.02} | 4.71 ^{+0.02} | S | |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate ID | Loc. ID | Fiber ID | JD (day) | bury ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | v sin i (km s ⁻¹) | (v sin i) ^{b,c} (km s ⁻¹) | T _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | M _d ^d |
|--------------------|----------|---------|----------|-------------|---|------|--------------------------|---|-------------------------------|--|------------------------|--------------------------------------|-----------------------------|--|-----------------------------|
| ... | 8969 | 5125 | 14 | 2457530.805 | -2.88 | 11.5 | -40.0 ^{+0.3} | ... | 14.2 ^{+0.5} | ... | 2399.3 ^{+0.6} | ... | 4.65 ^{+0.03} | ... | S |
| ... | 8970 | 5125 | 23 | 2457532.763 | -3.50 | 20.4 | -40.2 ^{+0.2} | ... | 8.9 ^{+0.4} | ... | 2399.4 ^{+0.5} | ... | 4.88 ^{+0.04} | ... | S |
| ... | 8970 | 5125 | 20 | 2457535.782 | -4.64 | 23.9 | -40.2 ^{+0.1} | ... | 9.5 ^{+0.9} | ... | 2399.5 ^{+0.7} | ... | 5.02 ^{+0.03} | ... | S |
| ... | 8970 | 5125 | 26 | 2457552.704 | -10.32 | 26.2 | -39.9 ^{+0.1} | ... | 7.7 ^{+0.7} | ... | 2399.4 ^{+0.4} | ... | 4.93 ^{+0.02} | ... | S |
| ... | 8970 | 5125 | 26 | 2457555.675 | -11.20 | 16.7 | -40.3 ^{+0.3} | ... | 10.7 ^{+0.3} | ... | 2399.4 ^{+0.5} | ... | 4.75 ^{+0.04} | ... | S |
| ... | 8970 | 5125 | 110 | 2457558.751 | -12.31 | 12.2 | -39.0 ^{+0.3} | ... | 14.5 ^{+0.7} | ... | 2399.1 ^{+0.7} | ... | 4.59 ^{+0.02} | ... | S |
| 2M16063110-1904576 | 9782 | 5332 | 67 | 2458176.882 | 30.26 | 16.8 | -4.9 ^{+0.2} | -4.9 ^{+0.2} | 16.1 ^{+1.2} | 16.7 ^{+1.2} | 2399.5 ^{+0.6} | 2399.5 ^{+0.5} | 3.51 ^{+0.01} | 3.51 ^{+0.01} | S |
| ... | 9782 | 5332 | 67 | 2458177.833 | 30.26 | 11.6 | -4.8 ^{+0.7} | ... | 19.7 ^{+1.5} | ... | 2399.3 ^{+1.0} | ... | 3.51 ^{+0.01} | ... | S |
| 2M16063390+4054216 | 8313 | 2123 | 32 | 2457166.793 | -4.49 | 28.8 | -40.7 ^{+0.2} | -41.0 ^{+0.2} | 0.7 ^{+0.3} | < 10 | 2398.9 ^{+0.7} | 2399.1 ^{+0.8} | 5.3 ^{+0.03} | 5.32 ^{+0.02} | S |
| ... | 8979 | 2330 | 116 | 2457464.950 | 11.21 | 64.1 | -41.1 ^{+0.1} | ... | 0.7 ^{+0.4} | ... | 2399.3 ^{+0.8} | ... | 5.32 ^{+0.02} | ... | S |
| 2M16081226+2252548 | 8468 | 5125 | 104 | 2457122.864 | 12.58 | 11.3 | 14.5 ^{+0.2} | 14.4 ^{+0.8} | 24.1 ^{+1.3} | 24.5 ^{+2.2} | 2399.3 ^{+0.5} | 2399.2 ^{+0.3} | 4.54 ^{+0.06} | 4.52 ^{+0.12} | S |
| ... | 8468 | 5125 | 8 | 2457151.784 | 2.59 | 11.3 | 13.1 ^{+0.5} | ... | 28.2 ^{+0.9} | ... | 2399.3 ^{+0.5} | ... | 4.63 ^{+0.03} | ... | S |
| ... | 8469 | 5125 | 116 | 2457175.720 | -6.10 | 10.6 | 15.4 ^{+0.4} | ... | 22.8 ^{+1.0} | ... | 2399.2 ^{+0.6} | ... | 4.45 ^{+0.05} | ... | S |
| ... | 8969 | 5125 | 53 | 2457500.888 | 8.23 | 11.1 | 14.3 ^{+0.3} | ... | 22.7 ^{+1.0} | ... | 2399.2 ^{+1.4} | ... | 4.36 ^{+0.04} | ... | S |
| 2M16090197-2151225 | 11628 | 6000 | 175 | 2458565.865 | 26.88 | 26.9 | -6.4 ^{+0.2} | -6.4 ^{+0.2} | 47.8 ^{+1.2} | 47.8 ^{+1.2} | 2399.7 ^{+0.6} | 2399.7 ^{+0.6} | 3.52 ^{+0.01} | 3.52 ^{+0.01} | S |
| 2M16090451-2224523 | 9852 | 5372 | 19 | 2458243.753 | 10.73 | 31.4 | -5.8 ^{+0.1} | -5.2 ^{+0.8} | 14.2 ^{+0.3} | 14.1 ^{+1.0} | 2399.7 ^{+0.2} | 2399.7 ^{+0.1} | 4.14 ^{+0.02} | 3.97 ^{+0.11} | S |
| ... | 10945 | 5786 | 125 | 2458320.473 | -23.29 | 34.8 | -3.8 ^{+0.2} | ... | 14.1 ^{+0.1} | ... | 2399.7 ^{+0.5} | ... | 3.88 ^{+0.02} | ... | S |
| ... | 11628 | 6000 | 251 | 2458565.865 | 26.90 | 43.8 | -4.7 ^{+0.2} | ... | 14.1 ^{+0.2} | ... | 2399.7 ^{+0.2} | ... | 3.95 ^{+0.02} | ... | S |
| 2M16090568-2245166 | 11628 | 6000 | 295 | 2458565.865 | 26.91 | 10.5 | -3.0 ^{+0.2} | -3.0 ^{+0.2} | 32.9 ^{+0.3} | 32.9 ^{+0.3} | 2398.7 ^{+2.0} | 2398.7 ^{+2.0} | 3.9 ^{+0.04} | 3.9 ^{+0.04} | S |
| 2M16093019-2059536 | 9852 | 5372 | 132 | 2458243.753 | 10.66 | 22.0 | -1.3 ^{+0.2} | -1.3 ^{+0.2} | 17.9 ^{+0.1} | 17.9 ^{+0.1} | 2399.6 ^{+0.5} | 2399.6 ^{+0.5} | 3.55 ^{+0.02} | 3.55 ^{+0.02} | S |
| ... | 10952 | 5793 | 151 | 2458350.594 | -29.04 | 21.9 | -1.5 ^{+0.2} | ... | 56.1 ^{+0.3} | 56.1 ^{+0.3} | 2399.5 ^{+0.3} | 2399.5 ^{+0.3} | 3.5 ^{+0.01} | 3.5 ^{+0.01} | S |
| 2M16095852-2345186 | 10591 | 5655 | 131 | 2458243.821 | 10.77 | 29.5 | -2.4 ^{+0.2} | -2.4 ^{+0.2} | 34.7 ^{+1.5} | 34.7 ^{+1.5} | 2399.6 ^{+0.5} | 2399.6 ^{+0.5} | 3.51 ^{+0.01} | 3.51 ^{+0.01} | S |
| ... | 11628 | 6000 | 157 | 2458565.865 | 26.94 | 19.0 | -3.8 ^{+0.4} | -3.8 ^{+0.4} | 22.0 ^{+1.5} | 22.0 ^{+1.5} | 2399.5 ^{+0.4} | 2399.5 ^{+0.4} | 3.6 ^{+0.05} | 3.6 ^{+0.05} | S |
| 2M16100608-2127440 | 11628 | 6000 | 164 | 2458565.865 | 26.93 | 10.7 | -5.4 ^{+0.3} | -5.4 ^{+0.3} | 16.5 ^{+0.5} | 16.5 ^{+0.5} | 2399.1 ^{+1.3} | 2399.1 ^{+1.3} | 3.84 ^{+0.06} | 3.84 ^{+0.06} | S |
| 2M16103014-2315167 | 9783 | 5333 | 247 | 2458560.866 | 28.10 | 19.9 | -3.9 ^{+0.2} | -3.9 ^{+0.2} | 14.2 ^{+0.1} | 14.2 ^{+0.1} | 2399.6 ^{+0.5} | 2399.6 ^{+0.5} | 3.55 ^{+0.03} | 3.55 ^{+0.03} | S |
| 2M16103040-3954258 | 8314 | 2124 | 204 | 2458282.788 | -8.74 | 35.3 | 14.6 ^{+0.3} | 14.2 ^{+0.1} | 12.3 ^{+0.6} | 11.0 ^{+1.1} | 2399.4 ^{+1.1} | 2399.5 ^{+0.7} | 5.17 ^{+0.03} | 5.16 ^{+0.02} | S |
| ... | 8314 | 2124 | 204 | 2458287.786 | -9.76 | 76.8 | 14.2 ^{+0.1} | ... | 10.7 ^{+0.5} | ... | 2399.6 ^{+0.3} | ... | 5.15 ^{+0.02} | ... | S |
| 2M16103232-1913085 | 10595 | 5659 | 258 | 2458242.662 | 11.26 | 16.7 | -6.2 ^{+0.1} | -6.2 ^{+0.1} | 42.4 ^{+0.3} | 42.4 ^{+0.3} | 2399.3 ^{+1.0} | 2399.3 ^{+1.0} | 3.55 ^{+0.02} | 3.55 ^{+0.02} | S |
| 2M16103232+2249116 | 8468 | 5125 | 50 | 2457116.907 | 14.49 | 10.8 | -3.6 ^{+0.4} | -4.0 ^{+0.5} | 10.8 ^{+0.4} | 11.8 ^{+1.9} | 2399.1 ^{+1.3} | 2399.3 ^{+0.2} | 4.78 ^{+0.03} | 4.84 ^{+0.13} | S |
| ... | 8468 | 5125 | 140 | 2457119.850 | 13.75 | 14.8 | -4.6 ^{+0.4} | ... | 12.2 ^{+1.0} | ... | 2399.1 ^{+0.7} | ... | 4.8 ^{+0.03} | ... | S |
| ... | 8469 | 5125 | 38 | 2457121.883 | 13.06 | 15.1 | -3.9 ^{+0.2} | ... | 12.1 ^{+0.2} | ... | 2399.2 ^{+1.0} | ... | 4.72 ^{+0.03} | ... | S |
| ... | 8468 | 5125 | 140 | 2457122.864 | 12.80 | 16.2 | -4.2 ^{+0.2} | ... | 10.9 ^{+0.4} | ... | 2399.4 ^{+0.5} | ... | 4.96 ^{+0.03} | ... | S |
| ... | 8468 | 5125 | 92 | 2457148.752 | 4.04 | 12.8 | -4.7 ^{+0.2} | ... | 16.0 ^{+0.5} | ... | 2399.4 ^{+0.7} | ... | 4.59 ^{+0.02} | ... | S |
| ... | 8468 | 5125 | 92 | 2457151.784 | 2.86 | 21.4 | -4.1 ^{+0.3} | ... | 10.6 ^{+0.3} | ... | 2399.5 ^{+0.9} | ... | 4.91 ^{+0.02} | ... | S |
| ... | 8468 | 5125 | 50 | 2457168.712 | -3.29 | 16.7 | -3.6 ^{+0.2} | ... | 10.1 ^{+0.8} | ... | 2399.2 ^{+0.7} | ... | 5.15 ^{+0.05} | ... | S |
| ... | 8469 | 5125 | 140 | 2457169.698 | -3.62 | 13.1 | -3.2 ^{+0.3} | ... | 11.4 ^{+0.9} | ... | 2399.2 ^{+0.9} | ... | 4.88 ^{+0.02} | ... | S |
| ... | 8469 | 5125 | 44 | 2457175.720 | -5.82 | 16.8 | -4.3 ^{+0.1} | ... | 10.6 ^{+0.5} | ... | 2399.3 ^{+0.8} | ... | 4.96 ^{+0.02} | ... | S |
| ... | 8469 | 5125 | 47 | 2457412.024 | 20.84 | 10.2 | -3.6 ^{+0.4} | ... | 13.8 ^{+1.1} | ... | 2399.3 ^{+1.0} | ... | 4.62 ^{+0.05} | ... | S |
| ... | 8469 | 5125 | 143 | 2457415.024 | 21.21 | 14.9 | -3.2 ^{+0.2} | ... | 9.7 ^{+0.1} | ... | 2398.9 ^{+0.6} | ... | 4.91 ^{+0.04} | ... | S |
| 2M16104714-2239492 | 11628 | 6000 | 235 | 2458565.865 | 27.00 | 10.2 | -7.5 ^{+0.2} | -7.5 ^{+0.2} | 9.2 ^{+3.3} | < 10 | 2399.1 ^{+1.4} | 2399.1 ^{+1.4} | 4.31 ^{+0.02} | 4.31 ^{+0.02} | S |
| 2M16113837-2307072 | 9783 | 5333 | 258 | 2458560.866 | 28.15 | 17.8 | -1.9 ^{+0.2} | -2.2 ^{+0.5} | 35.5 ^{+1.0} | 36.6 ^{+1.1} | 2399.6 ^{+0.7} | 2399.6 ^{+0.4} | 3.51 ^{+0.01} | 3.51 ^{+0.01} | S |
| ... | 11628 | 6000 | 216 | 2458565.865 | 27.06 | 28.2 | -2.9 ^{+0.3} | ... | 36.6 ^{+0.2} | ... | 2399.7 ^{+0.4} | ... | 3.52 ^{+0.02} | ... | S |
| 2M16114261-2525511 | 9762 | 5310 | 199 | 2457878.674 | 11.26 | 56.4 | -5.3 ^{+0.2} | -4.7 ^{+0.6} | 55.1 ^{+0.4} | 55.3 ^{+1.0} | 2399.8 ^{+0.3} | 2399.8 ^{+0.2} | 3.5 ^{+0.0} | 3.5 ^{+0.0} | S |
| ... | 9853 | 5373 | 235 | 2458243.877 | 10.94 | 58.4 | -4.0 ^{+0.2} | ... | 55.5 ^{+0.6} | ... | 2399.8 ^{+0.2} | ... | 3.5 ^{+0.0} | ... | S |

Table 3.4 (continued)

Table 3.4 (continued)

| APOGEE ID | Plate | Loc. ID | Fiber ID | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | vsini ^c (km s ⁻¹) | (v sin i) ^{b,c} (km s ⁻¹) | T _{eff} (K) | (T _{eff}) ^b (K) | log g (cm s ⁻²) | (log g) ^b (cm s ⁻²) | Mdl ^d |
|---------------------|-------|---------|----------|-------------|--|------|---------------------------------------|---|--|--|--|--|--|--|------------------|
| 2M16115439-2236491 | 11628 | 6000 | 186 | 2458565.865 | 27.06 | 18.6 | -2.5 ^{+0.8} _{-0.3} | 50.3 ^{+0.5} _{-1.2} | 50.3 ^{+0.5} _{-1.2} | 2399.5 ^{+0.5} _{-0.3} | 2399.5 ^{+0.5} _{-0.3} | 3.53 ^{+0.02} _{-0.02} | 3.53 ^{+0.02} _{-0.02} | S | |
| 2M16122703-2013250 | 9763 | 5311 | 186 | 2457878.837 | 10.56 | 41.1 | -4.9 ^{+0.3} _{-0.3} | 30.9 ^{+0.4} _{-0.3} | 30.9 ^{+0.4} _{-0.3} | 2399.7 ^{+0.2} _{-0.2} | 2399.7 ^{+0.2} _{-0.2} | 3.58 ^{+0.02} _{-0.02} | 3.58 ^{+0.02} _{-0.02} | S | |
| 2M16124726-1903531 | 9763 | 5311 | 61 | 2457878.837 | 10.49 | 27.7 | -7.1 ^{+0.1} _{-0.1} | 29.2 ^{+0.3} _{-0.3} | 29.2 ^{+0.3} _{-0.3} | 2977.8 ^{+0.1} _{-0.1} | 2977.8 ^{+0.1} _{-0.1} | 4.51 ^{+0.01} _{-0.01} | 4.5 ^{+0.02} _{-0.02} | B | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2M16132665-2230348 | 11628 | 6000 | 1 | 2458565.865 | 27.14 | 30.1 | -4.7 ^{+0.2} _{-0.2} | 19.9 ^{+0.1} _{-0.1} | 19.9 ^{+0.1} _{-0.1} | 2964.6 ^{+0.4} _{-0.4} | 2964.6 ^{+0.4} _{-0.4} | 4.47 ^{+0.02} _{-0.02} | 4.47 ^{+0.02} _{-0.02} | B | |
| 2M16132809-1924524 | 9763 | 5311 | 80 | 2457878.837 | 10.60 | 44.0 | -4.8 ^{+0.1} _{-0.1} | 23.1 ^{+0.1} _{-0.1} | 23.1 ^{+0.1} _{-0.1} | 2399.8 ^{+0.2} _{-0.2} | 2399.7 ^{+0.1} _{-0.1} | 3.53 ^{+0.01} _{-0.01} | 3.56 ^{+0.06} _{-0.06} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2M16134027-223192 | 11628 | 6000 | 114 | 2458565.865 | 27.15 | 24.6 | -6.4 ^{+0.1} _{-0.1} | 14.1 ^{+0.2} _{-0.2} | 14.1 ^{+0.2} _{-0.2} | 2399.6 ^{+0.5} _{-0.5} | 2399.6 ^{+0.5} _{-0.5} | 3.8 ^{+0.03} _{-0.03} | 3.8 ^{+0.03} _{-0.03} | S | |
| 2M16134079-2219459 | 11628 | 6000 | 108 | 2458565.865 | 27.15 | 11.8 | -0.8 ^{+0.3} _{-0.3} | 19.4 ^{+0.3} _{-0.3} | 19.4 ^{+0.3} _{-0.3} | 2399.4 ^{+0.4} _{-0.4} | 2399.4 ^{+0.4} _{-0.4} | 3.8 ^{+0.06} _{-0.06} | 3.8 ^{+0.06} _{-0.06} | S | |
| 2M16134264-2301279 | 11628 | 6000 | 27 | 2458565.865 | 27.17 | 24.8 | -2.0 ^{+0.9} _{-0.9} | 59.3 ^{+0.4} _{-0.4} | 59.3 ^{+0.4} _{-0.4} | 2399.6 ^{+0.6} _{-0.6} | 2399.6 ^{+0.6} _{-0.6} | 3.52 ^{+0.01} _{-0.01} | 3.52 ^{+0.01} _{-0.01} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2M16143287-2242133 | 11628 | 6000 | 115 | 2458565.865 | 27.20 | 14.4 | 0.2 ^{+0.1} _{-0.1} | 18.0 ^{+0.2} _{-0.2} | 18.0 ^{+0.2} _{-0.2} | 2399.4 ^{+0.3} _{-0.3} | 2399.4 ^{+0.3} _{-0.3} | 3.53 ^{+0.03} _{-0.03} | 3.53 ^{+0.03} _{-0.03} | S | |
| 2M161672079-4113032 | 8600 | 2230 | 97 | 2457459.007 | 12.28 | 24.0 | 0.5 ^{+0.2} _{-0.2} | 11.0 ^{+0.4} _{-0.4} | 11.0 ^{+0.4} _{-0.4} | 2399.5 ^{+0.8} _{-0.8} | 2399.4 ^{+0.5} _{-0.5} | 4.81 ^{+0.02} _{-0.02} | 5.07 ^{+0.19} _{-0.19} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2M16183317-2517504 | 10592 | 5656 | 95 | 2457464.950 | 11.47 | 51.4 | 0.9 ^{+0.2} _{-0.2} | 2.6 ^{+1.4} _{-1.4} | 2.6 ^{+1.4} _{-1.4} | 2399.3 ^{+0.8} _{-0.8} | 2399.3 ^{+0.8} _{-0.8} | 5.27 ^{+0.01} _{-0.01} | 5.27 ^{+0.01} _{-0.01} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 10948 | 10948 | 5789 | 158 | 2458320.566 | -22.60 | 43.4 | -1.0 ^{+0.1} _{-0.1} | 18.2 ^{+0.3} _{-0.3} | 16.3 ^{+1.2} _{-1.4} | 3128.6 ^{+5.8} _{-5.2} | 3130.1 ^{+3.8} _{-3.9} | 4.59 ^{+0.02} _{-0.02} | 4.62 ^{+0.03} _{-0.03} | B | |
| 10594 | 10594 | 5658 | 252 | 2458242.784 | 12.33 | 13.5 | -4.2 ^{+0.4} _{-0.4} | 18.0 ^{+0.7} _{-0.7} | 17.0 ^{+1.2} _{-1.2} | 2399.5 ^{+0.9} _{-0.9} | 2399.5 ^{+0.9} _{-0.9} | 4.64 ^{+0.03} _{-0.03} | 4.64 ^{+0.03} _{-0.03} | B | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2M16195143-2241332 | 9855 | 5317 | 223 | 2458243.690 | 12.07 | 12.9 | -4.6 ^{+0.1} _{-0.1} | 16.4 ^{+0.6} _{-0.6} | 16.4 ^{+0.6} _{-0.6} | 2399.5 ^{+0.3} _{-0.3} | 2399.5 ^{+0.3} _{-0.3} | 3.61 ^{+0.04} _{-0.04} | 3.61 ^{+0.04} _{-0.04} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2M16204144-2425491 | 10947 | 5788 | 115 | 2458560.798 | 28.63 | 15.7 | 1.5 ^{+0.6} _{-0.6} | 25.4 ^{+0.2} _{-0.2} | 25.4 ^{+0.2} _{-0.2} | 2399.6 ^{+0.6} _{-0.6} | 2399.6 ^{+0.6} _{-0.6} | 3.52 ^{+0.01} _{-0.01} | 3.52 ^{+0.01} _{-0.01} | S | |
| 2M16222304-2407108 | 10947 | 5788 | 127 | 2458560.798 | 28.70 | 15.1 | -1.9 ^{+0.5} _{-0.5} | 44.5 ^{+1.1} _{-1.1} | 44.5 ^{+1.1} _{-1.1} | 2399.4 ^{+0.5} _{-0.5} | 2399.4 ^{+0.5} _{-0.5} | 3.53 ^{+0.02} _{-0.02} | 3.53 ^{+0.02} _{-0.02} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2M16225251-2405139 | 10947 | 5788 | 131 | 2458560.798 | 28.70 | 16.5 | -1.2 ^{+0.3} _{-0.3} | 18.0 ^{+0.3} _{-0.3} | 18.0 ^{+0.3} _{-0.3} | 2399.4 ^{+0.5} _{-0.5} | 2399.4 ^{+0.5} _{-0.5} | 3.56 ^{+0.02} _{-0.02} | 3.56 ^{+0.02} _{-0.02} | S | |
| 2M16235155-2317270 | 10594 | 5658 | 216 | 2458242.784 | 12.81 | 27.5 | -3.9 ^{+0.2} _{-0.2} | 52.6 ^{+0.8} _{-0.8} | 52.6 ^{+0.8} _{-0.8} | 2399.6 ^{+0.8} _{-0.8} | 2399.6 ^{+0.8} _{-0.8} | 3.53 ^{+0.02} _{-0.02} | 3.53 ^{+0.02} _{-0.02} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11942 | 11942 | 2704 | 120 | 2458641.850 | -5.90 | 27.0 | 3.1 ^{+0.3} _{-0.3} | 28.3 ^{+0.8} _{-0.8} | 27.1 ^{+1.7} _{-1.7} | 2399.0 ^{+1.8} _{-1.8} | 2399.1 ^{+0.2} _{-0.2} | 5.45 ^{+0.02} _{-0.02} | 5.34 ^{+0.13} _{-0.13} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11943 | 11943 | 2705 | 55 | 2458643.851 | -6.17 | 19.1 | 2.9 ^{+0.4} _{-0.4} | 29.1 ^{+0.5} _{-0.5} | 29.1 ^{+0.5} _{-0.5} | 2398.9 ^{+1.4} _{-1.4} | 2398.9 ^{+1.4} _{-1.4} | 5.39 ^{+0.05} _{-0.05} | 5.39 ^{+0.05} _{-0.05} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11943 | 11943 | 2705 | 60 | 2458656.654 | -8.72 | 22.9 | 3.6 ^{+0.2} _{-0.2} | 25.7 ^{+0.3} _{-0.3} | 25.7 ^{+0.3} _{-0.3} | 2399.1 ^{+0.6} _{-0.6} | 2399.1 ^{+0.6} _{-0.6} | 5.22 ^{+0.07} _{-0.07} | 5.22 ^{+0.07} _{-0.07} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11941 | 11941 | 2703 | 102 | 2458656.714 | -8.84 | 15.9 | 3.1 ^{+0.3} _{-0.3} | 28.1 ^{+0.7} _{-0.7} | 28.1 ^{+0.7} _{-0.7} | 2398.8 ^{+0.9} _{-0.9} | 2398.8 ^{+0.9} _{-0.9} | 5.19 ^{+0.02} _{-0.02} | 5.19 ^{+0.02} _{-0.02} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11941 | 11941 | 2703 | 102 | 2458657.673 | -8.96 | 20.5 | 2.8 ^{+0.5} _{-0.5} | 25.7 ^{+0.4} _{-0.4} | 25.7 ^{+0.4} _{-0.4} | 2399.3 ^{+0.5} _{-0.5} | 2399.3 ^{+0.5} _{-0.5} | 5.12 ^{+0.04} _{-0.04} | 5.12 ^{+0.04} _{-0.04} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11941 | 11941 | 2703 | 102 | 2458658.640 | -9.09 | 17.5 | 2.6 ^{+0.2} _{-0.2} | 25.7 ^{+0.4} _{-0.4} | 25.7 ^{+0.4} _{-0.4} | 2399.0 ^{+1.2} _{-1.2} | 2399.0 ^{+1.2} _{-1.2} | 5.41 ^{+0.02} _{-0.02} | 5.41 ^{+0.02} _{-0.02} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 12674 | 12674 | 2871 | 259 | 2459022.755 | -9.08 | 14.9 | 2.3 ^{+0.2} _{-0.2} | 29.1 ^{+0.6} _{-0.6} | 29.1 ^{+0.6} _{-0.6} | 2399.1 ^{+0.6} _{-0.6} | 2399.1 ^{+0.6} _{-0.6} | 5.14 ^{+0.03} _{-0.03} | 5.14 ^{+0.03} _{-0.03} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 12674 | 12674 | 2871 | 259 | 2459023.763 | -9.30 | 20.1 | 2.5 ^{+0.2} _{-0.2} | 27.4 ^{+0.2} _{-0.2} | 27.4 ^{+0.2} _{-0.2} | 2399.1 ^{+0.4} _{-0.4} | 2399.1 ^{+0.4} _{-0.4} | 5.38 ^{+0.02} _{-0.02} | 5.38 ^{+0.02} _{-0.02} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 12673 | 12673 | 2870 | 198 | 2459078.740 | -14.79 | 12.0 | 3.8 ^{+0.4} _{-0.4} | 31.1 ^{+0.6} _{-0.6} | 31.1 ^{+0.6} _{-0.6} | 2398.7 ^{+0.9} _{-0.9} | 2398.7 ^{+0.9} _{-0.9} | 5.13 ^{+0.06} _{-0.06} | 5.13 ^{+0.06} _{-0.06} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 12673 | 12673 | 2870 | 198 | 2459080.723 | -14.76 | 15.4 | 2.8 ^{+0.4} _{-0.4} | 27.5 ^{+0.4} _{-0.4} | 27.5 ^{+0.4} _{-0.4} | 2399.3 ^{+1.0} _{-1.0} | 2399.3 ^{+1.0} _{-1.0} | 5.32 ^{+0.03} _{-0.03} | 5.32 ^{+0.03} _{-0.03} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 12673 | 12673 | 2870 | 198 | 2459084.705 | -14.64 | 18.8 | 2.9 ^{+0.2} _{-0.2} | 25.9 ^{+0.4} _{-0.4} | 25.9 ^{+0.4} _{-0.4} | 2399.3 ^{+0.5} _{-0.5} | 2399.3 ^{+0.5} _{-0.5} | 5.44 ^{+0.03} _{-0.03} | 5.44 ^{+0.03} _{-0.03} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 2M16271693-3514132 | 11940 | 2702 | 139 | 2459042.784 | -13.68 | 17.3 | -12.1 ^{+0.7} _{-0.7} | 21.8 ^{+0.9} _{-0.9} | 21.9 ^{+1.3} _{-1.3} | 2399.3 ^{+0.5} _{-0.5} | 2399.3 ^{+0.5} _{-0.5} | 4.7 ^{+0.02} _{-0.02} | 4.75 ^{+0.11} _{-0.11} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11940 | 11940 | 2702 | 139 | 2459069.678 | -14.39 | 16.5 | -11.3 ^{+0.3} _{-0.3} | 31.1 ^{+1.5} _{-1.5} | 31.1 ^{+1.5} _{-1.5} | 2399.2 ^{+1.1} _{-1.1} | 2399.2 ^{+1.1} _{-1.1} | 4.6 ^{+0.08} _{-0.08} | 4.6 ^{+0.08} _{-0.08} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11940 | 11940 | 2702 | 139 | 2459069.678 | -16.42 | 20.7 | -12.9 ^{+0.4} _{-0.4} | 21.7 ^{+0.2} _{-0.2} | 21.7 ^{+0.2} _{-0.2} | 2399.3 ^{+0.5} _{-0.5} | 2399.3 ^{+0.5} _{-0.5} | 4.88 ^{+0.04} _{-0.04} | 4.88 ^{+0.04} _{-0.04} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11940 | 11940 | 2702 | 43 | 2459042.784 | -13.58 | 26.3 | -8.8 ^{+0.3} _{-0.3} | 9.1 ^{+0.5} _{-0.5} | < 10 | 2399.0 ^{+1.2} _{-1.2} | 2398.9 ^{+0.8} _{-0.8} | 5.49 ^{+0.01} _{-0.01} | 5.49 ^{+0.01} _{-0.01} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11940 | 11940 | 2702 | 43 | 2459047.746 | -14.27 | 25.7 | -8.2 ^{+0.2} _{-0.2} | 7.8 ^{+0.1} _{-0.1} | 7.8 ^{+0.1} _{-0.1} | 2398.7 ^{+1.0} _{-1.0} | 2398.7 ^{+1.0} _{-1.0} | 5.45 ^{+0.02} _{-0.02} | 5.45 ^{+0.02} _{-0.02} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11940 | 11940 | 2702 | 43 | 2459050.735 | -14.66 | 10.7 | -6.3 ^{+0.3} _{-0.3} | 16.3 ^{+0.3} _{-0.3} | 16.3 ^{+0.3} _{-0.3} | 2399.2 ^{+1.5} _{-1.5} | 2399.2 ^{+1.5} _{-1.5} | 4.85 ^{+0.03} _{-0.03} | 4.85 ^{+0.03} _{-0.03} | S | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 11940 | 11940 | 2702 | 43 | 2459069.678 | -16.26 | 31.5 | -8.9 ^{+0.1} _{-0.1} | 7.8 ^{+0.4} _{-0.4} | 7.8 ^{+0.4} _{-0.4} | 2399.0 ^{+1.4} _{-1.4} | 2399.0 ^{+1.4} _{-1.4} | 5.49 ^{+0.01} _{-0.01} | 5.49 ^{+0.01} | | |

Table 3.4 (continued)

| APOGEE ID | Plate ID | Loc. ID | Fiber ID | JD (day) | bury ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | v sin <i>i</i> (km s ⁻¹) | (v sin <i>i</i>) ^{b,c} (km s ⁻¹) | <i>T</i> _{eff} (K) | (<i>T</i> _{eff}) ^b (K) | log <i>g</i> (cm s ⁻²) | (log <i>g</i>) ^b (cm s ⁻²) | Mdl ^d |
|--------------------|----------|---------|----------|-------------|---|-------|--|--|--|--|--|--|--|--|------------------|
| 2M16311879+4051516 | 8312 | 2122 | 171 | 2457160.893 | -0.85 | 241.5 | -21.8 ^{+0.1} -21.8 ^{-0.1} | -21.8 ^{+0.2} -21.8 ^{-0.2} | 12.3 ^{+0.1} 12.3 ^{-0.1} | 14.8 ^{+1.8} 14.8 ^{-1.6} | 2399.6 ^{+0.5} 2399.6 ^{-0.3} | 2399.6 ^{+0.2} 2399.6 ^{-0.1} | 5.33 ^{+0.02} 5.33 ^{-0.05} | 5.33 ^{+0.05} 5.33 ^{-0.05} | S |
| ... | 8601 | 2231 | 214 | 2457192.686 | -7.70 | 275.2 | -21.6 ^{+0.3} -21.4 ^{+0.2} | ... | ... | ... | 2399.5 ^{+0.3} 2399.7 ^{+0.5} | ... | 5.36 ^{+0.02} 5.39 ^{+0.02} | 5.36 ^{-0.02} 5.39 ^{-0.02} | S |
| ... | 9869 | 2440 | 292 | 2457899.827 | -2.76 | 123.2 | -21.4 ^{+0.2} -21.4 ^{-0.2} | ... | ... | ... | 2399.7 ^{+0.5} 2399.6 ^{+0.3} | ... | 5.39 ^{+0.02} 5.29 ^{+0.03} | 5.39 ^{-0.02} 5.29 ^{-0.03} | S |
| ... | 9869 | 2440 | 292 | 2457900.806 | -2.95 | 184.0 | -21.7 ^{+0.2} -21.7 ^{-0.2} | ... | ... | ... | 2399.6 ^{+0.3} 2399.6 ^{+0.4} | ... | 5.29 ^{+0.03} 5.3 ^{+0.01} | 5.29 ^{-0.03} 5.3 ^{-0.01} | S |
| ... | 11942 | 2704 | 195 | 2458641.850 | -5.46 | 170.9 | -21.7 ^{+0.2} -21.5 ^{+0.2} | ... | ... | ... | 2399.5 ^{+0.3} 2399.5 ^{+0.4} | ... | 5.3 ^{+0.01} 5.3 ^{-0.02} | 5.3 ^{-0.01} 5.3 ^{-0.02} | S |
| ... | 11942 | 2704 | 195 | 2458642.869 | -5.72 | 133.8 | -21.5 ^{+0.2} -21.9 ^{+0.2} | ... | ... | ... | 2399.5 ^{+0.4} 2399.5 ^{+0.4} | ... | 5.3 ^{-0.02} 5.29 ^{+0.01} | 5.3 ^{-0.02} 5.29 ^{+0.01} | S |
| ... | 11943 | 2705 | 159 | 2458643.851 | -5.91 | 199.6 | -21.9 ^{+0.2} -21.8 ^{+0.2} | ... | ... | ... | 2399.5 ^{+0.4} 2399.5 ^{+0.7} | ... | 5.29 ^{+0.01} 5.24 ^{+0.03} | 5.29 ^{-0.01} 5.24 ^{-0.03} | S |
| ... | 11943 | 2705 | 159 | 2458645.863 | -6.36 | 44.7 | -21.8 ^{+0.2} -21.8 ^{-0.2} | ... | ... | ... | 2399.5 ^{+0.3} 2399.5 ^{+0.3} | ... | 5.24 ^{+0.03} 5.3 ^{-0.02} | 5.24 ^{-0.03} 5.3 ^{-0.02} | S |
| ... | 11943 | 2705 | 261 | 2458656.654 | -8.20 | 226.8 | -21.5 ^{+0.2} -21.8 ^{+0.1} | ... | ... | ... | 2399.7 ^{+0.2} 2399.5 ^{+0.5} | ... | 5.3 ^{-0.02} 5.41 ^{+0.03} | 5.3 ^{-0.02} 5.41 ^{+0.03} | S |
| ... | 11941 | 2703 | 82 | 2458656.714 | -8.32 | 145.8 | -21.8 ^{+0.1} -21.8 ^{-0.1} | ... | ... | ... | 2399.5 ^{+0.3} 2399.5 ^{+0.3} | ... | 5.41 ^{+0.03} 5.41 ^{-0.01} | 5.41 ^{+0.03} 5.41 ^{-0.01} | S |
| ... | 11941 | 2703 | 82 | 2458657.673 | -8.44 | 224.8 | -21.9 ^{+0.1} -21.6 ^{+0.1} | ... | ... | ... | 2399.5 ^{+0.3} 2399.6 ^{+0.4} | ... | 5.41 ^{-0.01} 5.38 ^{+0.06} | 5.41 ^{-0.01} 5.38 ^{+0.06} | S |
| ... | 11941 | 2703 | 82 | 2458658.640 | -8.56 | 171.6 | -21.6 ^{+0.1} -21.4 ^{+0.1} | ... | ... | ... | 2399.6 ^{+0.4} 2399.3 ^{+0.5} | ... | 5.38 ^{+0.06} 5.19 ^{+0.02} | 5.38 ^{+0.06} 5.19 ^{+0.02} | S |
| 2M16360984+4000243 | 11942 | 2704 | 132 | 2458641.850 | -5.00 | 33.6 | -11.4 ^{+0.2} -11.4 ^{-0.2} | -11.5 ^{+0.2} -11.5 ^{-0.2} | 6.0 ^{+0.1} 6.0 ^{-0.1} | < 10 | 2399.3 ^{+0.5} 2399.4 ^{+0.5} | 2399.4 ^{+0.5} 2399.4 ^{+0.5} | 5.08 ^{+0.13} 5.08 ^{-0.16} | 5.08 ^{+0.13} 5.08 ^{-0.16} | S |
| ... | 11942 | 2704 | 132 | 2458642.869 | -5.27 | 24.0 | -11.7 ^{+0.1} -11.7 ^{-0.1} | ... | ... | ... | 2399.4 ^{+0.5} 2399.4 ^{+0.5} | ... | 4.86 ^{+0.03} 5.23 ^{+0.04} | 4.86 ^{-0.03} 5.23 ^{+0.04} | S |
| ... | 11943 | 2705 | 90 | 2458643.851 | -5.46 | 31.0 | -11.1 ^{+0.1} -11.1 ^{-0.1} | ... | ... | ... | 2399.3 ^{+0.5} 2399.3 ^{+0.5} | ... | 5.23 ^{+0.04} 5.17 ^{-0.01} | 5.23 ^{-0.04} 5.17 ^{-0.01} | S |
| ... | 11943 | 2705 | 66 | 2458656.654 | -7.86 | 31.0 | -11.6 ^{+0.1} -11.6 ^{-0.1} | ... | ... | ... | 2399.3 ^{+0.5} 2399.3 ^{+0.5} | ... | 5.17 ^{-0.01} 5.32 ^{+0.01} | 5.17 ^{-0.01} 5.32 ^{+0.01} | S |
| 2M16402068+6736046 | 11922 | 6078 | 3 | 2458893.999 | 1.41 | 201.0 | -17.4 ^{+0.1} -17.4 ^{-0.1} | -17.4 ^{+0.1} -17.4 ^{-0.1} | 16.0 ^{+0.1} 16.0 ^{-0.1} | 16.0 ^{+0.1} 16.0 ^{-0.1} | 2399.6 ^{+0.6} 2399.6 ^{+0.6} | 2399.6 ^{+0.6} 2399.6 ^{+0.6} | 5.32 ^{+0.01} 5.04 ^{-0.02} | 5.32 ^{+0.01} 5.04 ^{-0.02} | S |
| 2M16463154+3434554 | 11947 | 2709 | 110 | 2459019.842 | -7.26 | 75.6 | -52.6 ^{+0.1} -52.6 ^{-0.1} | ... | ... | ... | 2399.5 ^{+0.3} 2399.5 ^{+0.3} | 2399.6 ^{+0.2} 2399.6 ^{+0.2} | 5.04 ^{-0.02} 4.96 ^{-0.04} | 5.04 ^{-0.02} 4.96 ^{-0.04} | S |
| ... | 11947 | 2709 | 110 | 2459020.835 | -7.50 | 68.6 | -52.6 ^{+0.1} -52.6 ^{-0.1} | ... | ... | ... | 2399.5 ^{+0.3} 2399.5 ^{+0.3} | ... | 4.96 ^{-0.02} 4.93 ^{-0.02} | 4.96 ^{-0.02} 4.93 ^{-0.02} | S |
| ... | 11949 | 2711 | 274 | 2459021.842 | -7.76 | 73.8 | -52.5 ^{+0.1} -52.5 ^{-0.1} | ... | ... | ... | 2399.6 ^{+0.6} 2399.6 ^{+0.6} | ... | 4.93 ^{-0.02} 4.93 ^{-0.02} | 4.93 ^{-0.02} 4.93 ^{-0.02} | S |
| ... | 11943 | 2705 | 66 | 2458656.654 | -7.86 | 31.0 | -11.6 ^{+0.1} -11.6 ^{-0.1} | ... | ... | ... | 2399.3 ^{+0.5} 2399.3 ^{+0.5} | ... | 5.17 ^{-0.01} 5.32 ^{+0.01} | 5.17 ^{-0.01} 5.32 ^{+0.01} | S |
| 2M16485878+3005366 | 11950 | 2712 | 168 | 2459022.821 | -18.26 | 10.5 | -46.4 ^{+0.3} -46.4 ^{-0.3} | -44.8 ^{+0.3} -44.8 ^{-0.3} | 16.1 ^{+0.2} 16.1 ^{-0.2} | 14.0 ^{+0.9} 14.0 ^{-0.9} | 2399.0 ^{+0.4} 2399.0 ^{+0.4} | 2398.6 ^{+2.4} 2398.6 ^{+2.4} | 4.67 ^{+0.09} 4.66 ^{-0.07} | 4.67 ^{+0.09} 4.66 ^{-0.07} | S |
| ... | 11950 | 2712 | 168 | 2459084.655 | -18.26 | 10.5 | -46.4 ^{+0.3} -46.4 ^{-0.3} | ... | ... | ... | 2399.0 ^{+0.4} 2399.0 ^{+0.4} | ... | 4.67 ^{+0.09} 4.66 ^{-0.07} | 4.67 ^{+0.09} 4.66 ^{-0.07} | S |
| ... | 11950 | 2712 | 168 | 2459085.653 | -18.28 | 11.5 | -44.8 ^{+0.3} -44.8 ^{-0.3} | ... | ... | ... | 2398.6 ^{+1.1} 2399.0 ^{+1.5} | ... | 4.66 ^{-0.07} 5.17 ^{+0.02} | 4.66 ^{-0.07} 5.17 ^{+0.02} | S |
| 2M16572919+2448509 | 9893 | 2464 | 1 | 2458008.620 | -19.95 | 25.5 | -57.7 ^{+0.3} -57.7 ^{-0.3} | -58.1 ^{+0.5} -58.1 ^{-0.5} | 16.0 ^{+0.2} 16.0 ^{-0.2} | 15.6 ^{+1.5} 15.6 ^{-1.3} | 2399.0 ^{+1.5} 2398.5 ^{+1.6} | 2398.9 ^{+0.9} 2398.9 ^{+0.9} | 5.17 ^{+0.02} 5.38 ^{-0.02} | 5.17 ^{+0.02} 5.38 ^{-0.02} | S |
| ... | 9893 | 2464 | 1 | 2458009.614 | -19.88 | 27.7 | -57.6 ^{+0.2} -57.6 ^{-0.2} | ... | ... | ... | 2398.5 ^{+1.1} 2399.2 ^{+1.6} | ... | 5.38 ^{-0.02} 5.4 ^{+0.02} | 5.38 ^{-0.02} 5.4 ^{+0.02} | S |
| ... | 9893 | 2464 | 1 | 2458222.897 | 14.58 | 35.4 | -57.7 ^{+0.1} -57.7 ^{-0.1} | ... | ... | ... | 2399.2 ^{+1.6} 2399.2 ^{+1.6} | ... | 5.4 ^{+0.02} 5.49 ^{-0.01} | 5.4 ^{+0.02} 5.49 ^{-0.01} | S |
| ... | 11977 | 2739 | 37 | 2458658.727 | -7.75 | 56.1 | -58.6 ^{+0.1} -58.6 ^{-0.1} | ... | ... | ... | 2397.3 ^{+2.2} 2399.4 ^{+0.4} | ... | 5.49 ^{-0.01} 3.52 ^{+0.02} | 5.49 ^{-0.01} 3.52 ^{+0.02} | S |
| 2M19005974+3647109 | 10718 | 5733 | 264 | 2458262.905 | 18.43 | 12.8 | 1.8 ^{+0.2} 1.8 ^{-0.2} | 1.5 ^{+0.2} 1.5 ^{-0.2} | 21.6 ^{+0.3} 21.6 ^{-0.3} | 20.1 ^{+1.4} 20.1 ^{-1.4} | 2399.6 ^{+0.2} 2399.6 ^{+0.2} | 2399.6 ^{+0.2} 2399.6 ^{+0.2} | 3.53 ^{+0.01} 3.54 ^{+0.02} | 3.53 ^{+0.01} 3.54 ^{+0.02} | S |
| ... | 10718 | 5733 | 264 | 2458263.800 | 18.28 | 24.4 | 1.4 ^{+0.2} 1.4 ^{-0.2} | ... | ... | ... | 2399.4 ^{+0.4} 2399.7 ^{+0.6} | ... | 3.52 ^{+0.02} 5.09 ^{-0.01} | 3.52 ^{+0.02} 5.09 ^{-0.01} | S |
| 2M19241634+7533121 | 10888 | 5770 | 172 | 2458293.823 | 2.85 | 189.8 | -18.5 ^{+0.2} -18.5 ^{-0.2} | -18.6 ^{+0.2} -18.6 ^{-0.2} | 7.0 ^{+0.3} 7.0 ^{-0.3} | < 10 | 2399.6 ^{+0.3} 2399.5 ^{+0.3} | 2399.5 ^{+0.2} 2399.5 ^{+0.2} | 5.08 ^{+0.04} 5.08 ^{+0.04} | 5.08 ^{+0.04} 5.08 ^{+0.04} | S |
| ... | 10888 | 5770 | 172 | 2458297.825 | 3.17 | 157.0 | -18.8 ^{+0.2} -18.8 ^{-0.2} | ... | ... | ... | 2399.5 ^{+0.6} 2399.5 ^{+0.6} | ... | 4.97 ^{+0.03} 4.97 ^{+0.03} | 4.97 ^{+0.03} 4.97 ^{+0.03} | S |
| 2M19544358+1801581 | 5217 | 4261 | 131 | 2456109.911 | 9.85 | 65.2 | -18.8 ^{+0.2} -18.8 ^{-0.2} | -18.6 ^{+0.3} -18.6 ^{-0.3} | 8.1 ^{+0.3} 8.1 ^{-0.3} | < 10 | 2398.7 ^{+1.1} 2399.0 ^{+1.6} | 2398.9 ^{+0.6} 2398.9 ^{+0.6} | 5.5 ^{+0.0} 5.5 ^{+0.0} | 5.5 ^{+0.0} 5.5 ^{+0.0} | S |
| ... | 5217 | 4261 | 137 | 2456164.738 | -10.85 | 71.9 | -18.6 ^{+0.1} -18.6 ^{-0.1} | ... | ... | ... | 2399.0 ^{+1.6} 2399.1 ^{+1.3} | ... | 5.5 ^{+0.0} 5.5 ^{+0.0} | 5.5 ^{+0.0} 5.5 ^{+0.0} | S |
| ... | 5217 | 4261 | 128 | 2456169.695 | -12.48 | 57.2 | -18.4 ^{+0.1} -18.4 ^{-0.1} | ... | ... | ... | 2399.1 ^{+1.5} 2399.2 ^{+1.3} | ... | 5.5 ^{+0.0} 5.5 ^{+0.0} | 5.5 ^{+0.0} 5.5 ^{+0.0} | S |
| ... | 6367 | 4261 | 133 | 2456193.598 | -19.30 | 37.7 | -19.0 ^{+0.1} -19.0 ^{-0.1} | ... | ... | ... | 2398.2 ^{+1.3} 2398.2 ^{+1.3} | ... | 5.49 ^{+0.02} 5.49 ^{+0.02} | 5.49 ^{+0.02} 5.49 ^{+0.02} | S |
| ... | 6367 | 4261 | 138 | 2456224.574 | -23.63 | 22.7 | -18.6 ^{+0.2} -18.6 ^{-0.2} | ... | ... | ... | 2398.4 ^{+2.2} 2399.1 ^{+1.3} | ... | 5.49 ^{+0.02} 5.5 ^{+0.0} | 5.49 ^{+0.02} 5.5 ^{+0.0} | S |
| ... | 6367 | 4261 | 133 | 2456228.567 | -23.70 | 51.5 | -18.3 ^{+0.1} -18.3 ^{-0.1} | ... | ... | ... | 2399.1 ^{+1.3} 2399.1 ^{+1.3} | ... | 5.5 ^{+0.0} 5.5 ^{+0.0} | 5.5 ^{+0.0} 5.5 ^{+0.0} | S |
| 2M20353517+0608285 | 11982 | 2744 | 19 | 2458663.888 | 15.46 | 19.8 | 8.7 ^{+0.2} 8.7 ^{-0.2} | 8.2 ^{+0.3} 8.2 ^{-0.3} | 9.0 ^{+0.7} 9.0 ^{-0.7} | < 10 | 3192.8 ^{+8.6} 3192.8 ^{+8.6} | 3193.5 ^{+8.6} 3193.5 ^{+8.6} | 5.44 ^{+0.04} 5.44 ^{+0.04} | 5.44 ^{+0.04} 5.44 ^{+0.04} | B |
| ... | 11982 | 2744 | 19 | 2458664.868 | 15.10 | 18.0 | 8.0 ^{+0.1} 8.0 ^{-0.1} | ... | ... | ... | 3186.1 ^{+10.1} 3186.1 ^{+10.1} | ... | 5.35 ^{+0.05} 5.35 ^{+0.05} | 5.35 ^{+0.05} 5.35 ^{+0.05} | B |
| ... | 11982 | 2744 | 19 | 2458665.873 | 14.66 | 13.3 | 8.0 ^{+0.1} 8.0 ^{-0.1} | ... | ... | ... | 3205.1 ^{+11.3} 3205.1 ^{+11.3} | ... | 5.41 ^{-0.04} 5.41 ^{-0.04} | 5.41 ^{-0.04} 5.41 ^{-0.04} | B |
| 2M20491376+3216514 | 6081 | 4297 | 77 | 2456604.557 | -19.93 | 45.4 | 11.4 ^{+0.2} 11.4 ^{-0.2} | 11.5 ^{+0.3} 11.5 ^{-0.3} | 11.6 ^{+0.9} 11.6 ^{-0.9} | 12.2 ^{+1.0} 12.2 ^{-1.0} | 2399.4 ^{+0.8} 2399.3 ^{+0.8} | 2399.4 ^{+0.5} 2399.4 ^{+0.5} | 5.48 ^{+0.01} 5.47 ^{+0.02} | 5.48 ^{+0.01} 5.47 ^{+0.02} | S |
| ... | 6081 | 4297 | 77 | 2456611.559 | -20.32 | 54.1 | 11.0 ^{+0.2} 11.0 ^{-0.2} | ... | ... | ... | 2399.3 ^{+0.8} 2399.3 ^{+0.8} | ... | 5.47 ^{+0.02} 5.36 ^{+0.01} | 5.47 ^{+0.02} 5.36 ^{+0.01} | S |
| ... | 7465 | 4297</ | | | | | | | | | | | | | |

Table 3.4 (continued)

| APOGEE ID | Plate | Loc. ID | Fiber ID | JD (day) | bary. ^a (km s ⁻¹) | S/N | RV (km s ⁻¹) | (RV) ^b (km s ⁻¹) | v sin <i>i</i> (km s ⁻¹) | (v sin <i>i</i>) ^{b,c} (km s ⁻¹) | <i>T</i> _{eff} (K) | (<i>T</i> _{eff}) ^b (K) | log <i>g</i> (cm s ⁻²) | (log <i>g</i>) ^b (cm s ⁻²) | Mdl ^d |
|--------------------|-------|---------|----------|-------------|--|------|--------------------------|---|--------------------------------------|--|-----------------------------|--|------------------------------------|--|------------------|
| ... | 6088 | 4546 | 39 | 2456233.576 | -8.37 | 58.1 | -12.2 ^{+0.1} | ... | 16.3 ^{+0.3} | ... | 2399.6 ^{+0.8} | ... | 5.5 ^{+0.0} | ... | S |
| ... | 6088 | 4546 | 40 | 2456259.550 | -12.13 | 64.9 | -12.1 ^{+0.1} | ... | 16.6 ^{+0.2} | ... | 2399.6 ^{+0.3} | ... | 5.5 ^{+0.0} | ... | S |
| 2M21381698+5257188 | 6087 | 4316 | 29 | 2456260.546 | -13.78 | 64.0 | -7.5 ^{+0.2} | -7.5 ^{+0.2} | 40.6 ^{+1.7} | 40.6 ^{+1.7} | 2399.7 ^{+0.4} | 2399.7 ^{+0.2} | 5.49 ^{+0.01} | 5.43 ^{+0.13} | S |
| ... | 6087 | 4316 | 23 | 2456582.686 | -6.29 | 59.0 | -7.8 ^{+0.2} | ... | 39.4 ^{+0.3} | ... | 2399.6 ^{+0.3} | ... | 5.4 ^{+0.01} | ... | S |
| ... | 6087 | 4316 | 29 | 2456588.628 | -7.57 | 67.9 | -7.4 ^{+0.1} | ... | 44.3 ^{+0.3} | ... | 2399.7 ^{+0.3} | ... | 5.13 ^{+0.02} | ... | S |
| 2M22021125-1109461 | 9997 | 5451 | 32 | 2458026.587 | -18.56 | 39.4 | -7.8 ^{+0.1} | -7.7 ^{+0.4} | 21.3 ^{+1.1} | 21.3 ^{+1.1} | 2399.6 ^{+0.7} | 2399.5 ^{+0.5} | 5.15 ^{+0.04} | 5.16 ^{+0.12} | S |
| ... | 9997 | 5451 | 89 | 2458028.607 | -19.40 | 26.5 | -8.1 ^{+0.1} | ... | 21.7 ^{+0.1} | ... | 2399.5 ^{+1.0} | ... | 4.96 ^{+0.03} | ... | S |
| ... | 9997 | 5451 | 206 | 2458052.514 | -26.88 | 45.1 | -7.0 ^{+0.2} | ... | 19.6 ^{+0.2} | ... | 2399.4 ^{+0.8} | ... | 5.21 ^{+0.02} | ... | S |
| 2M22400144+0532162 | 6558 | 4474 | 23 | 2456606.610 | -26.53 | 68.9 | -10.3 ^{+0.1} | -10.1 ^{+0.3} | 17.8 ^{+1.0} | 17.8 ^{+1.1} | 2399.6 ^{+0.3} | 2399.5 ^{+0.3} | 5.1 ^{+0.03} | 5.12 ^{+0.03} | S |
| ... | 6558 | 4474 | 5 | 2456628.558 | -29.43 | 52.5 | -9.7 ^{+0.2} | ... | 17.5 ^{+0.3} | ... | 2399.3 ^{+1.1} | ... | 5.19 ^{+0.04} | ... | S |
| ... | 6558 | 4474 | 5 | 2456637.545 | -29.38 | 63.3 | -9.9 ^{+0.1} | ... | 18.0 ^{+0.3} | ... | 2399.4 ^{+0.5} | ... | 5.13 ^{+0.01} | ... | S |
| 12083 | 2767 | 247 | 247 | 2458776.666 | -16.55 | 21.4 | -13.7 ^{+1.5} | -14.1 ^{+1.0} | 55.5 ^{+1.7} | 56.7 ^{+1.7} | 2399.4 ^{+0.9} | 2399.5 ^{+0.3} | 3.52 ^{+0.01} | 3.57 ^{+0.1} | S |
| 12083 | 2767 | 247 | 247 | 2458777.593 | -16.76 | 24.8 | -13.9 ^{+0.3} | ... | 57.3 ^{+0.9} | ... | 2399.4 ^{+0.7} | ... | 3.55 ^{+0.05} | ... | S |
| 12083 | 2767 | 247 | 247 | 2458778.572 | -17.11 | 20.0 | -12.6 ^{+1.0} | ... | 59.0 ^{+1.8} | ... | 2399.5 ^{+0.6} | ... | 3.52 ^{+0.02} | ... | S |
| 12084 | 2768 | 198 | 198 | 2458781.688 | -18.58 | 28.9 | -12.7 ^{+0.3} | ... | 54.4 ^{+0.9} | ... | 2399.6 ^{+0.7} | ... | 3.82 ^{+0.03} | ... | S |
| ... | 12084 | 2768 | 198 | 2458782.694 | -18.98 | 34.2 | -14.8 ^{+0.4} | ... | 57.2 ^{+0.6} | ... | 2399.6 ^{+0.3} | ... | 3.62 ^{+0.03} | ... | S |
| 2M23200703+1150071 | 6559 | 4475 | 36 | 2456578.743 | -12.37 | 45.2 | -53.9 ^{+0.2} | -54.5 ^{+0.4} | 0.5 ^{+0.3} | < 10 | 2399.4 ^{+1.1} | 2399.5 ^{+0.2} | 5.31 ^{+0.02} | 5.34 ^{+0.08} | S |
| ... | 6559 | 4475 | 79 | 2456583.743 | -14.62 | 57.7 | -54.8 ^{+0.1} | ... | 0.4 ^{+0.3} | ... | 2399.5 ^{+0.2} | ... | 5.45 ^{+0.02} | ... | S |
| ... | 6559 | 4475 | 37 | 2456606.665 | -23.27 | 50.8 | -54.5 ^{+0.1} | ... | 0.7 ^{+0.4} | ... | 2399.4 ^{+0.6} | ... | 5.26 ^{+0.02} | ... | S |

^a Barycentric correction.

^b Weighted average over all epochs.

^c Averaged v sin *i* < 10 km s⁻¹ is below my v sin *i* detection limit; see Section 3.3.2 for details.

^d Models used: S = Sonora, 2018 (Murley et al. 2018); B = BT-Settl (Baraffe et al. 2015).

Note – Measurements from individual spectra over individual or multiple epochs are combined using inverse uncertainty weighting (weight = 1/(σ_{upper}² + σ_{lower}²)); upper and lower uncertainties are also combined using inverse uncertainty-squared weighting. In cases where individual spectra have S/N < 10, spectral data are combined first, then modeled.

3.4 APOGEE M/L Dwarf Analysis

3.4.1 *UVW* Space Motions

Stars near the Sun are representative of the Milky Way’s thin disk, thick disk and halo populations in approximate proportions of X:Y:Z (Jurić et al. 2008). Kinematics can be a useful tool for separating these populations, as well as identifying members of young moving groups and associations (Gagné et al. 2015b). I combined my RV measurements with *Gaia* and ground-based astrometry to compute heliocentric *UVW* space motions following Johnson & Soderblom (1987), where the *U* velocity points to the Galactic center, *V* velocity follows the direction of the Galactic rotation, and *W* velocity is in the direction of Galactic North pole. I used the Solar $(U_{\odot}, V_{\odot}, W_{\odot}) = (11.1 \text{ km s}^{-1}, 12.24 \text{ km s}^{-1}, 7.5 \text{ km s}^{-1})$ measured by Schönrich et al. (2010) to correct these velocities to the local standard of rest (LSR). These values are visualized in Figure 3.17 and listed in Table 3.6. It should be noted that I used heliocentric velocities to assess their cluster membership (see Section 3.4.3). The mean U_{LSR} and V_{LSR} velocities of my sample are consistent with zero ($\langle U_{LSR} \rangle = -2.1 \pm 2.0 \text{ km s}^{-1}$ and $\langle W_{LSR} \rangle = 1.7 \pm 0.9 \text{ km s}^{-1}$), while the average V_{LSR} velocity is negative ($\langle V_{LSR} \rangle = -9.5 \pm 1.5 \text{ km s}^{-1}$), which can be attributed to asymmetric drift (Strömberg 1924).

I followed Bensby et al. (2003) to determine the probabilities of kinematic membership for each star to thin disk, thick disk, or halo populations based on the LSR velocities. I specifically separated thin disk, intermediate thin/thick disk, and thick disk membership by using the ratios $P[\text{TD}]/P[\text{D}] < 0.1$, $0.1 \leq P[\text{TD}]/P[\text{D}] \leq 10$, and $P[\text{TD}]/P[\text{D}] > 10$, respectively. As expected, the majority of my sample⁴ is thin disk sources (171 sources), with 11 intermediate thin disk/thick disk members and 1 thick disk member (LP 327–24; 2MASS J15115124+3033065), as labeled in Figure 3.17. LP

⁴2MASS J05350162–0521489 was removed for the kinematic analysis due to its large proper motion uncertainties.

327–24 has an optical classification of M5 using the Kitt Peak 4 m telescope with the RC Spectrograph from Cruz et al. (2003), and its magnitudes $M_G = 13.01$ and $M_R = 13.92$ with its colors $G - J = 3.64$ and $R - J = 4.56$ were normal using the empirical color-magnitude relation in (Cifuentes et al. 2020) (empirical $M_G = 13.50$ and $M_R = 13.93$). Correlations between UVW velocities can be useful diagnostics of different Galactic populations (e.g. thin disk and thick disk sources). I did not detect significant correlations between $U_{LSR}W_{LSR}$ or $V_{LSR}W_{LSR}$ velocity pairs (p-value = 0.62 and 0.73, respectively), but did find a significant positive correlation for UV velocities ($R = 0.16$, p-value < 0.05), driven largely by my intermediate thin/thick disk and thick disk members, likely due to asymmetric drift. Removing these kinematically hot sources eliminates the $U_{LSR}V_{LSR}$ correlation ($R = 0.07$, p-value = 0.37). I also found significant positive correlations between total velocity-squared v_{LSR}^2 and absolute $|W_{LSR}|$ -velocity for the full sample ($R = 0.53$, p-value < 0.001) and thin disk subsample ($R = 0.50$, p-value < 0.001), implying that my sample show correlations between different metrics of ages. v_{LSR}^2 is the square of the magnitude of V_{LSR} velocities, which correlates with the asymmetric drift (Strömberg 1924), while absolute $|W_{LSR}|$ -velocity has been used as a proxy of ages (Wielen 1977). While the APOGEE sample selection is not volume-complete, this result is consistent with my prior analysis of the 20 pc UCD sample (Hsu et al. 2021).

3.4.2 Galactic Orbits

Galactic orbits can identify sources with different spatial origins, including stars that had drifted radially inward or outward to the Solar Neighborhood. Starting with the LSR velocities and XYZ spatial coordinates⁵ of each source, Galactic orbits were computed using the `galpy` package (Bovy 2015), an ordinary differential equation

⁵ XYZ are the transformation from Galactic spherical coordinates to Galactic rectangular coordinates from Galactic longitude l , latitude b , and distance d to the Galactic center following $X = d \cos b \cos l$, $Y = d \cos b \sin l$, and $Z = d \sin b$ (Bovy 2015).

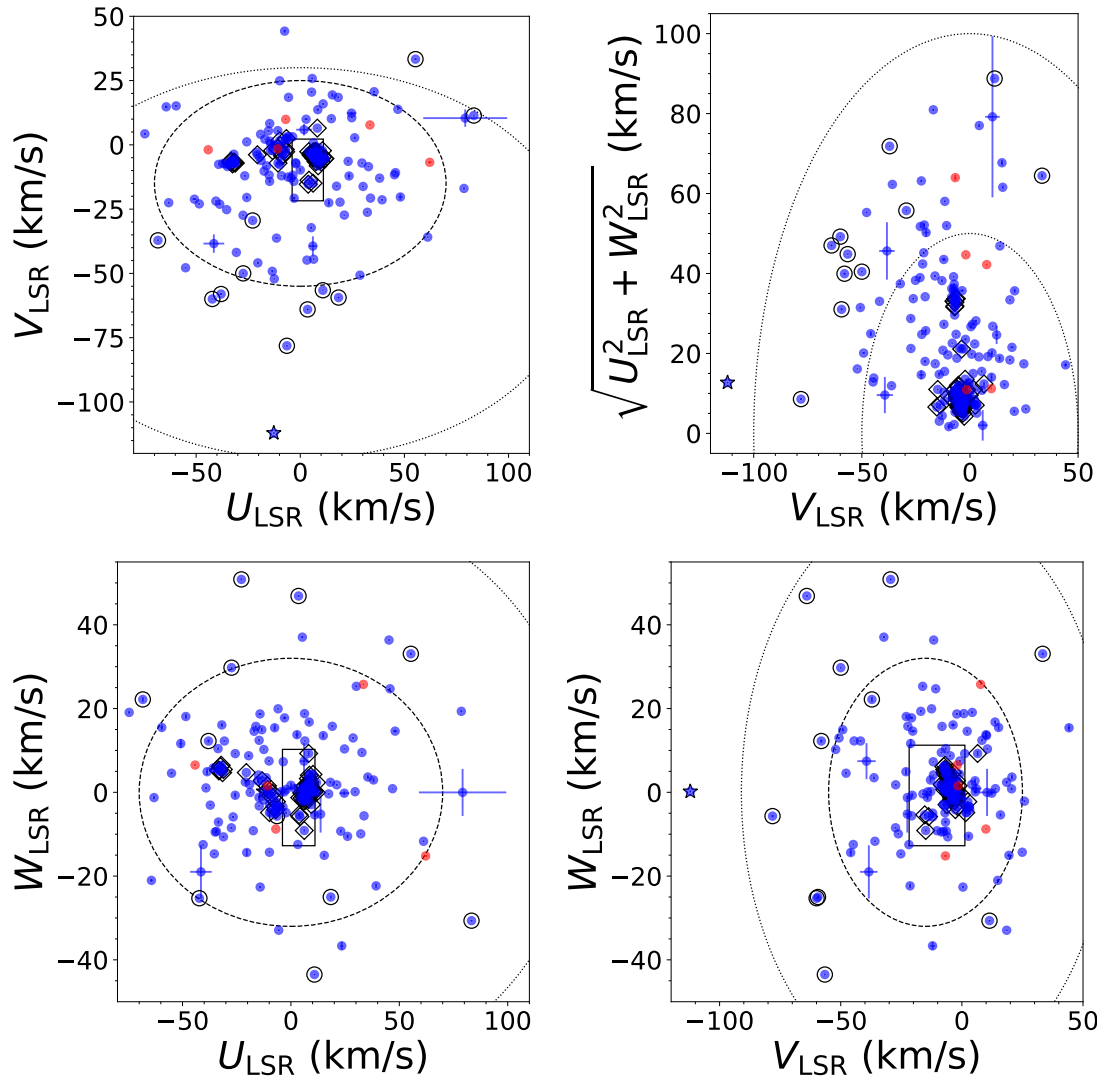


Figure 3.17: Space motions of my sample in the Local Standard of Rest (LSR; Schönrich et al. 2010). The $U_{\text{LSR}}V_{\text{LSR}}$, $U_{\text{LSR}}W_{\text{LSR}}$, and $V_{\text{LSR}}W_{\text{LSR}}$ velocities are shown along with the 2σ uncertainty spheres for the thin disk (dashed lines) and thick disk (dotted lines) populations based on Bensby et al. (2003). M and L dwarfs are labeled as blue and red circles, respectively. The “good box” from Zuckerman & Song (2004) that segregates members of young moving groups is also labeled. The upper-right corner is a Toomre plot, with total velocities $v_{\text{tot}} = \sqrt{U_{\text{LSR}}^2 + V_{\text{LSR}}^2 + W_{\text{LSR}}^2}$ indicated in steps of 50 km s^{-1} . Young sources, intermediate thin/thick disk, and thick disk sources are highlighted with open diamonds, open circles, and stars, respectively.

solver that conserves energy and momentum. I used an axisymmetric potential from Miyamoto & Nagai (1975) with spatial coordinates measured relative to a solar coordinate $(R_{\odot}, Z_{\odot}) = (8.43 \text{ kpc}, 0.027 \text{ kpc})$ and azimuthal velocity, $v_{\phi} = 220 \text{ km s}^{-1}$ (Bovy & Tremaine 2012; Chen et al. 2001; Reid et al. 2014). Each orbit was integrated from -5 to $+5$ Gyr in steps of 10 Myr, and 1000 orbit realizations were computed using Monte Carlo sampling of velocity uncertainties assuming normal distributions. I examined the specific orbital parameters of minimum and maximum Galactic cylindrical radius (R_{\min}, R_{\max}) , maximum Galactic vertical height $(|Z|)$, median orbital eccentricity $(e \equiv \langle R_{\max} - R_{\min} \rangle / \langle R_{\max} + R_{\min} \rangle)$, and median orbital inclination $(\tan i \equiv |Z| / \sqrt{X^2 + Y^2})$. These parameters are listed in Table 3.7.

Figure 3.18 shows the distributions of the derived orbital parameters. The majority of my sample exhibit circular ($\langle e \rangle = 0.08^{+0.13}_{-0.04}$) and planar orbits ($\langle i \rangle = 0.6^{\circ} \text{ }^{+0.9^{\circ}}_{-0.2^{\circ}}$), residing mostly at the Solar Galactic radius ($\langle R_{\min} \rangle = 7.5^{+0.5}_{-1.3} \text{ kpc}$, $\langle R_{\max} \rangle = 8.6^{+0.7}_{-0.3} \text{ kpc}$) and close to the Galactic Plane ($\langle |Z| \rangle = 0.09^{+0.12}_{-0.03} \text{ kpc}$). There are 31 sources that have $e > 0.2$, 11 of which are intermediate thin/thick disk or thick disk members. There are also 16 sources with non-planar orbits ($i > 2^{\circ}$), with 9 of these being intermediate thin/thick disk members. $0.6^{\circ} \text{ }^{+0.9^{\circ}}_{-0.2^{\circ}}$).

3.4.3 Cluster Membership

Kinematics allows me to identify members of young clusters and moving groups, sources which are crucial for testing theoretical brown dwarf evolution models at early ages (Burrows et al. 1997; Baraffe et al. 2003) as well as empirical trends between effective spectral type, temperature, luminosity, mass, and age. I examined my sample for young association membership by comparing their 6D spatial and velocity coordinates (determined from RVs and *Gaia* astrometry) to known nearby systems using the BANYAN Σ web tool (Gagné et al. 2018c). Results are summarized in Table 3.6.

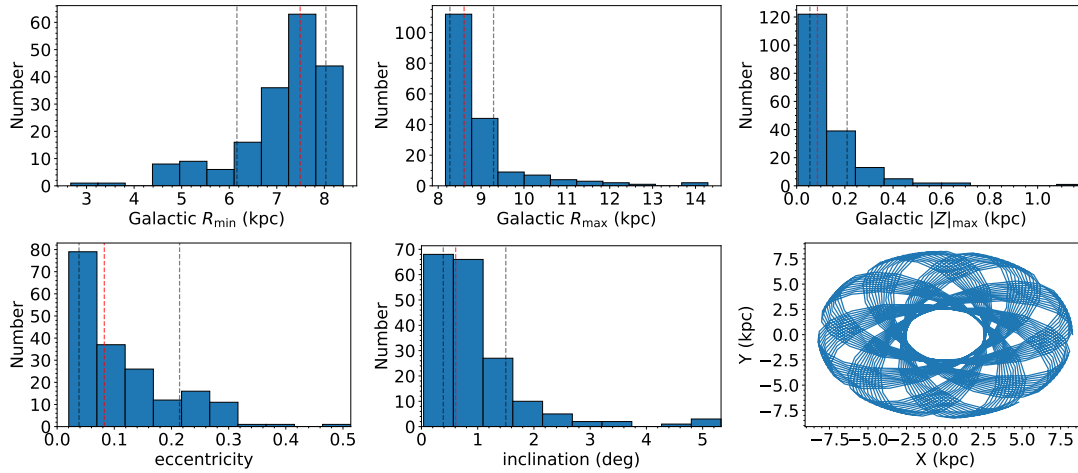


Figure 3.18: The distributions of inferred orbital parameters for my sample. *upper left:* minimum Galactic radius R_{\min} ; *upper middle:* maximum Galactic radius R_{\max} ; *upper right:* minimum vertical displacement $|Z|$; *lower left:* eccentricity e ; *lower middle:* inclination i ; *lower right:* The Galactic XY orbit of the thick disk source 2MASS J15115124+3033065, integrated between -5 Gyr to $+5$ Gyr. The median values and the 16th/84th percentiles are shown in red and grey dashed lines, respectively.

My APOGEE DR17 sample is highly biased toward young clusters, which is confirmed in the cluster membership analysis. Out of 66 young sources in my sample, I identified 64 kinematic members of young moving groups, with 61 previously reported in the literature. Two of the young sources were not identified due to their parent clusters not being included in the BANYAN Σ web tool (see below). The majority of cluster members are associated with Upper Scorpius (10 ± 3 Myr, Picaud & Mamajek 2016; 41 sources), Taurus (1–2 Myr, Kenyon & Hartmann 1995; 7 sources), and the Hyades (750 ± 100 Myr, Brandt & Huang 2015; 6 sources). The three sources not previously reported in the literature are 2MASS J05402570+2448090 (G 100-28; 54.7% Argus moving group, 40-50 Myr, Zuckerman 2019; 43.2% Carina Near moving group, ~ 200 Myr, Zuckerman et al. 2006), 2MASS J14093200+4138080 (LP 220-50; 99.6% Argus moving group), and 2MASS J21272531+5553150 (LSPM J2127+5553; 99.3% Carina Near moving group). On the other hand, I ruled out 2MASS J07140394+3702459 (LSPM J0714+3702) as a member of the Argus Moving Group and classified as M7 β intermediate gravity class

using the SpeX data reported in (Gagné et al. 2015b), but they did not have the radial velocity information⁶ I also ruled out two members of the Coma Berenices Cluster (562_{-84}^{+98} Myr with my full 6D kinematics information, Silaj & Landstreet 2014), 2MASS J12205439+2525568 and 2MASS J12235346+2534559, reported in Melnikov & Eislöffel (2012) with only astrometry and photometry. Melnikov & Eislöffel (2012) used proper motions from the Lépine Shara Proper Motion (LSPM) catalog (Lépine & Shara 2005), but unfortunately these sources were not measured in the LSPM catalog due to their relatively small proper motions. This also highlights the importance of RVs when the proper motions of the cluster as the Coma Berenices Cluster ($\mu_{\alpha} = -12.0 \pm 0.5$ mas, $\mu_{\delta} = -9.0 \pm 0.8$ mas) are small. While BANYAN Σ web tool is extremely useful, it does not have all of the young clusters and moving groups, so two young sources were not recovered, including 2MASS J03293053+3127280 and J08294949+2646348. 2MASS J03293053+3127280 was reported as a member in NGC 1333 (Cantat-Gaudin et al. 2018; Yao et al. 2018; Cantat-Gaudin & Anders 2020; Cantat-Gaudin et al. 2020), which is part of the IN-SYNC Survey (Cook et al. 2014; Yao et al. 2018) and identified in *Gaia* DR2 astrometry (without RVs; Cantat-Gaudin et al. 2018; Cantat-Gaudin & Anders 2020; Cantat-Gaudin et al. 2020). 2MASS J08294949+2646348 reported as a member of the Castor Moving Group (>200 Myr, Zuckerman et al. 2013), but the Castor Moving Group does not have a precise age determination (Zuckerman et al. 2013). I include these two sources as young sources in the kinematic analysis in Section 3.4.4.

Finally, I examine the best-fit parameters between the young and the field sample. For $\log g$, I found significant difference between the young ($\log g = 3.58_{-0.06}^{+1.37}$ cm s⁻² dex) and field objects ($\log g = 5.08_{-0.45}^{+0.40}$ cm s⁻² dex) with the Sonora models. For $v \sin i$, I found more high $v \sin i$ for the young ($v \sin i = 20_{-6}^{+24}$ km s⁻¹) than field objects ($v \sin i$

⁶With the BANYAN Σ web tool (Gagné et al. 2018c), the optimal RV to make 2MASS J07140394+3702459 as a member of the Argus Moving Group is 20.9 km s⁻¹, which is completely ruled out with my RV of 35.3 ± 0.2 km s⁻¹.

$= 13_{-5}^{+13}$ km s⁻¹) for Sonora models, but their distributions overlap. For the BT-Settl models, I found lower T_{eff} s and $\log g$ for the young objects ($T_{\text{eff}} = 2983_{-175}^{+148}$ K; $\log g = 4.5_{-0.03}^{+0.43}$ cm s⁻² dex) than the field objects ($T_{\text{eff}} = 3177_{-126}^{+16}$ K; $\log g = 5.41_{-0.28}^{+0.07}$ cm s⁻² dex) and higher $v \sin i$ s for the young objects ($v \sin i = 16_{-2}^{+14}$ km s⁻¹) than the field objects ($v \sin i = 11_{-3}^{+17}$ km s⁻¹) but with a much smaller sample size (N=22, including 7 young and 15 field objects).

3.4.4 Kinematic Ages

Ensemble kinematics of a population also provides age information, as stellar velocities become increasingly dispersed through dynamical interactions of Galactic structures (Spitzer & Schwarzschild 1953; Wielen 1977; Aumer & Binney 2009; Ting & Rix 2019; Sharma et al. 2021). The increased dispersion over time has been historically captured in empirical age-velocity dispersion relations (AVRs), which can be inverted to derive mean kinematic ages for stellar samples (Hsu et al. 2021). I considered two functional forms of the AVR in this study: the exponential relation of Wielen (1977), and the power-law relation from Aumer & Binney (2009). I followed the same analysis methodology as described in Hsu et al. (2021), and the results are summarized in Table 3.8. Since 2MASS J05350162–0521489 does not have precise proper motion measurements which give larger UVW errors, so I excluded this source for the kinematic age analysis.

The overall velocity dispersion of my sample $\sigma_{\text{tot}} = 35.4 \pm 0.4$ km s⁻¹, which corresponds to a kinematic age of $\tau = 2.64 \pm 0.17$ Gyr using the Aumer & Binney (2009) relation. For the Wielen (1977) relation, the W -weighted velocity dispersion $\sigma_{W\text{-tot}} = 45.7 \pm 0.3$ km s⁻¹ corresponds to a kinematic age of $\tau = 3.81 \pm 0.05$ Gyr. Compared to the late-M age of 4.0 ± 0.3 Gyr in Hsu et al. (2021) based on the Aumer & Binney (2009) relation, my sample appears to have a younger average age, likely reflecting

the sample bias toward young clusters. Removing the 66⁷ identified young cluster members increases the velocity dispersion to $\sigma_{\text{tot}} = 42.7 \pm 0.6 \text{ km s}^{-1}$, corresponding to a kinematic age of $4.5 \pm 0.3 \text{ Gyr}$ for the Aumer & Binney (2009) relation, in line with prior results (Reiners & Basri 2009a; Blake et al. 2010; Burgasser et al. 2015a; Hsu et al. 2021). There is also better agreement in this case with the W -weighted velocity dispersion and Wielen (1977) age of $4.19 \pm 0.05 \text{ Gyr}$. I can also discern the distinct young and field populations using the velocity probability plot, or probit plot, that ranks the individual velocity components in steps of overall sample standard deviation. A normal distribution would be represented as a straight line whose slope equals the sample dispersion (Chambers et al. 1983). Figure 3.19 displays probit plots for each of the UVW velocity components, all of which show two clear linear trends: a shallower “core” sample and a steeper (and hence more dispersed) “wide” sample. A piece-wise linear fit to these trends broken at $\pm 1\sigma$ components yields total velocity dispersions of $\sigma_{\text{tot}} = 38.9 \pm 0.4 \text{ km s}^{-1}$, $\sigma_{\text{tot}} = 49.5 \pm 1.7 \text{ km s}^{-1}$, and $\sigma_{\text{tot}} = 53.0 \pm 2.5 \text{ km s}^{-1}$ for the shallow, lower wide, and upper wide sample, respectively, corresponding to kinematic ages of $3.5 \pm 0.2 \text{ Gyr}$, $6.9 \pm 1.7 \text{ Gyr}$, and $8.4 \pm 1.1 \text{ Gyr}$, based on the Aumer & Binney (2009) relation. The core sample is fully consistent with the thin disk without young and binary sources; the wing sample for the upper and lower wide samples both have similar ages and are older than the core sample as expected for thick disk ages. I also examined the removal of sources of 12 thick disk and intermediate thin/thick disk sources and young sources (Section 3.4.1), which slightly reduces the velocity dispersion and sample age to $3.2 \pm 0.2 \text{ Gyr}$ based on the Aumer & Binney (2009) relation. Segregating thin disk M dwarfs (100 sources) and L dwarfs (4 sources), I find similar kinematic ages ($3.1 \pm 0.2 \text{ Gyr}$ and $4.3 \pm 2.4 \text{ Gyr}$, respectively), albeit with large uncertainties for the latter. I also examined removing 36 RV variables from the thin disk sample as likely

⁷This number includes 2MASS J05350162–0521489, which has huge proper motion uncertainties.

binaries; this had minimal influence on the inferred age (3.5 ± 0.3 Gyr).

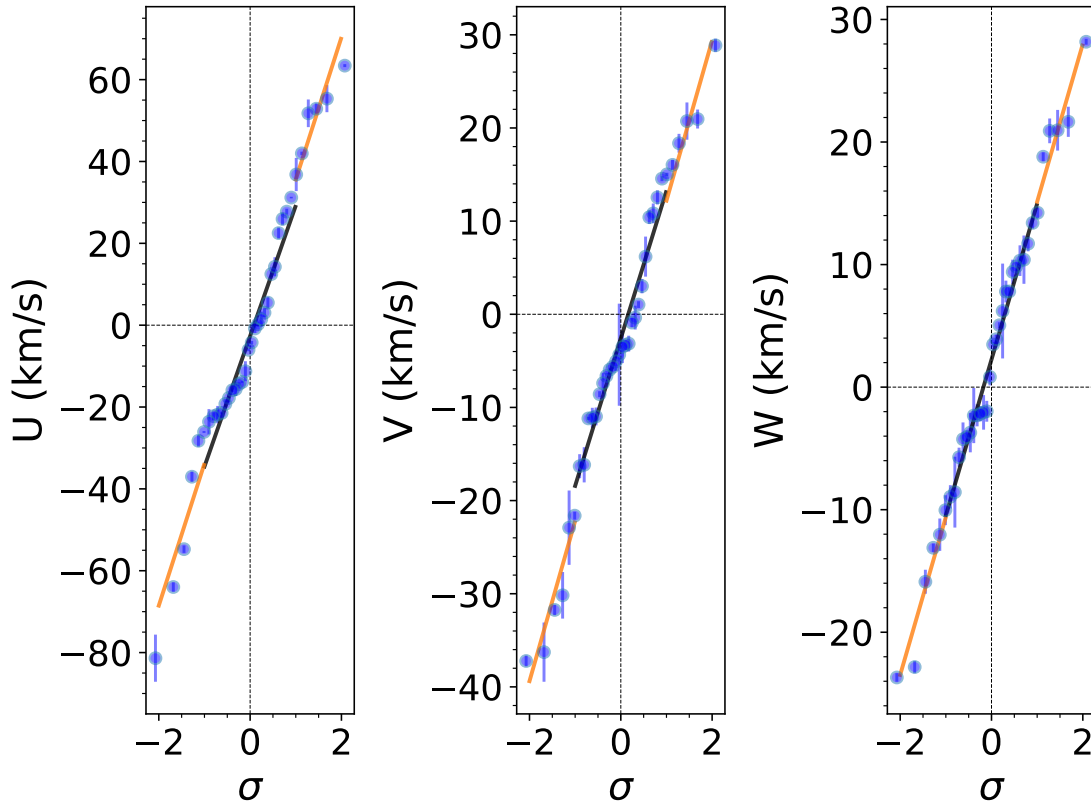


Figure 3.19: Space velocity probit plots of the APOGEE sample. Individual velocities are indicated by blue and red circles for my M and L dwarfs, respectively, while a piece-wise linear fit broken at $\pm 1 \sigma$ is shown (orange dashed lines). Note that 2MASS J05350162–0521489 is not plotted here due to its huge proper motion errors.

3.4.5 Radial Velocity Variables

One of the main stellar science goals of the APOGEE survey is to identify closely-separated binary systems, which are crucial for mass measurements and testing binary formation and evolution models. While the APOGEE ASPCAP pipeline is unable to provide robust RVs in the ultracool dwarf temperature regime, my RV precisions are sufficient to identify binaries at projected separations $\lesssim 0.7$ AU from RV variability, assuming the total mass of $0.3 M_{\odot}$, secondary mass of $5 M_{\text{Jup}}$ and RV precision of 0.3 km

s^{-1} . My sample contains 137 sources with at least two epochs of observations, 51 of which have four or more epochs. Of the latter, 18 exhibit evidence of significant RV variations ($p < 0.01$) based on a χ^2 test,⁸ and I consider these high probability binary systems. Among the 90 sources with 2 or 3 epochs of observations, 11 show significant RV variations, and I consider these promising binary candidates. All of the RV variables are listed in Table 3.9.

The majority of the RV variables have too few epochs to full sample a complete orbit, and hence only partial constraints can be made on orbital parameters. I attempted to make these constraints for each RV variable with at least four epochs of observation using `The Joker` (Price-Whelan et al. 2017), a Monte Carlo rejection sampler that quantifies single-line RV orbits in terms of period (P), velocity variation semi-amplitude (K), eccentricity (e), systemic velocity (v_0), the mean anomaly (M_0), and the argument of periastron (ω), and identifies a family of orbits consistent with the measurements. I ran the `The Joker` using its default settings. For each system, I initially selected limiting ranges for the minimum and maximum orbital period (P_{\min} and P_{\max}), the maximum RV semi-amplitude (K_0), and the number of input samplers ($10^5 \leq N_{\text{samp}} \leq 5 \times 10^6$) by optimizing the reasonable number of survival simulated orbital solutions. Initial estimates of v_0 and K were determined from the mean and standard deviation of RV measurements), and both of these quantities were assumed to follow normal distributions with scale factors $\sigma_K, \sigma_v = 1\text{--}4 \text{ km s}^{-1}$ constrained from the ΔRV variations in the observed RV time series. The period distribution was assumed to follow $\mathcal{P}(P) \propto P^{-1}$ following Uehara et al. (2016); Price-Whelan et al. (2017); Kipping (2018). The eccentricity distribution was assumed to be a Beta distribution

$$\mathcal{P}(e) = \frac{\Gamma(a+b)}{\Gamma(a)+\Gamma(b)} e^{a-1} [1-e]^{b-1} \quad (3.4)$$

⁸This includes an assumed systematic RV uncertainty of 0.19 km s^{-1} ; see Section 3.3.1)

, where Γ is the Gamma function and $a = 0.867$ and $b = 3.03$ (Kipping 2013). The distributions of mean anomaly and periastron angle were assumed to be uniformly distributed between 0 and 2π . The standard deviation of the RV semi-amplitude σ_K prior, assumed to be a normal distribution Price-Whelan et al. (2020), is defined as

$$\sigma_K^2 = \sigma_{K,0}^2 \left(\frac{P}{1 \text{ year}} \right)^{-2/3} (1 - e^2)^{-1}. \quad (3.5)$$

Since RV semi-amplitude of the primary $K_1 = \sqrt{\frac{G}{(1-e^2)}} m_2 \sin i (m_1 + m_2)^{-1/2} a^{-1/2}$, for the gravitational constant G , eccentricity e , masses of the primary m_1 and secondary m_2 , inclination i , and semi-major axis a , this form of priors has the advantage that the RV semi-amplitude K has a fixed form of primary mass independent of the period and eccentricity at a fixed primary mass (Price-Whelan et al. 2020). Typical computation time is within 0.5–2 min.

Results for these fits are provided in Table 3.10, and individual fits to all RV variables are provided in Appendix C. Figure 3.20 illustrates an example orbit fit for 2MASS J07564895+6649595, which has 17 epochs of observations. For this fit I were able to constrain its period $P_{\text{fit}} = 409_{-52}^{+120}$ day, RV semi-amplitude $K_{\text{fit}} = 0.5 \pm 0.2 \text{ km s}^{-1}$, and eccentricity $e_{\text{fit}} = 0.18_{-0.14}^{+0.26}$. There are two sources with orbits less than 2 day (2MASS J13500476+3207596, $P = 1.7_{-0.7}^{+0.2}$ day; and 2MASS J14005977+3226109, $P = 1.4_{-0.3}^{+321.9}$ day⁹) and one source with larger RV semi-amplitude (2MASS J13482307+3321508, $K = 10.8_{-1.6}^{+1.6} \text{ km s}^{-1}$). The major limitation of my binary orbital parameter estimates is the eccentricity (median uncertainty = 0.27) as well as the period (median uncertainty = 29 day), which requires complete sampling of the RV orbit to be well-constrained. Finally, I emphasize that given the sparse RVs in my APOGEE sample, more data are required to provide robust constraints of orbital parameters.

⁹not well constrained for the upper bound since long-period solutions are also possible

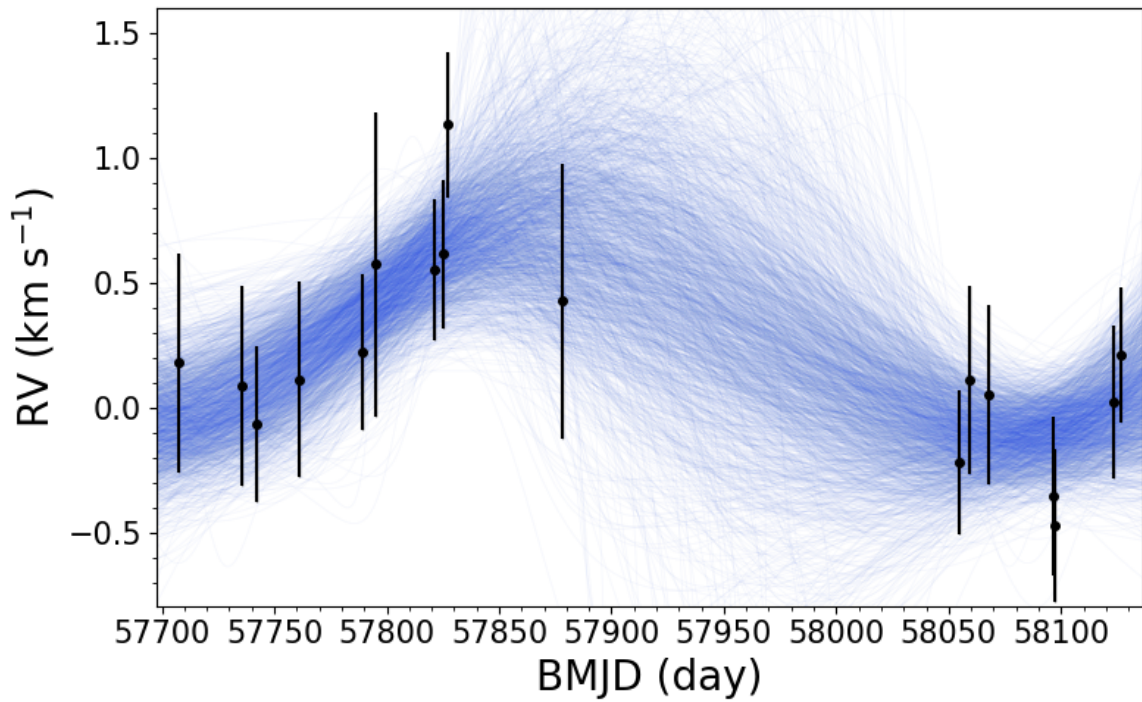


Figure 3.20: Binary orbital fit for 2MASS J07564895+6649595 using the Monte Carlo rejection sampler *The Joker*. The black dots are my measured RVs, and possible binary orbital solutions are labeled in blue lines. The inferred orbital parameters are period $P_{\text{fit}} = 409^{+120}_{-52}$ day, the RV semi-amplitude $K_{\text{fit}} = 0.5 \pm +0.2 \text{ km s}^{-1}$, and eccentricity $e_{\text{fit}} = 0.18^{+0.26}_{-0.14}$, with the full information summarized in Table 3.10.

3.4.6 Rotation Periods, Projected Radii, and Inclinations

Finally, I examine in some detail the results of my $v \sin i$ analysis, which provides information on the ages, sizes, and viewing geometries of my targets, particularly when an independent measure of rotation period is available. Recalling that roughly one-third of my sample is kinematically associated with a nearby young cluster (Section 3.4.3), such measurements can be used to examine radius evolution as a function of time to test evolutionary models (Jackson & Jeffries 2010). The projected radius $R \sin i$ can be directly inferred from rotational velocity and period using the relation

$$\frac{R \sin i}{R_{\odot}} = 0.0198 \frac{P}{\text{day}} \frac{v \sin i}{\text{km/s}} \quad (3.6)$$

Thanks to the K2 Mission (Howell et al. 2014), the Transiting Exoplanet Survey Satellite (TESS; Ricker et al. 2015), and other ground-based programs, rotational periods have been measured for several sources in my APOGEE sample, in particular for several members of the Upper Scorpius cluster. I have compiled period measurements from the literature for 53 APOGEE sources, listed in Table 3.11. These include 37 young cluster members and 11 field objects. An initial assessment shows that the young sources (median period of 0.87 days) rotate significantly slower than the field sources (median period of 0.40 days). I computed the projected radii of each source and show the trend with age in Figure 3.21, assuming the uncertainty of periods of 5% for sources without period uncertainties in the literature and the $R \sin i$ uncertainties were propagated through the Monte Carlo method. I also removed five objects with periods > 5 day or $v \sin i < 10 \text{ km s}^{-1}$ (lower than my $v \sin i$ detection limit; see Section 3.3.2), which are all field objects (2MASS J07140394+3702459, 2MASS J10323297+0630074, 2MASS J10570380+2217203, 2MASS J14320849+0811313, and 2MASS J19241634+7533121). Since the $v \sin i$ close to my detection limit could potentially give overestimated projected

radii, I conservatively constrain my analysis for sources with $v \sin i > 20 \text{ km s}^{-1}$, which leaves 26 sources in total, including 21 young sources (14 sources in the Upper Scorpius cluster) and 5 field objects. Overall, the projected radii are larger for the young sources (median $0.48 R_{\odot}$) compared to the field objects (median $0.15 R_{\odot}$), and show a consistent decline with age from Upper Scorpius' $10 \pm 3 \text{ Myr}$ Pecaut & Mamajek 2016 to Hyades' $750 \pm 100 \text{ Myr}$ (Brandt & Huang 2015) and field age (assumed as 5 Gyr). In particular, the projected radii are $0.53_{-0.15}^{+0.16} R_{\odot}$ for the Upper Scorpius cluster and $0.15_{-0.06}^{+0.09} R_{\odot}$ for the field objects. These radii are slightly larger but consistent with the evolutionary models, which predict radii of $0.39\text{--}0.45 R_{\odot}$ at 10 Myr, $0.17\text{--}0.22 R_{\odot}$ at 100 Myr, and $0.12\text{--}0.18 R_{\odot}$ at 1 Gyr for a $0.10\text{--}0.15 M_{\odot}$ star (Burrows et al. 2001). It should be noted that the radius inflation of M dwarfs is commonly reported in the literature ($\Delta R/R \sim 14 \pm 2\%$; e.g. Jackson et al. 2018; Kesseli et al. 2018; Parsons et al. 2018; Khata et al. 2020)

As a final assessment, I attempted to infer inclination angles for those sources with robust determinations of $v \sin i$ and period, using model-based radii (cf. Vos et al. 2017). Radii were drawn from the Burrows et al. (2001) evolutionary models, adopting uniform distributions with T_{eff} s from the spectral type using Pecaut & Mamajek (2013) relation (assuming ± 1 subtype uncertainty) and ages for each cluster (Taurus: 1–2 Myr, Kenyon & Hartmann 1995; Corona Australis: $45_{-7}^{+11} \text{ Myr}$, Bell et al. 2015; Upper Scorpius: $10 \pm 3 \text{ Myr}$, Pecaut & Mamajek 2016; Argus: 40–50 Myr, Zuckerman 2019; AB Doradus: $149_{19}^{+51} \text{ Myr}$, Bell et al. 2015; Carina-Near: $\sim 200 \text{ Myr}$, Zuckerman et al. 2006; Castor: $200 \sim 100 \text{ Myr}$ (Barrado y Navascues 1998)¹⁰; and Hyades: $750 \pm 100 \text{ Myr}$, Brandt & Huang 2015) or 5 Gyr for the field, which is a reasonable assumption for field ages between 1–10 Gyr in theoretical models (Burrows et al. 1997; Chabrier et al. 2000; Allard et al. 2001; Baraffe et al. 2003) and observational studies (Burgasser & Blake 2009;

¹⁰The stars associated with the Castor Moving Group might not share a common age; see the discussion in Mamajek et al. (2013) in their § 2.11.

Burgasser & Mamajek 2017; Dupuy & Liu 2017).¹¹ I drew 100,000 samples from both measurement distributions in normal distributions and radii in uniform distributions, and propagated uncertainties using the Monte Carlo method. The resulting inclinations are summarized in Table 3.11. Again, I constrained the inclination analysis for sources with $P < 5$ day and $v \sin i > 20 \text{ km s}^{-1}$. From this select sample of 26 sources, 17 inclinations were found to be non-physical ($\sin i > 1$), leaving 9 sources with realistic measurements: 3 Upper Scorpius sources and 3 field objects. While this is a small sample, I examined the distribution of orientations to assess whether there were any obvious biases in inferred inclinations that may be related to measurement errors. If a given population of stars is randomly oriented, the cumulative distribution function follows $CDF(i) = 1 - \cos i$ (Jackson & Jeffries 2010). I used the Kolmogorov–Smirnov (K-S) test (Massey 1951) to compare the distribution of inclinations in my sample to this random orientation distribution, and found that the Upper Scorpius (K-S statistic = 0.55, p-value = 0.22), field (K-S statistic = 0.20, p-value = 0.99), and the full sample (K-S statistic = 0.28, p-value = 0.39) are all consistent with a random orientation.

¹¹The radii were inferred to be $0.518\text{--}0.585 R_{\odot}$ for 1 source Corona Australis (45_{-7}^{+11} Myr, Bell et al. 2015), $0.226\text{--}0.314 R_{\odot}$ for 23 sources in Upper Scorpius (10 ± 3 Myr, Pecaut & Mamajek 2016), $0.137\text{--}0.141 R_{\odot}$ for 1 source in Argus (40–50 Myr, Zuckerman 2019), $0.128\text{--}0.157 R_{\odot}$ for 1 source in AB Doradus (149_{19}^{+51} Myr, Bell et al. 2015), $0.097\text{--}0.111 R_{\odot}$ for 6 sources in Hyades (750 ± 100 Myr, Brandt & Huang 2015), and $0.090\text{--}0.137 R_{\odot}$ for field (5 Gyr, see references in the main text).

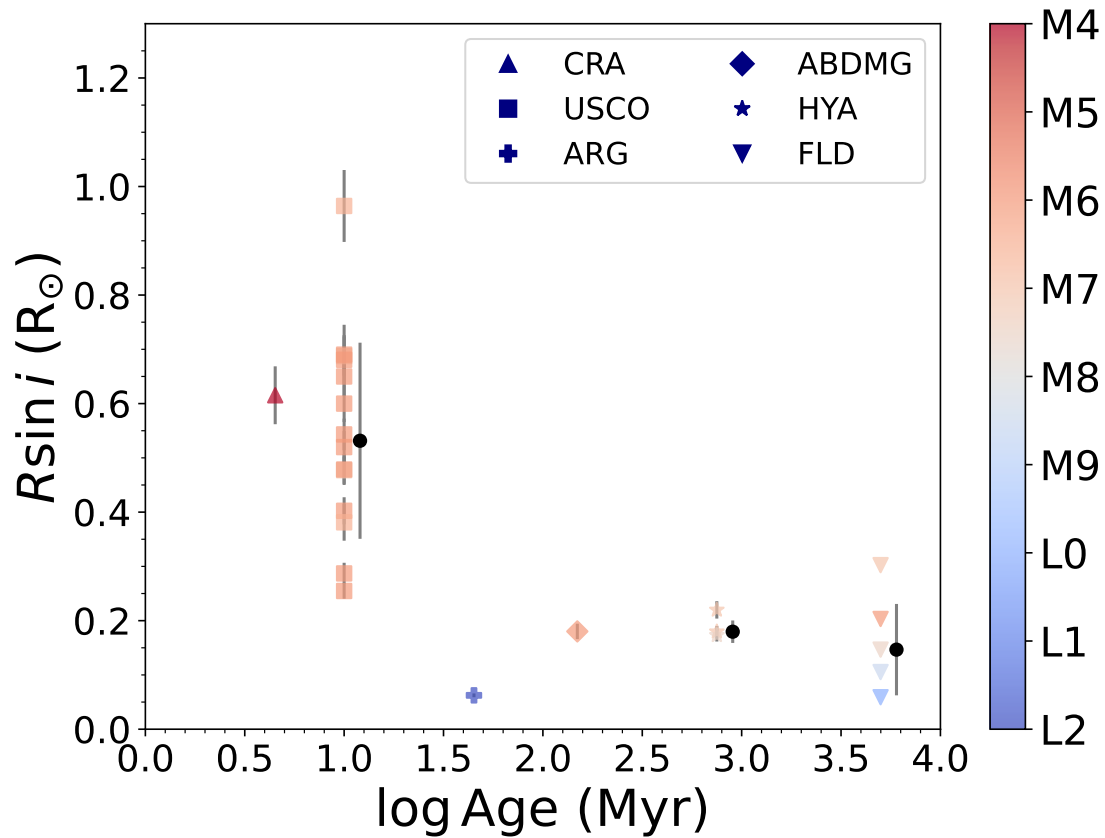


Table 3.5: RV and $v \sin i$ Measurements with ASPCAP and Literature Comparison

| APOGEE ID | (RV) ^a (km s ⁻¹) | ASPCAP RV ^b (km s ⁻¹) | Lit. RV (km s ⁻¹) | Lit. RV Ref. | ($v \sin i$) ^a (km s ⁻¹) | Lit. $v \sin i$ (km s ⁻¹) | Lit. $v \sin i$ Ref. |
|---------------------|--|---|----------------------------------|--------------------------|--|--|-------------------------|
| 2M00312793+6139333 | -34.44 ^{+0.19} _{-0.2} | -38.02 ± 0.69 | ... | ... | < 10 | ... | ... |
| 2M00452143+1634446 | 3.71 ^{+0.4} _{-0.56} | 555.81 ± 4.96 | 3.16 ± 0.83 | Fäherty et al. (2016) | 31.64 ^{+1.07} _{-1.21} | 32.82 ± 0.17 | Blake et al. (2010) |
| 2M01120002+1502170 | -44.31 ^{+0.58} _{-0.78} | -45.61 ± 0.44 | ... | ... | < 10 | ... | ... |
| 2M01154176+0059317 | 10.78 ^{+0.18} _{-0.11} | 11.7 ± 0.41 | ... | ... | 33.69 ^{+2.15} _{-2.57} | ... | ... |
| 2M01215816+0101007 | 10.28 ^{+0.13} _{-0.16} | 586.83 ± 0.92 | ... | ... | < 10 | ... | ... |
| 2M01243124-0027556 | -3.88 ^{+0.17} _{-0.16} | 577.03 ± 1.68 | 0.69 ± 10.14 | Kimani et al. (2019) | 27.7 ^{+1.11} _{-1.84} | ... | ... |
| 2M01514363+0046188 | 14.44 ^{+0.64} _{-0.64} | 14.49 ± 2.0 | 16.55 ± 10.07 | Kimani et al. (2019) | 18.12 ^{+1.35} _{-1.35} | ... | ... |
| 2M02500239-0808417 | 25.61 ^{+0.66} _{-0.66} | 25.06 ± 0.81 | ... | ... | < 10 | ... | ... |
| 2M03040207+0045512 | 29.94 ^{+0.35} _{-0.31} | 29.18 ± 0.77 | 28.38 ± 2.52 | Kimani et al. (2019) | 19.99 ^{+2.42} _{-1.73} | ... | ... |
| 2M03282839+31116273 | 15.41 ^{+0.77} _{-0.48} | 14.09 ± 9.08 | 15.06 ± 2.15 | Kounkel et al. (2019) | 30.46 ^{+2.51} _{-0.93} | 26.9 ± 3.16 | Kounkel et al. (2019) |
| 2M03293053+3127280 | 15.77 ^{+0.54} _{-0.54} | 15.83 ± 0.43 | 14.9 ± 0.8 | Cottaar et al. (2015) | 16.05 ^{+0.22} _{-0.22} | 16.25 ± 1.16 | Kounkel et al. (2019) |
| 2M03505737+1818069 | 6.05 ^{+0.16} _{-0.13} | 105.07 ± 0.81 | 32.2 ± 1.8 | Deshpande et al. (2012) | 12.71 ^{+0.4} _{-1.02} | 12.2 ± 3.0 | Deshpande et al. (2012) |
| 2M04110642+1247481 | 39.28 ^{+0.19} _{-0.23} | 37.66 ± 0.63 | ... | ... | 14.15 ^{+0.97} _{-1.12} | ... | ... |
| 2M04185115+2814332 | 21.13 ^{+0.23} _{-0.27} | 16.61 ± 1.44 | ... | ... | < 10 | ... | ... |
| 2M04204796+5624202 | -29.54 ^{+0.24} _{-0.24} | -31.93 ± 1.44 | ... | ... | 14.75 ^{+2.7} _{-2.01} | ... | ... |
| 2M04214435+2024105 | 40.78 ^{+0.42} _{-0.45} | 30.36 ± 0.42 | ... | ... | 32.8 ^{+1.48} _{-1.96} | ... | ... |
| 2M04214955+1929086 | 39.43 ^{+0.19} _{-0.17} | 636.19 ± 0.61 | ... | ... | 44.43 ^{+0.34} _{-1.34} | ... | ... |
| 2M04262939+2624137 | 20.01 ^{+0.47} _{-0.22} | 17.36 ± 0.58 | 17.55 ± 0.26 | Kounkel et al. (2019) | 12.95 ^{+1.33} _{-1.33} | 12.06 ± 0.66 | Kounkel et al. (2019) |
| 2M04294568+2630468 | 18.13 ^{+0.22} _{-0.21} | 16.8 ± 0.38 | 15.77 ± 0.23 | Kounkel et al. (2019) | 14.21 ^{+0.96} _{-1.05} | 14.34 ± 0.51 | Kounkel et al. (2019) |
| 2M04330945+2246487 | 19.6 ^{+0.37} _{-0.39} | 16.04 ± 1.02 | 16.31 ± 0.29 | Kounkel et al. (2019) | 15.96 ^{+1.0} _{-1.06} | 13.59 ± 0.65 | Kounkel et al. (2019) |
| 2M04351354+2008014 | 40.01 ^{+0.28} _{-0.19} | 283.03 ± 0.99 | ... | ... | 23.66 ^{+0.96} _{-1.16} | ... | ... |
| 2M04440164+1621324 | 21.82 ^{+0.21} _{-0.21} | 843.02 ± 5.32 | ... | ... | 14.28 ^{+1.24} _{-1.24} | ... | ... |
| 2M04464498+2436404 | 42.22 ^{+0.46} _{-0.34} | 40.79 ± 0.45 | ... | ... | 17.88 ^{+0.08} _{-0.17} | ... | ... |
| 2M04552333+3027366 | 17.46 ^{+0.19} _{-0.13} | 15.63 ± 2.53 | ... | ... | 14.22 ^{+0.95} _{-0.92} | ... | ... |
| 2M04565141+2939310 | 17.91 ^{+0.37} _{-0.31} | 16.65 ± 2.42 | ... | ... | 12.44 ^{+1.0} _{-1.0} | ... | ... |
| 2M05350162-0521489 | 25.07 ^{+0.62} _{-0.24} | 53.21 ± 0.77 | ... | ... | 67.65 ^{+2.38} _{-1.62} | ... | ... |
| 2M05392474+4038437 | -5.42 ^{+0.23} _{-0.24} | 524.06 ± 1.22 | 10.0 ± 30.0 | Lépine et al. (2003) | < 10 | ... | ... |
| 2M05402570+2448090 | 23.07 ^{+0.63} _{-0.33} | 18.67 ± 6.31 | 21.0 ± 5.0 | Newton et al. (2014) | 30.37 ^{+2.0} _{-1.93} | 25.9 ± 1.7 | Gilhool et al. (2018) |
| 2M06154934-0100415 | -19.69 ^{+0.19} _{-0.22} | 1024.34 ± 3.38 | -21.0 ± 2.0 | Burgasser et al. (2015a) | 16.62 ^{+1.38} _{-1.38} | ... | ... |
| 2M06521977-2534505 | 14.9 ^{+0.21} _{-0.13} | 595.94 ± 0.96 | 12.0 ± 2.0 | Burgasser et al. (2015a) | < 10 | ... | ... |
| 2M07025026-6102482 | 21.31 ^{+0.14} _{-0.13} | 17.85 ± 0.43 | ... | ... | 15.98 ^{+0.06} _{-0.1} | ... | ... |
| 2M07140394+3702459 | 35.34 ^{+0.23} _{-0.23} | 618.83 ± 2.03 | 40.03 ± 0.11 | Deshpande et al. (2013) | < 10 | 12.8 ± 0.5 | Deshpande et al. (2013) |
| 2M07464256+20000321 | 52.78 ^{+0.11} _{-0.1} | 635.3 ± 0.91 | 52.37 ± 0.59 | Blake et al. (2010) | 34.59 ^{+1.04} _{-1.08} | 32.72 ± 0.56 | Blake et al. (2010) |
| 2M07475737+6653337 | 7.45 ^{+0.7} _{-0.82} | 116.13 ± 28.51 | ... | ... | 45.85 ^{+3.03} _{-1.93} | ... | ... |

Table 3.5 (continued)

Table 3.5 (*continued*)

| APOGEE ID | (RV) ^a (km s ⁻¹) | ASPCAP RV ^b (km s ⁻¹) | Lit. RV (km s ⁻¹) | Lit. RV Ref. | (v sin i) ^a (km s ⁻¹) | Lit. v sin i (km s ⁻¹) | Lit. v sin i Ref. |
|--------------------|--|---|----------------------------------|--------------------------|---|---------------------------------------|-----------------------|
| 2M07552256+2755318 | -3.86 ^{+0.28} _{-0.41} | -5.72 ± 0.53 | ... | ... | < 10 | ... | ... |
| 2M07564895+6649595 | 0.19 ^{+0.42} _{-0.25} | -215.64 ± 28.35 | ... | ... | 10.67 ^{+0.99} _{-1.25} | ... | ... |
| 2M08072607+3213101 | 34.41 ^{+0.22} _{-0.32} | 619.69 ± 2.2 | ... | ... | 13.68 ^{+1.28} _{-1.35} | ... | ... |
| 2M08080189+3157054 | 30.61 ^{+0.32} _{-0.33} | 616.38 ± 2.69 | ... | ... | 12.55 ^{+1.35} _{-1.32} | ... | ... |
| 2M08092892+3235226 | -6.66 ^{+0.54} _{-0.48} | -10.32 ± 1.08 | ... | ... | 23.35 ^{+1.32} _{-1.7} | ... | ... |
| 2M08144389+4650522 | 24.39 ^{+0.3} _{-0.29} | 23.56 ± 0.53 | ... | ... | 17.87 ^{+0.95} _{-1.01} | ... | ... |
| 2M08185804+2333522 | 35.74 ^{+0.29} _{-0.22} | 617.93 ± 0.78 | 33.1 ± 3.0 | Reiners & Basri (2009a) | < 10 | ... | ... |
| 2M08211639+5658358 | 7.17 ^{+0.22} _{-0.32} | 4.85 ± 1.16 | ... | ... | 14.09 ^{+1.16} _{-1.32} | ... | ... |
| 2M08294949+2646348 | 10.69 ^{+0.32} _{-0.31} | 594.91 ± 1.82 | 53.84 ± 5.53 | Terrien et al. (2015) | 11.91 ^{+1.12} _{-1.1} | 9.6 ± 0.8 | Kesseli et al. (2018) |
| 2M08440350+0434356 | 66.68 ^{+0.5} _{-0.49} | 648.94 ± 1.83 | ... | ... | 16.16 ^{+0.97} _{-1.1} | ... | ... |
| 2M08490052+0220155 | 22.37 ^{+0.37} _{-0.44} | 625.5 ± 0.97 | ... | ... | 53.72 ^{+2.13} _{-1.73} | ... | ... |
| 2M08501918+1056436 | 31.45 ^{+0.44} _{-0.41} | 821.19 ± 1.74 | 32.97 ± 0.09 | Deshpande et al. (2013) | 17.94 ^{+1.32} _{-1.32} | 15.8 ± 1.5 | Gilhool et al. (2018) |
| 2M09020690+0033195 | 29.56 ^{+0.2} _{-0.22} | 28.14 ± 0.38 | ... | ... | < 10 | ... | ... |
| 2M09130162+3037583 | 42.63 ^{+0.25} _{-0.24} | 41.72 ± 0.59 | 41.0 ± 2.0 | Burgasser et al. (2015a) | < 10 | ... | ... |
| 2M09373349+5534057 | 51.79 ^{+0.35} _{-0.34} | 49.63 ± 0.51 | ... | ... | < 10 | ... | ... |
| 2M09381783+0132490 | 0.68 ^{+0.45} _{-1.51} | -0.68 ± 2.26 | 8.89 ± 6.97 | Kimani et al. (2019) | 19.41 ^{+2.87} _{-1.95} | ... | ... |
| 2M09442625+3521233 | -16.8 ^{+1.04} _{-0.78} | -21.85 ± 57.4 | ... | ... | 96.07 ^{+3.47} _{-16.05} | ... | ... |
| 2M09453388+5458511 | 51.2 ^{+0.87} _{-0.68} | 50.47 ± 0.49 | ... | ... | 13.83 ^{+1.43} _{-1.7} | ... | ... |
| 2M09472006-0020093 | -3.67 ^{+0.68} _{-0.68} | -0.5 ± 15.12 | ... | ... | 23.46 ^{+1.4} _{-1.44} | ... | ... |
| 2M09474477+0224327 | 15.0 ^{+0.09} _{-0.26} | 14.31 ± 0.44 | ... | ... | < 10 | ... | ... |
| 2M09522188-1924319 | 8.76 ^{+0.2} _{-0.26} | 234.77 ± 0.87 | ... | ... | 12.62 ^{+1.36} _{-1.58} | ... | ... |
| 2M09524622+0620410 | -17.11 ^{+0.91} _{-0.93} | 561.77 ± 1.58 | ... | ... | 16.04 ^{+1.87} _{-1.84} | ... | ... |
| 2M09560888+0134128 | 12.8 ^{+0.45} _{-0.45} | 11.65 ± 1.0 | ... | ... | 17.2 ^{+1.66} _{-1.66} | ... | ... |
| 2M10031918-0105079 | 21.12 ^{+0.53} _{-0.53} | 605.29 ± 5.22 | ... | ... | 30.09 ^{+2.73} _{-2.12} | ... | ... |
| 2M10134315+0000406 | 23.99 ^{+0.27} _{-0.26} | -818.36 ± 0.78 | 22.0 ± 2.0 | Burgasser et al. (2015a) | 32.73 ^{+1.01} _{-1.18} | ... | ... |
| 2M10225090+0032169 | 3.95 ^{+0.35} _{-0.35} | 2.3 ± 1.03 | ... | ... | 10.24 ^{+1.34} _{-1.36} | ... | ... |
| 2M10240997+1815533 | 34.04 ^{+0.3} _{-0.87} | 744.1 ± 0.88 | ... | ... | 11.2 ^{+1.54} _{-1.54} | ... | ... |
| 2M10323297+0630074 | 8.22 ^{+0.09} _{-0.14} | 588.4 ± 0.91 | 6.0 ± 3.0 | Reiners & Basri (2009a) | < 10 | ... | ... |
| 2M10372897+3011117 | 13.22 ^{+0.15} _{-0.14} | 12.16 ± 0.24 | 8.0 ± 4.0 | Newton et al. (2014) | < 10 | ... | ... |
| 2M10541102-8505023 | 7.97 ^{+0.19} _{-0.13} | 6.39 ± 1.01 | ... | ... | 13.07 ^{+1.16} _{-1.1} | ... | ... |
| 2M10543366+0503467 | -10.8 ^{+0.82} _{-1.13} | 563.45 ± 36.52 | ... | ... | 10.73 ^{+0.97} _{-1.1} | ... | ... |
| 2M10570380+2217203 | -20.17 ^{+0.1} _{-0.11} | 560.48 ± 1.44 | ... | ... | < 10 | ... | ... |
| 2M11194647+0820356 | 11.68 ^{+0.1} _{-0.18} | 10.83 ± 0.24 | 9.0 ± 5.0 | Newton et al. (2014) | < 10 | ... | ... |
| 2M11203609+0704135 | -44.98 ^{+0.17} _{-0.57} | 743.33 ± 4.96 | -45.0 ± 2.0 | Burgasser et al. (2015a) | < 10 | ... | ... |
| | -14.41 ^{+0.6} _{-0.6} | -15.62 ± 0.66 | -16.65 ± 7.23 | Kimani et al. (2019) | < 10 | ... | ... |

Table 3.5 (*continued*)

Table 3.5 (continued)

| APOGEE ID | (RV) ^a (km s ⁻¹) | ASPCAP RV ^b (km s ⁻¹) | Lit. RV (km s ⁻¹) | Lit. RV Ref. | (v sin i) ^a (km s ⁻¹) | Lit. v sin i (km s ⁻¹) | Lit. v sin i Ref. |
|--------------------|--|---|----------------------------------|--------------------------|---|---------------------------------------|-----------------------|
| 2M11210854+2126274 | -0.3 ^{+0.16} _{-0.16} | -2.37 ± 0.36 | ... | ... | 12.36 ^{+0.11} _{-0.37} | ... | ... |
| 2M11232934+0154040 | -0.21 ^{+0.65} _{-0.59} | 580.32 ± 0.98 | ... | ... | 18.32 ^{+1.4} _{-1.4} | ... | ... |
| 2M12080810+3520281 | 29.17 ^{+0.56} _{-0.54} | 27.76 ± 1.37 | ... | ... | 13.66 ^{+1.65} _{-1.48} | ... | ... |
| 2M12153877+5205050 | -4.75 ^{+0.2} _{-0.23} | -5.92 ± 0.24 | ... | ... | 12.88 ^{+0.58} _{-0.92} | ... | ... |
| 2M12201166+3315379 | 11.16 ^{+0.26} _{-0.23} | 542.27 ± 1.15 | ... | ... | < 10 | ... | ... |
| 2M12205439+2525568 | 14.81 ^{+0.33} _{-0.27} | 260.45 ± 20.52 | ... | ... | 25.61 ^{+0.28} _{-0.78} | ... | ... |
| 2M12215013+4632447 | -10.44 ^{+0.27} _{-0.22} | 563.85 ± 0.36 | ... | ... | 29.1 ^{+1.0} _{-1.58} | ... | ... |
| 2M12235346+2534559 | 7.03 ^{+0.78} _{-0.76} | 3.44 ± 1.94 | ... | ... | 16.42 ^{+1.67} _{-1.32} | ... | ... |
| 2M12252076+2517082 | 7.24 ^{+0.81} _{-0.76} | -216.12 ± 0.6 | ... | ... | 32.88 ^{+1.65} _{-1.65} | ... | ... |
| 2M12270429+2541012 | 2.63 ^{+0.59} _{-0.61} | 0.28 ± 0.93 | ... | ... | 19.56 ^{+2.69} _{-2.13} | ... | ... |
| 2M12315462+5130389 | 8.92 ^{+0.26} _{-0.14} | 6.24 ± 0.44 | ... | ... | < 10 | ... | ... |
| 2M12493960+5255340 | -56.77 ^{+0.43} _{-0.38} | -272.74 ± 0.62 | ... | ... | 10.36 ^{+2.98} _{-0.58} | ... | ... |
| 2M1252354+2528469 | 9.43 ^{+0.24} _{-0.24} | 6.23 ± 0.48 | ... | ... | 12.6 ^{+0.7} _{-0.7} | ... | ... |
| 2M13004379+3557591 | -24.58 ^{+0.23} _{-0.26} | -27.07 ± 1.49 | -22.18 ± 6.05 | Kimani et al. (2019) | 17.75 ^{+1.83} _{-1.67} | ... | ... |
| 2M13022083+3227103 | 6.77 ^{+0.33} _{-0.33} | 2.13 ± 1.16 | 7.58 ± 7.77 | Kimani et al. (2019) | 25.7 ^{+0.99} _{-1.72} | ... | ... |
| 2M13034100+2414020 | -9.3 ^{+0.37} _{-0.37} | 566.48 ± 0.63 | ... | ... | 27.42 ^{+1.73} _{-1.26} | ... | ... |
| 2M13065141+7056376 | 15.29 ^{+0.3} _{-0.42} | -199.04 ± 4.21 | ... | ... | 11.75 ^{+1.3} _{-1.3} | ... | ... |
| 2M13192677+1301119 | 6.27 ^{+0.11} _{-0.15} | 4.66 ± 0.38 | ... | ... | < 10 | ... | ... |
| 2M13202007+7213140 | -27.34 ^{+0.52} _{-0.54} | 574.4 ± 146.73 | ... | ... | 18.65 ^{+1.4} _{-1.88} | ... | ... |
| 2M13232423+5132272 | -5.41 ^{+0.49} _{-0.49} | -6.29 ± 0.26 | -4.69 ± 3.73 | Kimani et al. (2019) | 18.91 ^{+1.66} _{-1.66} | ... | ... |
| 2M13342918+3303043 | -18.03 ^{+0.3} _{-0.27} | -28.1 ± 5.22 | ... | ... | 10.71 ^{+0.3} _{-0.41} | ... | ... |
| 2M13430646+0038442 | -11.91 ^{+0.72} _{-0.72} | -14.72 ± 1.0 | ... | ... | < 10 | ... | ... |
| 2M13482307+3321508 | -19.22 ^{+0.53} _{-0.53} | -17.38 ± 9.06 | ... | ... | 14.37 ^{+5.08} _{-2.44} | ... | ... |
| 2M13500476+3207596 | -5.83 ^{+0.61} _{-0.61} | -7.99 ± 2.41 | ... | ... | 10.56 ^{+1.84} _{-1.84} | ... | ... |
| 2M13564148+4342587 | -19.51 ^{+0.62} _{-0.57} | 559.79 ± 1.51 | -22.2 ± 3.0 | Reiners & Basri (2009a) | 16.16 ^{+0.96} _{-1.06} | 13.5 ± 1.6 | Gilhool et al. (2018) |
| 2M14320849+0811313 | -43.22 ^{+0.72} _{-0.72} | -48.07 ± 16.87 | ... | ... | 38.4 ^{+4.05} _{-3.57} | ... | ... |
| 2M14005977+3226109 | -17.9 ^{+0.98} _{-0.98} | -21.8 ± 1.48 | ... | ... | 11.53 ^{+1.79} _{-1.79} | ... | ... |
| 2M14081562+5236281 | -43.49 ^{+0.14} _{-0.14} | -45.07 ± 0.31 | ... | ... | < 10 | ... | ... |
| 2M14093200+4138080 | -10.96 ^{+0.22} _{-0.13} | -13.51 ± 0.27 | -11.0 ± 5.0 | Newton et al. (2014) | 19.73 ^{+0.07} _{-0.15} | ... | ... |
| 2M14320849+0811313 | -21.3 ^{+0.13} _{-0.13} | -22.66 ± 0.42 | -18.0 ± 4.0 | Newton et al. (2014) | < 10 | 8.49 ± 1.5 | Gilhool et al. (2018) |
| 2M14340140+5039480 | -6.39 ^{+0.34} _{-0.34} | -630.07 ± 0.63 | ... | ... | 16.32 ^{+1.5} _{-1.5} | ... | ... |
| 2M14402293+1339230 | -3.49 ^{+0.24} _{-0.24} | 578.19 ± 0.46 | -5.0 ± 2.0 | Burgasser et al. (2015a) | < 10 | ... | ... |
| 2M14432796+0316543 | -38.45 ^{+0.27} _{-0.29} | 501.09 ± 1.77 | ... | ... | 22.67 ^{+0.76} _{-0.44} | ... | ... |
| 2M1453384+1545593 | 19.3 ^{+0.18} _{-0.18} | 17.59 ± 0.6 | ... | ... | 14.81 ^{+2.57} _{-2.57} | ... | ... |
| 2M14554964+0321420 | -39.92 ^{+0.16} _{-0.09} | -41.88 ± 0.24 | ... | ... | < 10 | ... | ... |

Table 3.5 (continued)

Table 3.5 (*continued*)

| APOGEE ID | (RV) ^a (km s ⁻¹) | ASPCAP RV ^b (km s ⁻¹) | Lit. RV (km s ⁻¹) | Lit. RV Ref. | (v sin i) ^a (km s ⁻¹) | Lit. v sin i (km s ⁻¹) | Lit. v sin i Ref. |
|--------------------|--|---|----------------------------------|--------------------------|---|---------------------------------------|-------------------|
| 2M15010818+2250020 | 6.53 ^{+0.69} _{-0.29} | 1014.81 ± 0.67 | 6.0 ± 2.0 | Burgasser et al. (2015a) | 65.29 ^{+1.25} _{-1.38} | ... | ... |
| 2M15041028+0923232 | -53.33 ^{+0.29} _{-0.26} | 529.61 ± 6.14 | ... | ... | 13.36 ^{+1.38} _{-1.4} | ... | ... |
| 2M15042797+0942464 | -35.61 ^{+1.26} _{-0.77} | -52.89 ± 13.56 | ... | ... | 51.13 ^{+1.13} _{-1.97} | ... | ... |
| 2M15115124+3033065 | -61.43 ^{+0.13} _{-0.14} | -63.94 ± 0.75 | ... | ... | 18.88 ^{+1.33} _{-1.55} | ... | ... |
| 2M15175638+0656388 | -19.8 ^{+0.33} _{-0.34} | -21.59 ± 0.21 | ... | ... | < 10 | ... | ... |
| 2M15210103+5053230 | 2.43 ^{+0.18} _{-0.13} | 564.62 ± 0.83 | 0.9 ± 3.0 | Reiners & Basri (2009a) | 48.72 ^{+0.31} _{-0.28} | ... | ... |
| 2M15242475+2925318 | -15.15 ^{+0.03} _{-0.06} | 787.03 ± 1.41 | ... | ... | < 10 | ... | ... |
| 2M15512179+2931062 | 26.03 ^{+0.22} _{-0.47} | 25.93 ± 0.13 | 61.52 ± 8.75 | Terrien et al. (2015) | < 10 | ... | ... |
| 2M15555600-2045187 | -4.1 ^{+0.47} _{-0.47} | -6.98 ± 0.28 | ... | ... | 19.91 ^{+0.97} _{-1.13} | ... | ... |
| 2M15560104-2338081 | 1.51 ^{+0.28} _{-0.23} | -2.49 ± 0.42 | ... | ... | 12.96 ^{+0.63} _{-0.86} | ... | ... |
| 2M15560497-2106461 | -4.14 ^{+1.35} _{-0.35} | 529.63 ± 1.02 | ... | ... | 92.77 ^{+1.75} _{-1.74} | ... | ... |
| 2M15574011+2952379 | 1.06 ^{+0.18} _{-0.18} | 0.51 ± 0.46 | ... | ... | 10.33 ^{+1.62} _{-0.95} | ... | ... |
| 2M15592591-2305081 | -3.31 ^{+0.11} _{-0.11} | -6.34 ± 0.78 | ... | ... | 23.51 ^{+1.01} _{-1.01} | ... | ... |
| 2M15594439-1928191 | -2.59 ^{+0.35} _{-0.24} | -6.27 ± 0.51 | ... | ... | 14.36 ^{+0.23} _{-0.88} | ... | ... |
| 2M16001944-2256287 | -4.27 ^{+0.67} _{-0.53} | -8.85 ± 5.05 | ... | ... | 24.86 ^{+2.09} _{-1.69} | ... | ... |
| 2M16002844-2209228 | -3.66 ^{+0.78} _{-0.51} | -4.51 ± 0.24 | ... | ... | < 10 | ... | ... |
| 2M16003023-2334457 | -3.74 ^{+0.36} _{-0.36} | -10.44 ± 0.37 | ... | ... | 73.58 ^{+1.75} _{-1.49} | ... | ... |
| 2M16014955-2351082 | -3.54 ^{+0.14} _{-0.14} | -7.03 ± 0.29 | ... | ... | 38.71 ^{+0.31} _{-1.5} | ... | ... |
| 2M16022585-2414081 | -2.1 ^{+0.36} _{-0.44} | -6.95 ± 0.54 | ... | ... | 17.87 ^{+0.9} _{-0.72} | ... | ... |
| 2M16044026-2254323 | -1.17 ^{+0.54} _{-0.54} | -5.8 ± 0.58 | ... | ... | 19.81 ^{+0.23} _{-0.12} | ... | ... |
| 2M16045199-2224108 | -1.06 ^{+0.78} _{-1.29} | -767.13 ± 0.93 | ... | ... | 73.3 ^{+1.12} _{-1.16} | ... | ... |
| 2M16055178-2206212 | -3.84 ^{+0.28} _{-0.22} | -6.52 ± 0.53 | ... | ... | 21.59 ^{+0.35} _{-0.23} | ... | ... |
| 2M16055380+2303058 | -40.3 ^{+0.26} _{-0.23} | -41.99 ± 0.7 | ... | ... | 10.83 ^{+1.84} _{-1.16} | ... | ... |
| 2M16063110-1904576 | -4.95 ^{+0.18} _{-0.18} | -7.62 ± 0.51 | ... | ... | 16.65 ^{+1.16} _{-1.79} | ... | ... |
| 2M16063390+4054216 | -41.01 ^{+0.22} _{-0.22} | 446.63 ± 732.5 | ... | ... | < 10 | ... | ... |
| 2M16081226+2252548 | 14.45 ^{+0.76} _{-0.43} | 26.98 ± 23.16 | ... | ... | 24.49 ^{+2.18} _{-1.77} | ... | ... |
| 2M16090197-2151225 | -6.38 ^{+1.14} _{-0.88} | -24.66 ± 0.53 | ... | ... | 47.77 ^{+0.43} _{-0.43} | ... | ... |
| 2M16090451-2224523 | -5.24 ^{+0.88} _{-0.78} | -8.63 ± 0.41 | ... | ... | 14.14 ^{+0.95} _{-1.0} | ... | ... |
| 2M16090568-2245166 | -3.03 ^{+0.24} _{-0.2} | 525.72 ± 1.62 | ... | ... | 32.9 ^{+0.35} _{-0.44} | ... | ... |
| 2M16093019-2059536 | -1.33 ^{+0.16} _{-0.22} | -3.32 ± 0.36 | -5.08 ± 0.6 | Dahm et al. (2012) | 17.95 ^{+0.28} _{-0.63} | ... | ... |
| 2M16095107-2722418 | -1.53 ^{+0.21} _{-0.21} | 7.33 ± 0.5 | ... | ... | 56.1 ^{+1.05} _{-1.05} | ... | ... |
| 2M16095852-2345186 | -2.44 ^{+0.16} _{-0.18} | -7.03 ± 0.36 | ... | ... | 34.66 ^{+1.46} _{-0.13} | ... | ... |
| 2M16095990-2155424 | -3.85 ^{+0.51} _{-0.41} | -7.97 ± 0.47 | ... | ... | 22.02 ^{+0.43} _{-0.35} | ... | ... |
| 2M16100608-2127440 | -5.44 ^{+1.32} _{-0.35} | -214.79 ± 1.2 | ... | ... | 16.51 ^{+0.51} _{-0.51} | ... | ... |
| 2M16103014-2315167 | -3.86 ^{+0.35} _{-0.2} | -5.21 ± 0.96 | ... | ... | 14.19 ^{+0.13} _{-0.29} | ... | ... |

Table 3.5 (*continued*)

Table 3.5 (continued)

| APOGEE ID | (RV) ^a (km s ⁻¹) | ASPCAP RV ^b (km s ⁻¹) | Lit. RV (km s ⁻¹) | Lit. RV Ref. | (v sin i) ^a (km s ⁻¹) | Lit. v sin i (km s ⁻¹) | Lit. v sin i Ref. |
|--------------------|--|---|----------------------------------|-----------------------|---|---------------------------------------|-----------------------|
| 2M16103040+3954258 | 14.24 ^{+0.12} _{-0.17} | 13.29 ± 0.85 | ... | ... | 11.0 ^{+1.12} _{-1.37} | ... | ... |
| 2M16103232-1913085 | -6.21 ^{+1.34} _{-0.29} | -17.48 ± 0.91 | ... | ... | 42.4 ^{+0.25} _{-0.78} | ... | ... |
| 2M16103232+2249116 | -3.96 ^{+0.48} _{-0.47} | -9.54 ± 4.23 | ... | ... | 11.8 ^{+1.42} _{-1.91} | ... | ... |
| 2M16104714-2239492 | -7.54 ^{+0.22} _{-0.18} | 525.76 ± 1.95 | ... | ... | < 10 | ... | ... |
| 2M16113837-2307072 | -2.24 ^{+0.42} _{-0.64} | -8.72 ± 0.51 | ... | ... | 36.63 ^{+0.96} _{-1.09} | ... | ... |
| 2M16114261-2525511 | -4.69 ^{+0.66} _{-0.3} | -10.43 ± 0.42 | ... | ... | 55.35 ^{+0.99} _{-1.15} | ... | ... |
| 2M16115439-2236491 | -2.51 ^{+0.76} _{-0.3} | -2.2 ± 0.58 | ... | ... | 50.29 ^{+0.55} _{-0.71} | ... | ... |
| 2M16122703-2013250 | -4.88 ^{+0.53} _{-0.37} | -11.8 ± 0.35 | ... | ... | 30.93 ^{+0.45} _{-1.06} | ... | ... |
| 2M16124726-1903531 | -7.06 ^{+0.24} _{-0.23} | -15.63 ± 0.32 | ... | ... | 29.03 ^{+1.05} _{-1.15} | ... | ... |
| 2M16132665-2230348 | -4.73 ^{+0.23} _{-0.23} | -7.95 ± 0.38 | ... | ... | 19.86 ^{+0.15} _{-1.96} | ... | ... |
| 2M16132809-1924524 | -4.75 ^{+0.22} _{-0.23} | -8.5 ± 0.25 | ... | ... | 23.09 ^{+1.14} _{-0.51} | ... | ... |
| 2M16134027-2233192 | -6.45 ^{+0.13} _{-0.13} | -209.93 ± 1.29 | ... | ... | 14.11 ^{+0.21} _{-0.21} | ... | ... |
| 2M16134079-2219459 | -0.81 ^{+0.27} _{-0.27} | -3.83 ± 1.06 | ... | ... | 19.41 ^{+0.27} _{-0.27} | ... | ... |
| 2M16134264-2301279 | -1.95 ^{+0.99} _{-0.19} | -14.35 ± 0.58 | ... | ... | 59.35 ^{+0.4} _{-1.69} | ... | ... |
| 2M16143287-2242133 | 0.19 ^{+0.19} _{-0.14} | -2.61 ± 0.68 | ... | ... | 18.02 ^{+0.18} _{-0.36} | ... | ... |
| 2M16172079+4113032 | 0.52 ^{+0.33} _{-0.15} | -0.64 ± 0.29 | ... | ... | < 10 | ... | ... |
| 2M16183317-2517504 | -0.99 ^{+0.15} _{-0.16} | -2.53 ± 0.14 | ... | ... | 16.35 ^{+1.17} _{-1.36} | ... | ... |
| 2M16195143-2241332 | -4.57 ^{+0.14} _{-0.19} | -4.9 ± 0.97 | ... | ... | 16.97 ^{+1.2} _{-0.36} | ... | ... |
| 2M16204144-2425491 | 1.46 ^{+0.32} _{-0.32} | -2.69 ± 0.45 | ... | ... | 25.43 ^{+0.35} _{-0.32} | ... | ... |
| 2M16222304-2407108 | -1.93 ^{+0.35} _{-0.49} | 241.12 ± 1.13 | ... | ... | 44.48 ^{+1.12} _{-3.52} | ... | ... |
| 2M16222521-2405139 | -1.23 ^{+0.32} _{-0.37} | -7.69 ± 0.49 | ... | ... | 17.96 ^{+0.15} _{-0.26} | ... | ... |
| 2M16235155-2317270 | -3.86 ^{+0.21} _{-0.84} | 20.42 ± 0.67 | -7.47 ± 2.45 | Dahm et al. (2012) | 52.56 ^{+0.81} _{-0.84} | 60.94 ± 3.03 | Dahm et al. (2012) |
| 2M16265698+3954482 | 2.92 ^{+0.73} _{-0.48} | 112.51 ± 0.73 | ... | ... | 27.06 ^{+1.65} _{-1.73} | ... | ... |
| 2M16271693+3514132 | -12.09 ^{+0.7} _{-0.27} | -15.89 ± 6.51 | -10.37 ± 6.6 | Kimani et al. (2019) | 21.9 ^{+1.26} _{-1.73} | ... | ... |
| 2M16271825+3538347 | -8.84 ^{+0.27} _{-0.38} | 567.04 ± 0.65 | ... | ... | < 10 | ... | ... |
| 2M16281707+1334204 | -36.56 ^{+0.16} _{-0.13} | -38.22 ± 0.35 | ... | ... | 15.81 ^{+0.98} _{-1.76} | ... | ... |
| 2M16311879+4051516 | -21.75 ^{+0.13} _{-0.24} | -22.82 ± 0.25 | 2.61 ± 4.43 | Terrien et al. (2015) | 14.79 ^{+1.59} _{-1.59} | 7.1 ± 1.5 | Reiners et al. (2018) |
| 2M16360984+4000243 | -11.5 ^{+0.24} _{-0.23} | -14.48 ± 0.36 | ... | ... | < 10 | ... | ... |
| 2M16402068+6736046 | -17.42 ^{+0.08} _{-0.13} | -18.96 ± 0.34 | -15.0 ± 5.0 | Newton et al. (2014) | 16.04 ^{+0.09} _{-0.16} | ... | ... |
| 2M16463154+3434554 | -52.64 ^{+0.12} _{-0.33} | -56.32 ± 0.36 | ... | ... | < 10 | ... | ... |
| 2M16485878+3005366 | -44.79 ^{+0.34} _{-0.34} | -49.35 ± 0.64 | ... | ... | 14.02 ^{+1.72} _{-0.87} | ... | ... |
| 2M16572919+2448509 | -58.12 ^{+0.51} _{-0.52} | 524.1 ± 0.6 | ... | ... | 15.56 ^{+1.5} _{-1.3} | ... | ... |
| 2M19005974-3647109 | 1.55 ^{+0.24} _{-0.17} | -1.51 ± 1.09 | ... | ... | 20.09 ^{+1.07} _{-1.39} | ... | ... |
| 2M19241634+7533121 | -18.62 ^{+0.16} _{-0.26} | -19.93 ± 0.31 | ... | ... | < 10 | ... | ... |
| 2M19544358+1801581 | -18.62 ^{+0.26} _{-0.26} | 365.56 ± 244.7 | ... | ... | < 10 | ... | ... |

Table 3.5 (continued)

Table 3.5 (*continued*)

| APOGEE ID | $\langle RV \rangle^a$ (km s ⁻¹) | ASPCAP RV ^b (km s ⁻¹) | Lit. RV (km s ⁻¹) | Lit. RV Ref. | $\langle v \sin i \rangle^a$ (km s ⁻¹) | Lit. $v \sin i$ (km s ⁻¹) | Lit. $v \sin i$ Ref. |
|--------------------|---|---|----------------------------------|--------------|---|--|-----------------------|
| 2M20353517-0608285 | 8.16 ^{+0.33} _{-0.35} | 6.06 ± 0.33 | ... | ... | < 10 | ... | ... |
| 2M20491376+3216514 | 11.5 ^{+0.31} _{-0.35} | 9.39 ± 0.91 | ... | ... | 12.2 ^{+1.04} _{-1.23} | 10 ± 1.6 | Gilhool et al. (2018) |
| 2M21272531+5553150 | -12.23 ^{+0.21} _{-0.24} | -224.75 ± 1086.03 | ... | ... | 17.29 ^{+1.12} _{-1.2} | ... | ... |
| 2M21381698+5257188 | -7.52 ^{+0.21} _{-0.19} | 111.53 ± 0.54 | ... | ... | 40.59 ^{+1.69} _{-1.45} | ... | ... |
| 2M22021125-1109461 | -7.72 ^{+0.47} _{-0.4} | 575.21 ± 1.36 | ... | ... | 21.34 ^{+1.38} _{-1.42} | ... | ... |
| 2M22400144+0532162 | -10.05 ^{+0.29} _{-0.3} | -12.35 ± 1.21 | ... | ... | 17.77 ^{+0.98} _{-1.08} | ... | ... |
| 2M22551142+1442456 | -14.08 ^{+1.01} _{-0.76} | -16.84 ± 0.51 | ... | ... | 56.68 ^{+1.67} _{-1.48} | ... | ... |
| 2M23200703+1150071 | -54.47 ^{+0.36} _{-0.34} | -57.79 ± 0.81 | ... | ... | < 10 | ... | ... |

^a My Weighted average measurements over all epochs.

^b RV from DR17 ASPCAP Pipeline.

Note – Measurements from individual spectra over individual or multiple epochs are combined using inverse uncertainty weighting (weight = 1/($\sigma_{\text{upper}}^2 + \sigma_{\text{lower}}^2$)); upper and lower uncertainties are also combined using inverse uncertainty-squared weighting. In cases where individual spectra have S/N < 10, spectral data are combined first, then modeled.

Table 3.6: Radial Velocities and Heliocentric Space Motions

| APOGEE ID | SpT | Adopted RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P[TD]/P[D] ^a | Population ^a | BANYAN Σ ^c |
|---------------------------------|------|--|----------------------------|----------------------------|----------------------------|-------------------------|-------------------------|------------------------------------|
| 2M000312793+6139333 | M7.0 | -34.44 ^{+0.19} _{-0.2} | -27.4±0.2 | -50.0±0.2 | 29.8±0.1 | 0.18 | D/TD | 99.9% field |
| 2M000452143+1634446 | L2.0 | 3.71 ^{+0.4} _{-0.36} | -10.8±0.2 | -1.5±0.3 | 1.5±0.4 | 0.01 | D | 99.7% ARG |
| 2M01120002+1502170 | M5.5 | -44.31 ^{+0.77} _{-0.78} | 28.7±0.1 | -50.7±0.2 | 13.0±0.2 | 0.06 | D | 99.9% field |
| 2M01154176+0059317 | M6.0 | 10.78 ^{+0.18} _{-0.18} | -35.8±0.6 | -7.4±0.4 | 5.8±1.0 | 0.01 | D | 99.9% field |
| 2M01215816+0101007 | M6.5 | 10.28 ^{+0.11} _{-0.13} | -9.0±0.1 | -12.0±0.1 | -5.0±0.1 | 0.01 | D | 99.9% field |
| 2M01243124+0027556 | M7.0 | -3.88 ^{+0.17} _{-0.16} | 17.4±0.1 | -16.1±0.2 | -0.4±0.2 | 0.01 | D | 99.9% field |
| 2M01514363+0046188 | M7.0 | 14.44 ^{+0.65} _{-0.67} | -15.3±0.3 | 5.4±0.2 | 2.8±0.6 | 0.01 | D | 98.3% field |
| 2M02500239+0808417 | M5.5 | 25.61 ^{+0.64} _{-0.66} | -48.5±0.4 | -23.0±0.0 | 18.1±0.6 | 0.02 | D | 99.9% field |
| 2M03040207+0045512 | M6.0 | 29.94 ^{+0.32} _{-0.31} | -31.5±0.2 | -6.9±0.0 | 4.7±0.2 | 0.01 | D | 77.1% HYA |
| 2M03282839+3116273 | M6.5 | 15.41 ^{+0.37} _{-0.33} | -6.2±0.8 | 2.2±1.1 | -3.6±0.6 | 0.01 | D | 99.9% field |
| 2M03293053+3127280 ^e | M6.5 | 15.77 ^{+0.54} _{-0.54} | -6.4±0.5 | 3.0±0.7 | 3.4±0.4 | 0.01 | D | 99.9% field |
| 2M03505737+1818069 | M9.0 | 6.05 ^{+0.13} _{-0.13} | -5.9±0.2 | -12.5±0.1 | 19.9±0.1 | 0.01 | D | 99.9% field |
| 2M04110642+1247481 | M6.0 | 39.28 ^{+0.19} _{-0.21} | -32.5±0.2 | -7.4±0.1 | 6.1±0.1 | 0.01 | D | 99.4% HYA |
| 2M04185115+2814332 | M7.5 | 21.13 ^{+0.27} _{-0.27} | -9.9±0.2 | 1.6±0.4 | -4.8±0.2 | 0.01 | D | 98.0% TAU |
| 2M04204796+5624202 | M8.0 | -29.54 ^{+0.27} _{-0.27} | 3.5±0.2 | -64.0±0.2 | 46.9±0.2 | 4.32 | D/TD | 99.9% field |
| 2M04214435+2024105 | M7.0 | 40.78 ^{+0.45} _{-0.45} | -33.3±0.4 | -6.3±0.1 | 5.3±0.2 | 0.01 | D | 99.9% HYA |
| 2M04214955+1929086 | M7.0 | 39.43 ^{+0.37} _{-0.37} | -32.2±0.2 | -6.9±0.3 | 6.5±0.2 | 0.01 | D | 99.9% HYA |
| 2M04262939+2624137 | M6.0 | 20.01 ^{+0.47} _{-0.47} | -9.6±0.4 | -0.3±0.4 | -0.6±0.2 | 0.01 | D | 70.8% TAU |
| 2M04294568+2630468 | M7.5 | 18.13 ^{+0.22} _{-0.21} | -6.7±0.2 | 2.4±0.3 | -2.2±0.1 | 0.01 | D | 99.8% TAU |
| 2M04330945+2246487 | M7.0 | 19.6 ^{+0.31} _{-0.38} | -8.5±0.4 | -4.3±1.0 | -0.2±0.3 | 0.01 | D | 17.1% TAU |
| 2M04351354+2008014 | M7.5 | 40.01 ^{+0.38} _{-0.38} | -31.2±0.3 | -7.1±0.1 | 5.5±0.1 | 0.01 | D | 99.9% HYA |
| 2M04440164+1621324 | M6.0 | 21.82 ^{+0.21} _{-0.21} | -8.4±0.2 | -3.8±0.3 | -1.3±0.1 | 0.01 | D | 86.9% TAU |
| 2M04464498+2436404 | M7.0 | 42.22 ^{+0.46} _{-0.34} | -33.2±0.4 | -6.7±0.1 | 5.1±0.1 | 0.01 | D | 99.2% HYA |
| 2M04552333+3027366 | M6.0 | 17.46 ^{+0.13} _{-0.13} | -7.0±0.2 | -2.7±0.4 | -4.1±0.2 | 0.01 | D | 34.2% TAU |
| 2M04565141+2939310 | M7.0 | 17.91 ^{+0.43} _{-0.43} | -7.2±0.4 | -1.8±0.3 | -3.4±0.2 | 0.01 | D | 87.2% TAU |
| 2M05350162+0521489 | L0.0 | 25.07 ^{+0.31} _{-0.31} | -9.6±0.4 | 0.8±0.2 | -1.1±0.2 | 0.01 | D | 99.9% field |
| 2M05392474+4038437 | M8.0 | -5.42 ^{+0.23} _{-0.24} | 6.4±0.2 | -44.5±0.1 | 12.3±0.0 | 0.03 | D | 99.9% field |
| 2M05402570+2448090 | M7.0 | 23.07 ^{+0.24} _{-0.24} | -10.7±0.9 | -7.1±0.6 | 0.6±0.4 | 0.01 | D | 54.7% ARG, 43.2% CARN ^d |
| 2M06154934+0100415 | L2.5 | -19.69 ^{+0.19} _{-0.21} | 33.4±0.2 | 7.7±0.1 | 25.8±0.1 | 0.02 | D | 99.9% field |
| 2M06521977+2534505 | L0.0 | 14.9 ^{+0.21} _{-0.22} | -7.0±0.1 | 9.9±0.2 | -8.8±0.0 | 0.01 | D | 99.9% field |
| 2M07025026+6102482 | M6.5 | 21.31 ^{+0.14} _{-0.14} | -22.9±0.1 | -29.4±0.2 | 50.8±0.2 | 0.6 | D/TD | 99.9% field |
| 2M07140394+3702459 | M8.0 | 35.34 ^{+0.24} _{-0.23} | -25.7±0.2 | 1.2±0.0 | 9.2±0.1 | 0.01 | D | 99.9% field |
| 2M07464256+2000321 | L0.0 | 52.78 ^{+0.11} _{-0.11} | -44.2±0.1 | -1.9±0.1 | 6.5±0.2 | 0.01 | D | 99.9% field |
| 2M07475737+6653337 | M7.0 | 7.45 ^{+0.7} _{-0.82} | 8.4±0.6 | 13.7±0.4 | 16.8±0.4 | 0.01 | D | 99.9% field |

Table 3.6 (continued)

Table 3.6 (continued)

| APOGEE ID | SpT | Adopted RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P[TD]/P[D] ^a | Population ^a | BANYAN Σ ^c |
|---------------------------------|------|--|----------------------------|----------------------------|----------------------------|-------------------------|-------------------------|-----------------------|
| 2M07552256+2755318 | M5.5 | -3.86 ^{+0.28} _{-0.24} | -5.6 ± 0.2 | 18.5 ± 0.1 | -32.9 ± 0.2 | 0.04 | D | 99.9% field |
| 2M07564895+6649595 | M7.5 | 0.19 ^{+0.41} _{-0.42} | 5.3 ± 0.3 | -32.2 ± 0.3 | 37.0 ± 0.3 | 0.09 | D | 99.9% field |
| 2M08072607+3213101 | M8.0 | 34.41 ^{+0.22} _{-0.35} | -34.9 ± 0.2 | -8.4 ± 0.0 | -9.5 ± 0.1 | 0.01 | D | 99.9% field |
| 2M08080189+3157054 | M7.5 | 30.61 ^{+0.32} _{-0.38} | -16.2 ± 0.3 | -8.2 ± 0.1 | 15.7 ± 0.2 | 0.01 | D | 99.9% field |
| 2M08092892+3235226 | M4.0 | -6.66 ^{+0.54} _{-0.58} | 11.0 ± 0.5 | 15.9 ± 0.2 | -5.4 ± 0.4 | 0.01 | D | 99.9% field |
| 2M08144389+4650522 | M6.0 | 24.39 ^{+0.48} _{-0.39} | -19.5 ± 0.4 | -4.8 ± 0.1 | 8.7 ± 0.3 | 0.01 | D | 99.9% field |
| 2M08185804+2333522 | M7.0 | 35.74 ^{+0.29} _{-0.39} | -27.5 ± 0.2 | -27.4 ± 0.1 | -8.5 ± 0.2 | 0.01 | D | 99.9% field |
| 2M08211639+5658358 | M6.5 | 7.17 ^{+0.27} _{-0.27} | 6.3 ± 0.2 | 0.8 ± 0.2 | 18.8 ± 0.2 | 0.01 | D | 99.9% field |
| 2M08294949+2646348 ^f | M6.5 | 10.69 ^{+0.32} _{-0.31} | -7.0 ± 0.3 | 2.0 ± 0.1 | -4.8 ± 0.2 | 0.01 | D | 99.9% field |
| 2M08440350+0434356 | M9.0 | 66.68 ^{+0.53} _{-0.49} | -74.6 ± 0.4 | 4.3 ± 0.3 | 19.1 ± 0.2 | 0.05 | D | 99.9% field |
| 2M08490052+0220155 | M7.0 | 22.37 ^{+0.37} _{-0.44} | -4.4 ± 0.4 | -12.9 ± 0.4 | 0.2 ± 0.3 | 0.01 | D | 99.9% field |
| 2M08501918+1056436 | M5.0 | 31.45 ^{+0.44} _{-0.44} | -26.6 ± 0.3 | -12.0 ± 0.2 | -5.9 ± 0.2 | 0.01 | D | 99.9% field |
| 2M08522464+2540591 | M7.0 | 29.56 ^{+0.21} _{-0.25} | -34.4 ± 0.3 | -7.6 ± 0.2 | -9.3 ± 0.5 | 0.01 | D | 99.9% field |
| 2M09020690+0033195 | M6.0 | 42.63 ^{+0.25} _{-0.22} | -40.5 ± 0.2 | -21.9 ± 0.2 | -12.5 ± 0.1 | 0.01 | D | 99.9% field |
| 2M09130162+3037583 | M7.0 | 51.79 ^{+0.35} _{-0.35} | -38.0 ± 0.4 | -58.0 ± 0.4 | 12.2 ± 0.4 | 0.15 | D/TD | 99.9% field |
| 2M09373349+5534057 | M6.0 | 0.68 ^{+0.45} _{-0.45} | -5.6 ± 0.4 | 3.2 ± 0.2 | -4.2 ± 0.4 | 0.01 | D | 99.9% field |
| 2M09381783+0132490 | M5.0 | -16.8 ^{+1.51} _{-1.04} | 23.4 ± 0.7 | -12.1 ± 1.0 | -36.7 ± 1.0 | 0.05 | D | 99.9% field |
| 2M09442625+3521233 | M6.0 | 51.2 ^{+0.87} _{-0.88} | -59.6 ± 0.6 | 15.2 ± 0.1 | 15.5 ± 0.7 | 0.03 | D | 99.9% field |
| 2M09453388+5458511 | M7.0 | -3.67 ^{+0.68} _{-0.68} | 8.7 ± 0.4 | -1.0 ± 0.2 | 4.4 ± 0.5 | 0.01 | D | 99.9% field |
| 2M09472006-0020093 | M7.0 | 15.0 ^{+0.68} _{-0.68} | -19.0 ± 0.0 | 4.1 ± 0.1 | 1.9 ± 0.1 | 0.01 | D | 99.9% field |
| 2M09474477+0224327 | M8.0 | 8.76 ^{+0.26} _{-0.26} | 6.2 ± 0.1 | -14.9 ± 0.2 | -9.1 ± 0.2 | 0.01 | D | 98.6% ABDMG |
| 2M09522188-1924319 | M7.0 | -17.11 ^{+0.93} _{-0.93} | 15.4 ± 0.2 | 19.4 ± 0.8 | -15.0 ± 0.4 | 0.01 | D | 99.9% field |
| 2M09524622+0620410 | M7.0 | 12.8 ^{+0.43} _{-0.45} | -2.1 ± 0.2 | -7.3 ± 0.3 | 0.7 ± 0.3 | 0.01 | D | 98.9% field |
| 2M09560888+0134128 | M5.0 | 21.12 ^{+0.53} _{-0.53} | -33.4 ± 0.3 | -6.8 ± 0.4 | -7.1 ± 0.4 | 0.01 | D | 99.9% field |
| 2M10031918-0105079 | M7.0 | 23.99 ^{+0.27} _{-0.35} | -37.2 ± 0.1 | -7.3 ± 0.2 | -3.1 ± 0.2 | 0.01 | D | 99.9% field |
| 2M10134315+0000406 | M6.0 | 3.95 ^{+0.33} _{-0.33} | 78.6 ± 0.2 | -17.0 ± 0.2 | 19.3 ± 0.2 | 0.07 | D | 99.9% field |
| 2M10225090+0032169 | M8.0 | 34.04 ^{+6.01} _{-6.01} | 6.0 ± 1.9 | -39.4 ± 3.8 | 7.4 ± 4.3 | 0.02 | D | 99.9% field |
| 2M10240997+1815533 | M7.0 | 8.22 ^{+0.69} _{-0.68} | -9.8 ± 0.2 | -7.7 ± 0.2 | -2.9 ± 0.2 | 0.01 | D | 10% CARN, 90% field |
| 2M10323297+0630074 | M6.0 | 13.22 ^{+0.15} _{-0.14} | -3.0 ± 0.0 | -14.2 ± 0.1 | 0.1 ± 0.1 | 0.01 | D | 99.9% field |
| 2M10372897+3011117 | M8.0 | 7.97 ^{+0.19} _{-0.19} | -42.2 ± 0.1 | -60.0 ± 0.1 | -25.3 ± 0.2 | 0.43 | D/TD | 99.9% field |
| 2M10541102-8505023 | M8.0 | -10.8 ^{+0.82} _{-1.13} | -31.9 ± 0.5 | -3.6 ± 0.9 | 16.1 ± 0.4 | 0.01 | D | 99.9% field |
| 2M10543366+0503467 | L1.0 | -20.17 ^{+0.11} _{-0.11} | 62.2 ± 0.7 | -6.8 ± 0.5 | -15.2 ± 0.1 | 0.02 | D | 99.9% field |
| 2M10570380+2217203 | M6.0 | 11.68 ^{+0.11} _{-0.11} | -3.5 ± 0.0 | -11.8 ± 0.0 | 7.3 ± 0.1 | 0.01 | D | 99.9% field |
| 2M11194647+0820356 | M8.0 | -44.98 ^{+0.18} _{-0.17} | 83.3 ± 0.2 | 11.4 ± 0.1 | -30.6 ± 0.2 | 0.21 | D/TD | 99.9% field |
| 2M11203609+0704135 | M6.0 | -14.41 ^{+0.57} _{-0.6} | 39.3 ± 0.1 | -21.4 ± 0.3 | -22.3 ± 0.5 | 0.02 | D | 99.9% field |

Table 3.6 (continued)

Table 3.6 (continued)

| APOGEE ID | SpT | Adopted RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P[TD]/P[D] ^a | Population ^a | BANYAN Σ ^c |
|--------------------|------|--|----------------------------|----------------------------|----------------------------|-------------------------|-------------------------|------------------------|
| 2M11210854+2126274 | M4.5 | -0.3 ^{+0.16} _{-0.16} | -14.6±0.1 | 1.4±0.0 | -3.3±0.2 | 0.01 | D | 99.9% field |
| 2M11232934+0154040 | M7.0 | -0.21 ^{+0.62} _{-0.59} | -10.8±0.2 | 5.5±0.3 | 0.1±0.5 | 0.01 | D | 99.6% field |
| 2M12080810+3520281 | M7.0 | 29.17 ^{+0.56} _{-0.54} | -68.3±0.2 | -37.1±0.2 | 22.2±0.6 | 0.12 | D/TD | 99.9% field |
| 2M12153877+5205050 | M4.5 | -4.75 ^{+0.53} _{-0.53} | 1.8±3.8 | 5.9±2.2 | 0.9±1.0 | 0.01 | D | 99.9% field |
| 2M12201166+3315379 | M8.0 | 11.16 ^{+0.22} _{-0.22} | 45.7±0.2 | -10.8±0.1 | 24.7±0.3 | 0.03 | D | 99.9% field |
| 2M12205439+2525568 | M6.0 | 14.81 ^{+0.22} _{-0.22} | -14.3±0.7 | -2.1±0.4 | 18.7±0.2 | 0.01 | D | 99.9% field |
| 2M12215013+4632447 | M8.0 | -10.44 ^{+0.27} _{-0.27} | 24.6±2.3 | 12.3±0.7 | -0.2±0.6 | 0.01 | D | 99.9% field |
| 2M12235346+2534559 | M6.0 | 7.03 ^{+0.78} _{-0.78} | -7.5±0.4 | 44.2±0.6 | 15.4±0.8 | 0.06 | D | 99.9% field |
| 2M12252076+2517082 | M7.0 | 7.24 ^{+0.70} _{-0.70} | 2.8±0.8 | 10.0±0.3 | 13.8±0.8 | 0.01 | D | 99.9% field |
| 2M12270429+2541012 | M6.5 | 2.63 ^{+0.59} _{-0.61} | 8.2±0.1 | 6.5±0.1 | 9.3±0.6 | 0.01 | D | 99.7% CBER |
| 2M12315462+5130389 | M6.5 | 8.92 ^{+0.26} _{-0.14} | -33.6±0.2 | -6.7±0.1 | 10.4±0.2 | 0.01 | D | 99.9% field |
| 2M12493960+5255340 | M7.5 | -56.77 ^{+0.38} _{-0.38} | 18.4±0.1 | -59.4±0.3 | -25.0±0.4 | 0.26 | D/TD | 99.9% field |
| 2M12522354+2528469 | M7.0 | 9.43 ^{+0.24} _{-0.24} | 19.1±0.0 | -22.3±0.1 | 15.8±0.3 | 0.01 | D | 99.9% field |
| 2M13004379+3557591 | M6.0 | -24.58 ^{+0.23} _{-0.23} | -35.3±0.1 | -25.2±0.1 | -14.7±0.3 | 0.02 | D | 99.9% field |
| 2M13022083+3227103 | M6.0 | 6.77 ^{+0.33} _{-0.33} | -17.0±0.0 | 2.2±0.0 | 14.6±0.3 | 0.01 | D | 99.9% field |
| 2M13034100+2414020 | M7.0 | -9.3 ^{+0.27} _{-0.27} | -39.2±0.1 | -7.6±0.1 | 1.0±0.3 | 0.01 | D | 99.9% field |
| 2M13065141+7056376 | M7.0 | 15.29 ^{+0.42} _{-0.42} | 55.3±0.3 | 33.3±0.3 | 33.1±0.3 | 0.23 | D/TD | 99.9% field |
| 2M13192677+1301119 | M5.0 | 6.27 ^{+0.11} _{-0.11} | -12.5±0.1 | -52.1±0.2 | 10.2±0.1 | 0.05 | D | 99.9% field |
| 2M13202007+7213140 | M7.5 | -27.34 ^{+0.52} _{-0.52} | 23.0±0.2 | -6.4±0.3 | -9.3±0.4 | 0.01 | D | 99.9% field |
| 2M13232423+5132272 | M6.0 | -5.41 ^{+0.52} _{-0.49} | -21.0±0.1 | -2.9±0.2 | 2.5±0.5 | 0.01 | D | 99.9% field |
| 2M13342918+3303043 | M7.0 | -18.03 ^{+0.37} _{-0.37} | -55.1±0.1 | -47.8±0.1 | 4.6±0.3 | 0.08 | D | 99.9% field |
| 2M13430646+0038442 | M4.0 | -11.91 ^{+0.72} _{-0.72} | -14.7±0.5 | -14.2±0.5 | -1.2±0.6 | 0.01 | D | 99.9% field |
| 2M13482307+3321508 | M4.5 | -19.22 ^{+0.53} _{-0.53} | 13.7±0.5 | -22.5±1.1 | -5.2±4.4 | 0.01 | D | 99.9% field |
| 2M13500476+3207596 | M4.5 | -5.83 ^{+0.61} _{-0.61} | 38.1±0.2 | -13.0±0.2 | 3.0±0.6 | 0.01 | D | 99.9% field |
| 2M13564148+4342587 | M8.0 | -19.51 ^{+0.62} _{-0.62} | -25.7±0.5 | -20.5±0.4 | -0.7±0.6 | 0.01 | D | 99.9% field |
| 2M13573443+5408223 | M5.0 | -43.22 ^{+0.37} _{-0.37} | -20.4±0.2 | -45.9±0.5 | -14.4±0.8 | 0.04 | D | 99.9% field |
| 2M14005977+3226109 | M7.0 | -17.9 ^{+0.74} _{-0.74} | -38.7±0.4 | -23.1±0.3 | 4.9±0.8 | 0.01 | D | 99.9% field |
| 2M14081562+5236281 | M4.5 | -43.49 ^{+0.14} _{-0.15} | 61.2±0.1 | -35.9±0.1 | -11.7±0.1 | 0.05 | D | 99.9% field |
| 2M14093200+4138080 | M6.0 | -10.96 ^{+0.22} _{-0.22} | -13.3±0.0 | -2.2±0.1 | 2.8±0.2 | 0.01 | D | 99.6% ARG ^d |
| 2M14320849+0811313 | M6.0 | -21.3 ^{+0.13} _{-0.13} | -18.8±0.1 | -6.1±0.0 | -0.0±0.1 | 0.01 | D | 99.9% field |
| 2M14340140+5039480 | M7.0 | -6.39 ^{+0.25} _{-0.25} | -10.1±0.1 | -0.8±0.1 | 7.5±0.2 | 0.01 | D | 55.9% ARG, 44.1% field |
| 2M14402293+1339230 | M7.0 | -3.49 ^{+0.24} _{-0.24} | 21.2±0.1 | -27.3±0.1 | 1.8±0.2 | 0.01 | D | 99.9% field |
| 2M14432796+0316543 | M7.0 | -38.45 ^{+0.29} _{-0.29} | -31.1±0.2 | -5.8±0.1 | -10.6±0.2 | 0.01 | D | 99.9% field |
| 2M14553384+1545593 | M4.5 | 19.3 ^{+0.16} _{-0.16} | 48.1±1.0 | -20.3±1.2 | 14.6±0.4 | 0.02 | D | 99.9% field |
| 2M14554964+0321420 | M4.5 | -39.92 ^{+0.16} _{-0.09} | 10.8±0.1 | -56.6±0.1 | -43.5±0.1 | 1.29 | D/TD | 99.9% field |

Table 3.6 (continued)

Table 3.6 (continued)

| APOGEE ID | SpT | Adopted RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P[TD]/P[D] ^a | Population ^a | BANYAN Σ^c |
|--------------------|------|--|----------------------------|----------------------------|----------------------------|-------------------------|-------------------------|-------------------|
| 2M15010818+2250020 | M8.5 | 6.53 ^{+0.69} _{-0.26} | 14.9±0.3 | 10.2±0.2 | 13.5±0.6 | 0.01 | D | 99.9% field |
| 2M15041028+0923232 | M7.5 | -53.33 ^{+0.29} _{-0.29} | -63.2±0.3 | -22.5±0.2 | -1.3±0.3 | 0.02 | D | 99.9% field |
| 2M15042797+0942464 | M6.0 | -35.61 ^{+1.26} _{-0.77} | -50.8±0.9 | -21.1±0.4 | 11.6±1.1 | 0.02 | D | 99.9% field |
| 2M15115124+3033065 | M5.0 | -61.43 ^{+0.13} _{-0.34} | -12.7±0.0 | -112.1±0.3 | 0.2±0.2 | 243.5 | TD | 99.9% field |
| 2M15175638+0656388 | M4.0 | -19.8 ^{+0.33} _{-0.38} | -2.2±0.2 | -7.0±0.1 | -4.9±0.3 | 0.01 | D | 99.9% field |
| 2M15210103+5053230 | M7.5 | 2.43 ^{+0.13} _{-0.13} | 24.7±0.0 | 10.5±0.1 | 10.4±0.1 | 0.01 | D | 99.9% field |
| 2M15242475+2925318 | M7.5 | -15.15 ^{+0.03} _{-0.06} | 33.7±0.0 | -20.7±0.0 | -5.6±0.0 | 0.01 | D | 99.9% field |
| 2M15512179+2931062 | M7.0 | 26.03 ^{+0.23} _{-0.27} | 45.2±0.1 | -11.6±0.1 | 36.4±0.2 | 0.08 | D | 99.9% field |
| 2M15555600-2045187 | M6.5 | -4.1 ^{+0.47} _{-0.47} | 6.4±0.4 | -4.9±0.4 | 1.5±0.2 | 0.01 | D | 99.9% USCO |
| 2M15560104-2338081 | M6.5 | 1.51 ^{+0.28} _{-0.33} | 10.2±0.3 | -6.7±0.3 | 4.3±0.1 | 0.01 | D | 93.5% USCO |
| 2M15560497-2106461 | M7.0 | -4.14 ^{+0.16} _{-0.16} | 6.3±1.2 | -4.9±0.6 | 1.4±0.6 | 0.01 | D | 99.9% USCO |
| 2M15574011+2952379 | M4.5 | 1.06 ^{+0.18} _{-0.24} | 32.8±0.1 | -8.5±0.1 | 9.5±0.2 | 0.01 | D | 99.9% field |
| 2M15592591-2305081 | M6.0 | -3.31 ^{+0.11} _{-0.11} | 7.2±0.1 | -4.7±0.2 | 0.4±0.1 | 0.01 | D | 99.9% USCO |
| 2M15594439-1928191 | M7.5 | -2.59 ^{+0.35} _{-0.24} | 8.8±0.3 | -4.5±0.7 | 1.2±0.3 | 0.01 | D | 99.8% USCO |
| 2M16001944-2256287 | M8.0 | -4.27 ^{+0.53} _{-0.53} | 6.6±0.6 | -4.7±0.8 | -0.4±0.4 | 0.01 | D | 99.9% USCO |
| 2M16002844-2209228 | M6.0 | -3.66 ^{+0.66} _{-0.78} | -2.9±0.7 | -20.8±0.6 | 17.8±0.4 | 0.01 | D | 99.9% field |
| 2M16003023-2334457 | M6.0 | -3.74 ^{+0.51} _{-0.36} | 6.5±0.5 | -5.1±0.2 | 0.4±0.2 | 0.01 | D | 99.9% USCO |
| 2M16014955-2351082 | M6.0 | -3.54 ^{+0.14} _{-0.14} | 6.8±0.1 | -4.4±0.3 | 0.5±0.1 | 0.01 | D | 99.9% USCO |
| 2M16022585-2414081 | M7.0 | -2.1 ^{+0.27} _{-0.27} | 7.8±0.4 | -4.1±0.6 | 1.8±0.3 | 0.01 | D | 99.8% USCO |
| 2M16044026-2254323 | M6.0 | -1.17 ^{+0.44} _{-0.54} | 8.8±0.5 | -5.9±0.6 | 2.4±0.3 | 0.01 | D | 99.8% USCO |
| 2M16045199-2224108 | M8.0 | -1.06 ^{+0.78} _{-1.29} | 10.0±1.2 | -5.4±0.6 | 0.4±0.5 | 0.01 | D | 99.7% USCO |
| 2M16055178-2206212 | M6.0 | -3.84 ^{+0.36} _{-0.36} | 7.2±0.3 | -5.1±0.4 | 0.1±0.2 | 0.01 | D | 99.9% USCO |
| 2M16055380+2303058 | M7.0 | -4.03 ^{+0.23} _{-0.42} | -14.2±0.2 | 0.4±0.2 | -22.6±0.3 | 0.01 | D | 99.9% field |
| 2M16063110-1904576 | M6.0 | -4.95 ^{+0.18} _{-0.18} | 7.5±0.2 | -3.7±0.4 | -0.7±0.2 | 0.01 | D | 99.9% USCO |
| 2M16063390+4054216 | M6.0 | -41.01 ^{+0.22} _{-0.72} | -30.7±0.1 | -41.8±0.1 | 12.2±0.2 | 0.03 | D | 99.9% field |
| 2M16081226+2252548 | M5.5 | 14.45 ^{+0.49} _{-0.23} | 35.5±0.4 | 20.7±0.3 | 3.6±0.6 | 0.01 | D | 99.9% field |
| 2M16090197-2151225 | M7.0 | -6.38 ^{+1.14} _{-0.78} | 5.0±1.0 | -3.4±0.4 | -0.2±0.4 | 0.01 | D | 99.9% USCO |
| 2M16090451-2224523 | M6.0 | -5.24 ^{+0.88} _{-0.78} | 6.2±0.8 | -3.8±0.4 | -0.7±0.4 | 0.01 | D | 99.9% USCO |
| 2M16090568-2245166 | M8.0 | -3.03 ^{+0.24} _{-0.16} | 8.1±0.3 | -3.9±1.4 | 0.2±0.6 | 0.01 | D | 99.9% USCO |
| 2M16093019-2059536 | M6.0 | -1.33 ^{+0.16} _{-0.16} | 10.7±0.2 | -2.3±0.3 | 0.4±0.2 | 0.01 | D | 99.8% USCO |
| 2M16095107-2722418 | M6.0 | -1.53 ^{+0.22} _{-0.21} | 7.6±0.2 | -6.5±0.4 | 0.9±0.2 | 0.01 | D | 98.8% USCO |
| 2M16095852-2345186 | M6.5 | -2.44 ^{+0.16} _{-0.18} | 8.3±0.2 | -3.8±0.3 | 0.8±0.2 | 0.01 | D | 99.9% USCO |
| 2M16095990-2155424 | M6.5 | -3.85 ^{+0.41} _{-0.31} | 7.5±0.5 | -4.1±0.5 | 0.2±0.3 | 0.01 | D | 99.9% USCO |
| 2M16100608-2127440 | M8.5 | -5.44 ^{+0.31} _{-1.32} | 6.2±1.2 | -3.2±0.9 | -0.2±0.6 | 0.01 | D | 99.9% USCO |
| 2M16103014-2315167 | M7.5 | -3.86 ^{+0.25} _{-0.2} | 7.2±0.2 | -4.3±0.6 | -0.2±0.3 | 0.01 | D | 99.9% USCO |

Table 3.6 (continued)

Table 3.6 (continued)

| APOGEE ID | SpT | Adopted RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P[TD]/P[D] ^a | Population ^a | BANYAN Σ^c |
|---------------------|------|--|----------------------------|----------------------------|----------------------------|-------------------------|-------------------------|------------------------|
| 2M16103040+3954258 | M5.0 | 14.24 ^{+0.17} _{-0.17} | 79.2 ± 20.2 | 10.4 ± 3.4 | -0.0 ± 5.6 | 0.04 | D | 99.9% field |
| 2M16103232-1913085 | M8.5 | -6.21 ^{+0.34} _{-0.29} | 6.8 ± 1.2 | -3.2 ± 0.6 | -1.9 ± 0.6 | 0.01 | D | 99.8% USCO |
| 2M16103232+2249116 | M7.0 | -3.96 ^{+0.48} _{-0.47} | 5.4 ± 0.3 | 20.5 ± 0.2 | 0.8 ± 0.3 | 0.01 | D | 99.9% field |
| 2M16104714-2239492 | M9.0 | -7.54 ^{+0.22} _{-0.22} | 4.1 ± 0.3 | -2.7 ± 1.2 | -1.3 ± 0.6 | 0.01 | D | 99.9% USCO |
| 2M16113837-2307072 | M6.0 | -2.24 ^{+0.51} _{-0.51} | 8.4 ± 0.5 | -5.6 ± 0.4 | 1.1 ± 0.2 | 0.01 | D | 99.9% USCO |
| 2M16114261-2525511 | M7.0 | -4.69 ^{+0.64} _{-0.66} | 6.1 ± 0.6 | -3.8 ± 0.2 | -1.1 ± 0.2 | 0.01 | D | 99.9% USCO |
| 2M16115439-2236491 | M6.0 | -2.51 ^{+0.76} _{-0.33} | 8.2 ± 0.7 | -3.1 ± 0.6 | 2.1 ± 0.4 | 0.01 | D | 99.9% USCO |
| 2M16122703-2013250 | M6.0 | -4.88 ^{+0.29} _{-0.29} | 7.1 ± 0.3 | -2.8 ± 0.2 | 0.4 ± 0.1 | 0.01 | D | 99.9% USCO |
| 2M16124726-1903531 | M6.0 | -7.06 ^{+0.31} _{-0.31} | 6.0 ± 0.3 | -3.0 ± 0.2 | -2.0 ± 0.2 | 0.01 | D | 99.9% USCO |
| 2M16132665-2230348 | M6.0 | -4.73 ^{+0.22} _{-0.22} | 7.0 ± 0.2 | -4.3 ± 0.3 | -1.1 ± 0.2 | 0.01 | D | 99.9% USCO |
| 2M16132809-1924524 | M6.0 | -4.75 ^{+0.22} _{-0.13} | 7.9 ± 0.2 | -2.6 ± 0.2 | -0.7 ± 0.1 | 0.01 | D | 99.9% USCO |
| 2M16134027-2233192 | M6.5 | -6.45 ^{+0.13} _{-0.13} | 5.2 ± 0.1 | -4.0 ± 0.3 | -1.4 ± 0.2 | 0.01 | D | 99.9% USCO |
| 2M16134079-2219459 | M7.5 | -0.81 ^{+0.23} _{-0.27} | 10.7 ± 0.3 | -4.8 ± 1.0 | 0.1 ± 0.5 | 0.01 | D | 99.7% USCO |
| 2M16134264-2301279 | M6.0 | -1.95 ^{+0.99} _{-0.19} | 9.1 ± 0.9 | -5.2 ± 0.4 | 0.5 ± 0.4 | 0.01 | D | 99.8% USCO |
| 2M16143287-2242133 | M6.5 | 0.19 ^{+0.14} _{-0.14} | 11.7 ± 0.2 | -5.3 ± 0.5 | -0.0 ± 0.3 | 0.01 | D | 99.2% USCO |
| 2M16172079+4113032 | M5.0 | 0.52 ^{+0.33} _{-0.33} | 30.2 ± 0.1 | -16.2 ± 0.2 | 25.3 ± 0.2 | 0.02 | D | 99.9% field |
| 2M16183317-2517504 | M6.0 | -0.99 ^{+0.15} _{-0.16} | 8.6 ± 0.2 | -8.2 ± 0.6 | 1.9 ± 0.2 | 0.01 | D | 70.7% USCO |
| 2M16195143-2241332 | M6.5 | -4.57 ^{+0.14} _{-0.19} | 7.1 ± 0.2 | -2.7 ± 0.7 | -0.3 ± 0.3 | 0.01 | D | 99.9% USCO |
| 2M16204144-2425491 | M7.5 | 1.46 ^{+0.32} _{-0.32} | 11.8 ± 0.6 | -5.3 ± 0.8 | 2.3 ± 0.4 | 0.01 | D | 89.6% USCO, 9.5% UCL |
| 2M16222304-2407108 | M6.0 | -1.93 ^{+0.49} _{-0.49} | 8.0 ± 0.6 | -5.6 ± 2.0 | 3.3 ± 0.7 | 0.01 | D | 97.5% USCO |
| 2M16222521-2405139 | M9.0 | -1.23 ^{+0.32} _{-0.37} | 8.5 ± 0.4 | -5.6 ± 0.7 | 4.1 ± 0.2 | 0.01 | D | 89.6% USCO, 9.5% UCL |
| 2M162335155-2317270 | M8.0 | -3.86 ^{+0.81} _{-0.81} | 8.1 ± 0.8 | -4.3 ± 0.4 | -1.7 ± 0.3 | 0.01 | D | 99.6% USCO |
| 2M16265698+3954482 | M7.5 | 2.92 ^{+0.44} _{-0.44} | 18.2 ± 0.2 | 18.5 ± 0.3 | 2.4 ± 0.3 | 0.01 | D | 99.9% field |
| 2M16271693+3514132 | M6.0 | -12.09 ^{+0.72} _{-0.77} | 26.1 ± 0.4 | 2.8 ± 0.4 | -10.5 ± 0.5 | 0.01 | D | 99.9% field |
| 2M16271825+3538347 | M7.0 | -8.84 ^{+0.27} _{-0.18} | -14.7 ± 0.2 | 8.3 ± 0.2 | 12.4 ± 0.3 | 0.01 | D | 99.9% field |
| 2M16281707+1334204 | M6.0 | -36.56 ^{+0.13} _{-0.13} | -11.4 ± 0.1 | -36.3 ± 0.4 | 3.5 ± 0.2 | 0.01 | D | 99.9% field |
| 2M16311879+4051516 | M6.0 | -21.75 ^{+0.17} _{-0.17} | -12.6 ± 0.0 | -0.1 ± 0.1 | -1.8 ± 0.1 | 0.01 | D | 30.5% ARG, 69.5% field |
| 2M16360984+4000243 | M5.0 | -11.5 ^{+0.24} _{-0.23} | 29.6 ± 0.2 | -7.1 ± 0.2 | 0.1 ± 0.2 | 0.01 | D | 99.9% field |
| 2M16402068+6736046 | M7.0 | -17.42 ^{+0.28} _{-0.28} | -14.9 ± 0.1 | -11.7 ± 0.1 | 4.1 ± 0.1 | 0.01 | D | 99.9% field |
| 2M16463154+3434554 | M6.0 | -52.64 ^{+0.13} _{-0.13} | 3.2 ± 0.1 | -44.8 ± 0.1 | -12.5 ± 0.1 | 0.03 | D | 99.9% field |
| 2M16485878+3005366 | M6.0 | -44.79 ^{+0.34} _{-0.34} | -13.4 ± 0.2 | -49.2 ± 0.4 | 15.0 ± 0.4 | 0.05 | D | 99.9% field |
| 2M16572919+2448509 | M5.0 | -58.12 ^{+0.31} _{-0.31} | -64.4 ± 0.6 | 14.8 ± 0.6 | -21.0 ± 0.3 | 0.05 | D | 99.9% field |
| 2M19005974-3647109 | M7.0 | 1.55 ^{+0.25} _{-0.25} | 9.5 ± 0.3 | -6.1 ± 0.6 | -2.9 ± 0.3 | 0.01 | D | 64.9% CRA, 35.1% UCRA |
| 2M19241634+7533121 | M6.0 | -18.62 ^{+0.17} _{-0.16} | -17.4 ± 0.0 | -10.2 ± 0.2 | -9.2 ± 0.1 | 0.01 | D | 99.9% field |
| 2M19544358+1801581 | M8.0 | -18.62 ^{+0.26} _{-0.26} | 32.2 ± 0.2 | -26.2 ± 0.2 | -9.9 ± 0.0 | 0.01 | D | 99.9% field |

Table 3.6 (continued)

Table 3.6 (*continued*)

| APOGEE ID | Spt | Adpoted RV (km s ⁻¹) | U (km s ⁻¹) | V (km s ⁻¹) | W (km s ⁻¹) | P[TD]/P[D] ^a | Population ^a | BANYAN Σ^c |
|--------------------|------|--|----------------------------|----------------------------|----------------------------|-------------------------|-------------------------|-------------------------|
| 2M20353517-0608285 | M7.0 | 8.16 ^{+0.33} _{-0.25} | 5.7 ± 0.2 | 25.8 ± 0.2 | -2.1 ± 0.2 | 0.01 | D | 99.9% field |
| 2M20491376+3216514 | M6.0 | 11.5 ^{+0.31} _{-0.35} | 46.9 ± 0.1 | 13.8 ± 0.3 | 0.9 ± 0.0 | 0.01 | D | 99.9% field |
| 2M21272531+5553150 | M8.0 | -12.23 ^{+0.21} _{-0.24} | -20.6 ± 0.0 | -3.8 ± 0.2 | 4.7 ± 0.0 | 0.01 | D | 99.3% CARN ^d |
| 2M21381698+5257188 | M7.5 | -7.52 ^{+0.21} _{-0.37} | -3.7 ± 0.0 | 3.2 ± 0.2 | -3.5 ± 0.0 | 0.01 | D | 99.9% field |
| 2M22021125-1109461 | M6.0 | -7.72 ^{+0.4} _{-0.4} | 3.8 ± 0.2 | -15.3 ± 0.2 | -5.4 ± 0.3 | 0.01 | D | 99.9% ABDMG |
| 2M22400144+0532162 | M6.0 | -10.05 ^{+0.29} _{-0.3} | 4.2 ± 0.1 | -13.8 ± 0.2 | -5.8 ± 0.2 | 0.01 | D | 99.6% ABDMG |
| 2M22551142+1442456 | M6.0 | -14.08 ^{+1.01} _{-0.76} | 0.0 ± 0.1 | -9.8 ± 0.8 | 1.7 ± 0.6 | 0.01 | D | 99.9% field |
| 2M23200703+1150071 | M6.5 | -54.47 ^{+0.34} _{-0.34} | -6.4 ± 0.0 | -78.2 ± 0.3 | -5.7 ± 0.3 | 0.87 | D/TD | 99.9% field |

^a Galactic thin disk (D), thick disk (TD), intermediate populations (D/TD) are assigned according to probability ratios

$P(\text{TD})/P(\text{D}) < 0.1$, $P(\text{TD})/P(\text{D}) > 10$, and $0.1 < P(\text{TD})/P(\text{D}) < 10$, respectively, following Bensby et al. (2003).

^b Known or candidate binary.

^c BANYAN Σ young moving group name abbreviation follows those defined in Gagné et al. (2018c): AB Doradus (ABDMG), Argus (ARG),

Coma Berenices (CBER), Corona Australis (CRA), Hyades (HYA), Taurus (TAU), Upper Scorpius (USCO).

^d Not reported in the literature as a member of young moving groups.

^e Reported as a member of NGC 1333 in Cantat-Gaudin et al. (2018); Yao et al. (2018);

Cantat-Gaudin & Anders (2020); Cantat-Gaudin et al. (2020), but I did not identify because NGC 1333 is not included in BANYAN Σ .

^f Reported as a member of the Castor Moving Group in Zuckerman et al. (2013), but I did not identify it because

the Castor Moving Group is not included in BANYAN Σ .

Table 3.7: Galactic Orbital Parameters

| APOGEE ID | R_{\min} (kpc) | R_{\max} (kpc) | Z_{\max} (kpc) | e | i (deg) |
|--------------------|---------------------|---------------------|---------------------|-------------------|-------------------|
| 2M00312793+6139333 | 5.0023 ± 0.0083 | 8.4886 ± 0.0024 | 0.3386 ± 0.0008 | 0.25838 ± 0.00076 | 2.86473 ± 0.01438 |
| 2M00452143+1634446 | 7.897 ± 0.013 | 8.5567 ± 0.0171 | 0.023 ± 0.0029 | 0.0401 ± 0.00034 | 0.1593 ± 0.02005 |
| 2M01120002+1502170 | 4.9281 ± 0.0091 | 8.4791 ± 0.0012 | 0.1345 ± 0.0025 | 0.26487 ± 0.0009 | 1.17157 ± 0.02209 |
| 2M01154176+0059317 | 7.0465 ± 0.0194 | 9.1796 ± 0.0265 | 0.0713 ± 0.0096 | 0.13147 ± 0.00161 | 0.49604 ± 0.06816 |
| 2M01215816+0101007 | 7.2423 ± 0.0102 | 8.3797 ± 0.0009 | 0.0494 ± 0.0011 | 0.07279 ± 0.00072 | 0.35879 ± 0.00781 |
| 2M01243124-0027556 | 6.8832 ± 0.0156 | 8.4725 ± 0.0015 | 0.0052 ± 0.0015 | 0.1035 ± 0.00109 | 0.03824 ± 0.01075 |
| 2M01514363+0046188 | 8.0498 ± 0.0047 | 9.1008 ± 0.0204 | 0.0309 ± 0.0057 | 0.06126 ± 0.00136 | 0.20332 ± 0.0383 |
| 2M02500239-0808417 | 6.1155 ± 0.0086 | 9.1541 ± 0.0101 | 0.202 ± 0.0063 | 0.199 ± 0.00119 | 1.49417 ± 0.04583 |
| 2M03040207+0045512 | 7.1719 ± 0.0048 | 9.039 ± 0.0074 | 0.0514 ± 0.0025 | 0.11517 ± 0.00072 | 0.35808 ± 0.01773 |
| 2M03282839+3116273 | 8.394 ± 0.0253 | 9.0218 ± 0.0602 | 0.0908 ± 0.008 | 0.03639 ± 0.00337 | 0.59335 ± 0.05366 |
| 2M03293053+3127280 | 8.3922 ± 0.0139 | 9.047 ± 0.0381 | 0.0796 ± 0.0047 | 0.03765 ± 0.00209 | 0.5192 ± 0.0313 |
| 2M03505737+1818069 | 7.2998 ± 0.0081 | 8.3618 ± 0.0014 | 0.2116 ± 0.0011 | 0.06783 ± 0.00058 | 1.52736 ± 0.00901 |
| 2M04110642+1247481 | 7.1471 ± 0.0065 | 9.0766 ± 0.0067 | 0.0675 ± 0.0013 | 0.11893 ± 0.00067 | 0.46931 ± 0.00948 |
| 2M04185115+2814332 | 8.1789 ± 0.0132 | 8.8298 ± 0.021 | 0.0496 ± 0.0025 | 0.03834 ± 0.00089 | 0.33173 ± 0.01676 |
| 2M04204796+5624202 | 4.5228 ± 0.0108 | 8.3366 ± 0.0003 | 0.6019 ± 0.0028 | 0.29658 ± 0.0011 | 5.32751 ± 0.0333 |
| 2M04214435+2024105 | 7.1898 ± 0.01 | 9.1533 ± 0.0153 | 0.0599 ± 0.0017 | 0.12018 ± 0.00135 | 0.41249 ± 0.01683 |
| 2M04214955+1929086 | 7.1772 ± 0.0154 | 9.0849 ± 0.0084 | 0.0719 ± 0.002 | 0.1173 ± 0.00089 | 0.49901 ± 0.01477 |
| 2M04262939+2624137 | 8.1481 ± 0.019 | 8.7549 ± 0.0209 | 0.0158 ± 0.0013 | 0.03595 ± 0.00152 | 0.1067 ± 0.00867 |
| 2M04294568+2630468 | 8.2917 ± 0.0065 | 8.7776 ± 0.0166 | 0.0225 ± 0.0016 | 0.02846 ± 0.00095 | 0.15037 ± 0.01061 |
| 2M04330945+2246487 | 7.9775 ± 0.0581 | 8.6105 ± 0.0136 | 0.0237 ± 0.0027 | 0.03823 ± 0.00328 | 0.16216 ± 0.01901 |
| 2M04351354+2008014 | 7.1949 ± 0.0085 | 9.0485 ± 0.0093 | 0.0614 ± 0.0014 | 0.11417 ± 0.0009 | 0.42658 ± 0.00978 |
| 2M04440164+1621324 | 7.9852 ± 0.0155 | 8.5697 ± 0.0061 | 0.0228 ± 0.001 | 0.03532 ± 0.00092 | 0.15652 ± 0.00684 |
| 2M04464498+2436404 | 7.1636 ± 0.0086 | 9.1264 ± 0.0162 | 0.0592 ± 0.001 | 0.1205 ± 0.0014 | 0.41023 ± 0.00748 |
| 2M04552333+3027366 | 8.0943 ± 0.0212 | 8.5972 ± 0.0075 | 0.0414 ± 0.0021 | 0.03014 ± 0.00111 | 0.28294 ± 0.01485 |
| 2M04565141+2939310 | 8.1333 ± 0.0176 | 8.6132 ± 0.0157 | 0.034 ± 0.0018 | 0.02866 ± 0.00147 | 0.23168 ± 0.01258 |
| 2M05350162-0521489 | 8.0894 ± 1.9855 | 11.3578 ± 16.7989 | 1.1982 ± 2.9632 | 0.31558 ± 0.29099 | 5.18459 ± 7.03864 |
| 2M05392474+4038437 | 5.2928 ± 0.0037 | 8.3211 ± 0.0007 | 0.1327 ± 0.0003 | 0.22245 ± 0.00035 | 1.11604 ± 0.01083 |
| 2M05402570+2448090 | 7.5608 ± 0.0469 | 8.4345 ± 0.0203 | 0.0279 ± 0.0012 | 0.05461 ± 0.00334 | 0.19782 ± 0.00814 |
| 2M06154934-0100415 | 7.7023 ± 0.0029 | 9.983 ± 0.0151 | 0.314 ± 0.0014 | 0.12893 ± 0.00078 | 1.96352 ± 0.0141 |
| 2M06521977-2534505 | 8.269 ± 0.002 | 9.2708 ± 0.0153 | 0.0978 ± 0.0004 | 0.05712 ± 0.00071 | 0.63112 ± 0.00333 |
| 2M07025026-6102482 | 6.2392 ± 0.0087 | 8.5044 ± 0.0025 | 0.6552 ± 0.0034 | 0.15361 ± 0.00069 | 4.89985 ± 0.0261 |
| 2M07140394+3702459 | 7.6589 ± 0.0055 | 9.1737 ± 0.0076 | 0.106 ± 0.0009 | 0.08999 ± 0.00076 | 0.71042 ± 0.00585 |
| 2M07464256+2000321 | 7.1091 ± 0.004 | 9.6899 ± 0.0083 | 0.0802 ± 0.002 | 0.15364 ± 0.00051 | 0.53629 ± 0.01383 |
| 2M07475737+6653337 | 8.3071 ± 0.0068 | 9.7905 ± 0.0347 | 0.2035 ± 0.0054 | 0.08198 ± 0.00136 | 1.26241 ± 0.0295 |
| 2M07552256+2755318 | 8.3147 ± 0.0011 | 10.4023 ± 0.007 | 0.4325 ± 0.0025 | 0.11155 ± 0.00028 | 2.54506 ± 0.01308 |
| 2M07564895+6649595 | 6.0959 ± 0.0182 | 8.3439 ± 0.0009 | 0.4414 ± 0.0039 | 0.15567 ± 0.00149 | 3.40782 ± 0.02954 |
| 2M08072607+3213101 | 7.022 ± 0.0059 | 9.0858 ± 0.0057 | 0.1071 ± 0.0014 | 0.12813 ± 0.00072 | 0.74881 ± 0.00919 |

Table 3.7 (continued)

Table 3.7 (*continued*)

| APOGEE ID | R_{\min} (kpc) | R_{\max} (kpc) | Z_{\max} (kpc) | e | i (deg) |
|--------------------|---------------------|---------------------|---------------------|-------------------|-------------------|
| 2M08080189+3157054 | 7.4324 ± 0.008 | 8.5594 ± 0.006 | 0.1714 ± 0.0017 | 0.0705 ± 0.00087 | 1.21252 ± 0.01212 |
| 2M08092892+3235226 | 8.302 ± 0.0074 | 10.0865 ± 0.0243 | 0.0982 ± 0.0043 | 0.09705 ± 0.00132 | 0.60058 ± 0.02155 |
| 2M08144389+4650522 | 7.5669 ± 0.0087 | 8.7618 ± 0.0141 | 0.1116 ± 0.0024 | 0.0732 ± 0.00122 | 0.77359 ± 0.01662 |
| 2M08185804+233522 | 6.1116 ± 0.008 | 8.5718 ± 0.0037 | 0.0943 ± 0.0016 | 0.16755 ± 0.00084 | 0.72993 ± 0.01274 |
| 2M08211639+5658358 | 8.2479 ± 0.0088 | 8.6016 ± 0.0085 | 0.2183 ± 0.002 | 0.10209 ± 0.0006 | 1.47567 ± 0.01356 |
| 2M08294949+2646348 | 8.158 ± 0.0091 | 8.5857 ± 0.0026 | 0.0568 ± 0.0015 | 0.02552 ± 0.00071 | 0.38711 ± 0.00985 |
| 2M08440350+0434356 | 6.7342 ± 0.0148 | 11.5646 ± 0.0213 | 0.2508 ± 0.0031 | 0.26396 ± 0.00116 | 1.5062 ± 0.02061 |
| 2M08490052+0220155 | 7.2227 ± 0.0297 | 8.3305 ± 0.0018 | 0.0412 ± 0.0002 | 0.07123 ± 0.00215 | 0.3004 ± 0.0014 |
| 2M08501918+1056436 | 7.0091 ± 0.0182 | 8.7437 ± 0.0036 | 0.078 ± 0.0019 | 0.1101 ± 0.00148 | 0.55992 ± 0.0134 |
| 2M08522464+2540591 | 7.0985 ± 0.014 | 9.1092 ± 0.0068 | 0.1139 ± 0.0046 | 0.12406 ± 0.00134 | 0.79184 ± 0.04135 |
| 2M09020690+0033195 | 6.2619 ± 0.0105 | 8.9221 ± 0.0015 | 0.1389 ± 0.0015 | 0.17518 ± 0.00087 | 1.0339 ± 0.01102 |
| 2M09130162+3037583 | 4.5784 ± 0.0193 | 8.6047 ± 0.0061 | 0.1474 ± 0.004 | 0.30535 ± 0.00208 | 1.33019 ± 0.03699 |
| 2M09373349+5534057 | 8.2936 ± 0.0086 | 8.777 ± 0.0173 | 0.1297 ± 0.0023 | 0.02832 ± 0.00126 | 0.86488 ± 0.01592 |
| 2M09381783+0132490 | 7.1498 ± 0.0465 | 8.8668 ± 0.0456 | 0.4725 ± 0.0149 | 0.10738 ± 0.00096 | 3.27406 ± 0.08562 |
| 2M09442625+3521233 | 7.323 ± 0.0136 | 11.7527 ± 0.0273 | 0.2134 ± 0.0093 | 0.23222 ± 0.00194 | 1.22742 ± 0.05159 |
| 2M09453388+5458511 | 8.0507 ± 0.0205 | 8.5448 ± 0.0097 | 0.0934 ± 0.0026 | 0.02976 ± 0.00169 | 0.6416 ± 0.01747 |
| 2M09472006-0020093 | 7.9328 ± 0.0028 | 9.0964 ± 0.0032 | 0.0501 ± 0.0002 | 0.06832 ± 0.00014 | 0.33294 ± 0.0018 |
| 2M09474477+0224327 | 7.065 ± 0.0134 | 8.3437 ± 0.0012 | 0.104 ± 0.0018 | 0.08298 ± 0.00087 | 0.76524 ± 0.01327 |
| 2M09522188-1924319 | 8.194 ± 0.0016 | 10.4839 ± 0.1024 | 0.1838 ± 0.0063 | 0.12261 ± 0.0047 | 1.09275 ± 0.03033 |
| 2M09524622+0620410 | 7.6573 ± 0.0209 | 8.3214 ± 0.0007 | 0.0546 ± 0.0004 | 0.04156 ± 0.00141 | 0.38904 ± 0.0035 |
| 2M09560888+0134128 | 7.1534 ± 0.0238 | 9.0782 ± 0.0059 | 0.0943 ± 0.0035 | 0.11858 ± 0.00139 | 0.6525 ± 0.02229 |
| 2M10031918-0105079 | 7.031 ± 0.0104 | 9.1817 ± 0.0037 | 0.0536 ± 0.0012 | 0.13264 ± 0.0006 | 0.37301 ± 0.00755 |
| 2M10134315+0000406 | 5.91 ± 0.008 | 10.511 ± 0.015 | 0.2471 ± 0.003 | 0.28017 ± 0.00061 | 1.68303 ± 0.02346 |
| 2M10225090+0032169 | 5.5556 ± 0.1953 | 8.3225 ± 0.0078 | 0.0918 ± 0.0347 | 0.19935 ± 0.01645 | 0.7599 ± 0.29988 |
| 2M10240997+1815533 | 7.5469 ± 0.0165 | 8.4103 ± 0.0022 | 0.063 ± 0.0012 | 0.0541 ± 0.00119 | 0.44809 ± 0.00896 |
| 2M10323297+0630074 | 7.119 ± 0.0076 | 8.3114 ± 0.001 | 0.0422 ± 0.0 | 0.07727 ± 0.00062 | 0.31027 ± 0.00046 |
| 2M10372897+3011117 | 4.4813 ± 0.0042 | 8.6312 ± 0.0014 | 0.2838 ± 0.0021 | 0.3165 ± 0.00048 | 2.51617 ± 0.05486 |
| 2M10541102-8505023 | 7.3148 ± 0.0282 | 9.1477 ± 0.0564 | 0.17 ± 0.0055 | 0.11135 ± 0.00124 | 1.15997 ± 0.03233 |
| 2M10543366+0503467 | 6.5581 ± 0.0295 | 10.231 ± 0.0107 | 0.1894 ± 0.0018 | 0.21874 ± 0.00255 | 1.25859 ± 0.01507 |
| 2M10570380+2217203 | 7.3002 ± 0.0026 | 8.3183 ± 0.0002 | 0.0899 ± 0.0008 | 0.06519 ± 0.00019 | 0.65433 ± 0.00549 |
| 2M11194647+0820356 | 6.7624 ± 0.0051 | 12.8571 ± 0.012 | 0.466 ± 0.0034 | 0.31061 ± 0.00056 | 2.52436 ± 0.01898 |
| 2M11203609+0704135 | 6.3093 ± 0.0165 | 8.9276 ± 0.0086 | 0.257 ± 0.0066 | 0.17182 ± 0.00087 | 1.89255 ± 0.04352 |
| 2M11210854+2126274 | 7.9455 ± 0.0032 | 8.7966 ± 0.001 | 0.0628 ± 0.0007 | 0.05083 ± 0.00019 | 0.42594 ± 0.00545 |
| 2M11232934+0154040 | 8.1569 ± 0.0088 | 8.9374 ± 0.0246 | 0.0547 ± 0.0004 | 0.04566 ± 0.00104 | 0.36335 ± 0.00275 |
| 2M12080810+3520281 | 5.2464 ± 0.0081 | 9.4749 ± 0.0063 | 0.2656 ± 0.0067 | 0.28721 ± 0.00091 | 2.05799 ± 0.05055 |
| 2M12153877+5205050 | 8.3045 ± 0.0262 | 8.8757 ± 0.2157 | 0.0815 ± 0.0152 | 0.03333 ± 0.01266 | 0.54241 ± 0.10651 |
| 2M12201166+3315379 | 6.7351 ± 0.0084 | 9.3994 ± 0.0026 | 0.2981 ± 0.0032 | 0.16513 ± 0.00073 | 2.05415 ± 0.02156 |
| 2M12205439+2525568 | 7.8265 ± 0.0328 | 8.6605 ± 0.0088 | 0.2363 ± 0.0024 | 0.05057 ± 0.00251 | 1.62106 ± 0.01652 |

Table 3.7 (*continued*)

Table 3.7 (*continued*)

| APOGEE ID | R_{\min} (kpc) | R_{\max} (kpc) | Z_{\max} (kpc) | e | i (deg) |
|--------------------|---------------------|---------------------|---------------------|---------------------|-------------------|
| 2M12215013+4632447 | 7.9789 ± 0.0361 | 9.9355 ± 0.1285 | 0.061 ± 0.0066 | 0.10935 ± 0.0083 | 0.3826 ± 0.0396 |
| 2M12235346+2534559 | 8.3003 ± 0.0007 | 14.29 ± 0.1367 | 0.3291 ± 0.011 | 0.26514 ± 0.00445 | 1.54487 ± 0.04595 |
| 2M12252076+2517082 | 8.2943 ± 0.0043 | 9.2443 ± 0.0333 | 0.1579 ± 0.0086 | 0.05419 ± 0.00198 | 1.01879 ± 0.05521 |
| 2M12270429+2541012 | 8.2195 ± 0.0016 | 8.9937 ± 0.0106 | 0.1588 ± 0.0042 | 0.04498 ± 0.00058 | 1.04662 ± 0.02797 |
| 2M12315462+5130389 | 7.1298 ± 0.0073 | 9.1229 ± 0.0063 | 0.1344 ± 0.0023 | 0.12262 ± 0.00061 | 0.92913 ± 0.01394 |
| 2M12493960+5255340 | 4.5924 ± 0.0122 | 8.3709 ± 0.0008 | 0.2798 ± 0.0051 | 0.29147 ± 0.00122 | 2.52634 ± 0.04295 |
| 2M12522354+2528469 | 6.4863 ± 0.0087 | 8.4524 ± 0.0005 | 0.1784 ± 0.0028 | 0.13162 ± 0.00064 | 1.35024 ± 0.02079 |
| 2M13004379+3557591 | 6.149 ± 0.0033 | 8.7497 ± 0.0011 | 0.1696 ± 0.0027 | 0.17456 ± 0.0003 | 1.2868 ± 0.02025 |
| 2M13022083+3227103 | 7.9079 ± 0.002 | 8.9367 ± 0.0029 | 0.1687 ± 0.0032 | 0.06108 ± 0.00013 | 1.13299 ± 0.02127 |
| 2M13034100+2414020 | 6.9639 ± 0.0054 | 9.2448 ± 0.003 | 0.0634 ± 0.0005 | 0.14072 ± 0.00051 | 0.44132 ± 0.00354 |
| 2M13065141+7056376 | 7.7469 ± 0.0068 | 14.0929 ± 0.0509 | 0.5604 ± 0.0079 | 0.29057 ± 0.00156 | 2.66023 ± 0.02791 |
| 2M13192677+1301119 | 4.8972 ± 0.008 | 8.3229 ± 0.0017 | 0.1241 ± 0.0009 | 0.25913 ± 0.00097 | 1.09808 ± 0.00889 |
| 2M13202007+7213140 | 7.4014 ± 0.0226 | 8.7591 ± 0.0037 | 0.1161 ± 0.0035 | 0.08399 ± 0.00134 | 0.81221 ± 0.02494 |
| 2M13232423+5132272 | 7.5775 ± 0.0098 | 8.8365 ± 0.0105 | 0.0737 ± 0.0018 | 0.07669 ± 0.00042 | 0.50807 ± 0.01152 |
| 2M13342918+3303043 | 4.8876 ± 0.0068 | 8.9437 ± 0.002 | 0.0746 ± 0.0021 | 0.29326 ± 0.00073 | 0.63382 ± 0.01766 |
| 2M13430646+0038442 | 6.9919 ± 0.0358 | 8.3663 ± 0.0063 | 0.1424 ± 0.002 | 0.08949 ± 0.00258 | 1.04984 ± 0.01637 |
| 2M13482307+3321508 | 6.5186 ± 0.0637 | 8.3518 ± 0.0072 | 0.2129 ± 0.0133 | 0.12326 ± 0.00443 | 1.60962 ± 0.11316 |
| 2M13500476+3207596 | 6.7381 ± 0.016 | 9.0094 ± 0.0063 | 0.1444 ± 0.002 | 0.14424 ± 0.00115 | 1.03309 ± 0.01385 |
| 2M13564148+4342587 | 6.5066 ± 0.0264 | 8.5898 ± 0.0065 | 0.0486 ± 0.0008 | 0.13799 ± 0.00223 | 0.36592 ± 0.00631 |
| 2M13573443+5408223 | 5.1874 ± 0.0236 | 8.4076 ± 0.002 | 0.1695 ± 0.0083 | 0.23687 ± 0.00206 | 1.43876 ± 0.07293 |
| 2M14005977+3226109 | 6.1934 ± 0.0219 | 8.8512 ± 0.0062 | 0.1097 ± 0.0039 | 0.17669 ± 0.00205 | 0.82459 ± 0.02858 |
| 2M14081562+5236281 | 5.3636 ± 0.005 | 9.2403 ± 0.0024 | 0.1513 ± 0.0013 | 0.26545 ± 0.00051 | 1.18993 ± 0.01061 |
| 2M14093200+4138080 | 7.7965 ± 0.0047 | 8.6023 ± 0.0023 | 0.058 ± 0.001 | 0.04914 ± 0.00017 | 0.40192 ± 0.00706 |
| 2M14320849+0811313 | 7.4594 ± 0.002 | 8.6388 ± 0.0016 | 0.0389 ± 0.0 | 0.07326 ± 0.00022 | 0.27407 ± 0.00011 |
| 2M14340140+5039480 | 7.9455 ± 0.0076 | 8.5756 ± 0.0055 | 0.103 ± 0.0018 | 0.03814 ± 0.0003 | 0.70906 ± 0.01337 |
| 2M14402293+1339230 | 6.1427 ± 0.0047 | 8.4405 ± 0.0017 | 0.0534 ± 0.0008 | 0.15756 ± 0.00037 | 0.41685 ± 0.00608 |
| 2M14432796+0316543 | 7.2042 ± 0.0057 | 9.0191 ± 0.006 | 0.1252 ± 0.0023 | 0.11186 ± 0.00058 | 0.8688 ± 0.01543 |
| 2M14553384+1545593 | 6.2066 ± 0.071 | 9.1128 ± 0.0066 | 0.1955 ± 0.0022 | 0.18967 ± 0.00557 | 1.43656 ± 0.01336 |
| 2M14554964+0321420 | 4.7885 ± 0.0041 | 8.3107 ± 0.0004 | 0.531 ± 0.0021 | 0.26888 ± 0.00041 | 4.59087 ± 0.02197 |
| 2M15010818+2250020 | 8.1285 ± 0.0031 | 9.4614 ± 0.0265 | 0.1545 ± 0.007 | 0.07578 ± 0.00158 | 0.9911 ± 0.04642 |
| 2M15041028+0923232 | 5.8786 ± 0.0111 | 9.5897 ± 0.0066 | 0.075 ± 0.0006 | 0.23992 ± 0.00116 | 0.55289 ± 0.00385 |
| 2M15042797+0942464 | 6.0613 ± 0.0303 | 9.1392 ± 0.0198 | 0.2293 ± 0.0075 | 0.20238 ± 0.00338 | 1.69649 ± 0.05449 |
| 2M15115124+3033065 | 2.6677 ± 0.0077 | 8.3032 ± 0.0002 | 0.0697 ± 0.0002 | 0.51367 ± 0.00107 | 0.94247 ± 0.00338 |
| 2M15175638+0656388 | 7.6036 ± 0.0076 | 8.2505 ± 0.0014 | 0.1078 ± 0.0013 | 0.04081 ± 0.00054 | 0.77359 ± 0.00936 |
| 2M15210103+5053230 | 7.9371 ± 0.0019 | 9.7724 ± 0.0104 | 0.1247 ± 0.0017 | 0.10363 ± 0.0004 | 0.78984 ± 0.00905 |
| 2M15242475+2925318 | 6.3859 ± 0.0014 | 8.7472 ± 0.0009 | 0.0691 ± 0.0004 | 0.15603 ± $9e - 05$ | 0.51866 ± 0.00314 |
| 2M15512179+2931062 | 6.7431 ± 0.004 | 9.3673 ± 0.0085 | 0.4574 ± 0.0036 | 0.16289 ± 0.00017 | 3.12668 ± 0.02221 |
| 2M15555600-2045187 | 7.62 ± 0.0337 | 8.2369 ± 0.0091 | 0.0892 ± 0.0013 | 0.0389 ± 0.0021 | 0.64042 ± 0.01034 |

Table 3.7 (*continued*)

Table 3.7 (*continued*)

| APOGEE ID | R_{\min} (kpc) | R_{\max} (kpc) | Z_{\max} (kpc) | e | i (deg) |
|--------------------|---------------------|---------------------|---------------------|-------------------|-------------------|
| 2M15560104-2338081 | 7.4612 ± 0.0228 | 8.3113 ± 0.0079 | 0.0864 ± 0.0007 | 0.05394 ± 0.00134 | 0.62239 ± 0.00594 |
| 2M15560497-2106461 | 7.6189 ± 0.059 | 8.2346 ± 0.0217 | 0.089 ± 0.0021 | 0.03875 ± 0.00413 | 0.63899 ± 0.01651 |
| 2M15574011+2952379 | 7.0505 ± 0.0039 | 8.9616 ± 0.0056 | 0.1183 ± 0.0011 | 0.11938 ± 0.00017 | 0.83323 ± 0.00745 |
| 2M15592591-2305081 | 7.6206 ± 0.0135 | 8.2566 ± 0.0037 | 0.0812 ± 0.0005 | 0.04007 ± 0.00073 | 0.58174 ± 0.00405 |
| 2M15594439-1928191 | 7.5982 ± 0.0527 | 8.2791 ± 0.0175 | 0.0925 ± 0.0022 | 0.04298 ± 0.00265 | 0.66316 ± 0.01838 |
| 2M16001944-2256287 | 7.6322 ± 0.0686 | 8.2427 ± 0.0182 | 0.082 ± 0.0027 | 0.03865 ± 0.00382 | 0.58799 ± 0.02188 |
| 2M16002844-2209228 | 6.5676 ± 0.0402 | 8.1692 ± 0.0028 | 0.2032 ± 0.0039 | 0.10859 ± 0.00288 | 1.5591 ± 0.03383 |
| 2M16003023-2334457 | 7.6 ± 0.0222 | 8.2386 ± 0.0067 | 0.0804 ± 0.0006 | 0.04035 ± 0.00165 | 0.57787 ± 0.00556 |
| 2M16014955-2351082 | 7.6424 ± 0.0244 | 8.2477 ± 0.0086 | 0.0805 ± 0.0009 | 0.03811 ± 0.00125 | 0.57725 ± 0.00705 |
| 2M16022585-2414081 | 7.6634 ± 0.0461 | 8.2879 ± 0.0152 | 0.0758 ± 0.0013 | 0.03921 ± 0.00235 | 0.54201 ± 0.01128 |
| 2M16044026-2254323 | 7.5041 ± 0.045 | 8.2645 ± 0.0146 | 0.0862 ± 0.0014 | 0.04818 ± 0.00256 | 0.62279 ± 0.01178 |
| 2M16045199-2224108 | 7.5062 ± 0.0523 | 8.2844 ± 0.0262 | 0.0873 ± 0.0019 | 0.04926 ± 0.00391 | 0.62833 ± 0.01611 |
| 2M16055178-2206212 | 7.5774 ± 0.0306 | 8.2239 ± 0.0082 | 0.0843 ± 0.0012 | 0.04186 ± 0.00172 | 0.60646 ± 0.0102 |
| 2M16055380+2303058 | 7.8874 ± 0.0123 | 8.7477 ± 0.0022 | 0.2568 ± 0.0035 | 0.05117 ± 0.00074 | 1.74634 ± 0.02441 |
| 2M16063110-1904576 | 7.6907 ± 0.0275 | 8.2726 ± 0.0086 | 0.0844 ± 0.0012 | 0.03645 ± 0.00143 | 0.60138 ± 0.01006 |
| 2M16063390+4054216 | 5.3283 ± 0.007 | 8.5303 ± 0.0003 | 0.1329 ± 0.0016 | 0.23105 ± 0.00064 | 1.10681 ± 0.01188 |
| 2M16081226+2252548 | 7.8531 ± 0.0044 | 11.0419 ± 0.0523 | 0.1173 ± 0.0028 | 0.16879 ± 0.00252 | 0.68996 ± 0.01519 |
| 2M16090197-2151225 | 7.7547 ± 0.0425 | 8.2281 ± 0.0197 | 0.0771 ± 0.0011 | 0.02965 ± 0.00333 | 0.55001 ± 0.00932 |
| 2M16090451-2224523 | 7.6929 ± 0.0349 | 8.2382 ± 0.0155 | 0.0798 ± 0.0012 | 0.03427 ± 0.00269 | 0.57095 ± 0.00911 |
| 2M16090568-2245166 | 7.6511 ± 0.109 | 8.2775 ± 0.0344 | 0.0795 ± 0.004 | 0.03929 ± 0.0051 | 0.56741 ± 0.03336 |
| 2M16093019-2059536 | 7.7001 ± 0.0225 | 8.3716 ± 0.0112 | 0.0835 ± 0.001 | 0.04179 ± 0.00091 | 0.59146 ± 0.00844 |
| 2M16095107-2722418 | 7.4732 ± 0.0302 | 8.2394 ± 0.0076 | 0.0723 ± 0.0007 | 0.04867 ± 0.00167 | 0.52292 ± 0.00621 |
| 2M16095852-2345186 | 7.6634 ± 0.0252 | 8.2899 ± 0.0088 | 0.0759 ± 0.0008 | 0.03928 ± 0.00124 | 0.54141 ± 0.00676 |
| 2M16095990-2155424 | 7.6554 ± 0.0444 | 8.2653 ± 0.0139 | 0.0784 ± 0.0015 | 0.03848 ± 0.00248 | 0.56068 ± 0.0121 |
| 2M16100608-2127440 | 7.742 ± 0.0778 | 8.25 ± 0.0293 | 0.0792 ± 0.0027 | 0.03174 ± 0.00487 | 0.56469 ± 0.02163 |
| 2M16103014-2315167 | 7.6464 ± 0.049 | 8.2569 ± 0.0131 | 0.0766 ± 0.0018 | 0.03834 ± 0.00257 | 0.54844 ± 0.01441 |
| 2M16103040+3954258 | 6.7999 ± 0.4649 | 12.1867 ± 0.8937 | 0.0954 ± 0.0262 | 0.2826 ± 0.06471 | 0.54909 ± 0.14659 |
| 2M16103232-1913085 | 7.7378 ± 0.0553 | 8.2611 ± 0.0274 | 0.084 ± 0.0025 | 0.03266 ± 0.0041 | 0.59867 ± 0.02 |
| 2M16103232+2249116 | 8.2486 ± 0.0012 | 10.3314 ± 0.0319 | 0.0944 ± 0.001 | 0.1121 ± 0.00159 | 0.56913 ± 0.00486 |
| 2M16104714-2239492 | 7.8411 ± 0.1062 | 8.2321 ± 0.0237 | 0.0714 ± 0.004 | 0.02432 ± 0.00531 | 0.50746 ± 0.03177 |
| 2M16113837-2307072 | 7.5279 ± 0.03 | 8.2581 ± 0.0109 | 0.0794 ± 0.0009 | 0.04625 ± 0.00195 | 0.57238 ± 0.00727 |
| 2M16114261-2525511 | 7.6996 ± 0.0264 | 8.2466 ± 0.0117 | 0.071 ± 0.0007 | 0.03434 ± 0.00203 | 0.50706 ± 0.0054 |
| 2M16115439-2236491 | 7.7031 ± 0.048 | 8.2948 ± 0.0212 | 0.0805 ± 0.0016 | 0.037 ± 0.00293 | 0.57269 ± 0.01292 |
| 2M16122703-2013250 | 7.7578 ± 0.0153 | 8.2746 ± 0.0075 | 0.0799 ± 0.0005 | 0.03226 ± 0.00099 | 0.56737 ± 0.00448 |
| 2M16124726-1903531 | 7.7642 ± 0.0164 | 8.2483 ± 0.0064 | 0.0832 ± 0.0008 | 0.03022 ± 0.00106 | 0.59219 ± 0.00625 |
| 2M16132665-2230348 | 7.6555 ± 0.0254 | 8.2536 ± 0.007 | 0.076 ± 0.001 | 0.03758 ± 0.00142 | 0.54402 ± 0.00809 |
| 2M16132809-1924524 | 7.7502 ± 0.0178 | 8.2964 ± 0.0079 | 0.0806 ± 0.0008 | 0.0341 ± 0.00102 | 0.57235 ± 0.00649 |
| 2M16134027-2233192 | 7.6961 ± 0.0246 | 8.2184 ± 0.0052 | 0.078 ± 0.0011 | 0.03285 ± 0.00132 | 0.55815 ± 0.00823 |

Table 3.7 (*continued*)

Table 3.7 (continued)

| APOGEE ID | R_{\min} (kpc) | R_{\max} (kpc) | Z_{\max} (kpc) | e | i (deg) |
|--------------------|---------------------|---------------------|---------------------|-------------------|--------------------|
| 2M16134079-2219459 | 7.5347 ± 0.0664 | 8.313 ± 0.0223 | 0.0809 ± 0.0026 | 0.04914 ± 0.00315 | 0.57913 ± 0.02159 |
| 2M16134264-2301279 | 7.5359 ± 0.0345 | 8.2619 ± 0.0191 | 0.0836 ± 0.001 | 0.04595 ± 0.0029 | 0.60217 ± 0.000871 |
| 2M16143287-2242133 | 7.4773 ± 0.0376 | 8.3209 ± 0.0133 | 0.0821 ± 0.0015 | 0.0534 ± 0.00181 | 0.59063 ± 0.01343 |
| 2M16172079+4113032 | 6.74 ± 0.0119 | 8.7278 ± 0.0066 | 0.2895 ± 0.0031 | 0.12851 ± 0.00052 | 2.09666 ± 0.02115 |
| 2M16183317-2517504 | 7.2968 ± 0.0474 | 8.1951 ± 0.0113 | 0.0886 ± 0.0014 | 0.05802 ± 0.00262 | 0.64909 ± 0.01201 |
| 2M16195143-2241332 | 7.7478 ± 0.0511 | 8.2684 ± 0.0186 | 0.0757 ± 0.002 | 0.03254 ± 0.00234 | 0.53861 ± 0.01661 |
| 2M16204144-2425491 | 7.4677 ± 0.0616 | 8.3203 ± 0.0248 | 0.0804 ± 0.0017 | 0.05412 ± 0.00311 | 0.5786 ± 0.01409 |
| 2M16222304-2407108 | 7.5178 ± 0.1607 | 8.2354 ± 0.0429 | 0.0845 ± 0.0043 | 0.04551 ± 0.00809 | 0.61046 ± 0.03743 |
| 2M16222521-2405139 | 7.5415 ± 0.0569 | 8.2727 ± 0.0148 | 0.0794 ± 0.0014 | 0.0463 ± 0.00298 | 0.57107 ± 0.01151 |
| 2M16235155-2317270 | 7.6352 ± 0.0348 | 8.2731 ± 0.0168 | 0.0718 ± 0.0013 | 0.04008 ± 0.00253 | 0.5134 ± 0.01026 |
| 2M16265698+3954482 | 8.1485 ± 0.0007 | 10.3335 ± 0.0396 | 0.0741 ± 0.0019 | 0.11823 ± 0.00189 | 0.44965 ± 0.0098 |
| 2M16271693+3514132 | 7.6989 ± 0.0096 | 9.1588 ± 0.0352 | 0.1548 ± 0.0039 | 0.08661 ± 0.0016 | 1.03471 ± 0.02832 |
| 2M16271825+3538347 | 8.0893 ± 0.0066 | 9.2988 ± 0.017 | 0.1435 ± 0.0031 | 0.06954 ± 0.00048 | 0.93242 ± 0.01747 |
| 2M16281707+1334204 | 5.6796 ± 0.024 | 8.3118 ± 0.0011 | 0.0628 ± 0.0014 | 0.18813 ± 0.00201 | 0.51201 ± 0.01109 |
| 2M16311879+4051516 | 7.9132 ± 0.0063 | 8.6581 ± 0.0032 | 0.0402 ± 0.0005 | 0.04495 ± 0.00021 | 0.27612 ± 0.00383 |
| 2M16360984+4000243 | 7.1885 ± 0.0093 | 8.8825 ± 0.0078 | 0.0716 ± 0.0003 | 0.10539 ± 0.00057 | 0.50319 ± 0.00237 |
| 2M16402068+6736046 | 7.187 ± 0.0062 | 8.4705 ± 0.0019 | 0.0535 ± 0.0006 | 0.08199 ± 0.00043 | 0.38752 ± 0.00375 |
| 2M16463154+3434554 | 5.2644 ± 0.004 | 8.2972 ± 0.0001 | 0.1307 ± 0.0008 | 0.22363 ± 0.00035 | 1.11318 ± 0.00767 |
| 2M16485878+3005366 | 5.022 ± 0.0206 | 8.3096 ± 0.0009 | 0.1726 ± 0.0046 | 0.2466 ± 0.00193 | 1.50168 ± 0.04089 |
| 2M16572919+2448509 | 7.1748 ± 0.0127 | 11.9375 ± 0.0749 | 0.2897 ± 0.0043 | 0.2492 ± 0.00292 | 1.64757 ± 0.02741 |
| 2M19005974-3647109 | 7.4711 ± 0.0398 | 8.2562 ± 0.0121 | 0.0342 ± 0.0033 | 0.04999 ± 0.00206 | 0.24731 ± 0.02447 |
| 2M19241634+7533121 | 7.263 ± 0.0083 | 8.5401 ± 0.0033 | 0.1042 ± 0.0005 | 0.08081 ± 0.00038 | 0.74711 ± 0.00533 |
| 2M19544358+1801581 | 6.1137 ± 0.0095 | 8.6403 ± 0.0051 | 0.1041 ± 0.0005 | 0.17125 ± 0.00054 | 0.80147 ± 0.01437 |
| 2M20353517-0608285 | 8.2203 ± 0.0011 | 10.9198 ± 0.0288 | 0.0352 ± 0.0016 | 0.14086 ± 0.00133 | 0.20511 ± 0.00079 |
| 2M20491376+3216514 | 7.5309 ± 0.0059 | 10.8981 ± 0.036 | 0.0307 ± 0.0001 | 0.18272 ± 0.0012 | 0.18041 ± 0.00184 |
| 2M21272531+5553150 | 7.5343 ± 0.0118 | 8.7775 ± 0.0095 | 0.0557 ± 0.0002 | 0.07624 ± 0.00028 | 0.38642 ± 0.0019 |
| 2M21381698+5257188 | 8.2525 ± 0.0023 | 8.5949 ± 0.0173 | 0.0454 ± 0.0001 | 0.02033 ± 0.00087 | 0.30758 ± 0.00067 |
| 2M22021125-1109461 | 7.0154 ± 0.0147 | 8.2945 ± 0.0009 | 0.0536 ± 0.0029 | 0.08355 ± 0.00099 | 0.3974 ± 0.02182 |
| 2M22400144+0532162 | 7.1407 ± 0.0153 | 8.3018 ± 0.0012 | 0.0578 ± 0.0029 | 0.07514 ± 0.00109 | 0.42499 ± 0.01606 |
| 2M22551142+1442456 | 7.4411 ± 0.0547 | 8.2977 ± 0.0003 | 0.0319 ± 0.0031 | 0.05443 ± 0.00368 | 0.22999 ± 0.02316 |
| 2M23200703+1150071 | 3.8072 ± 0.0112 | 8.3068 ± 0.0001 | 0.0575 ± 0.0029 | 0.37144 ± 0.00126 | 0.59684 ± 0.02957 |

Table 3.8: Velocity Dispersions and Group Kinematic Ages

| Sample | N | $\langle U \rangle$ (km s ⁻¹) | $\langle V \rangle$ (km s ⁻¹) | $\langle W \rangle$ (km s ⁻¹) | σ_U (km s ⁻¹) | σ_V (km s ⁻¹) | σ_W (km s ⁻¹) | σ_{tot} (km s ⁻¹) | Age (Gyr) | Note |
|----------------------------------|-----|--|--|--|-------------------------------------|-------------------------------------|-------------------------------------|--|--------------|-------------|
| All | 181 | -1.8 ± 2.0 | -9.5 ± 1.5 | 1.9 ± 0.9 | 26.5 ± 0.4 | 19.7 ± 0.1 | 12.7 ± 0.1 | 35.4 ± 0.4 | 2.6 ± 0.2 | Unweighted |
| Not Young | 116 | -3.1 ± 2.9 | -12.4 ± 2.2 | 2.8 ± 1.4 | 34.0 ± 0.4 | 25.6 ± 0.2 | 16.7 ± 0.1 | 45.7 ± 0.3 | 3.81 ± 0.05 | W Weighted |
| Thin Disk & Not Young | 104 | -3.0 ± 3.0 | -8.5 ± 1.8 | 2.5 ± 1.3 | 31.7 ± 0.5 | 23.9 ± 0.2 | 15.6 ± 0.1 | 42.7 ± 0.6 | 4.5 ± 0.3 | Unweighted |
| M Dwarfs (Thin Disk) | 100 | -3.5 ± 3.0 | -8.9 ± 1.8 | 2.6 ± 1.3 | 35.5 ± 0.4 | 26.7 ± 0.2 | 17.7 ± 0.2 | 47.8 ± 0.3 | 4.19 ± 0.05 | W Weighted |
| L Dwarfs (Thin Disk) | 4 | 11.1 ± 20.1 | 2.2 ± 3.4 | 2.1 ± 7.9 | 30.5 ± 0.6 | 18.2 ± 0.2 | 12.8 ± 0.1 | 37.8 ± 0.6 | 3.2 ± 0.2 | Unweighted |
| Thin Disk & Not Young, Binary | 75 | -1.3 ± 3.6 | -9.6 ± 2.3 | 4.1 ± 1.5 | 33.7 ± 0.4 | 19.2 ± 0.2 | 13.9 ± 0.2 | 41.2 ± 0.4 | 3.0 ± 0.1 | W Weighted |
| Shallow ^a | 80 | -4.6 ± 1.9 | -9.7 ± 1.2 | 2.8 ± 0.8 | 30.0 ± 0.6 | 18.4 ± 0.2 | 12.7 ± 0.1 | 37.4 ± 0.7 | 3.1 ± 0.2 | Unweighted |
| Wide Lower ^a | 16 | -45.5 ± 2.5 | -50.1 ± 1.9 | -18.6 ± 1.7 | 33.4 ± 0.5 | 19.5 ± 0.2 | 13.9 ± 0.2 | 41.1 ± 0.4 | 3.0 ± 0.1 | W Weighted |
| Wide Upper ^a | 16 | 44.9 ± 3.3 | 15.7 ± 1.1 | 23.9 ± 1.6 | 37.4 ± 7.4 | 6.4 ± 0.9 | 14.5 ± 3.4 | 40.7 ± 8.2 | 4.3 ± 2.4 | Unweighted |
| | | | | | 47.2 ± 10.6 | 6.9 ± 1.0 | 12.3 ± 3.8 | 49.7 ± 9.4 | 4.6 ± 1.6 | W Weighted |
| | | | | | 31.6 ± 0.8 | 19.6 ± 0.2 | 12.8 ± 0.2 | 39.3 ± 0.8 | 3.6 ± 0.3 | Unweighted |
| | | | | | 33.6 ± 0.6 | 20.2 ± 0.3 | 14.0 ± 0.2 | 41.6 ± 0.5 | 3.1 ± 0.1 | W Weighted |
| | | | | | 30.5 ± 0.4 | 20.0 ± 0.4 | 13.6 ± 0.2 | 38.9 ± 0.4 | 3.5 ± 0.2 | Unweighted |
| | | | | | 34.2 ± 2.1 | 26.3 ± 1.5 | 24.3 ± 1.1 | 49.5 ± 1.7 | 6.9 ± 0.7 | Unweighted |
| | | | | | 45.4 ± 2.8 | 15.1 ± 0.7 | 22.7 ± 1.3 | 53.0 ± 2.5 | 8.4 ± 1.1 | Unweighted |

Note – Ages for unweighted velocities are computed from Aumer & Binney (2009) using the parameters in Aumer & Binney (2009). Ages for |W|-weighted velocities are computed from Wielen (1977) using the parameters in Wielen (1977), following the implementation in Hsu et al. (2021).

^a Piece-wise linear fits to unweighted velocities, broken at $\sigma = \pm 1$; see Section 3.4.4.

Table 3.9: Radial Velocity Variations for Multi-epoch Observations

| APOGEE ID | N_{obs} | Mean RV (km s^{-1}) | χ^2 | p-value | Significance Type ^a |
|--------------------|------------------|-----------------------------------|----------|---------|--------------------------------|
| 2M03282839+3116273 | 10 | +15.25 | 39.8 | < 0.001 | $N \geq 4$ significant |
| 2M05402570+2448090 | 4 | +22.93 | 28.17 | < 0.001 | $N \geq 4$ significant |
| 2M08092892+3235226 | 4 | -6.65 | 11.52 | 0.009 | $N \geq 4$ significant |
| 2M08501918+1056436 | 23 | +31.45 | 82.19 | < 0.001 | $N \geq 4$ significant |
| 2M09373349+5534057 | 20 | +0.8 | 109.65 | < 0.001 | $N \geq 4$ significant |
| 2M09442625+3521233 | 6 | +51.18 | 36.42 | < 0.001 | $N \geq 4$ significant |
| 2M09453388+5458511 | 10 | -3.78 | 22.9 | 0.006 | $N \geq 4$ significant |
| 2M09522188-1924319 | 3 | -17.09 | 53.22 | < 0.001 | $N < 4$ significant |
| 2M09560888+0134128 | 4 | +21.15 | 12.68 | 0.005 | $N \geq 4$ significant |
| 2M10225090+0032169 | 3 | +34.09 | 1172.27 | < 0.001 | $N < 4$ significant |
| 2M10541102-8505023 | 2 | -10.55 | 45.52 | < 0.001 | $N < 4$ significant |
| 2M11203609+0704135 | 3 | -14.47 | 11.74 | 0.003 | $N < 4$ significant |
| 2M11232934+0154040 | 3 | -0.13 | 14.16 | 0.001 | $N < 4$ significant |
| 2M12080810+3520281 | 2 | +29.19 | 8.46 | 0.004 | $N < 4$ significant |
| 2M13202007+7213140 | 12 | -27.34 | 35.62 | < 0.001 | $N \geq 4$ significant |
| 2M13232423+5132272 | 7 | -5.39 | 17.91 | 0.006 | $N \geq 4$ significant |
| 2M13430646+0038442 | 15 | -11.9 | 63.8 | < 0.001 | $N \geq 4$ significant |
| 2M13482307+3321508 | 6 | -19.82 | 558.78 | < 0.001 | $N \geq 4$ significant |
| 2M13500476+3207596 | 15 | -5.77 | 52.01 | < 0.001 | $N \geq 4$ significant |
| 2M13564148+4342587 | 3 | -19.5 | 13.18 | 0.001 | $N < 4$ significant |
| 2M14005977+3226109 | 16 | -17.89 | 70.77 | < 0.001 | $N \geq 4$ significant |
| 2M15010818+2250020 | 5 | +6.55 | 44.72 | < 0.001 | $N \geq 4$ significant |
| 2M16002844-2209228 | 3 | -3.56 | 19.69 | < 0.001 | $N < 4$ significant |
| 2M16090451-2224523 | 3 | -5.15 | 43.57 | < 0.001 | $N < 4$ significant |
| 2M16114261-2525511 | 2 | -4.78 | 10.0 | 0.002 | $N < 4$ significant |
| 2M16271825+3538347 | 4 | -8.56 | 48.52 | < 0.001 | $N \geq 4$ significant |
| 2M16572919+2448509 | 4 | -58.04 | 14.52 | 0.002 | $N \geq 4$ significant |
| 2M22551142+1442456 | 5 | -14.27 | 18.55 | 0.001 | $N \geq 4$ significant |

^a I regard sources with numbers of observations < 4 promising candidates; see Section 3.4.5 for more details.

Table 3.10: Binary Orbital Parameter Estimate

| APOGEE ID | N_{obs} | P_{Prior} (day) | $K_{0,\text{Prior}}$ (km s^{-1}) | σ_{K_0} (km s^{-1}) | σ_v (km s^{-1}) | $N_{\text{sam,in}}$ | P_{fit} (day) | K_{fit} (km s^{-1}) | e_{fit} | $Gaia$ RUWE |
|--------------------|------------------|-----------------------------|--|--|--------------------------------------|---------------------|----------------------------|--|---------------------------|---------------|
| 2M03282839+3116273 | 10 | 1–300 | 3.0 | 2.0 | 2.0 | 1000000 | $24.1^{+86.9}_{-21.8}$ | $1.0^{+0.3}_{-0.2}$ | $0.175^{+0.245}_{-0.132}$ | 0.995 |
| 2M05402570+2448090 | 4 | 1–800 | 4.0 | 3.0 | 3.0 | 1000000 | $27.8^{+49.5}_{-24.8}$ | $2.3^{+1.2}_{-0.9}$ | $0.186^{+0.268}_{-0.143}$ | ... |
| 2M08092892+3235226 | 4 | 6–100 | 1.5 | 1.0 | 1.0 | 1000000 | $17.7^{+11.9}_{-4.6}$ | $0.9^{+0.5}_{-0.3}$ | $0.199^{+0.255}_{-0.151}$ | 4.424 |
| 2M08501918+1056436 | 23 | 1–300 | 4.0 | 3.0 | 3.0 | 5000000 | $26.0^{+17.4}_{-24.0}$ | $0.7^{+0.3}_{-0.1}$ | $0.365^{+0.43}_{-0.232}$ | 1.154 & 1.185 |
| 2M09373349+5534057 | 20 | 1–100 | 4.0 | 3.0 | 2.0 | 5000000 | $5.7^{+13.5}_{-3.9}$ | $0.4^{+0.3}_{-0.2}$ | $0.271^{+0.297}_{-0.199}$ | 1.103 & ... |
| 2M09442625+3521233 | 6 | 1–100 | 1.5 | 1.0 | 1.0 | 1000000 | $4.8^{+5.2}_{-3.4}$ | $1.2^{+0.5}_{-0.3}$ | $0.227^{+0.273}_{-0.179}$ | 0.994 |
| 2M09453388+5458511 | 10 | 1–800 | 4.0 | 3.0 | 2.0 | 5000000 | $15.1^{+19.8}_{-12.7}$ | $1.0^{+0.3}_{-0.2}$ | $0.315^{+0.298}_{-0.244}$ | 0.947 |
| 2M09560888+0134128 | 4 | 15–800 | 1.5 | 1.0 | 1.0 | 1000000 | $47.1^{+188.3}_{-25.4}$ | $1.4^{+0.7}_{-0.7}$ | $0.177^{+0.262}_{-0.14}$ | 0.929 |
| 2M13202007+7213140 | 12 | 20–150 | 3.0 | 2.0 | 3.0 | 5000000 | $52.6^{+4.1}_{-16.0}$ | $0.9^{+0.6}_{-0.5}$ | $0.338^{+0.268}_{-0.213}$ | 1.332 |
| 2M13232423+5132272 | 7 | 1–50 | 3.0 | 2.0 | 2.0 | 1000000 | $3.6^{+8.0}_{-2.0}$ | $0.7^{+0.4}_{-0.3}$ | $0.207^{+0.332}_{-0.154}$ | 1.090 & 0.918 |
| 2M13430646+0038442 | 15 | 20–200 | 3.0 | 2.0 | 2.0 | 5000000 | $106.7^{+40.4}_{-2.0}$ | $1.1^{+0.2}_{-0.2}$ | $0.124^{+0.207}_{-0.096}$ | 1.022 |
| 2M13482307+3321508 | 6 | 1–200 | 15.0 | 4.0 | 3.0 | 5000000 | $10.7^{+0.1}_{-3.4}$ | $10.8^{+3.6}_{-1.6}$ | $0.101^{+0.182}_{-0.066}$ | 1.030 |
| 2M13500476+3207596 | 15 | 1–100 | 4.0 | 3.0 | 3.0 | 5000000 | $1.7^{+0.7}_{-0.2}$ | $1.1^{+0.9}_{-0.2}$ | $0.655^{+0.093}_{-0.177}$ | 1.054 |
| 2M14005977+3226109 | 16 | 1–600 | 3.0 | 3.0 | 3.0 | 5000000 | $1.4^{+321.0}_{-0.3}$ | $1.5^{+1.0}_{-0.4}$ | $0.419^{+0.258}_{-0.255}$ | 0.986 |
| 2M15010818+2250020 | 5 | 5–50 | 3.0 | 3.0 | 2.0 | 1000000 | $23.3^{+1.3}_{-11.0}$ | $1.2^{+0.7}_{-0.3}$ | $0.189^{+0.284}_{-0.142}$ | 1.661 |
| 2M16271825+3538347 | 4 | 60–200 | 5.0 | 4.0 | 3.0 | 5000000 | $69.7^{+17.6}_{-7.4}$ | $3.4^{+2.1}_{-1.3}$ | $0.524^{+0.175}_{-0.238}$ | 0.976 |
| 2M16572919+2448509 | 4 | 100–3000 | 3.0 | 3.0 | 3.0 | 1000000 | $989.0^{+1158.0}_{-800.9}$ | $0.8^{+0.6}_{-0.3}$ | $0.195^{+0.29}_{-0.15}$ | 7.898 |
| 2M22551142+1442456 | 5 | 1–50 | 3.0 | 3.0 | 2.0 | 1000000 | $2.8^{+4.8}_{-1.1}$ | $1.6^{+0.9}_{-0.5}$ | $0.178^{+0.256}_{-0.135}$ | 1.091 |

^a The *Gaia* Renormalised Unit Weight Error (RUWE) (Gaia Collaboration et al. 2018a) is a common used of binary indicator. The RUWEs of two resolved sources with consistent proper motions and parallaxes in *Gaia* are both listed.

Table 3.11: Inferred Projected Radii, Inclination and Literature Period Measurements

| APOGEE ID | BANYAN Σ^a | $v \sin i$ (km s^{-1}) | Period ^b (day) | $R \sin i$ (R_{\odot}) | inclination (deg) | Period Ref |
|--------------------|--------------------------|--------------------------------------|------------------------------|-------------------------------|----------------------|------------|
| 2M00452143+1634446 | 99.7% ARG | 31.64 ± 1.21 | 0.1 ± 0.004 | 0.06 ± 0.0 | 26.7 ± 1.1 | (14) |
| 2M01243124-0027556 | 99.9% field | 27.7 ± 1.84 | 0.555 | 0.3 ± 0.03 | ... | (2) |
| 2M03040207+0045512 | 77.1% HYA | 19.99 ± 1.77 | 1.293 | 0.51 ± 0.06 | ... | (6) |
| 2M04110642+1247481 | 99.4% HYA | 14.15 ± 1.12 | 0.897 | 0.25 ± 0.02 | ... | (5) |
| 2M04214435+2024105 | 99.9% HYA | 32.8 ± 1.43 | 0.34 | 0.22 ± 0.02 | ... | (9), (11) |
| 2M04214955+1929086 | 99.9% HYA | 44.43 ± 1.24 | 0.205 | 0.18 ± 0.01 | ... | (5) |
| 2M04330945+2246487 | 17.1% TAU | 15.96 ± 1.1 | 3.492 | 1.11 ± 0.1 | ... | (13) |
| 2M04351354+2008014 | 99.9% HYA | 23.66 ± 1.05 | 0.37 | 0.17 ± 0.01 | ... | (9), (11) |
| 2M04440164+1621324 | 86.9% TAU | 14.28 ± 1.25 | 2.172 | 0.61 ± 0.07 | ... | (13) |
| 2M04464498+2436404 | 99.2% HYA | 17.88 ± 0.17 | 0.66 | 0.23 ± 0.01 | ... | (9), (11) |
| 2M05402570+2448090 | 54.7% ARG, 43.2% CARN | 30.37 ± 1.63 | 0.294 | 0.18 ± 0.01 | ... | (6) |
| 2M07140394+3702459 | 99.9% field | 7.31 ± 1.23 | 60.2 | 8.76 ± 1.58 | ... | (6) |
| 2M07464256+2000321 | 99.9% field | 34.59 ± 1.16 | 0.086 | 0.06 ± 0.0 | 31.3 ± 5.9 | (3) |
| 2M08072607+3213101 | 99.9% field | 13.68 ± 1.33 | 0.345 | 0.09 ± 0.01 | ... | (6) |
| 2M08294949+2646348 | 99.9% field ^c | 11.91 ± 1.22 | 0.459 | 0.11 ± 0.01 | ... | (6) |
| 2M10323297+0630074 | 99.9% field | 10.13 ± 1.2 | 16.52 | 3.29 ± 0.42 | ... | (6) |
| 2M10372897+3011117 | 99.9% field | 13.07 ± 1.36 | 1.012 | 0.26 ± 0.03 | ... | (6) |
| 2M10570380+2217203 | 99.9% field | 8.96 ± 1.27 | 23.7 | 4.19 ± 0.66 | ... | (6) |
| 2M13022083+3227103 | 99.9% field | 25.7 ± 1.4 | 0.4 | 0.2 ± 0.02 | ... | (6) |
| 2M13564148+4342587 | 99.9% field | 16.16 ± 1.06 | 0.477 | 0.15 ± 0.01 | ... | (6) |
| 2M14320849+0811313 | 99.9% field | 9.17 ± 1.09 | 0.757 | 0.14 ± 0.02 | ... | (6) |
| 2M15010818+2250020 | 99.9% field | 65.29 ± 1.32 | 0.082 | 0.11 ± 0.01 | 60.4 ± 12.2 | (4) |
| 2M15555600-2045187 | 99.9% USCO | 19.91 ± 1.13 | 1.7 | 0.67 ± 0.05 | ... | (7) |
| 2M15560104-2338081 | 93.5% USCO | 12.96 ± 0.86 | 1.505 | 0.39 ± 0.03 | ... | (7) |
| 2M15560497-2106461 | 99.9% USCO | 92.77 ± 1.54 | 0.26 | 0.48 ± 0.03 | ... | (1) |
| 2M15592591-2305081 | 99.9% USCO | 23.51 ± 1.01 | 0.62 | 0.29 ± 0.02 | 72.2 ± 7.8 | (7) |
| 2M16003023-2334457 | 99.9% USCO | 73.58 ± 1.54 | 0.448 | 0.65 ± 0.04 | ... | (7) |
| 2M16014955-2351082 | 99.9% USCO | 38.71 ± 1.5 | 0.527 | 0.4 ± 0.02 | ... | (7) |
| 2M16063110-1904576 | 99.9% USCO | 16.65 ± 1.79 | 2.301 | 0.76 ± 0.09 | ... | (7) |
| 2M16090197-2151225 | 99.9% USCO | 47.77 ± 1.17 | 0.269 | 0.25 ± 0.01 | 63.4 ± 11.1 | (7) |
| 2M16090451-2224523 | 99.9% USCO | 14.14 ± 1.0 | 2.181 | 0.61 ± 0.06 | ... | (7) |
| 2M16093019-2059536 | 99.8% USCO | 17.95 ± 0.28 | 1.593 | 0.57 ± 0.03 | ... | (7) |
| 2M16095107-2722418 | 98.8% USCO | 56.1 ± 1.05 | 0.543 | 0.6 ± 0.03 | ... | (7) |
| 2M16095852-2345186 | 99.9% USCO | 34.66 ± 1.46 | 1.411 | 0.96 ± 0.07 | ... | (7) |
| 2M16095990-2155424 | 99.9% USCO | 22.02 ± 1.55 | 0.874 | 0.38 ± 0.03 | 78.4 ± 5.2 | (7) |
| 2M16113837-2307072 | 99.9% USCO | 36.63 ± 1.09 | 0.72 | 0.52 ± 0.03 | ... | (7) |
| 2M16114261-2525511 | 99.9% USCO | 55.35 ± 1.15 | 0.629 | 0.69 ± 0.04 | ... | (7) |

Table 3.11 (continued)

Table 3.11 (*continued*)

| APOGEE ID | BANYAN Σ^a | $v \sin i$ (km s^{-1}) | Period ^b (day) | $R \sin i$ (R_{\odot}) | inclination (deg) | Period Ref |
|--------------------|------------------------|--------------------------------------|------------------------------|-------------------------------|----------------------|------------|
| 2M16115439–2236491 | 99.9% USCO | 50.29 ± 1.21 | 0.484 | 0.48 ± 0.03 | ... | (7) |
| 2M16122703–2013250 | 99.9% USCO | 30.93 ± 0.43 | 0.888 | 0.54 ± 0.03 | ... | (7) |
| 2M16124726–1903531 | 99.9% USCO | 29.03 ± 1.17 | 1.188 | 0.68 ± 0.05 | ... | (7) |
| 2M16132665–2230348 | 99.9% USCO | 19.86 ± 1.66 | 1.532 | 0.6 ± 0.06 | ... | (7) |
| 2M16132809–1924524 | 99.9% USCO | 23.09 ± 1.4 | 1.512 | 0.69 ± 0.06 | ... | (7) |
| 2M16134027–2233192 | 99.9% USCO | 14.11 ± 0.21 | 1.716 | 0.48 ± 0.02 | ... | (1) |
| 2M16134079–2219459 | 99.7% USCO | 19.41 ± 0.27 | 1.336 | 0.51 ± 0.03 | ... | (7) |
| 2M16143287–2242133 | 99.2% USCO | 18.02 ± 0.36 | 1.823 | 0.65 ± 0.03 | ... | (7) |
| 2M16281707+1334204 | 99.9% field | 15.81 ± 1.07 | 0.603 | 0.19 ± 0.02 | ... | (6) |
| 2M16311879+4051516 | 30.5% ARG, 69.5% field | 14.79 ± 1.59 | 0.512 | 0.15 ± 0.02 | ... | (6) |
| 2M16402068+6736046 | 99.9% field | 16.04 ± 0.16 | 0.378 | 0.12 ± 0.01 | ... | (6) |
| 2M19005974–3647109 | 64.9% CRA, 35.1% UCRA | 20.09 ± 1.39 | 1.552 | 0.62 ± 0.05 | 76.3 ± 7.6 | (12) |
| 2M19241634+7533121 | 99.9% field | 7.18 ± 1.41 | 162.7 | 23.46 ± 4.76 | ... | (6) |
| 2M21272531+5553150 | 99.3% CARN | 17.29 ± 1.22 | 0.54 | 0.18 ± 0.02 | ... | (6) |
| 2M21381698+5257188 | 99.9% field | 40.59 ± 1.52 | 0.183 | 0.15 ± 0.01 | 82.1 ± 5.1 | (6) |
| 2M22021125–1109461 | 99.9% ABDMG | 21.34 ± 1.38 | 0.428 | 0.18 ± 0.01 | 68.3 ± 9.5 | (1) |

^a BANYAN Σ young moving group name abbreviation follows those defined in Gagné et al. (2018c).

AB Doradus (ABDMG), Argus (ARG), Coma Berenices (CBER), Corona Australis (CRA), Hyades (HYA), Taurus (TAU), Upper Scorpius (USCO).

^b I assume 5% uncertainty for each period without reported uncertainty. See Section 3.4.6 for details.

^c This source is a confirmed member of the Castor Moving Group (“CMG”) but the CMG is not included in BANYAN Σ , see Section 3.4.3.

References – (1) Watson et al. (2006), (2) Ivezic et al. (2007), (3) Berger et al. (2009), (4) Crossfield (2014), (5) Douglas et al. (2019), (6) Newton et al. (2016), (7) Rebull et al. (2018), (8) Reiners et al. (2018), (9) Douglas et al. (2019), (10) Vos et al. (2019), (11) Freund et al. (2020), (12) Nardiello (2020), (13) Rebull et al. (2020), (14) Vos et al. (2020)

Chapter 3, in full is currently being prepared for submission for publication of the material. Hsu, Chih-Chun; Burgasser, Adam J.; Theissen, Christopher A.; Birky, Jessica L.; Aganze, C.; Gerasimov, R.; Covey K. R.; Blake, Cullen H.; Moreno-Hilario, E. The thesis author was the primary investigator and author of this paper.

Chapter 4

Conclusions and Future Work

4.1 Summary of the Thesis Work

In this thesis work, I have measured and compiled the largest sample of high-resolution spectral observations for 385 local ultracool dwarfs. In particular, I presented multi-epoch, precise radial and projected rotational velocity measurements for 175 late-M/L/T dwarfs with NIRSPEC and 182 M4–L2 dwarfs with APOGEE, as well as determinations of their effective temperatures and surface gravities, for a total of 352 sources with 1194 epochs. I summarize the key findings of the Keck/NIRSPEC T dwarf, the SDSS/APOGEE M/L dwarf, and the Keck/NISPEC late-M/L dwarf samples as follows.

4.1.1 NIRSPEC T Dwarfs

Drawing from the new and archival observations , I have measured new and refined multi-epoch RV and $v \sin i$ measurements for a total of 37 T dwarfs. In addition to 23 sources without previously reported RV or $v \sin i$ measurements, I improved the measurements of 14 T dwarfs by reducing RV uncertainties by an average factor of 5 and

$v \sin i$ uncertainties by an average factor of 3 using a forward-modeling approach. The key scientific results are summarized as follows:

1. Most of the local T dwarfs are fast rotators, with a median $v \sin i$ of 27 km s^{-1} independent of T dwarf spectral type. This is larger than the median rotational velocities of late-M dwarfs (12 km s^{-1}) and L dwarfs (20 km s^{-1}), a trend that supports prior work indicating that the angular momenta of brown dwarfs are not lost effectively to magnetic winds. In addition, T dwarfs with larger space velocities, which are likely older and more massive, have larger $v \sin i$ values, which may reflect their larger moments of inertia (resistance to angular momentum loss) or more compact radii (greater spin-up).
2. Combining my RVs with published and *Gaia* astrometry, I calculated the Galactic UVW velocities and orbits for my sample. I found that all of my T dwarfs are in the thin disk population; the one exception in my sample, 2MASS J1331–0116, is an unusually blue L dwarf.
3. I kinematically confirmed two previously-identified, planetary-mass, young moving group members SIMP J0136+0933 (Carina-Near; Gagné et al. 2017) and 2MASS J1324+6358 (AB Doradus; Gagné et al. 2018a). The T4 dwarf 2MASS J0819–0335 and the T6.5+T7.5 binary J1553+1532AB are identified as candidate kinematic members of β Pictoris and Carina-Near moving groups, respectively, but the absence of spectral indicators of youth suggest that these are coincident field brown dwarfs.
4. Among 5 T dwarfs with multiple-epoch RV measurements, I found that two objects exhibited statistically significant RV variability consistent with binary orbital motion: the T0.0+T4.5 spectral binary 2MASS J1106+2754, which has an orbital period of $3.92^{+0.07}_{-0.09} \text{ yr}$ and semi-amplitude of $6.30 \pm 0.05 \text{ km s}^{-1}$; and the L7+T3.5

spectral binary 2MASS J2126+7617 which has an orbit period of $12_{-1.2}^{+1.5}$ yr and semi-amplitude of $3.0_{-0.6}^{+0.7}$ km s⁻¹. In addition, 2MASS J0559–1404, a suspected overluminous T4.5, shows evidence of RV variability over the course of 20 years, but no clear periodic signal; future observations are needed to confirm and assess the origin of these variations.

5. Using empirical age-velocity dispersion relations, I determined the kinematic age of local T dwarfs to be 3.5 ± 0.3 Gyr, which is consistent with the kinematic age of local late-M dwarfs (4.1 ± 0.3 Gyr), but considerably younger than the kinematic age of local L dwarfs (5.8 ± 0.3 Gyr). By excluding likely thick disk population members ($P(\text{TD})/P(\text{D}) > 1$), the kinematic age of local L dwarfs is lowered to 4.2 ± 0.3 Gyr, in line with late-M and T dwarfs. This analysis appears to partly resolve the long-standing kinematic anomaly of local L dwarfs.
6. Population simulations reproduce the measured ages of local thin-disk late-M, L, and T dwarfs, although L dwarf ages are predicted to be younger than observed. Varying the star formation history, mass function, evolutionary models, maximum age, and minimum mass of these simulations and comparing to my kinematic sample allows me to constrain some of these population parameters, but several degeneracies remain. I am able to rule out mass function evolution (bottom-heavy to top-heavy) as an explanation for old L dwarfs due to disagreement with the T dwarf velocity dispersion, but find tentative evidence of a lower hydrogen burning minimum mass (HBMM). A more refined breakdown in spectral type can improve this analysis, but will require larger samples to make robust constraints.
7. A detailed evaluation of kinematic age as a function of spectral type for L dwarfs reveals a linear trend of decreasing mean age with spectral type, as predicted by population simulations. I also identify an age upturn and sudden break in ages at

subtypes L4–L6 which likely reflects the terminus of the stellar Main Sequence. This spectral type range aligns with evolutionary model predictions for the HBMM at an age of 4–5 Gyr.

The work reported in Chapter 2 provides a significant expansion in the number and spectral type range of UCDs with precise 6D coordinates, and the inclusion of T dwarfs in particular allows me to constrain many of the underlying population parameters. It has also allowed me to resolve the L dwarf age anomaly and identify empirical diagnostics of brown dwarf evolution and the Main Sequence terminus. However, the size of the current sample remains the primary limitation in precisely quantifying key aspects of this analysis, notably the contaminating fraction of thick disk/blue L dwarfs in the local population, the location and sharpness of the stellar Main Sequence, and degeneracies among simulation parameters. There is considerable capacity to increase the size of the kinematic sample even in the local volume, which is necessary to properly address issues related to completeness, resolution and accuracy in per-spectral-type analyses, as well as the sample bias induced by distinct subpopulations such as blue L dwarfs. Moreover, even a volume-complete 20 pc sample represents a tiny fraction of the Milky Way environment, and it is possible that the immediate local volume around the Sun is not representative of the Galactic disk, a form of cosmic scatter. This motivates a deeper kinematic survey, to 50 pc or 100 pc for example, which may be feasible with future spectroscopic survey facilities or through a more restricted analysis of 2D kinematics (cf. Faherty et al. 2009). Improvements can also be made to the characterization of the UCD kinematic sample. While I specifically evaluated the contributions of young, binary, and unusually blue UCDs, I did not explicitly evaluate model metallicity or cloud variations, or inclination angle, which are of particular importance for the L dwarfs and can influence both empirical calibrations and the underlying evolution of brown dwarfs. There are also improvements to be made to the population simulations. I have not explicitly taken into

account thick disk or halo populations in the simulation, which are likely well-mixed and not easily separable from the thin disk sample based on simple probability thresholds. There are also spatial-temporal correlations to consider, since sources found closer to the Sun (smaller scaleheights) will be preferentially younger than the broader Milky Way population (cf. Ryan et al. 2017). All of these considerations are open for exploration in future studies.

4.1.2 SDSS/APOGEE M and L Dwarfs

I summarize my main results for SDSS/APOGEE (Chapter 3) as follows:

1. I constructed a robust UCD sample of 182 ultracool dwarfs with 671 epochs of observations from APOGEE DR17, with spectral types ranging from M4 to L2. This is a subset of the full DR17 sample of 1563 candidate UCDs with 8055 epochs based on color magnitude selection criteria with photometry and astrometry from 2MASS and *Gaia* EDR3. I focused my analysis on the smaller “gold” sample to assure accurate assessment of source properties. I obtained additional low-resolution optical spectra using the Lick Shane KAST spectrograph to classify eleven sources with spectral types ranging from M5 to M9.
2. I employed a Markov Chain Monte Carlo forward-modeling method to measure RVs and $v \sin i$ s with precisions of 0.3 km s^{-1} and 1.0 km s^{-1} , respectively, using the BT-Settl models (Baraffe et al. 2015) for higher-temperature sources and Sonora models (Marley et al. 2018; Marley et al. 2021), for lower-temperature sources.
3. The $v \sin i$ measurements of my sample have a median value of 16 km s^{-1} , and the distribution is consistent with literature M4–M9 dwarf measurements (median $v \sin i$ of 12.1 km s^{-1}).

4. I examined both individual and population 6D kinematics for my sample, facilitated by my RV measurements. Using the BANYAN Σ tool, I found roughly one third of my sample (66 sources) are known members of nearby young clusters or moving groups. The majority are previously reported in the literature, and I add three new sources 2MASS J05402570+2448090 (54.7% 40–50 Myr Argus moving group, 43.2% \sim 200 Myr Carina Near moving group), 2MASS J14093200+4138080 (99.6% 40–50 Myr Argus moving group), and 2MASS J21272531+5553150 (99.3% \sim 200 Myr Carina Near moving group). I also determined their Galactic orbits of the sample, most of which show are circular and planar ($e \leq 0.1$, $i \leq 2\%$). There are 11 sources with intermediate thin/thick disk kinematics and 1 source with thick disk kinematics.
5. I computed the kinematic ages of the sample using empirical age-velocity dispersion relations. After removal of known young cluster members, I found a total velocity dispersion of $42.7 \pm 0.6 \text{ km s}^{-1}$, corresponding to a kinematic age of $4.5 \pm 0.3 \text{ Gyr}$ using the empirical age-velocity dispersion relation, consistent with measurements of the 20 pc late-M dwarfs in the literature and my NIRSPEC analysis.
6. The averaged RV precision is sufficient for the identification of binaries in the sample with multi-epoch observations. I identified 29 sources with significant RV variability. For a subset of these sources with more than four epochs, I estimated their possible orbital parameters using the sparse RV and the Monte Carlo rejection sampler `The Joker`. Follow-up observations of these sources are needed to robustly determine their true orbital parameters.
7. Combining literature measurements of rotation periods from the *Kepler* K2 mission and other ground-based facilities, I computed the projected radii ($R \sin i$) for 26

sources, including 21 young and 5 field objects. $R \sin i$ shows a general decline with age as expected for pre-degeneracy contraction. The inferred $R \sin i$ s for the Upper Scorpius cluster ($0.53_{-0.15}^{+0.16} R_{\odot}$) and the field objects ($0.15_{-0.06}^{+0.09} R_{\odot}$) are consistent with the Burrows et al. (2001) evolutionary models.

8. I computed the inclinations for a subset of my sample (9 sources) with robust periods and $v \sin i$. I found the Upper Scorpius (3 sources), field objects (3 sources), and the full sample (9 sources) are all consistent with randomly orientated distribution, although the sample size is small.

This work illustrates the need for improvements in the theoretical stellar atmosphere and evolutionary models, particularly for temperatures $\leq 3,500$ K in H -band spectra. While the Sonora models provided better fits in numerous cases compared to BT-Settl models even for earlier spectral types, a better model that has updated opacities across the mid-M to early-L dwarfs will fully utilize the APOGEE spectra to their maximum scientific content, and allow for robust determination of T_{eff} and $\log g$ in addition to RV and $v \sin i$.

4.2 Future Work

The process of measuring and compiling of the largest RV and $v \sin i$ velocity sample for local ultracool dwarfs has revealed several new directions to improve my understanding of kinematics, rotation, and multiplicity of ultracool dwarfs.

First, despite the substantial increase in measurements, high-resolution spectral coverage of ultracool dwarfs is still very incomplete. This sample is largely limited to <20 pc, and remains only partly complete for late-M and L dwarfs, and largely incomplete for T dwarfs. A volume-complete high-resolution spectroscopic sample is necessary to robustly determine ultracool dwarf population statistics with subtype

resolution to clarify features related to brown dwarf evolution. This work requires next-generation high-resolution spectrometer on larger aperture telescopes such as the High resolution Infrared Spectrograph for Exoplanet Characterization (HISPEC; Mawet et al. 2019) on the Thirty Meter Telescope (TMT) or the Immersion Grating Near Infrared Spectrograph (IGNIS) on the W. M. Keck Telescope.

While multi-epoch NIRSPEC and APOGEE observations identified several promising RV binary candidates, I need follow-up high-resolution spectral observations to confirm and characterize these sources and increase the close-in binary sample. RV binaries yield the orbital parameters (periods, eccentricities, and separations) that can be compared to statistics for wider resolved brown dwarf binaries, as well as gas giant extrasolar planets sharing similar temperature ranges and atmospheric properties (Bowler et al. 2020). Binary statistics provide insight into their formation pathways (capture, in-situ formation, tertiary interactions), which also serving as benchmarks for theoretical models and tests of their long-term dynamical stability.

Higher precision wavelength calibration will be essential for identifying very-low mass companions around ultracool dwarfs, pushing into the exoplanet regime. Exoplanets around ultracool dwarfs are starting to be discovered, including the TRAPPIST-1 system (Gillon et al. 2017; transit method) and the Teegarden Star system (Zechmeister et al. 2019; RV method). Examination of the occurrence rate of exoplanets around ultracool dwarfs require more precise and sensitive high-resolution near-infrared spectrometers mounted on large aperture telescopes. For example, the laser frequency comb offers wavelength precision of $\sim 1 \text{ m s}^{-1}$. Such precision can allow me to detect a Neptune mass $17.0 M_{\text{earth}}$ exoplanet orbiting a $0.08 M_{\odot}$ ultracool dwarf host at 0.01 AU.

Improved theoretical atmosphere model grids for low-mass stars and brown dwarfs are also needed. With updated molecular opacities and line lists, the Sonora model has provided significantly better fits for Keck/NIRSPEC T dwarf spectra in *J*-band

(demonstrated in Chapter 2) and late-M and early-L dwarf SDSS/APOGEE spectra in H -band (demonstrated in Chapter 3). However, the Sonora model is limited to its upper T_{eff} ceiling of 2,400 K, hindering comprehensive assessment of associated stellar atmospheric parameters including T_{eff} and $\log g$. Furthermore, the Sonora model does not include clouds, which are especially important for L-type ultracool dwarfs. Even in its applicable temperature regimes, the Sonora model fits show residuals in both CH_4 in J -band (Hsu et al. 2021), and H -band and CO in K -band (Tannock et al. 2022). Retrieval and forward-modeling methods are useful in identifying these missing molecular features and inaccurate molecular opacities.

An important next step for building on the high-resolution kinematic sample is to obtain detailed and precise abundance measurements. Coarse metallicity measurements are possible using low-resolution optical or infrared spectra, but precise and detailed abundances are needed, which can be used to probe different formation environments for single or multiple systems (e.g. C/O and D/H ratios, CO isotopes; Crossfield et al. 2019; Zhang et al. 2021a; Souto et al. 2022) as well as to compare with exoplanets (Mollière & Snellen 2019; Line et al. 2021). Abundance studies on higher mass stars have identified different Galactic populations such as streams (Ji et al. 2020) and dwarf galaxies (Escala et al. 2018), work that can be extended to ultracool dwarfs with sensitive high-resolution spectrometers on larger telescopes and accurate atmosphere models.

Finally, the hundreds of lines and molecular transitions provided by high-resolution spectra offers an opportunity to measure magnetic fields, especially for slow rotators identified in this thesis. With $S/N \sim 200$, detailed line profiles, including pressure, rotation broadening and Zeeman effects can be studied. With possible variability period measurements with light curves and transit surveys (e.g. The Perkins INfrared Exosatellite Survey (PINES) survey; Tamburo et al. 2022), orientations inferred from inclinations can be examined with magnetic emission diagnostics to constrain magnetic field geometries.

For rapid rotators, line profile variability can be used to probe Doppler maps probing magnetic spots and clouds of different heights in the atmosphere. All of the measurements will enrich my understanding of the physical, evolutionary, and statistical properties of the UCD population.

A Minimum $v \sin i$ Determination

In Section 2.2.1, I described my method to determine the minimum $v \sin i$. Here I provide the corresponding diagnostic plots on the minimum $v \sin i$ values as a function of T_{eff} and S/N.

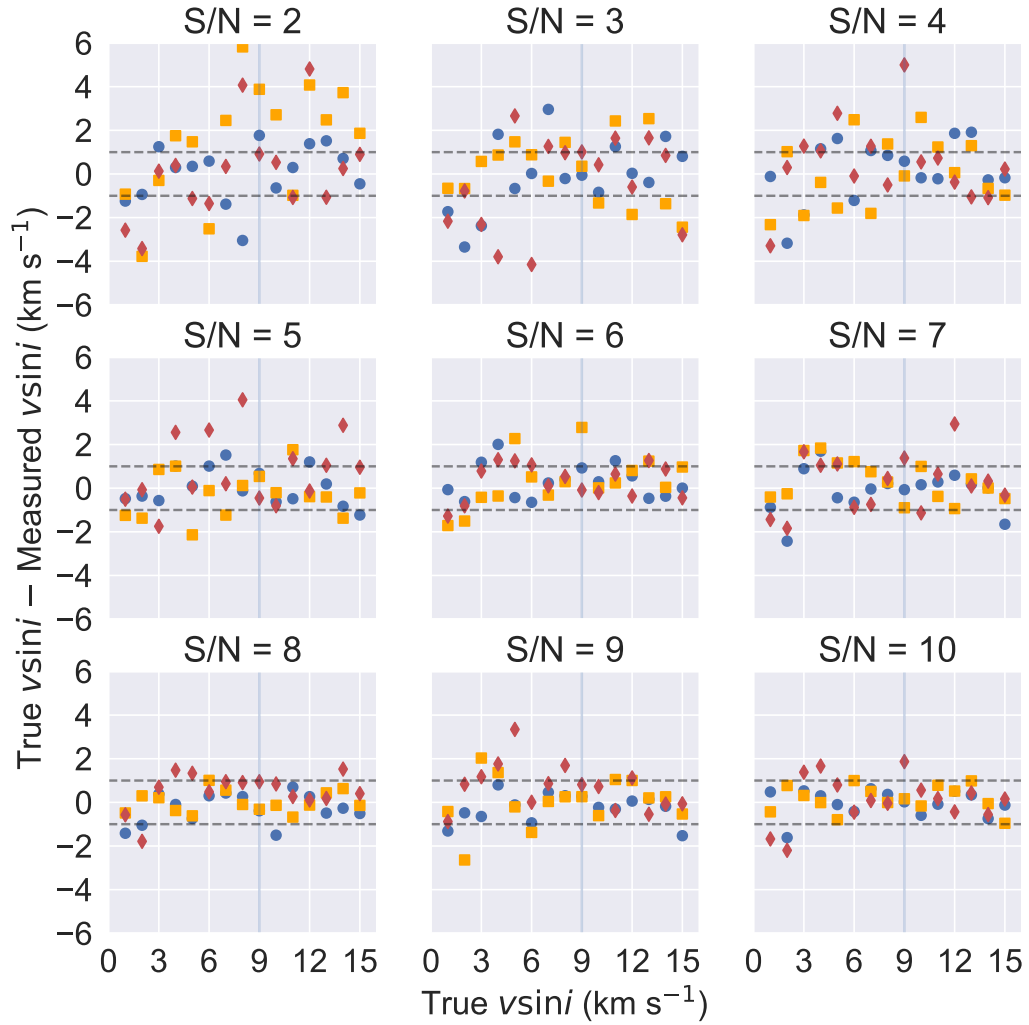


Figure A.1: The difference between true and measured $v \sin i$ compared to true $v \sin i$ values as a function of S/N and T_{eff} for BT-Settl models. The T_{eff} grid points are 900 K (blue), 1200 K (orange), and 1500 K (red). The grey horizontal dash lines represent $v \sin i$ difference = 1 km s^{-1} . The vertical blue line indicates the $v \sin i = 9 \text{ km s}^{-1}$

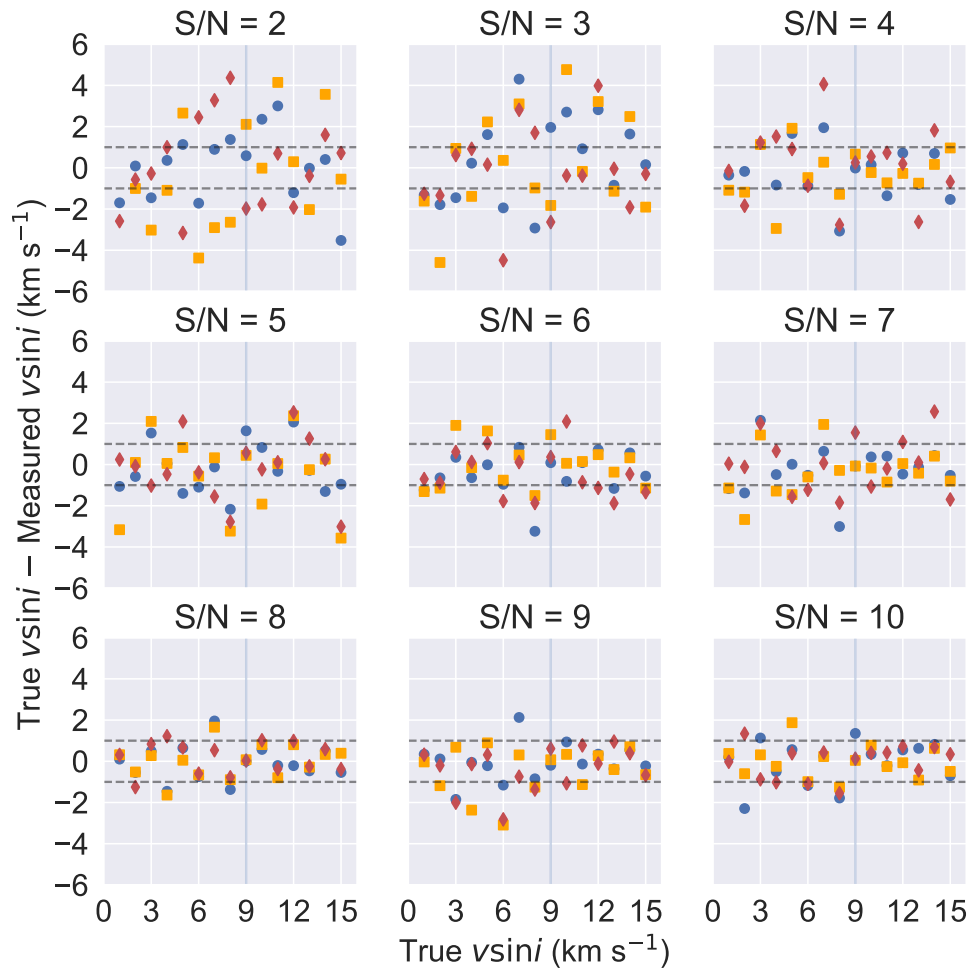


Figure A.2: Same as Figure A.1 for Sonora models.

B Simulated UCD Population Ages Under Different Assumptions

This Appendix supplements the analysis in Section 2.5.4 by providing the full list of parameters and corresponding χ^2 fit values for the population simulation examined. Select visualizations of the age distributions and comparative χ^2 plots are provided in the main text.

Table B.1: Simulated UCD Population Ages Under Different Assumptions

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|--|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| Observations | | | | | | | | |
| ALL SOURCES | | | | | 4.9 ± 0.3 | 7.1 ± 0.4 | 3.5 ± 0.3 | ... |
| NOT THICK DISK ($P(\text{TD})/P(\text{D}) < 10$) | | | | | 4.1 ± 0.3 | 5.8 ± 0.3 | 3.5 ± 0.3 | ... |
| THIN DISK ($P(\text{TD})/P(\text{D}) < 1$) | | | | | 4.1 ± 0.3 | 4.2 ± 0.3 | 3.5 ± 0.3 | ... |
| Simulations | | | | | | | | |
| 9 ^a | uniform | 0.5 | B03 | 0.01 | 4.1 ± 0.8 | 3.1 ± 0.7 | 4.3 ± 1.2 | 2.1 |
| 9 | uniform | 0.5 | B01 | 0.01 | 3.5 ± 0.7 | 3.1 ± 0.6 | 4.2 ± 1.2 | 3.0 |
| 9 | uniform | 0.5 | S08 | 0.01 | 4.3 ± 0.8 | 3.4 ± 0.7 | 4.5 ± 1.2 | 1.7 |
| 9 | uniform | 0.5 | M19 | 0.01 | 1.6 ± 0.3 | 3.1 ± 0.6 | 4.0 ± 1.1 | 42.1 |
| 9 | uniform | 0.5 | P20C | 0.01 | 0.2 ± 0.0 | 2.6 ± 0.5 | 4.2 ± 1.2 | 172.0 |
| 9 | uniform | 0.5 | P20NW | 0.01 | 0.3 ± 0.0 | 2.6 ± 0.6 | 4.3 ± 1.2 | 162.3 |
| 9 | uniform | 0.5 | P20NS | 0.01 | 0.4 ± 0.0 | 2.7 ± 0.6 | 4.1 ± 1.2 | 154.4 |
| 9 | exponential | 0.5 | B03 | 0.01 | 4.5 ± 0.8 | 3.8 ± 0.8 | 4.7 ± 1.2 | 1.3 |
| 9 | exponential | 0.5 | B01 | 0.01 | 3.6 ± 0.6 | 3.7 ± 0.7 | 4.9 ± 1.4 | 1.7 |
| 9 | exponential | 0.5 | S08 | 0.01 | 4.6 ± 0.8 | 4.2 ± 0.8 | 4.8 ± 1.2 | 1.5 |
| 9 | log-normal | 0.5 | B03 | 0.01 | 6.8 ± 1.3 | 6.1 ± 1.0 | 6.5 ± 1.6 | 11.6 |
| 9 | log-normal | 0.5 | B01 | 0.01 | 7.4 ± 1.3 | 6.0 ± 1.0 | 6.2 ± 1.5 | 12.7 |
| 9 | log-normal | 0.5 | S08 | 0.01 | 6.4 ± 1.0 | 6.2 ± 1.1 | 6.4 ± 1.6 | 11.3 |
| 9 | uniform | -1.5 | B03 | 0.01 | 4.1 ± 0.7 | 3.6 ± 0.7 | 5.0 ± 1.3 | 1.5 |
| 9 | uniform | -1.5 | B01 | 0.01 | 3.6 ± 0.7 | 3.7 ± 0.7 | 5.1 ± 1.3 | 2.0 |
| 9 | uniform | -1.5 | S08 | 0.01 | 3.9 ± 0.6 | 3.9 ± 0.7 | 5.3 ± 1.2 | 2.2 |
| 9 | uniform | -0.5 | B03 | 0.01 | 4.0 ± 0.8 | 3.3 ± 0.6 | 5.1 ± 1.4 | 2.7 |
| 9 | uniform | -0.5 | B01 | 0.01 | 4.0 ± 0.8 | 3.2 ± 0.6 | 4.6 ± 1.3 | 2.2 |
| 9 | uniform | -0.5 | S08 | 0.01 | 3.5 ± 0.6 | 3.7 ± 0.7 | 4.7 ± 1.3 | 1.7 |
| 9 | uniform | 1.5 | B03 | 0.01 | 3.8 ± 0.7 | 2.7 ± 0.6 | 3.6 ± 1.0 | 4.7 |
| 9 | uniform | 1.5 | B01 | 0.01 | 3.6 ± 0.6 | 2.4 ± 0.5 | 3.6 ± 1.1 | 8.1 |
| 9 | uniform | 1.5 | S08 | 0.01 | 3.5 ± 0.5 | 2.8 ± 0.6 | 3.6 ± 1.0 | 5.5 |
| 9 ^b | uniform | 0.0/1.0/3.0 | B03 | 0.01 | 4.4 ± 0.9 | 3.8 ± 0.7 | 3.5 ± 1.0 | 0.3 |
| 9 | uniform | 0.0/1.0/3.0 | B01 | 0.01 | 3.6 ± 0.7 | 3.1 ± 0.6 | 4.0 ± 1.1 | 2.6 |
| 9 | uniform | 0.0/1.0/3.0 | S08 | 0.01 | 5.4 ± 1.0 | 3.6 ± 0.7 | 3.8 ± 1.0 | 2.2 |
| 9 ^c | uniform | 1.0/0.0/3.0 | B03 | 0.01 | 3.7 ± 0.7 | 3.8 ± 0.7 | 4.3 ± 1.1 | 0.9 |
| 9 | uniform | 1.0/0.0/3.0 | B01 | 0.01 | 3.1 ± 0.7 | 3.0 ± 0.6 | 4.4 ± 1.2 | 4.9 |
| 9 | uniform | 1.0/0.0/3.0 | S08 | 0.01 | 3.8 ± 0.6 | 3.1 ± 0.6 | 4.8 ± 1.2 | 3.3 |
| 9 | uniform | C03 | B03 | 0.01 | 3.7 ± 0.7 | 2.8 ± 0.6 | 4.1 ± 1.1 | 4.4 |
| 9 | uniform | C03 | B01 | 0.01 | 3.6 ± 0.7 | 2.8 ± 0.6 | 4.0 ± 1.2 | 4.2 |
| 9 | uniform | C03 | S08 | 0.01 | 3.6 ± 0.6 | 2.8 ± 0.6 | 4.2 ± 1.2 | 5.2 |
| 9 | exponential | -1.5 | B03 | 0.01 | 5.2 ± 0.9 | 4.6 ± 0.9 | 5.5 ± 1.4 | 3.3 |
| 9 | exponential | -1.5 | B01 | 0.01 | 4.4 ± 0.8 | 4.8 ± 0.9 | 5.8 ± 1.6 | 2.8 |
| 9 | exponential | -1.5 | S08 | 0.01 | 4.8 ± 0.8 | 4.6 ± 0.8 | 5.2 ± 1.2 | 2.9 |
| 9 | exponential | -0.5 | B03 | 0.01 | 4.5 ± 0.8 | 4.2 ± 0.7 | 5.2 ± 1.5 | 1.5 |
| 9 | exponential | -0.5 | B01 | 0.01 | 4.1 ± 0.8 | 3.9 ± 0.8 | 5.4 ± 1.4 | 1.8 |

Table B.1 (continued)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 9 | exponential | -0.5 | S08 | 0.01 | 4.3 ± 0.8 | 4.4 ± 0.8 | 5.2 ± 1.4 | 1.6 |
| 9 | exponential | 1.5 | B03 | 0.01 | 5.1 ± 0.9 | 3.6 ± 0.7 | 4.2 ± 1.2 | 2.0 |
| 9 | exponential | 1.5 | B01 | 0.01 | 4.7 ± 1.0 | 3.3 ± 0.7 | 4.3 ± 1.2 | 1.9 |
| 9 | exponential | 1.5 | S08 | 0.01 | 4.0 ± 0.5 | 3.8 ± 0.8 | 4.4 ± 1.2 | 0.6 |
| 9 | exponential | 0.0/1.0/3.0 | B03 | 0.01 | 5.3 ± 1.0 | 5.0 ± 0.9 | 4.2 ± 1.2 | 2.5 |
| 9 | exponential | 0.0/1.0/3.0 | B01 | 0.01 | 3.9 ± 0.7 | 3.6 ± 0.7 | 4.5 ± 1.2 | 1.2 |
| 9 | exponential | 0.0/1.0/3.0 | S08 | 0.01 | 5.8 ± 0.9 | 4.2 ± 0.8 | 4.5 ± 1.2 | 3.9 |
| 9 | exponential | 1.0/0.0/3.0 | B03 | 0.01 | 4.2 ± 0.7 | 4.8 ± 0.8 | 5.2 ± 1.3 | 2.3 |
| 9 | exponential | 1.0/0.0/3.0 | B01 | 0.01 | 4.6 ± 1.0 | 3.6 ± 0.7 | 5.1 ± 1.4 | 2.0 |
| 9 | exponential | 1.0/0.0/3.0 | S08 | 0.01 | 4.3 ± 0.8 | 3.8 ± 0.7 | 5.5 ± 1.4 | 2.1 |
| 9 | exponential | C03 | B03 | 0.01 | 4.5 ± 0.9 | 3.8 ± 0.8 | 4.8 ± 1.3 | 1.2 |
| 9 | exponential | C03 | B01 | 0.01 | 3.6 ± 0.7 | 3.2 ± 0.6 | 4.6 ± 1.2 | 2.5 |
| 9 | exponential | C03 | S08 | 0.01 | 4.5 ± 0.7 | 3.9 ± 0.8 | 4.6 ± 1.3 | 1.1 |
| 9 | log-normal | -1.5 | B03 | 0.01 | 7.1 ± 1.2 | 6.2 ± 0.9 | 7.0 ± 1.7 | 14.6 |
| 9 | log-normal | -1.5 | B01 | 0.01 | 6.4 ± 1.1 | 5.8 ± 0.8 | 6.6 ± 1.6 | 11.3 |
| 9 | log-normal | -1.5 | S08 | 0.01 | 7.2 ± 1.0 | 6.9 ± 1.2 | 6.7 ± 1.6 | 17.5 |
| 9 | log-normal | -0.5 | B03 | 0.01 | 6.9 ± 1.2 | 6.0 ± 1.0 | 6.4 ± 1.5 | 11.6 |
| 9 | log-normal | -0.5 | B01 | 0.01 | 6.9 ± 1.2 | 6.0 ± 1.1 | 6.2 ± 1.5 | 11.6 |
| 9 | log-normal | -0.5 | S08 | 0.01 | 7.1 ± 1.1 | 6.0 ± 0.9 | 6.8 ± 1.8 | 14.6 |
| 9 | log-normal | 1.5 | B03 | 0.01 | 6.5 ± 1.0 | 5.7 ± 1.0 | 6.1 ± 1.6 | 10.2 |
| 9 | log-normal | 1.5 | B01 | 0.01 | 5.7 ± 0.8 | 5.1 ± 0.8 | 6.2 ± 1.6 | 7.2 |
| 9 | log-normal | 1.5 | S08 | 0.01 | 5.7 ± 0.8 | 5.6 ± 0.9 | 6.3 ± 1.6 | 8.9 |
| 9 | log-normal | 0.0/1.0/3.0 | B03 | 0.01 | 7.4 ± 1.2 | 6.0 ± 0.9 | 6.1 ± 1.6 | 13.9 |
| 9 | log-normal | 0.0/1.0/3.0 | B01 | 0.01 | 6.3 ± 1.0 | 6.3 ± 1.0 | 6.2 ± 1.5 | 12.0 |
| 9 | log-normal | 0.0/1.0/3.0 | S08 | 0.01 | 6.2 ± 0.9 | 6.3 ± 1.1 | 6.2 ± 1.5 | 11.9 |
| 9 | log-normal | 1.0/0.0/3.0 | B03 | 0.01 | 6.4 ± 1.1 | 6.1 ± 0.9 | 6.4 ± 1.6 | 11.6 |
| 9 | log-normal | 1.0/0.0/3.0 | B01 | 0.01 | 5.7 ± 0.9 | 5.8 ± 1.0 | 6.6 ± 1.8 | 8.4 |
| 9 | log-normal | 1.0/0.0/3.0 | S08 | 0.01 | 6.1 ± 1.0 | 5.8 ± 1.0 | 6.3 ± 1.5 | 10.3 |
| 9 | log-normal | C03 | B03 | 0.01 | 6.5 ± 1.1 | 5.6 ± 0.9 | 6.4 ± 1.6 | 9.6 |
| 9 | log-normal | C03 | B01 | 0.01 | 6.3 ± 1.0 | 5.1 ± 0.8 | 6.2 ± 1.5 | 9.0 |
| 9 | log-normal | C03 | S08 | 0.01 | 6.7 ± 0.8 | 6.1 ± 1.0 | 6.6 ± 1.6 | 15.4 |
| 9 | uniform | -1.5 | B03 | 0.02 | 4.0 ± 0.8 | 3.9 ± 0.7 | 5.0 ± 1.3 | 1.4 |
| 9 | uniform | -1.5 | B03 | 0.03 | 4.0 ± 0.8 | 3.5 ± 0.6 | 5.1 ± 1.3 | 2.3 |
| 9 | uniform | -1.5 | B01 | 0.02 | 3.6 ± 0.7 | 3.9 ± 0.7 | 4.8 ± 1.3 | 1.7 |
| 9 | uniform | -1.5 | B01 | 0.03 | 3.9 ± 0.7 | 4.1 ± 0.7 | 5.2 ± 1.2 | 2.1 |
| 9 | uniform | -1.5 | S08 | 0.02 | 4.1 ± 0.7 | 4.0 ± 0.7 | 5.5 ± 1.4 | 2.0 |
| 9 | uniform | -1.5 | S08 | 0.03 | 3.4 ± 0.6 | 3.6 ± 0.7 | 5.6 ± 1.5 | 3.2 |
| 9 | uniform | 0.5 | B03 | 0.02 | 4.2 ± 0.8 | 3.1 ± 0.6 | 4.9 ± 1.4 | 3.0 |
| 9 | uniform | 0.5 | B03 | 0.03 | 4.0 ± 0.8 | 3.3 ± 0.7 | 5.2 ± 1.4 | 2.5 |
| 9 | uniform | 0.5 | B01 | 0.02 | 3.4 ± 0.7 | 3.1 ± 0.6 | 4.5 ± 1.2 | 3.3 |
| 9 | uniform | 0.5 | B01 | 0.03 | 3.2 ± 0.7 | 3.0 ± 0.6 | 4.7 ± 1.3 | 4.9 |
| 9 | uniform | 0.5 | S08 | 0.02 | 4.1 ± 0.8 | 3.1 ± 0.6 | 4.5 ± 1.2 | 2.4 |
| 9 | uniform | 0.5 | S08 | 0.03 | 3.6 ± 0.7 | 3.3 ± 0.6 | 5.0 ± 1.3 | 3.2 |
| 9 | uniform | -0.5 | B03 | 0.02 | 4.2 ± 0.8 | 3.5 ± 0.7 | 5.0 ± 1.3 | 1.8 |
| 9 | uniform | -0.5 | B03 | 0.03 | 4.2 ± 0.8 | 3.6 ± 0.7 | 5.2 ± 1.3 | 2.1 |
| 9 | uniform | -0.5 | B01 | 0.02 | 3.3 ± 0.7 | 3.5 ± 0.7 | 4.9 ± 1.3 | 2.9 |
| 9 | uniform | -0.5 | B01 | 0.03 | 4.1 ± 0.9 | 3.6 ± 0.8 | 4.9 ± 1.3 | 1.5 |
| 9 | uniform | -0.5 | S08 | 0.02 | 4.0 ± 0.8 | 3.7 ± 0.7 | 4.9 ± 1.3 | 1.5 |
| 9 | uniform | -0.5 | S08 | 0.03 | 3.6 ± 0.6 | 3.8 ± 0.7 | 5.5 ± 1.4 | 2.5 |
| 9 | uniform | 1.5 | B03 | 0.02 | 4.0 ± 0.8 | 2.6 ± 0.6 | 4.3 ± 1.2 | 5.3 |
| 9 | uniform | 1.5 | B03 | 0.03 | 4.1 ± 0.8 | 2.7 ± 0.6 | 4.8 ± 1.3 | 5.8 |
| 9 | uniform | 1.5 | B01 | 0.02 | 3.3 ± 0.7 | 2.5 ± 0.6 | 4.1 ± 1.2 | 7.5 |
| 9 | uniform | 1.5 | B01 | 0.03 | 3.1 ± 0.6 | 2.6 ± 0.6 | 4.7 ± 1.2 | 8.6 |
| 9 | uniform | 1.5 | S08 | 0.02 | 3.3 ± 0.6 | 3.0 ± 0.6 | 4.2 ± 1.2 | 4.4 |
| 9 | uniform | 1.5 | S08 | 0.03 | 4.0 ± 0.8 | 3.0 ± 0.6 | 4.8 ± 1.2 | 3.8 |
| 9 | uniform | 0.0/1.0/3.0 | B03 | 0.02 | 4.5 ± 0.9 | 3.2 ± 0.6 | 4.1 ± 1.1 | 2.1 |
| 9 | uniform | 0.0/1.0/3.0 | B03 | 0.03 | 4.2 ± 0.9 | 3.6 ± 0.7 | 4.4 ± 1.1 | 0.9 |
| 9 | uniform | 0.0/1.0/3.0 | B01 | 0.02 | 3.7 ± 0.8 | 3.1 ± 0.6 | 4.2 ± 1.2 | 2.6 |
| 9 | uniform | 0.0/1.0/3.0 | B01 | 0.03 | 3.3 ± 0.7 | 2.8 ± 0.6 | 4.4 ± 1.2 | 5.9 |
| 9 | uniform | 0.0/1.0/3.0 | S08 | 0.02 | 3.5 ± 0.6 | 3.0 ± 0.6 | 4.3 ± 1.2 | 3.4 |
| 9 | uniform | 0.0/1.0/3.0 | S08 | 0.03 | 4.2 ± 0.8 | 3.2 ± 0.6 | 4.4 ± 1.1 | 2.2 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 9 | uniform | 1.0/0.0/3.0 | B03 | 0.02 | 3.7 ± 0.7 | 3.8 ± 0.7 | 5.2 ± 1.4 | 2.0 |
| 9 | uniform | 1.0/0.0/3.0 | B03 | 0.03 | 3.8 ± 0.8 | 4.0 ± 0.7 | 5.5 ± 1.4 | 2.0 |
| 9 | uniform | 1.0/0.0/3.0 | B01 | 0.02 | 3.0 ± 0.6 | 3.0 ± 0.6 | 4.8 ± 1.3 | 5.8 |
| 9 | uniform | 1.0/0.0/3.0 | B01 | 0.03 | 3.5 ± 0.7 | 3.3 ± 0.7 | 5.4 ± 1.4 | 3.5 |
| 9 | uniform | 1.0/0.0/3.0 | S08 | 0.02 | 3.4 ± 0.6 | 3.4 ± 0.6 | 4.9 ± 1.2 | 3.7 |
| 9 | uniform | 1.0/0.0/3.0 | S08 | 0.03 | 3.8 ± 0.7 | 3.6 ± 0.7 | 5.6 ± 1.4 | 2.6 |
| 9 | uniform | C03 | B03 | 0.02 | 3.6 ± 0.7 | 2.7 ± 0.6 | 4.6 ± 1.2 | 5.7 |
| 9 | uniform | C03 | B03 | 0.03 | 4.0 ± 0.8 | 2.9 ± 0.6 | 5.0 ± 1.3 | 4.4 |
| 9 | uniform | C03 | B01 | 0.02 | 3.5 ± 0.7 | 2.5 ± 0.6 | 4.2 ± 1.2 | 7.6 |
| 9 | uniform | C03 | B01 | 0.03 | 3.2 ± 0.7 | 2.6 ± 0.5 | 4.6 ± 1.2 | 8.6 |
| 9 | uniform | C03 | S08 | 0.02 | 3.2 ± 0.5 | 3.0 ± 0.6 | 4.4 ± 1.2 | 5.0 |
| 9 | uniform | C03 | S08 | 0.03 | 4.2 ± 0.8 | 3.1 ± 0.6 | 5.0 ± 1.3 | 3.7 |
| 9 | exponential | -1.5 | B03 | 0.02 | 4.8 ± 0.9 | 4.5 ± 0.8 | 5.9 ± 1.5 | 3.3 |
| 9 | exponential | -1.5 | B03 | 0.03 | 5.1 ± 1.0 | 4.8 ± 0.8 | 5.5 ± 1.4 | 3.7 |
| 9 | exponential | -1.5 | B01 | 0.02 | 4.7 ± 0.9 | 4.0 ± 0.7 | 5.4 ± 1.3 | 2.4 |
| 9 | exponential | -1.5 | B01 | 0.03 | 3.7 ± 0.6 | 4.3 ± 0.8 | 5.2 ± 1.2 | 2.2 |
| 9 | exponential | -1.5 | S08 | 0.02 | 4.6 ± 0.7 | 4.4 ± 0.8 | 5.3 ± 1.2 | 2.5 |
| 9 | exponential | -1.5 | S08 | 0.03 | 4.2 ± 0.7 | 4.9 ± 0.8 | 5.9 ± 1.5 | 3.4 |
| 9 | exponential | 0.5 | B03 | 0.02 | 4.6 ± 0.9 | 4.2 ± 0.8 | 5.1 ± 1.3 | 1.6 |
| 9 | exponential | 0.5 | B03 | 0.03 | 4.9 ± 1.0 | 3.9 ± 0.8 | 5.4 ± 1.3 | 2.6 |
| 9 | exponential | 0.5 | B01 | 0.02 | 4.5 ± 0.7 | 4.1 ± 0.7 | 5.0 ± 1.4 | 1.4 |
| 9 | exponential | 0.5 | B01 | 0.03 | 4.2 ± 0.9 | 4.0 ± 0.8 | 5.3 ± 1.3 | 1.8 |
| 9 | exponential | 0.5 | S08 | 0.02 | 4.7 ± 0.7 | 4.1 ± 0.8 | 5.3 ± 1.4 | 2.2 |
| 9 | exponential | 0.5 | S08 | 0.03 | 4.5 ± 0.9 | 4.0 ± 0.7 | 5.6 ± 1.4 | 2.4 |
| 9 | exponential | -0.5 | B03 | 0.02 | 4.8 ± 0.9 | 4.5 ± 0.8 | 5.6 ± 1.5 | 2.6 |
| 9 | exponential | -0.5 | B03 | 0.03 | 4.9 ± 1.0 | 4.4 ± 0.8 | 5.5 ± 1.3 | 3.1 |
| 9 | exponential | -0.5 | B01 | 0.02 | 4.0 ± 0.7 | 4.2 ± 0.8 | 5.3 ± 1.4 | 1.5 |
| 9 | exponential | -0.5 | B01 | 0.03 | 4.1 ± 0.8 | 3.8 ± 0.7 | 5.6 ± 1.4 | 2.3 |
| 9 | exponential | -0.5 | S08 | 0.02 | 5.1 ± 0.9 | 4.0 ± 0.7 | 5.2 ± 1.4 | 2.7 |
| 9 | exponential | -0.5 | S08 | 0.03 | 4.5 ± 0.8 | 4.4 ± 0.8 | 6.1 ± 1.6 | 3.1 |
| 9 | exponential | 1.5 | B03 | 0.02 | 4.2 ± 0.8 | 3.5 ± 0.6 | 4.8 ± 1.3 | 1.8 |
| 9 | exponential | 1.5 | B03 | 0.03 | 4.8 ± 0.9 | 3.5 ± 0.8 | 5.3 ± 1.4 | 2.9 |
| 9 | exponential | 1.5 | B01 | 0.02 | 3.6 ± 0.6 | 3.0 ± 0.6 | 4.8 ± 1.3 | 4.4 |
| 9 | exponential | 1.5 | B01 | 0.03 | 4.4 ± 0.8 | 3.3 ± 0.6 | 5.2 ± 1.3 | 3.1 |
| 9 | exponential | 1.5 | S08 | 0.02 | 4.7 ± 0.6 | 3.7 ± 0.7 | 4.8 ± 1.3 | 1.8 |
| 9 | exponential | 1.5 | S08 | 0.03 | 5.5 ± 1.1 | 3.7 ± 0.7 | 5.6 ± 1.5 | 3.8 |
| 9 | exponential | 0.0/1.0/3.0 | B03 | 0.02 | 4.9 ± 0.8 | 4.3 ± 0.8 | 4.6 ± 1.2 | 1.5 |
| 9 | exponential | 0.0/1.0/3.0 | B03 | 0.03 | 4.8 ± 0.9 | 4.2 ± 0.8 | 4.8 ± 1.2 | 1.6 |
| 9 | exponential | 0.0/1.0/3.0 | B01 | 0.02 | 4.2 ± 0.8 | 3.7 ± 0.7 | 4.8 ± 1.3 | 1.3 |
| 9 | exponential | 0.0/1.0/3.0 | B01 | 0.03 | 4.4 ± 0.9 | 3.6 ± 0.7 | 5.3 ± 1.4 | 2.0 |
| 9 | exponential | 0.0/1.0/3.0 | S08 | 0.02 | 5.4 ± 0.9 | 4.0 ± 0.7 | 4.9 ± 1.3 | 2.8 |
| 9 | exponential | 0.0/1.0/3.0 | S08 | 0.03 | 4.7 ± 0.8 | 4.0 ± 0.8 | 5.3 ± 1.4 | 1.9 |
| 9 | exponential | 1.0/0.0/3.0 | B03 | 0.02 | 4.7 ± 0.9 | 4.7 ± 0.8 | 5.6 ± 1.4 | 3.0 |
| 9 | exponential | 1.0/0.0/3.0 | B03 | 0.03 | 4.7 ± 0.8 | 4.9 ± 0.9 | 5.8 ± 1.5 | 3.4 |
| 9 | exponential | 1.0/0.0/3.0 | B01 | 0.02 | 4.2 ± 0.8 | 3.6 ± 0.8 | 5.3 ± 1.3 | 2.3 |
| 9 | exponential | 1.0/0.0/3.0 | B01 | 0.03 | 4.2 ± 0.8 | 3.9 ± 0.7 | 5.5 ± 1.3 | 2.3 |
| 9 | exponential | 1.0/0.0/3.0 | S08 | 0.02 | 4.6 ± 0.8 | 4.1 ± 0.8 | 5.8 ± 1.5 | 2.7 |
| 9 | exponential | 1.0/0.0/3.0 | S08 | 0.03 | 3.7 ± 0.6 | 4.2 ± 0.8 | 6.4 ± 1.6 | 3.7 |
| 9 | exponential | C03 | B03 | 0.02 | 4.4 ± 0.9 | 3.5 ± 0.7 | 4.9 ± 1.3 | 1.9 |
| 9 | exponential | C03 | B03 | 0.03 | 4.6 ± 0.9 | 3.9 ± 0.8 | 5.6 ± 1.4 | 2.4 |
| 9 | exponential | C03 | B01 | 0.02 | 4.8 ± 0.9 | 3.4 ± 0.6 | 5.0 ± 1.4 | 2.5 |
| 9 | exponential | C03 | B01 | 0.03 | 4.3 ± 0.9 | 3.2 ± 0.6 | 5.4 ± 1.4 | 3.2 |
| 9 | exponential | C03 | S08 | 0.02 | 3.4 ± 0.6 | 3.9 ± 0.8 | 5.1 ± 1.3 | 2.7 |
| 9 | exponential | C03 | S08 | 0.03 | 4.5 ± 0.7 | 3.9 ± 0.8 | 5.6 ± 1.4 | 2.4 |
| 9 | log-normal | -1.5 | B03 | 0.02 | 6.6 ± 1.2 | 6.1 ± 1.0 | 6.7 ± 1.6 | 11.8 |
| 9 | log-normal | -1.5 | B03 | 0.03 | 6.5 ± 1.1 | 6.2 ± 1.0 | 6.9 ± 1.7 | 12.0 |
| 9 | log-normal | -1.5 | B01 | 0.02 | 6.6 ± 1.1 | 6.1 ± 1.0 | 6.9 ± 1.6 | 12.3 |
| 9 | log-normal | -1.5 | B01 | 0.03 | 6.2 ± 1.1 | 6.4 ± 1.0 | 6.7 ± 1.7 | 11.2 |
| 9 | log-normal | -1.5 | S08 | 0.02 | 6.9 ± 1.1 | 6.6 ± 1.0 | 6.5 ± 1.5 | 15.9 |
| 9 | log-normal | -1.5 | S08 | 0.03 | 6.7 ± 1.0 | 6.2 ± 1.0 | 6.6 ± 1.6 | 13.8 |
| 9 | log-normal | 0.5 | B03 | 0.02 | 6.8 ± 1.1 | 5.8 ± 0.9 | 6.2 ± 1.5 | 11.8 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 9 | log-normal | 0.5 | B03 | 0.03 | 5.9 ± 0.9 | 6.2 ± 1.0 | 6.9 ± 1.7 | 10.8 |
| 9 | log-normal | 0.5 | B01 | 0.02 | 5.7 ± 0.8 | 5.8 ± 0.9 | 6.3 ± 1.5 | 9.9 |
| 9 | log-normal | 0.5 | B01 | 0.03 | 6.2 ± 1.0 | 6.0 ± 1.0 | 6.6 ± 1.6 | 11.1 |
| 9 | log-normal | 0.5 | S08 | 0.02 | 6.7 ± 1.0 | 6.0 ± 1.0 | 6.6 ± 1.6 | 12.9 |
| 9 | log-normal | 0.5 | S08 | 0.03 | 5.7 ± 0.8 | 6.4 ± 1.1 | 6.6 ± 1.6 | 11.0 |
| 9 | log-normal | -0.5 | B03 | 0.02 | 6.2 ± 1.1 | 6.5 ± 1.0 | 6.6 ± 1.7 | 12.0 |
| 9 | log-normal | -0.5 | B03 | 0.03 | 6.5 ± 1.0 | 6.2 ± 0.9 | 6.6 ± 1.6 | 13.0 |
| 9 | log-normal | -0.5 | B01 | 0.02 | 6.6 ± 1.2 | 6.5 ± 1.1 | 6.5 ± 1.6 | 11.8 |
| 9 | log-normal | -0.5 | B01 | 0.03 | 5.8 ± 0.9 | 6.3 ± 1.0 | 6.9 ± 1.7 | 11.6 |
| 9 | log-normal | -0.5 | S08 | 0.02 | 5.5 ± 0.9 | 6.2 ± 0.9 | 6.4 ± 1.6 | 9.8 |
| 9 | log-normal | -0.5 | S08 | 0.03 | 6.4 ± 1.0 | 6.5 ± 1.2 | 6.8 ± 1.7 | 12.1 |
| 9 | log-normal | 1.5 | B03 | 0.02 | 6.6 ± 1.2 | 5.7 ± 1.0 | 6.2 ± 1.6 | 9.7 |
| 9 | log-normal | 1.5 | B03 | 0.03 | 6.5 ± 1.1 | 5.6 ± 0.9 | 6.8 ± 1.6 | 11.0 |
| 9 | log-normal | 1.5 | B01 | 0.02 | 6.0 ± 1.0 | 6.0 ± 0.9 | 6.3 ± 1.6 | 10.4 |
| 9 | log-normal | 1.5 | B01 | 0.03 | 5.2 ± 0.9 | 5.8 ± 1.0 | 6.4 ± 1.6 | 7.3 |
| 9 | log-normal | 1.5 | S08 | 0.02 | 6.9 ± 1.2 | 5.4 ± 0.9 | 6.2 ± 1.6 | 9.7 |
| 9 | log-normal | 1.5 | S08 | 0.03 | 6.5 ± 1.0 | 6.1 ± 1.0 | 6.8 ± 1.7 | 12.4 |
| 9 | log-normal | 0.0/1.0/3.0 | B03 | 0.02 | 7.0 ± 1.3 | 6.4 ± 1.0 | 6.0 ± 1.5 | 12.3 |
| 9 | log-normal | 0.0/1.0/3.0 | B03 | 0.03 | 6.6 ± 1.1 | 6.7 ± 1.1 | 6.3 ± 1.6 | 12.8 |
| 9 | log-normal | 0.0/1.0/3.0 | B01 | 0.02 | 6.8 ± 1.1 | 5.8 ± 0.8 | 6.0 ± 1.5 | 12.0 |
| 9 | log-normal | 0.0/1.0/3.0 | B01 | 0.03 | 6.0 ± 0.9 | 5.7 ± 1.0 | 6.4 ± 1.6 | 9.0 |
| 9 | log-normal | 0.0/1.0/3.0 | S08 | 0.02 | 5.7 ± 0.9 | 6.1 ± 1.1 | 6.2 ± 1.5 | 9.1 |
| 9 | log-normal | 0.0/1.0/3.0 | S08 | 0.03 | 7.8 ± 1.3 | 5.8 ± 1.0 | 6.6 ± 1.5 | 14.6 |
| 9 | log-normal | 1.0/0.0/3.0 | B03 | 0.02 | 6.2 ± 1.0 | 6.4 ± 1.0 | 6.4 ± 1.6 | 11.6 |
| 9 | log-normal | 1.0/0.0/3.0 | B03 | 0.03 | 6.6 ± 1.1 | 6.8 ± 1.1 | 7.0 ± 1.7 | 14.9 |
| 9 | log-normal | 1.0/0.0/3.0 | B01 | 0.02 | 5.5 ± 0.8 | 5.6 ± 0.9 | 6.5 ± 1.6 | 8.6 |
| 9 | log-normal | 1.0/0.0/3.0 | B01 | 0.03 | 6.4 ± 1.0 | 5.7 ± 0.9 | 7.2 ± 1.8 | 11.5 |
| 9 | log-normal | 1.0/0.0/3.0 | S08 | 0.02 | 6.3 ± 0.9 | 5.8 ± 1.0 | 6.7 ± 1.6 | 11.6 |
| 9 | log-normal | 1.0/0.0/3.0 | S08 | 0.03 | 7.4 ± 1.3 | 6.2 ± 1.0 | 7.0 ± 1.7 | 14.5 |
| 9 | log-normal | C03 | B03 | 0.02 | 6.1 ± 1.1 | 5.4 ± 0.9 | 6.4 ± 1.5 | 8.5 |
| 9 | log-normal | C03 | B03 | 0.03 | 6.3 ± 1.1 | 5.8 ± 1.0 | 6.9 ± 1.7 | 10.2 |
| 9 | log-normal | C03 | B01 | 0.02 | 6.7 ± 1.1 | 5.0 ± 0.8 | 6.5 ± 1.7 | 9.7 |
| 9 | log-normal | C03 | B01 | 0.03 | 6.8 ± 1.2 | 6.0 ± 1.1 | 6.6 ± 1.6 | 11.5 |
| 9 | log-normal | C03 | S08 | 0.02 | 5.6 ± 0.9 | 5.6 ± 0.9 | 6.3 ± 1.6 | 7.9 |
| 9 | log-normal | C03 | S08 | 0.03 | 5.7 ± 0.9 | 5.9 ± 1.0 | 6.8 ± 1.7 | 9.8 |
| 6 | uniform | 0.5 | B03 | 0.01 | 2.8 ± 0.6 | 2.2 ± 0.4 | 3.0 ± 0.8 | 18.1 |
| 6 | uniform | 0.5 | B01 | 0.01 | 1.9 ± 0.4 | 2.4 ± 0.5 | 3.0 ± 0.9 | 28.6 |
| 6 | uniform | 0.5 | S08 | 0.01 | 2.7 ± 0.5 | 2.2 ± 0.5 | 3.0 ± 0.9 | 16.5 |
| 6 | uniform | 0.5 | M19 | 0.01 | 1.2 ± 0.2 | 2.2 ± 0.4 | 2.9 ± 0.8 | 72.8 |
| 6 | uniform | 0.5 | P20C | 0.01 | 0.4 ± 0.0 | 2.0 ± 0.4 | 3.0 ± 0.8 | 164.1 |
| 6 | uniform | 0.5 | P20NW | 0.01 | 0.3 ± 0.0 | 2.0 ± 0.4 | 3.0 ± 0.8 | 173.3 |
| 6 | uniform | 0.5 | P20NS | 0.01 | 0.2 ± 0.0 | 1.8 ± 0.4 | 2.9 ± 0.8 | 189.3 |
| 6 | exponential | 0.5 | B03 | 0.01 | 3.0 ± 0.6 | 2.5 ± 0.5 | 3.2 ± 0.9 | 10.4 |
| 6 | exponential | 0.5 | B01 | 0.01 | 2.6 ± 0.6 | 2.4 ± 0.4 | 3.2 ± 0.9 | 16.2 |
| 6 | exponential | 0.5 | S08 | 0.01 | 3.2 ± 0.6 | 2.7 ± 0.6 | 3.2 ± 0.9 | 6.7 |
| 6 | log-normal | 0.5 | B03 | 0.01 | 3.6 ± 0.6 | 3.2 ± 0.6 | 3.9 ± 1.1 | 2.4 |
| 6 | log-normal | 0.5 | B01 | 0.01 | 3.4 ± 0.6 | 3.2 ± 0.6 | 3.7 ± 1.0 | 3.1 |
| 6 | log-normal | 0.5 | S08 | 0.01 | 3.7 ± 0.7 | 3.3 ± 0.6 | 3.5 ± 0.9 | 1.7 |
| 6 | uniform | -1.5 | B03 | 0.01 | 2.8 ± 0.6 | 2.8 ± 0.5 | 3.8 ± 1.0 | 9.0 |
| 6 | uniform | -1.5 | B01 | 0.01 | 2.5 ± 0.5 | 2.6 ± 0.5 | 3.8 ± 1.1 | 14.2 |
| 6 | uniform | -1.5 | S08 | 0.01 | 2.3 ± 0.4 | 2.7 ± 0.5 | 3.8 ± 1.1 | 17.9 |
| 6 | uniform | -0.5 | B03 | 0.01 | 2.8 ± 0.6 | 2.5 ± 0.5 | 3.4 ± 1.0 | 11.3 |
| 6 | uniform | -0.5 | B01 | 0.01 | 2.1 ± 0.5 | 2.3 ± 0.4 | 3.1 ± 0.9 | 24.7 |
| 6 | uniform | -0.5 | S08 | 0.01 | 2.6 ± 0.5 | 2.8 ± 0.6 | 3.4 ± 0.9 | 10.2 |
| 6 | uniform | 1.5 | B03 | 0.01 | 2.2 ± 0.4 | 1.7 ± 0.4 | 2.5 ± 0.7 | 38.3 |
| 6 | uniform | 1.5 | B01 | 0.01 | 2.4 ± 0.6 | 1.8 ± 0.4 | 2.6 ± 0.8 | 27.5 |
| 6 | uniform | 1.5 | S08 | 0.01 | 1.7 ± 0.4 | 2.0 ± 0.4 | 2.6 ± 0.8 | 44.9 |
| 6 | uniform | 0.0/1.0/3.0 | B03 | 0.01 | 2.9 ± 0.6 | 2.6 ± 0.5 | 2.4 ± 0.7 | 12.5 |
| 6 | uniform | 0.0/1.0/3.0 | B01 | 0.01 | 2.3 ± 0.4 | 2.4 ± 0.5 | 2.6 ± 0.8 | 20.4 |
| 6 | uniform | 0.0/1.0/3.0 | S08 | 0.01 | 3.1 ± 0.6 | 2.3 ± 0.5 | 2.6 ± 0.8 | 12.3 |
| 6 | uniform | 1.0/0.0/3.0 | B03 | 0.01 | 2.4 ± 0.5 | 2.4 ± 0.5 | 3.2 ± 0.8 | 18.1 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 6 | uniform | 1.0/0.0/3.0 | B01 | 0.01 | 2.0 ± 0.4 | 2.2 ± 0.4 | 3.1 ± 0.8 | 31.8 |
| 6 | uniform | 1.0/0.0/3.0 | S08 | 0.01 | 2.1 ± 0.4 | 2.3 ± 0.5 | 3.4 ± 1.0 | 23.8 |
| 6 | uniform | C03 | B03 | 0.01 | 2.4 ± 0.6 | 1.9 ± 0.4 | 2.8 ± 0.8 | 24.7 |
| 6 | uniform | C03 | B01 | 0.01 | 2.0 ± 0.4 | 1.8 ± 0.4 | 2.9 ± 0.8 | 38.7 |
| 6 | uniform | C03 | S08 | 0.01 | 2.4 ± 0.4 | 2.1 ± 0.4 | 3.0 ± 0.9 | 27.3 |
| 6 | exponential | -1.5 | B03 | 0.01 | 2.9 ± 0.6 | 3.0 ± 0.5 | 3.8 ± 0.9 | 6.8 |
| 6 | exponential | -1.5 | B01 | 0.01 | 2.8 ± 0.5 | 2.7 ± 0.5 | 3.9 ± 1.0 | 11.0 |
| 6 | exponential | -1.5 | S08 | 0.01 | 2.6 ± 0.5 | 3.1 ± 0.6 | 4.0 ± 1.0 | 9.0 |
| 6 | exponential | -0.5 | B03 | 0.01 | 3.1 ± 0.6 | 2.8 ± 0.6 | 3.8 ± 1.0 | 6.2 |
| 6 | exponential | -0.5 | B01 | 0.01 | 2.7 ± 0.6 | 2.9 ± 0.6 | 3.4 ± 0.9 | 8.9 |
| 6 | exponential | -0.5 | S08 | 0.01 | 2.7 ± 0.5 | 2.7 ± 0.5 | 3.8 ± 0.9 | 10.7 |
| 6 | exponential | 1.5 | B03 | 0.01 | 2.9 ± 0.5 | 2.1 ± 0.4 | 2.9 ± 0.8 | 20.2 |
| 6 | exponential | 1.5 | B01 | 0.01 | 2.2 ± 0.4 | 1.9 ± 0.4 | 2.7 ± 0.8 | 33.1 |
| 6 | exponential | 1.5 | S08 | 0.01 | 2.5 ± 0.4 | 2.2 ± 0.4 | 2.9 ± 0.9 | 22.8 |
| 6 | exponential | 0.0/1.0/3.0 | B03 | 0.01 | 3.1 ± 0.6 | 3.0 ± 0.6 | 2.7 ± 0.8 | 5.6 |
| 6 | exponential | 0.0/1.0/3.0 | B01 | 0.01 | 2.6 ± 0.5 | 2.4 ± 0.5 | 2.9 ± 0.8 | 16.2 |
| 6 | exponential | 0.0/1.0/3.0 | S08 | 0.01 | 3.6 ± 0.6 | 2.5 ± 0.5 | 2.9 ± 0.8 | 8.5 |
| 6 | exponential | 1.0/0.0/3.0 | B03 | 0.01 | 2.6 ± 0.5 | 2.5 ± 0.5 | 3.6 ± 1.0 | 14.2 |
| 6 | exponential | 1.0/0.0/3.0 | B01 | 0.01 | 2.2 ± 0.4 | 2.5 ± 0.5 | 3.4 ± 0.9 | 18.8 |
| 6 | exponential | 1.0/0.0/3.0 | S08 | 0.01 | 2.9 ± 0.5 | 2.6 ± 0.5 | 3.7 ± 1.0 | 10.3 |
| 6 | exponential | C03 | B03 | 0.01 | 3.1 ± 0.6 | 2.3 ± 0.4 | 3.1 ± 0.9 | 14.1 |
| 6 | exponential | C03 | B01 | 0.01 | 2.3 ± 0.5 | 2.0 ± 0.4 | 3.0 ± 0.8 | 25.3 |
| 6 | exponential | C03 | S08 | 0.01 | 2.9 ± 0.5 | 2.3 ± 0.5 | 3.2 ± 0.9 | 14.8 |
| 6 | log-normal | -1.5 | B03 | 0.01 | 3.8 ± 0.8 | 3.6 ± 0.6 | 4.2 ± 1.0 | 1.1 |
| 6 | log-normal | -1.5 | B01 | 0.01 | 3.5 ± 0.6 | 3.5 ± 0.6 | 4.1 ± 1.0 | 1.9 |
| 6 | log-normal | -1.5 | S08 | 0.01 | 3.5 ± 0.6 | 3.5 ± 0.6 | 4.2 ± 1.0 | 2.0 |
| 6 | log-normal | -0.5 | B03 | 0.01 | 3.7 ± 0.7 | 3.6 ± 0.6 | 4.0 ± 1.1 | 0.9 |
| 6 | log-normal | -0.5 | B01 | 0.01 | 3.4 ± 0.6 | 3.4 ± 0.6 | 4.0 ± 1.0 | 2.7 |
| 6 | log-normal | -0.5 | S08 | 0.01 | 3.6 ± 0.6 | 3.6 ± 0.6 | 4.0 ± 1.0 | 1.3 |
| 6 | log-normal | 1.5 | B03 | 0.01 | 4.1 ± 0.7 | 3.0 ± 0.5 | 3.5 ± 1.0 | 3.0 |
| 6 | log-normal | 1.5 | B01 | 0.01 | 3.2 ± 0.6 | 2.9 ± 0.6 | 3.5 ± 1.0 | 5.1 |
| 6 | log-normal | 1.5 | S08 | 0.01 | 3.7 ± 0.5 | 3.1 ± 0.6 | 3.4 ± 0.9 | 2.8 |
| 6 | log-normal | 0.0/1.0/3.0 | B03 | 0.01 | 3.9 ± 0.7 | 4.0 ± 0.7 | 3.5 ± 0.9 | 0.1 |
| 6 | log-normal | 0.0/1.0/3.0 | B01 | 0.01 | 3.3 ± 0.6 | 3.0 ± 0.6 | 3.7 ± 1.0 | 4.5 |
| 6 | log-normal | 0.0/1.0/3.0 | S08 | 0.01 | 3.8 ± 0.6 | 3.4 ± 0.6 | 3.4 ± 0.9 | 1.1 |
| 6 | log-normal | 1.0/0.0/3.0 | B03 | 0.01 | 3.4 ± 0.6 | 3.5 ± 0.6 | 3.8 ± 1.0 | 1.7 |
| 6 | log-normal | 1.0/0.0/3.0 | B01 | 0.01 | 3.0 ± 0.5 | 2.9 ± 0.5 | 4.1 ± 1.1 | 7.3 |
| 6 | log-normal | 1.0/0.0/3.0 | S08 | 0.01 | 3.0 ± 0.6 | 3.2 ± 0.6 | 4.1 ± 1.0 | 5.2 |
| 6 | log-normal | C03 | B03 | 0.01 | 3.3 ± 0.7 | 3.0 ± 0.6 | 3.8 ± 1.0 | 4.0 |
| 6 | log-normal | C03 | B01 | 0.01 | 3.3 ± 0.5 | 2.8 ± 0.5 | 3.6 ± 1.0 | 6.6 |
| 6 | log-normal | C03 | S08 | 0.01 | 3.8 ± 0.7 | 2.9 ± 0.6 | 3.8 ± 1.0 | 3.5 |
| 6 | uniform | -1.5 | B03 | 0.02 | 2.7 ± 0.6 | 2.7 ± 0.5 | 3.8 ± 1.1 | 10.2 |
| 6 | uniform | -1.5 | B03 | 0.03 | 2.7 ± 0.5 | 2.5 ± 0.4 | 3.6 ± 0.9 | 14.5 |
| 6 | uniform | -1.5 | B01 | 0.02 | 2.4 ± 0.5 | 2.7 ± 0.5 | 3.5 ± 0.9 | 12.8 |
| 6 | uniform | -1.5 | B01 | 0.03 | 2.4 ± 0.5 | 2.7 ± 0.5 | 3.7 ± 0.9 | 16.0 |
| 6 | uniform | -1.5 | S08 | 0.02 | 2.6 ± 0.5 | 2.7 ± 0.5 | 3.5 ± 0.9 | 12.2 |
| 6 | uniform | -1.5 | S08 | 0.03 | 3.0 ± 0.5 | 2.8 ± 0.5 | 3.6 ± 0.9 | 8.6 |
| 6 | uniform | 0.5 | B03 | 0.02 | 2.7 ± 0.6 | 2.3 ± 0.5 | 3.4 ± 0.9 | 15.8 |
| 6 | uniform | 0.5 | B03 | 0.03 | 2.6 ± 0.5 | 2.3 ± 0.5 | 3.4 ± 0.9 | 16.1 |
| 6 | uniform | 0.5 | B01 | 0.02 | 2.0 ± 0.5 | 2.2 ± 0.5 | 3.3 ± 0.9 | 25.3 |
| 6 | uniform | 0.5 | B01 | 0.03 | 2.3 ± 0.5 | 2.2 ± 0.5 | 3.4 ± 0.9 | 22.6 |
| 6 | uniform | 0.5 | S08 | 0.02 | 2.2 ± 0.4 | 2.2 ± 0.5 | 3.6 ± 0.9 | 24.4 |
| 6 | uniform | 0.5 | S08 | 0.03 | 2.1 ± 0.4 | 2.2 ± 0.4 | 3.6 ± 0.9 | 28.8 |
| 6 | uniform | -0.5 | B03 | 0.02 | 2.7 ± 0.5 | 2.3 ± 0.5 | 3.6 ± 0.9 | 15.5 |
| 6 | uniform | -0.5 | B03 | 0.03 | 2.8 ± 0.6 | 2.6 ± 0.5 | 3.5 ± 0.8 | 10.4 |
| 6 | uniform | -0.5 | B01 | 0.02 | 2.4 ± 0.5 | 2.4 ± 0.5 | 3.6 ± 1.0 | 17.4 |
| 6 | uniform | -0.5 | B01 | 0.03 | 2.4 ± 0.5 | 2.6 ± 0.5 | 3.6 ± 1.0 | 16.7 |
| 6 | uniform | -0.5 | S08 | 0.02 | 2.3 ± 0.4 | 2.6 ± 0.5 | 3.4 ± 0.9 | 17.6 |
| 6 | uniform | -0.5 | S08 | 0.03 | 2.9 ± 0.6 | 2.6 ± 0.5 | 3.5 ± 1.0 | 10.0 |
| 6 | uniform | 1.5 | B03 | 0.02 | 2.6 ± 0.5 | 2.0 ± 0.4 | 3.1 ± 0.8 | 23.4 |
| 6 | uniform | 1.5 | B03 | 0.03 | 2.6 ± 0.6 | 2.0 ± 0.4 | 3.4 ± 0.9 | 21.5 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 6 | uniform | 1.5 | B01 | 0.02 | 2.5 ± 0.6 | 1.7 ± 0.4 | 3.0 ± 0.9 | 31.5 |
| 6 | uniform | 1.5 | B01 | 0.03 | 1.7 ± 0.4 | 1.9 ± 0.4 | 3.4 ± 0.9 | 44.0 |
| 6 | uniform | 1.5 | S08 | 0.02 | 2.1 ± 0.4 | 2.0 ± 0.4 | 3.1 ± 0.9 | 32.7 |
| 6 | uniform | 1.5 | S08 | 0.03 | 2.3 ± 0.5 | 2.1 ± 0.5 | 3.6 ± 1.0 | 23.2 |
| 6 | uniform | 0.0/1.0/3.0 | B03 | 0.02 | 2.8 ± 0.6 | 2.3 ± 0.5 | 2.6 ± 0.7 | 15.5 |
| 6 | uniform | 0.0/1.0/3.0 | B03 | 0.03 | 2.8 ± 0.6 | 2.3 ± 0.4 | 2.9 ± 0.8 | 15.0 |
| 6 | uniform | 0.0/1.0/3.0 | B01 | 0.02 | 2.6 ± 0.6 | 2.3 ± 0.5 | 2.7 ± 0.7 | 16.4 |
| 6 | uniform | 0.0/1.0/3.0 | B01 | 0.03 | 2.3 ± 0.5 | 2.1 ± 0.4 | 3.0 ± 0.8 | 25.0 |
| 6 | uniform | 0.0/1.0/3.0 | S08 | 0.02 | 2.7 ± 0.5 | 2.2 ± 0.5 | 2.9 ± 0.8 | 17.6 |
| 6 | uniform | 0.0/1.0/3.0 | S08 | 0.03 | 2.2 ± 0.4 | 2.3 ± 0.4 | 3.2 ± 0.8 | 24.3 |
| 6 | uniform | 1.0/0.0/3.0 | B03 | 0.02 | 2.8 ± 0.6 | 2.7 ± 0.5 | 3.5 ± 1.0 | 9.2 |
| 6 | uniform | 1.0/0.0/3.0 | B03 | 0.03 | 2.8 ± 0.6 | 3.0 ± 0.6 | 3.6 ± 0.9 | 6.7 |
| 6 | uniform | 1.0/0.0/3.0 | B01 | 0.02 | 2.2 ± 0.5 | 2.1 ± 0.4 | 3.5 ± 0.9 | 28.3 |
| 6 | uniform | 1.0/0.0/3.0 | B01 | 0.03 | 1.9 ± 0.4 | 2.5 ± 0.5 | 3.7 ± 1.0 | 27.0 |
| 6 | uniform | 1.0/0.0/3.0 | S08 | 0.02 | 2.0 ± 0.4 | 2.3 ± 0.4 | 3.7 ± 1.0 | 28.1 |
| 6 | uniform | 1.0/0.0/3.0 | S08 | 0.03 | 2.8 ± 0.6 | 2.2 ± 0.4 | 3.9 ± 1.0 | 16.4 |
| 6 | uniform | C03 | B03 | 0.02 | 2.5 ± 0.5 | 2.0 ± 0.5 | 3.2 ± 0.8 | 22.6 |
| 6 | uniform | C03 | B03 | 0.03 | 2.6 ± 0.6 | 2.2 ± 0.4 | 3.3 ± 0.9 | 18.2 |
| 6 | uniform | C03 | B01 | 0.02 | 1.9 ± 0.4 | 1.8 ± 0.4 | 3.2 ± 0.9 | 39.4 |
| 6 | uniform | C03 | B01 | 0.03 | 2.2 ± 0.4 | 1.9 ± 0.4 | 3.4 ± 0.9 | 31.1 |
| 6 | uniform | C03 | S08 | 0.02 | 2.2 ± 0.4 | 2.1 ± 0.5 | 3.4 ± 0.9 | 26.9 |
| 6 | uniform | C03 | S08 | 0.03 | 2.2 ± 0.4 | 2.2 ± 0.5 | 3.6 ± 0.9 | 24.9 |
| 6 | exponential | -1.5 | B03 | 0.02 | 2.9 ± 0.6 | 2.9 ± 0.5 | 3.5 ± 0.9 | 8.2 |
| 6 | exponential | -1.5 | B03 | 0.03 | 2.9 ± 0.6 | 3.2 ± 0.6 | 4.2 ± 1.1 | 5.7 |
| 6 | exponential | -1.5 | B01 | 0.02 | 2.7 ± 0.5 | 3.0 ± 0.5 | 3.6 ± 0.9 | 9.7 |
| 6 | exponential | -1.5 | B01 | 0.03 | 2.9 ± 0.6 | 3.0 ± 0.5 | 3.5 ± 0.8 | 6.6 |
| 6 | exponential | -1.5 | S08 | 0.02 | 2.9 ± 0.6 | 3.0 ± 0.6 | 3.9 ± 0.9 | 6.3 |
| 6 | exponential | -1.5 | S08 | 0.03 | 3.1 ± 0.6 | 2.8 ± 0.5 | 4.2 ± 1.1 | 7.1 |
| 6 | exponential | 0.5 | B03 | 0.02 | 3.0 ± 0.6 | 2.6 ± 0.5 | 3.6 ± 1.0 | 9.1 |
| 6 | exponential | 0.5 | B03 | 0.03 | 3.0 ± 0.6 | 2.7 ± 0.5 | 3.6 ± 0.9 | 8.0 |
| 6 | exponential | 0.5 | B01 | 0.02 | 2.4 ± 0.5 | 2.3 ± 0.5 | 3.4 ± 1.0 | 18.2 |
| 6 | exponential | 0.5 | B01 | 0.03 | 2.3 ± 0.5 | 2.7 ± 0.6 | 3.5 ± 0.9 | 15.4 |
| 6 | exponential | 0.5 | S08 | 0.02 | 2.7 ± 0.5 | 2.6 ± 0.6 | 3.5 ± 1.0 | 11.2 |
| 6 | exponential | 0.5 | S08 | 0.03 | 2.6 ± 0.5 | 2.6 ± 0.5 | 3.8 ± 1.0 | 14.3 |
| 6 | exponential | -0.5 | B03 | 0.02 | 3.2 ± 0.6 | 2.7 ± 0.5 | 3.5 ± 0.9 | 6.6 |
| 6 | exponential | -0.5 | B03 | 0.03 | 3.0 ± 0.6 | 2.9 ± 0.6 | 3.9 ± 1.0 | 6.5 |
| 6 | exponential | -0.5 | B01 | 0.02 | 2.7 ± 0.5 | 2.6 ± 0.5 | 3.7 ± 1.0 | 13.4 |
| 6 | exponential | -0.5 | B01 | 0.03 | 2.4 ± 0.5 | 2.6 ± 0.4 | 3.7 ± 0.9 | 17.0 |
| 6 | exponential | -0.5 | S08 | 0.02 | 2.6 ± 0.4 | 2.8 ± 0.6 | 3.9 ± 1.0 | 11.9 |
| 6 | exponential | -0.5 | S08 | 0.03 | 2.9 ± 0.6 | 3.1 ± 0.6 | 3.8 ± 1.0 | 5.5 |
| 6 | exponential | 1.5 | B03 | 0.02 | 2.8 ± 0.5 | 2.2 ± 0.5 | 3.5 ± 1.0 | 16.2 |
| 6 | exponential | 1.5 | B03 | 0.03 | 3.0 ± 0.6 | 2.5 ± 0.5 | 3.7 ± 1.0 | 9.9 |
| 6 | exponential | 1.5 | B01 | 0.02 | 2.6 ± 0.5 | 2.3 ± 0.5 | 3.3 ± 0.9 | 16.9 |
| 6 | exponential | 1.5 | B01 | 0.03 | 2.4 ± 0.5 | 2.2 ± 0.4 | 3.7 ± 0.9 | 21.7 |
| 6 | exponential | 1.5 | S08 | 0.02 | 2.7 ± 0.5 | 2.3 ± 0.5 | 3.4 ± 0.9 | 16.1 |
| 6 | exponential | 1.5 | S08 | 0.03 | 2.6 ± 0.4 | 2.4 ± 0.5 | 3.7 ± 0.9 | 16.3 |
| 6 | exponential | 0.0/1.0/3.0 | B03 | 0.02 | 3.1 ± 0.5 | 2.8 ± 0.5 | 3.0 ± 0.8 | 7.6 |
| 6 | exponential | 0.0/1.0/3.0 | B03 | 0.03 | 3.3 ± 0.7 | 2.7 ± 0.5 | 3.4 ± 0.9 | 6.6 |
| 6 | exponential | 0.0/1.0/3.0 | B01 | 0.02 | 2.5 ± 0.5 | 2.6 ± 0.5 | 3.2 ± 0.9 | 15.2 |
| 6 | exponential | 0.0/1.0/3.0 | B01 | 0.03 | 2.6 ± 0.5 | 2.3 ± 0.5 | 3.4 ± 0.9 | 15.9 |
| 6 | exponential | 0.0/1.0/3.0 | S08 | 0.02 | 2.6 ± 0.5 | 2.4 ± 0.4 | 3.2 ± 0.9 | 18.2 |
| 6 | exponential | 0.0/1.0/3.0 | S08 | 0.03 | 2.8 ± 0.5 | 2.5 ± 0.5 | 3.5 ± 0.8 | 12.6 |
| 6 | exponential | 1.0/0.0/3.0 | B03 | 0.02 | 2.9 ± 0.6 | 2.9 ± 0.5 | 3.9 ± 1.1 | 7.4 |
| 6 | exponential | 1.0/0.0/3.0 | B03 | 0.03 | 3.1 ± 0.6 | 3.1 ± 0.6 | 4.1 ± 1.1 | 4.4 |
| 6 | exponential | 1.0/0.0/3.0 | B01 | 0.02 | 2.3 ± 0.5 | 2.7 ± 0.5 | 3.6 ± 0.9 | 16.1 |
| 6 | exponential | 1.0/0.0/3.0 | B01 | 0.03 | 2.6 ± 0.5 | 2.7 ± 0.5 | 4.0 ± 1.0 | 11.8 |
| 6 | exponential | 1.0/0.0/3.0 | S08 | 0.02 | 2.7 ± 0.5 | 2.6 ± 0.5 | 3.9 ± 1.0 | 11.9 |
| 6 | exponential | 1.0/0.0/3.0 | S08 | 0.03 | 2.7 ± 0.5 | 2.9 ± 0.6 | 4.1 ± 1.0 | 9.6 |
| 6 | exponential | C03 | B03 | 0.02 | 2.8 ± 0.6 | 2.4 ± 0.5 | 3.4 ± 0.9 | 13.1 |
| 6 | exponential | C03 | B03 | 0.03 | 2.9 ± 0.6 | 2.2 ± 0.4 | 3.6 ± 1.0 | 16.3 |
| 6 | exponential | C03 | B01 | 0.02 | 2.7 ± 0.5 | 2.3 ± 0.5 | 3.4 ± 0.9 | 17.1 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 6 | exponential | C03 | B01 | 0.03 | 2.4 ± 0.5 | 2.5 ± 0.5 | 3.8 ± 1.0 | 16.3 |
| 6 | exponential | C03 | S08 | 0.02 | 2.4 ± 0.6 | 2.4 ± 0.5 | 3.5 ± 0.9 | 15.6 |
| 6 | exponential | C03 | S08 | 0.03 | 3.0 ± 0.6 | 2.7 ± 0.5 | 4.0 ± 1.0 | 8.5 |
| 6 | log-normal | -1.5 | B03 | 0.02 | 4.0 ± 0.7 | 3.4 ± 0.6 | 4.5 ± 1.1 | 1.8 |
| 6 | log-normal | -1.5 | B03 | 0.03 | 3.6 ± 0.6 | 3.6 ± 0.7 | 4.4 ± 1.1 | 1.7 |
| 6 | log-normal | -1.5 | B01 | 0.02 | 3.5 ± 0.6 | 3.5 ± 0.6 | 4.1 ± 1.0 | 2.3 |
| 6 | log-normal | -1.5 | B01 | 0.03 | 3.4 ± 0.6 | 3.7 ± 0.6 | 4.3 ± 1.1 | 2.1 |
| 6 | log-normal | -1.5 | S08 | 0.02 | 3.2 ± 0.6 | 3.6 ± 0.6 | 4.1 ± 1.0 | 2.5 |
| 6 | log-normal | -1.5 | S08 | 0.03 | 3.1 ± 0.6 | 4.0 ± 0.7 | 4.1 ± 1.0 | 2.7 |
| 6 | log-normal | 0.5 | B03 | 0.02 | 3.5 ± 0.6 | 3.4 ± 0.6 | 4.2 ± 1.1 | 2.4 |
| 6 | log-normal | 0.5 | B03 | 0.03 | 3.7 ± 0.8 | 3.5 ± 0.7 | 4.0 ± 1.0 | 1.2 |
| 6 | log-normal | 0.5 | B01 | 0.02 | 3.7 ± 0.7 | 3.0 ± 0.6 | 3.9 ± 1.0 | 3.3 |
| 6 | log-normal | 0.5 | B01 | 0.03 | 3.3 ± 0.6 | 3.4 ± 0.6 | 4.1 ± 1.0 | 3.1 |
| 6 | log-normal | 0.5 | S08 | 0.02 | 4.2 ± 0.8 | 3.3 ± 0.6 | 4.0 ± 1.1 | 1.7 |
| 6 | log-normal | 0.5 | S08 | 0.03 | 3.6 ± 0.6 | 3.2 ± 0.6 | 4.1 ± 1.0 | 2.6 |
| 6 | log-normal | -0.5 | B03 | 0.02 | 3.5 ± 0.7 | 3.6 ± 0.6 | 4.0 ± 1.0 | 1.5 |
| 6 | log-normal | -0.5 | B03 | 0.03 | 3.9 ± 0.7 | 3.3 ± 0.6 | 4.1 ± 1.0 | 1.9 |
| 6 | log-normal | -0.5 | B01 | 0.02 | 3.1 ± 0.6 | 3.0 ± 0.5 | 4.2 ± 1.1 | 5.7 |
| 6 | log-normal | -0.5 | B01 | 0.03 | 3.8 ± 0.7 | 3.3 ± 0.6 | 4.3 ± 1.1 | 2.1 |
| 6 | log-normal | -0.5 | S08 | 0.02 | 3.6 ± 0.6 | 3.6 ± 0.6 | 4.1 ± 1.0 | 1.4 |
| 6 | log-normal | -0.5 | S08 | 0.03 | 4.1 ± 0.7 | 3.5 ± 0.6 | 4.2 ± 1.0 | 1.2 |
| 6 | log-normal | 1.5 | B03 | 0.02 | 4.0 ± 0.8 | 3.0 ± 0.6 | 3.8 ± 0.9 | 3.1 |
| 6 | log-normal | 1.5 | B03 | 0.03 | 3.8 ± 0.7 | 3.1 ± 0.6 | 4.0 ± 1.0 | 2.4 |
| 6 | log-normal | 1.5 | B01 | 0.02 | 3.1 ± 0.5 | 2.7 ± 0.5 | 3.7 ± 1.0 | 7.9 |
| 6 | log-normal | 1.5 | B01 | 0.03 | 3.3 ± 0.6 | 2.8 ± 0.5 | 4.3 ± 1.1 | 6.2 |
| 6 | log-normal | 1.5 | S08 | 0.02 | 3.8 ± 0.6 | 3.1 ± 0.5 | 3.9 ± 1.0 | 2.9 |
| 6 | log-normal | 1.5 | S08 | 0.03 | 3.6 ± 0.6 | 3.2 ± 0.6 | 4.0 ± 1.0 | 2.6 |
| 6 | log-normal | 0.0/1.0/3.0 | B03 | 0.02 | 3.6 ± 0.7 | 3.3 ± 0.6 | 3.5 ± 1.0 | 1.9 |
| 6 | log-normal | 0.0/1.0/3.0 | B03 | 0.03 | 3.7 ± 0.6 | 3.4 ± 0.6 | 3.6 ± 1.0 | 1.6 |
| 6 | log-normal | 0.0/1.0/3.0 | B01 | 0.02 | 3.5 ± 0.6 | 2.9 ± 0.5 | 3.7 ± 1.0 | 4.6 |
| 6 | log-normal | 0.0/1.0/3.0 | B01 | 0.03 | 3.1 ± 0.6 | 2.8 ± 0.5 | 4.1 ± 1.1 | 7.0 |
| 6 | log-normal | 0.0/1.0/3.0 | S08 | 0.02 | 3.9 ± 0.7 | 3.4 ± 0.6 | 3.6 ± 1.0 | 1.2 |
| 6 | log-normal | 0.0/1.0/3.0 | S08 | 0.03 | 3.5 ± 0.6 | 3.2 ± 0.6 | 3.8 ± 1.0 | 2.8 |
| 6 | log-normal | 1.0/0.0/3.0 | B03 | 0.02 | 3.5 ± 0.6 | 3.5 ± 0.6 | 4.1 ± 1.0 | 1.9 |
| 6 | log-normal | 1.0/0.0/3.0 | B03 | 0.03 | 3.7 ± 0.6 | 4.0 ± 0.8 | 4.6 ± 1.1 | 1.1 |
| 6 | log-normal | 1.0/0.0/3.0 | B01 | 0.02 | 2.9 ± 0.5 | 3.2 ± 0.6 | 4.1 ± 1.1 | 6.4 |
| 6 | log-normal | 1.0/0.0/3.0 | B01 | 0.03 | 2.9 ± 0.6 | 3.3 ± 0.6 | 4.5 ± 1.1 | 5.4 |
| 6 | log-normal | 1.0/0.0/3.0 | S08 | 0.02 | 3.4 ± 0.6 | 3.3 ± 0.6 | 4.3 ± 1.1 | 3.4 |
| 6 | log-normal | 1.0/0.0/3.0 | S08 | 0.03 | 3.3 ± 0.5 | 3.4 ± 0.6 | 4.4 ± 1.1 | 3.8 |
| 6 | log-normal | C03 | B03 | 0.02 | 3.6 ± 0.6 | 2.9 ± 0.6 | 3.9 ± 1.0 | 4.1 |
| 6 | log-normal | C03 | B03 | 0.03 | 3.3 ± 0.7 | 3.1 ± 0.6 | 4.1 ± 1.1 | 3.4 |
| 6 | log-normal | C03 | B01 | 0.02 | 2.7 ± 0.5 | 2.9 ± 0.6 | 3.7 ± 1.0 | 9.8 |
| 6 | log-normal | C03 | B01 | 0.03 | 3.3 ± 0.6 | 2.9 ± 0.5 | 4.1 ± 1.1 | 5.7 |
| 6 | log-normal | C03 | S08 | 0.02 | 2.9 ± 0.5 | 3.2 ± 0.6 | 4.0 ± 1.1 | 6.8 |
| 6 | log-normal | C03 | S08 | 0.03 | 3.5 ± 0.6 | 3.1 ± 0.6 | 4.2 ± 1.1 | 3.5 |
| 12 | uniform | 0.5 | B03 | 0.01 | 4.4 ± 0.9 | 3.2 ± 0.6 | 4.7 ± 1.3 | 2.5 |
| 12 | uniform | 0.5 | B01 | 0.01 | 4.2 ± 0.9 | 3.3 ± 0.6 | 4.4 ± 1.3 | 1.7 |
| 12 | uniform | 0.5 | S08 | 0.01 | 3.6 ± 0.7 | 3.7 ± 0.8 | 4.7 ± 1.2 | 1.4 |
| 12 | uniform | 0.5 | M19 | 0.01 | 2.7 ± 0.4 | 3.8 ± 0.7 | 5.4 ± 1.4 | 10.4 |
| 12 | uniform | 0.5 | P20C | 0.01 | 0.3 ± 0.1 | 2.9 ± 0.6 | 4.7 ± 1.3 | 153.5 |
| 12 | uniform | 0.5 | P20NW | 0.01 | 0.3 ± 0.1 | 2.8 ± 0.6 | 4.7 ± 1.3 | 150.0 |
| 12 | uniform | 0.5 | P20NS | 0.01 | 0.3 ± 0.1 | 2.7 ± 0.6 | 4.7 ± 1.3 | 153.4 |
| 12 | exponential | 0.5 | B03 | 0.01 | 5.5 ± 1.1 | 4.3 ± 0.7 | 5.4 ± 1.5 | 3.3 |
| 12 | exponential | 0.5 | B01 | 0.01 | 4.2 ± 0.8 | 4.4 ± 0.8 | 5.6 ± 1.4 | 2.2 |
| 12 | exponential | 0.5 | S08 | 0.01 | 4.7 ± 0.7 | 4.2 ± 0.8 | 5.3 ± 1.4 | 2.3 |
| 12 | log-normal | 0.5 | B03 | 0.01 | 7.3 ± 0.9 | 6.4 ± 0.8 | 7.3 ± 1.8 | 23.8 |
| 12 | log-normal | 0.5 | B01 | 0.01 | 7.3 ± 0.4 | 7.3 ± 0.8 | 7.6 ± 1.8 | 66.0 |
| 12 | log-normal | 0.5 | S08 | 0.01 | 7.1 ± 1.0 | 7.0 ± 1.1 | 7.3 ± 1.9 | 19.2 |
| 12 | uniform | -1.5 | B03 | 0.01 | 4.3 ± 0.8 | 4.3 ± 0.7 | 5.5 ± 1.4 | 2.0 |
| 12 | uniform | -1.5 | B01 | 0.01 | 5.0 ± 1.0 | 4.4 ± 0.8 | 5.4 ± 1.3 | 3.0 |
| 12 | uniform | -1.5 | S08 | 0.01 | 4.7 ± 0.8 | 4.2 ± 0.8 | 5.7 ± 1.5 | 2.5 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 12 | uniform | -0.5 | B03 | 0.01 | 4.3 ± 0.8 | 3.6 ± 0.6 | 5.1 ± 1.3 | 1.9 |
| 12 | uniform | -0.5 | B01 | 0.01 | 3.8 ± 0.8 | 3.8 ± 0.7 | 4.8 ± 1.2 | 1.3 |
| 12 | uniform | -0.5 | S08 | 0.01 | 4.7 ± 1.0 | 4.0 ± 0.7 | 5.2 ± 1.3 | 2.2 |
| 12 | uniform | 1.5 | B03 | 0.01 | 4.4 ± 0.8 | 3.0 ± 0.6 | 3.8 ± 1.1 | 2.7 |
| 12 | uniform | 1.5 | B01 | 0.01 | 2.9 ± 0.5 | 3.1 ± 0.6 | 3.8 ± 1.1 | 6.7 |
| 12 | uniform | 1.5 | S08 | 0.01 | 3.1 ± 0.4 | 2.9 ± 0.6 | 4.0 ± 1.2 | 6.4 |
| 12 | uniform | 0.0/1.0/3.0 | B03 | 0.01 | 4.7 ± 0.9 | 4.2 ± 0.8 | 4.1 ± 1.2 | 0.7 |
| 12 | uniform | 0.0/1.0/3.0 | B01 | 0.01 | 4.1 ± 0.8 | 2.9 ± 0.7 | 4.4 ± 1.3 | 2.8 |
| 12 | uniform | 0.0/1.0/3.0 | S08 | 0.01 | 3.7 ± 0.6 | 3.4 ± 0.7 | 4.2 ± 1.1 | 1.5 |
| 12 | uniform | 1.0/0.0/3.0 | B03 | 0.01 | 4.0 ± 0.7 | 4.3 ± 0.8 | 4.6 ± 1.3 | 0.8 |
| 12 | uniform | 1.0/0.0/3.0 | B01 | 0.01 | 4.0 ± 0.9 | 3.2 ± 0.6 | 5.0 ± 1.4 | 3.0 |
| 12 | uniform | 1.0/0.0/3.0 | S08 | 0.01 | 3.7 ± 0.6 | 3.6 ± 0.7 | 5.2 ± 1.3 | 2.2 |
| 12 | uniform | C03 | B03 | 0.01 | 4.4 ± 0.8 | 3.2 ± 0.7 | 4.8 ± 1.4 | 2.3 |
| 12 | uniform | C03 | B01 | 0.01 | 4.2 ± 0.9 | 2.9 ± 0.6 | 4.4 ± 1.3 | 3.7 |
| 12 | uniform | C03 | S08 | 0.01 | 3.9 ± 0.6 | 3.4 ± 0.7 | 4.4 ± 1.3 | 1.3 |
| 12 | exponential | -1.5 | B03 | 0.01 | 5.5 ± 1.0 | 5.0 ± 0.8 | 6.2 ± 1.5 | 6.1 |
| 12 | exponential | -1.5 | B01 | 0.01 | 5.3 ± 0.9 | 4.8 ± 0.9 | 6.3 ± 1.5 | 5.7 |
| 12 | exponential | -1.5 | S08 | 0.01 | 5.5 ± 0.8 | 5.0 ± 0.9 | 7.0 ± 1.6 | 8.2 |
| 12 | exponential | -0.5 | B03 | 0.01 | 5.9 ± 1.1 | 4.7 ± 0.9 | 5.6 ± 1.4 | 5.0 |
| 12 | exponential | -0.5 | B01 | 0.01 | 6.0 ± 1.0 | 4.8 ± 0.8 | 6.5 ± 1.7 | 6.9 |
| 12 | exponential | -0.5 | S08 | 0.01 | 4.7 ± 0.7 | 4.4 ± 0.7 | 5.8 ± 1.4 | 3.2 |
| 12 | exponential | 1.5 | B03 | 0.01 | 5.3 ± 0.9 | 3.9 ± 0.7 | 5.0 ± 1.3 | 2.6 |
| 12 | exponential | 1.5 | B01 | 0.01 | 5.2 ± 0.8 | 3.6 ± 0.6 | 4.9 ± 1.4 | 3.0 |
| 12 | exponential | 1.5 | S08 | 0.01 | 4.7 ± 0.4 | 3.9 ± 0.7 | 5.3 ± 1.5 | 2.8 |
| 12 | exponential | 0.0/1.0/3.0 | B03 | 0.01 | 5.3 ± 1.0 | 4.8 ± 0.8 | 4.6 ± 1.3 | 2.6 |
| 12 | exponential | 0.0/1.0/3.0 | B01 | 0.01 | 4.6 ± 0.8 | 3.8 ± 0.7 | 5.2 ± 1.5 | 2.0 |
| 12 | exponential | 0.0/1.0/3.0 | S08 | 0.01 | 4.9 ± 0.7 | 4.4 ± 0.8 | 5.1 ± 1.4 | 2.6 |
| 12 | exponential | 1.0/0.0/3.0 | B03 | 0.01 | 6.0 ± 1.1 | 5.3 ± 1.0 | 5.2 ± 1.4 | 5.7 |
| 12 | exponential | 1.0/0.0/3.0 | B01 | 0.01 | 5.4 ± 1.0 | 3.9 ± 0.7 | 5.4 ± 1.4 | 3.4 |
| 12 | exponential | 1.0/0.0/3.0 | S08 | 0.01 | 4.8 ± 0.8 | 5.0 ± 0.9 | 5.6 ± 1.3 | 4.0 |
| 12 | exponential | C03 | B03 | 0.01 | 5.6 ± 1.0 | 4.1 ± 0.8 | 5.2 ± 1.4 | 3.5 |
| 12 | exponential | C03 | B01 | 0.01 | 5.7 ± 1.0 | 3.7 ± 0.8 | 5.1 ± 1.4 | 4.1 |
| 12 | exponential | C03 | S08 | 0.01 | 4.9 ± 0.7 | 4.4 ± 0.8 | 5.1 ± 1.4 | 2.7 |
| 12 | log-normal | -1.5 | B03 | 0.01 | 6.6 ± 0.9 | 6.5 ± 0.6 | 7.6 ± 1.7 | 25.0 |
| 12 | log-normal | -1.5 | B01 | 0.01 | 8.9 ± 0.4 | 9.6 ± 0.9 | 7.7 ± 1.6 | 118.9 |
| 12 | log-normal | -1.5 | S08 | 0.01 | 6.7 ± 1.0 | 6.8 ± 1.0 | 7.9 ± 1.9 | 19.0 |
| 12 | log-normal | -0.5 | B03 | 0.01 | 7.3 ± 0.9 | 6.4 ± 0.7 | 7.8 ± 1.7 | 26.6 |
| 12 | log-normal | -0.5 | B01 | 0.01 | 8.6 ± 0.6 | 8.3 ± 0.9 | 7.1 ± 1.8 | 66.4 |
| 12 | log-normal | -0.5 | S08 | 0.01 | 7.5 ± 1.0 | 7.4 ± 1.3 | 7.9 ± 1.9 | 21.6 |
| 12 | log-normal | 1.5 | B03 | 0.01 | 8.0 ± 0.5 | 6.3 ± 0.4 | 7.9 ± 1.7 | 75.2 |
| 12 | log-normal | 1.5 | B01 | 0.01 | 8.0 ± 1.0 | 6.8 ± 0.9 | 7.0 ± 1.8 | 26.4 |
| 12 | log-normal | 1.5 | S08 | 0.01 | 8.4 ± 0.9 | 7.3 ± 1.2 | 7.3 ± 1.8 | 32.0 |
| 12 | log-normal | 0.0/1.0/3.0 | B03 | 0.01 | 9.1 ± 1.3 | 8.4 ± 1.1 | 6.7 ± 1.6 | 31.5 |
| 12 | log-normal | 0.0/1.0/3.0 | B01 | 0.01 | 7.5 ± 1.0 | 6.4 ± 1.1 | 7.6 ± 1.8 | 19.3 |
| 12 | log-normal | 0.0/1.0/3.0 | S08 | 0.01 | 8.1 ± 1.3 | 7.1 ± 1.2 | 7.1 ± 1.6 | 20.4 |
| 12 | log-normal | 1.0/0.0/3.0 | B03 | 0.01 | 7.8 ± 1.0 | 7.0 ± 1.1 | 7.6 ± 1.8 | 24.2 |
| 12 | log-normal | 1.0/0.0/3.0 | B01 | 0.01 | 7.3 ± 1.3 | 7.6 ± 1.2 | 7.6 ± 1.7 | 18.8 |
| 12 | log-normal | 1.0/0.0/3.0 | S08 | 0.01 | 7.2 ± 1.2 | 7.4 ± 1.2 | 7.5 ± 1.8 | 18.2 |
| 12 | log-normal | C03 | B03 | 0.01 | 7.1 ± 0.8 | 6.2 ± 0.7 | 7.9 ± 1.8 | 26.9 |
| 12 | log-normal | C03 | B01 | 0.01 | 7.6 ± 0.9 | 6.0 ± 0.9 | 7.4 ± 1.8 | 21.9 |
| 12 | log-normal | C03 | S08 | 0.01 | 7.0 ± 1.0 | 6.8 ± 1.0 | 7.3 ± 1.7 | 19.3 |
| 12 | uniform | -1.5 | B03 | 0.02 | 4.5 ± 0.8 | 4.6 ± 0.9 | 6.0 ± 1.6 | 2.6 |
| 12 | uniform | -1.5 | B03 | 0.03 | 4.3 ± 0.8 | 4.7 ± 0.9 | 5.8 ± 1.5 | 2.6 |
| 12 | uniform | -1.5 | B01 | 0.02 | 4.2 ± 0.8 | 3.9 ± 0.7 | 5.6 ± 1.4 | 2.1 |
| 12 | uniform | -1.5 | B01 | 0.03 | 4.0 ± 0.7 | 4.0 ± 0.8 | 5.6 ± 1.3 | 2.4 |
| 12 | uniform | -1.5 | S08 | 0.02 | 4.5 ± 0.8 | 4.2 ± 0.8 | 5.6 ± 1.4 | 2.4 |
| 12 | uniform | -1.5 | S08 | 0.03 | 4.8 ± 0.8 | 4.2 ± 0.7 | 5.9 ± 1.5 | 3.1 |
| 12 | uniform | 0.5 | B03 | 0.02 | 4.5 ± 0.9 | 3.3 ± 0.7 | 5.2 ± 1.3 | 3.0 |
| 12 | uniform | 0.5 | B03 | 0.03 | 4.3 ± 0.8 | 3.5 ± 0.7 | 5.5 ± 1.4 | 2.7 |
| 12 | uniform | 0.5 | B01 | 0.02 | 3.6 ± 0.7 | 3.2 ± 0.7 | 4.9 ± 1.3 | 2.8 |
| 12 | uniform | 0.5 | B01 | 0.03 | 3.8 ± 0.7 | 3.6 ± 0.8 | 5.2 ± 1.3 | 2.0 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|-------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 12 | uniform | 0.5 | S08 | 0.02 | 4.0 ± 0.7 | 3.5 ± 0.6 | 5.0 ± 1.3 | 2.0 |
| 12 | uniform | 0.5 | S08 | 0.03 | 4.1 ± 0.7 | 3.6 ± 0.7 | 5.8 ± 1.4 | 2.8 |
| 12 | uniform | -0.5 | B03 | 0.02 | 4.6 ± 1.0 | 3.9 ± 0.8 | 5.3 ± 1.4 | 1.9 |
| 12 | uniform | -0.5 | B03 | 0.03 | 4.5 ± 0.9 | 3.8 ± 0.7 | 5.5 ± 1.3 | 2.4 |
| 12 | uniform | -0.5 | B01 | 0.02 | 4.1 ± 0.8 | 3.5 ± 0.6 | 4.9 ± 1.3 | 1.9 |
| 12 | uniform | -0.5 | B01 | 0.03 | 3.8 ± 0.7 | 3.8 ± 0.8 | 5.6 ± 1.4 | 2.3 |
| 12 | uniform | -0.5 | S08 | 0.02 | 3.8 ± 0.6 | 4.0 ± 0.8 | 5.5 ± 1.4 | 2.1 |
| 12 | uniform | -0.5 | S08 | 0.03 | 4.2 ± 0.7 | 4.1 ± 0.8 | 6.0 ± 1.5 | 2.6 |
| 12 | uniform | 1.5 | B03 | 0.02 | 4.3 ± 0.8 | 2.8 ± 0.7 | 4.6 ± 1.3 | 3.4 |
| 12 | uniform | 1.5 | B03 | 0.03 | 4.5 ± 0.9 | 3.2 ± 0.7 | 5.2 ± 1.4 | 3.1 |
| 12 | uniform | 1.5 | B01 | 0.02 | 4.5 ± 0.8 | 2.7 ± 0.6 | 4.5 ± 1.2 | 5.0 |
| 12 | uniform | 1.5 | B01 | 0.03 | 3.8 ± 0.8 | 2.8 ± 0.6 | 5.3 ± 1.4 | 5.9 |
| 12 | uniform | 1.5 | S08 | 0.02 | 4.7 ± 0.8 | 3.4 ± 0.7 | 4.6 ± 1.2 | 2.1 |
| 12 | uniform | 1.5 | S08 | 0.03 | 4.8 ± 0.8 | 3.4 ± 0.7 | 5.4 ± 1.5 | 3.3 |
| 12 | uniform | 0.0/1.0/3.0 | B03 | 0.02 | 4.3 ± 0.8 | 4.0 ± 0.7 | 4.6 ± 1.2 | 0.8 |
| 12 | uniform | 0.0/1.0/3.0 | B03 | 0.03 | 4.5 ± 0.9 | 4.2 ± 0.8 | 5.2 ± 1.4 | 1.6 |
| 12 | uniform | 0.0/1.0/3.0 | B01 | 0.02 | 3.7 ± 0.8 | 3.2 ± 0.7 | 4.6 ± 1.3 | 2.4 |
| 12 | uniform | 0.0/1.0/3.0 | B01 | 0.03 | 3.4 ± 0.6 | 3.2 ± 0.7 | 5.2 ± 1.4 | 3.9 |
| 12 | uniform | 0.0/1.0/3.0 | S08 | 0.02 | 3.5 ± 0.6 | 3.5 ± 0.7 | 4.9 ± 1.3 | 2.4 |
| 12 | uniform | 0.0/1.0/3.0 | S08 | 0.03 | 4.0 ± 0.6 | 3.6 ± 0.7 | 5.4 ± 1.4 | 2.2 |
| 12 | uniform | 1.0/0.0/3.0 | B03 | 0.02 | 4.6 ± 0.8 | 4.1 ± 0.8 | 5.2 ± 1.4 | 1.7 |
| 12 | uniform | 1.0/0.0/3.0 | B03 | 0.03 | 5.0 ± 1.0 | 4.1 ± 0.7 | 5.3 ± 1.2 | 2.7 |
| 12 | uniform | 1.0/0.0/3.0 | B01 | 0.02 | 3.6 ± 0.8 | 3.3 ± 0.6 | 5.0 ± 1.3 | 3.2 |
| 12 | uniform | 1.0/0.0/3.0 | B01 | 0.03 | 3.6 ± 0.7 | 3.7 ± 0.7 | 5.4 ± 1.3 | 2.7 |
| 12 | uniform | 1.0/0.0/3.0 | S08 | 0.02 | 3.8 ± 0.7 | 3.7 ± 0.7 | 5.4 ± 1.4 | 2.2 |
| 12 | uniform | 1.0/0.0/3.0 | S08 | 0.03 | 3.9 ± 0.7 | 3.5 ± 0.7 | 6.1 ± 1.5 | 3.3 |
| 12 | uniform | C03 | B03 | 0.02 | 4.5 ± 0.9 | 2.9 ± 0.6 | 4.8 ± 1.3 | 4.2 |
| 12 | uniform | C03 | B03 | 0.03 | 4.3 ± 0.8 | 3.0 ± 0.6 | 5.3 ± 1.3 | 4.8 |
| 12 | uniform | C03 | B01 | 0.02 | 3.5 ± 0.7 | 2.9 ± 0.7 | 4.6 ± 1.3 | 4.1 |
| 12 | uniform | C03 | B01 | 0.03 | 3.6 ± 0.7 | 3.1 ± 0.6 | 5.2 ± 1.3 | 3.8 |
| 12 | uniform | C03 | S08 | 0.02 | 4.4 ± 0.7 | 3.3 ± 0.7 | 4.9 ± 1.4 | 2.2 |
| 12 | uniform | C03 | S08 | 0.03 | 3.8 ± 0.7 | 3.4 ± 0.7 | 5.6 ± 1.4 | 3.0 |
| 12 | exponential | -1.5 | B03 | 0.02 | 5.8 ± 1.1 | 5.2 ± 0.8 | 6.8 ± 1.7 | 7.2 |
| 12 | exponential | -1.5 | B03 | 0.03 | 5.5 ± 1.0 | 5.4 ± 0.9 | 6.1 ± 1.5 | 6.4 |
| 12 | exponential | -1.5 | B01 | 0.02 | 4.9 ± 0.9 | 4.9 ± 0.9 | 6.2 ± 1.6 | 4.2 |
| 12 | exponential | -1.5 | B01 | 0.03 | 4.6 ± 0.8 | 4.5 ± 0.7 | 6.3 ± 1.6 | 3.7 |
| 12 | exponential | -1.5 | S08 | 0.02 | 4.1 ± 0.6 | 5.2 ± 0.9 | 6.3 ± 1.6 | 4.5 |
| 12 | exponential | -1.5 | S08 | 0.03 | 5.6 ± 0.9 | 5.1 ± 0.9 | 6.6 ± 1.7 | 6.8 |
| 12 | exponential | 0.5 | B03 | 0.02 | 5.5 ± 1.0 | 4.4 ± 0.8 | 5.9 ± 1.5 | 4.2 |
| 12 | exponential | 0.5 | B03 | 0.03 | 5.6 ± 1.0 | 4.2 ± 0.8 | 6.3 ± 1.7 | 4.6 |
| 12 | exponential | 0.5 | B01 | 0.02 | 4.8 ± 0.8 | 4.4 ± 0.9 | 5.4 ± 1.4 | 2.5 |
| 12 | exponential | 0.5 | B01 | 0.03 | 4.9 ± 0.9 | 4.3 ± 0.8 | 6.0 ± 1.5 | 3.5 |
| 12 | exponential | 0.5 | S08 | 0.02 | 4.6 ± 0.7 | 5.0 ± 0.9 | 6.1 ± 1.6 | 3.8 |
| 12 | exponential | 0.5 | S08 | 0.03 | 5.4 ± 0.9 | 4.6 ± 0.9 | 6.1 ± 1.5 | 4.7 |
| 12 | exponential | -0.5 | B03 | 0.02 | 5.8 ± 1.1 | 4.3 ± 0.8 | 5.7 ± 1.4 | 4.6 |
| 12 | exponential | -0.5 | B03 | 0.03 | 5.8 ± 1.1 | 5.0 ± 0.9 | 6.1 ± 1.6 | 6.0 |
| 12 | exponential | -0.5 | B01 | 0.02 | 5.3 ± 0.9 | 5.2 ± 0.9 | 5.9 ± 1.5 | 5.4 |
| 12 | exponential | -0.5 | B01 | 0.03 | 5.0 ± 0.8 | 4.7 ± 0.8 | 6.2 ± 1.6 | 4.3 |
| 12 | exponential | -0.5 | S08 | 0.02 | 5.7 ± 1.0 | 4.9 ± 0.8 | 6.1 ± 1.6 | 5.8 |
| 12 | exponential | -0.5 | S08 | 0.03 | 6.1 ± 0.9 | 5.1 ± 1.0 | 6.4 ± 1.7 | 8.7 |
| 12 | exponential | 1.5 | B03 | 0.02 | 5.5 ± 1.0 | 4.3 ± 0.9 | 5.5 ± 1.5 | 3.5 |
| 12 | exponential | 1.5 | B03 | 0.03 | 4.9 ± 0.9 | 3.8 ± 0.6 | 6.3 ± 1.6 | 3.9 |
| 12 | exponential | 1.5 | B01 | 0.02 | 4.7 ± 0.7 | 3.7 ± 0.8 | 5.4 ± 1.5 | 2.5 |
| 12 | exponential | 1.5 | B01 | 0.03 | 4.2 ± 0.7 | 3.9 ± 0.7 | 5.8 ± 1.4 | 2.7 |
| 12 | exponential | 1.5 | S08 | 0.02 | 5.4 ± 0.8 | 4.5 ± 0.9 | 5.2 ± 1.4 | 4.4 |
| 12 | exponential | 1.5 | S08 | 0.03 | 5.6 ± 0.8 | 4.4 ± 0.8 | 6.0 ± 1.5 | 5.8 |
| 12 | exponential | 0.0/1.0/3.0 | B03 | 0.02 | 5.3 ± 1.0 | 4.7 ± 0.8 | 5.4 ± 1.5 | 3.4 |
| 12 | exponential | 0.0/1.0/3.0 | B03 | 0.03 | 5.6 ± 1.0 | 5.2 ± 1.0 | 6.1 ± 1.6 | 5.9 |
| 12 | exponential | 0.0/1.0/3.0 | B01 | 0.02 | 4.1 ± 0.8 | 3.7 ± 0.7 | 5.3 ± 1.4 | 1.9 |
| 12 | exponential | 0.0/1.0/3.0 | B01 | 0.03 | 4.9 ± 0.9 | 3.6 ± 0.7 | 5.7 ± 1.4 | 3.4 |
| 12 | exponential | 0.0/1.0/3.0 | S08 | 0.02 | 5.7 ± 0.9 | 4.3 ± 0.8 | 5.4 ± 1.4 | 4.4 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|--------------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
| 12 | exponential | 0.0/1.0/3.0 | S08 | 0.03 | 6.0 ± 0.9 | 4.4 ± 0.8 | 6.2 ± 1.7 | 6.4 |
| 12 | exponential | 1.0/0.0/3.0 | B03 | 0.02 | 5.4 ± 1.0 | 5.7 ± 1.0 | 5.6 ± 1.6 | 5.4 |
| 12 | exponential | 1.0/0.0/3.0 | B03 | 0.03 | 5.1 ± 0.9 | 5.6 ± 1.0 | 6.2 ± 1.6 | 6.0 |
| 12 | exponential | 1.0/0.0/3.0 | B01 | 0.02 | 5.5 ± 0.9 | 4.3 ± 0.7 | 6.0 ± 1.5 | 4.8 |
| 12 | exponential | 1.0/0.0/3.0 | B01 | 0.03 | 5.1 ± 1.0 | 4.5 ± 0.8 | 6.1 ± 1.8 | 3.1 |
| 12 | exponential | 1.0/0.0/3.0 | S08 | 0.02 | 5.3 ± 0.9 | 4.6 ± 0.9 | 5.8 ± 1.5 | 4.4 |
| 12 | exponential | 1.0/0.0/3.0 | S08 | 0.03 | 4.8 ± 0.8 | 4.7 ± 0.9 | 6.6 ± 1.7 | 4.5 |
| 12 | exponential | C03 | B03 | 0.02 | 5.6 ± 1.0 | 4.2 ± 0.8 | 5.8 ± 1.4 | 4.3 |
| 12 | exponential | C03 | B03 | 0.03 | 5.5 ± 0.9 | 4.4 ± 0.8 | 6.2 ± 1.6 | 5.0 |
| 12 | exponential | C03 | B01 | 0.02 | 4.7 ± 0.8 | 4.2 ± 0.9 | 5.2 ± 1.4 | 2.1 |
| 12 | exponential | C03 | B01 | 0.03 | 4.4 ± 0.8 | 4.2 ± 0.8 | 5.8 ± 1.5 | 2.5 |
| 12 | exponential | C03 | S08 | 0.02 | 5.4 ± 0.9 | 4.2 ± 0.8 | 5.6 ± 1.4 | 3.7 |
| 12 | exponential | C03 | S08 | 0.03 | 5.3 ± 0.9 | 4.3 ± 0.8 | 6.0 ± 1.6 | 4.2 |
| 12 | log-normal | -1.5 | B03 | 0.02 | 6.9 ± 0.9 | 6.8 ± 0.8 | 6.8 ± 1.5 | 23.6 |
| 12 | log-normal | -1.5 | B03 | 0.03 | 8.3 ± 1.0 | 8.1 ± 0.8 | 7.8 ± 1.5 | 47.0 |
| 12 | log-normal | -1.5 | B01 | 0.02 | 6.0 ± 0.5 | 5.6 ± 0.3 | 7.2 ± 1.5 | 30.7 |
| 12 | log-normal | -1.5 | B01 | 0.03 | 7.2 ± 0.4 | 7.4 ± 0.7 | 7.6 ± 1.6 | 60.8 |
| 12 | log-normal | -1.5 | S08 | 0.02 | 7.2 ± 1.0 | 7.5 ± 1.2 | 7.6 ± 1.6 | 22.4 |
| 12 | log-normal | -1.5 | S08 | 0.03 | 7.7 ± 1.1 | 7.6 ± 1.2 | 7.4 ± 1.8 | 22.6 |
| 12 | log-normal | 0.5 | B03 | 0.02 | 6.8 ± 0.9 | 8.2 ± 1.2 | 7.6 ± 1.7 | 23.2 |
| 12 | log-normal | 0.5 | B03 | 0.03 | 7.4 ± 0.8 | 8.4 ± 1.0 | 7.6 ± 1.7 | 35.3 |
| 12 | log-normal | 0.5 | B01 | 0.02 | 6.8 ± 0.5 | 6.3 ± 0.6 | 7.2 ± 1.6 | 34.9 |
| 12 | log-normal | 0.5 | B01 | 0.03 | 7.5 ± 0.6 | 6.6 ± 0.8 | 7.4 ± 1.6 | 42.2 |
| 12 | log-normal | 0.5 | S08 | 0.02 | 7.8 ± 1.3 | 7.0 ± 1.1 | 7.6 ± 1.8 | 19.1 |
| 12 | log-normal | 0.5 | S08 | 0.03 | 6.4 ± 0.4 | 6.6 ± 0.8 | 8.8 ± 1.9 | 40.4 |
| 12 | log-normal | -0.5 | B03 | 0.02 | 6.6 ± 0.8 | 7.5 ± 0.8 | 7.0 ± 1.5 | 29.4 |
| 12 | log-normal | -0.5 | B03 | 0.03 | 6.7 ± 0.9 | 7.1 ± 0.9 | 7.4 ± 1.5 | 24.1 |
| 12 | log-normal | -0.5 | B01 | 0.02 | 7.4 ± 0.5 | 7.6 ± 1.1 | 7.7 ± 1.7 | 48.7 |
| 12 | log-normal | -0.5 | B01 | 0.03 | 9.1 ± 0.8 | 8.5 ± 1.1 | 7.8 ± 1.8 | 51.7 |
| 12 | log-normal | -0.5 | S08 | 0.02 | 8.2 ± 1.4 | 7.2 ± 1.2 | 8.1 ± 1.9 | 20.7 |
| 12 | log-normal | -0.5 | S08 | 0.03 | 8.0 ± 1.2 | 7.2 ± 1.2 | 8.1 ± 2.0 | 22.7 |
| 12 | log-normal | 1.5 | B03 | 0.02 | 8.4 ± 0.9 | 7.0 ± 0.7 | 6.9 ± 1.7 | 39.1 |
| 12 | log-normal | 1.5 | B03 | 0.03 | 8.2 ± 1.0 | 7.3 ± 1.1 | 8.0 ± 1.9 | 28.6 |
| 12 | log-normal | 1.5 | B01 | 0.02 | 5.7 ± 0.2 | 5.1 ± 0.3 | 7.2 ± 1.9 | 28.0 |
| 12 | log-normal | 1.5 | B01 | 0.03 | 9.7 ± 0.0 | 6.5 ± 0.8 | 7.6 ± 1.8 | 359.3 |
| 12 | log-normal | 1.5 | S08 | 0.02 | 9.3 ± 1.3 | 7.4 ± 1.3 | 7.6 ± 1.9 | 26.1 |
| 12 | log-normal | 1.5 | S08 | 0.03 | 7.5 ± 1.1 | 7.4 ± 1.2 | 7.8 ± 1.9 | 21.7 |
| 12 | log-normal | 0.0/1.0/3.0 | B03 | 0.02 | 8.8 ± 1.1 | 7.5 ± 1.1 | 7.8 ± 1.9 | 32.5 |
| 12 | log-normal | 0.0/1.0/3.0 | B03 | 0.03 | 7.7 ± 1.2 | 7.4 ± 1.1 | 7.7 ± 1.8 | 22.6 |
| 12 | log-normal | 0.0/1.0/3.0 | B01 | 0.02 | 9.1 ± 0.6 | 7.2 ± 0.9 | 7.1 ± 1.6 | 79.2 |
| 12 | log-normal | 0.0/1.0/3.0 | B01 | 0.03 | 5.5 ± 0.3 | 5.8 ± 0.7 | 8.0 ± 1.8 | 20.6 |
| 12 | log-normal | 0.0/1.0/3.0 | S08 | 0.02 | 8.1 ± 1.2 | 7.6 ± 1.3 | 7.6 ± 1.7 | 22.6 |
| 12 | log-normal | 0.0/1.0/3.0 | S08 | 0.03 | 7.6 ± 1.2 | 7.5 ± 1.2 | 7.9 ± 1.9 | 19.6 |
| 12 | log-normal | 1.0/0.0/3.0 | B03 | 0.02 | 7.4 ± 1.0 | 6.8 ± 1.0 | 6.9 ± 1.5 | 20.5 |
| 12 | log-normal | 1.0/0.0/3.0 | B03 | 0.03 | 6.9 ± 1.1 | 7.7 ± 1.2 | 7.8 ± 1.8 | 19.9 |
| 12 | log-normal | 1.0/0.0/3.0 | B01 | 0.02 | 6.7 ± 0.5 | 7.4 ± 1.1 | 7.8 ± 1.8 | 34.2 |
| 12 | log-normal | 1.0/0.0/3.0 | B01 | 0.03 | 7.6 ± 1.2 | 7.0 ± 1.2 | 7.7 ± 1.8 | 18.4 |
| 12 | log-normal | 1.0/0.0/3.0 | S08 | 0.02 | 7.8 ± 1.2 | 7.2 ± 1.3 | 7.8 ± 1.8 | 20.1 |
| 12 | log-normal | 1.0/0.0/3.0 | S08 | 0.03 | 8.6 ± 1.4 | 7.2 ± 1.2 | 7.5 ± 1.8 | 20.4 |
| 12 | log-normal | C03 | B03 | 0.02 | 6.8 ± 0.9 | 7.4 ± 0.9 | 8.0 ± 1.9 | 26.1 |
| 12 | log-normal | C03 | B03 | 0.03 | 7.7 ± 1.0 | 6.2 ± 0.9 | 7.5 ± 1.9 | 20.2 |
| 12 | log-normal | C03 | B01 | 0.02 | 7.3 ± 0.3 | 7.4 ± 0.7 | 7.6 ± 1.8 | 73.9 |
| 12 | log-normal | C03 | B01 | 0.03 | 7.6 ± 0.6 | 5.9 ± 0.7 | 7.4 ± 1.7 | 37.2 |
| 12 | log-normal | C03 | S08 | 0.02 | 7.3 ± 1.1 | 7.0 ± 1.2 | 7.6 ± 1.9 | 17.5 |
| 12 | log-normal | C03 | S08 | 0.03 | 7.8 ± 1.2 | 7.5 ± 1.3 | 7.8 ± 1.8 | 21.3 |
| 9 ^d | uniform | 0.5 | B03 | 0.01 | 4.0 ± 0.8 | 3.0 ± 0.6 | 3.8 ± 1.1 | 2.8 |
| 9 ^e | uniform | 0.5 | B03* | 0.01 | 4.1 ± 0.8 | 4.1 ± 0.8 | 4.4 ± 1.2 | 0.5 |
| 9 ^c | uniform | 1.5/-0.5/3.0 | B03 | 0.01 | 3.4 ± 0.6 | 3.5 ± 0.7 | 5.0 ± 1.2 | 3.2 |
| 9 ^c | uniform | 1.5/-0.5/4.5 | B03 | 0.01 | 2.9 ± 0.6 | 3.5 ± 0.7 | 5.4 ± 1.4 | 5.6 |
| 9 ^c | uniform | 1.5/-0.5/6.0 | B03 | 0.01 | 3.2 ± 0.7 | 3.4 ± 0.7 | 4.3 ± 1.1 | 2.7 |

Table B.1 (*continued*)

Table B.1 (*continued*)

| τ (Gyr) | Star formation (rate) | α | Models | MBDM (M_{\odot}) | late-M dwarf age (Gyr) | L dwarf age (Gyr) | T dwarf age (Gyr) | χ^2 |
|-----------------|--------------------------|----------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|
|-----------------|--------------------------|----------|--------|-------------------------|---------------------------|----------------------|----------------------|----------|

Note — Kinematics ages computed using the Aumer & Binney (2009) relation and the procedure described in Section 2.5.4. τ is the maximum age of the sample, α is the mass function power law index ($\frac{dN}{dM} = M^{-\alpha}$), MBDM is the minimum brown dwarf mass. Evolving mass functions are labeled in the order of early α , late α , and age (in Gyr) of transition. A log-normal mass function from Chabrier (2003) is labeled as “log-normal”. Star formation rates considered in my simulations: uniform, exponential (Aumer & Binney 2009), and cosmic star formation rate (Rujopakarn et al. 2010). Brown dwarf evolution models are B03 (Baraffe et al. 2003), B01 (Burrows et al. 2001), S08 (Saumon & Marley 2008), M19 (Marley et al. 2018), and P20 (Phillips et al. 2020). For the last model set, C, NW, and NS stand for chemical equilibrium, weak, and strong chemical disequilibrium, respectively. Note that only substellar models are available in the P20 set. See Table B.1 in Appendix B for the full list of simulations.

^a Baseline simulation

^b Simulations with an evolving mass function from top-heavy to bottom-heavy over time using Baraffe et al. (2003) evolutionary models. See Section 2.5.4 for details.

^c Simulations with an evolving mass function from bottom-heavy to top-heavy over time using Baraffe et al. (2003) evolutionary models. See Section 2.5.4 for details.

^d Baseline simulation with selection within 20 pc and J or $K < 15.5$. See Section 2.6.1 for details.

^e Simulation with an artificial decrease in the HBMM for the Baraffe et al. (2003) evolutionary models by fixing the temperatures of brown dwarfs down to masses of $0.060 M_{\odot}$ to their 1 Gyr values. See Section 2.5.4 for details.

Table B.2: APOGEE DR17 Sample

| APOGEE ID | RA (deg) | Dec (deg) | <i>Gaia</i> eDR3 Source ID | SpT | N_{obs} | 2MASS H (mag) | μ_{α} (mas yr $^{-1}$) | μ_{δ} (mas yr $^{-1}$) | π (mas) |
|--------------------|-------------|--------------|----------------------------|------|------------------|--------------------|-------------------------------------|-------------------------------------|----------------|
| 2M00034394+8606422 | 0.933088 | +86.111732 | 574059045248283008 | 4.8 | 10 | 11.738 ± 0.031 | 175.94 ± 0.04 | -25.83 ± 0.04 | 30.81 ± 0.03 |
| 2M00050140+0053081 | 1.255859 | +0.885589 | 2546208620551960064 | 4.3 | 3 | 12.142 ± 0.037 | 65.1 ± 0.59 | 7.73 ± 0.31 | 7.69 ± 0.48 |
| 2M00073367-2008192 | 1.890326 | -20.138685 | 2365564632543830016 | 10.3 | 6 | 12.609 ± 0.031 | 124.82 ± 0.4 | 61.89 ± 0.35 | 8.56 ± 0.4 |
| 2M00091064+2116214 | 2.294345 | -21.272621 | 2364486119011979776 | 5.1 | 3 | 11.53 ± 0.021 | -108.87 ± 0.09 | -51.74 ± 0.09 | 21.54 ± 0.09 |
| 2M00104654-2003471 | 2.693939 | -20.063097 | 2364900000000000000 | 4.4 | 6 | 12.865 ± 0.027 | -19.99 ± 0.08 | -130.0 ± 0.06 | 14.5 ± 0.07 |
| 2M00111055-2021034 | 2.793974 | -20.350962 | 2364839646360019968 | 5.9 | 3 | 11.616 ± 0.026 | 71.88 ± 0.07 | -44.11 ± 0.05 | 14.16 ± 0.07 |
| 2M00114208-2057129 | 2.925351 | -20.953594 | 2364524086522970112 | 5.1 | 1 | 12.848 ± 0.025 | 613.35 ± 0.09 | -0.33 ± 0.08 | 21.2 ± 0.1 |
| 2M00124831-2036481 | 3.201292 | -20.613363 | 2364630601711690240 | 4.6 | 6 | 12.601 ± 0.03 | 107.25 ± 0.07 | -47.19 ± 0.05 | 16.49 ± 0.07 |
| 2M00133672-2110568 | 3.403002 | -21.182453 | 2364536937064889856 | 5.8 | 3 | 11.616 ± 0.024 | 37.88 ± 0.68 | -0.03 ± 0.52 | 10.43 ± 0.69 |
| 2M00203491-1445567 | 5.145497 | -14.765753 | 2416897433126550016 | 5.4 | 5 | 11.867 ± 0.024 | -3.57 ± 0.47 | -48.34 ± 0.41 | 9.54 ± 0.47 |
| 2M00222083+8619567 | 5.586817 | +86.332428 | 574152263218374976 | 4.4 | 10 | 11.018 ± 0.033 | 475.44 ± 0.02 | 29.57 ± 0.03 | 27.77 ± 0.02 |
| 2M00225340+1459299 | 5.72253 | +14.991654 | 2792262456511220224 | | 3 | 10.589 ± 0.022 | 115.05 ± 0.76 | -1.82 ± 0.43 | 14.47 ± 0.53 |
| 2M00272223+0104266 | 6.842657 | +1.074072 | 2546970620766130176 | | 7 | 8.979 ± 0.03 | 202.77 ± 0.26 | -13.15 ± 0.18 | 28.82 ± 0.2 |
| 2M00272392+1623565 | 6.849681 | +16.399036 | 2792881000522279936 | 3.9 | 3 | 11.249 ± 0.03 | 10.16 ± 0.03 | 13.21 ± 0.03 | 25.27 ± 0.03 |
| 2M00381273+3850323 | 9.553082 | +38.842308 | 368514898441865984 | 4.9 | 6 | 12.459 ± 0.033 | 163.84 ± 0.05 | 12.5 ± 0.05 | 17.21 ± 0.06 |
| 2M00385741+3733423 | 9.739221 | +37.561775 | 368190405071763968 | 6.4 | 6 | 13.292 ± 0.043 | 23.1 ± 0.11 | -21.1 ± 0.09 | 4.0 ± 0.12 |
| 2M00393995-6717510 | 9.916475 | -67.297523 | 470390326553039488 | 6.0 | 3 | 11.871 ± 0.039 | -30.98 ± 0.05 | 25.05 ± 0.06 | 9.15 ± 0.05 |
| 2M00394923+0017110 | 9.955147 | +0.286397 | 2543281175138169856 | 4.3 | 4 | 11.11 ± 0.023 | 75.65 ± 0.04 | -205.77 ± 0.03 | 29.51 ± 0.03 |
| 2M00403709+0314141 | 10.15457 | +3.23726 | 2550655290388109824 | 4.0 | 3 | 12.831 ± 0.033 | 69.37 ± 0.08 | 1.05 ± 0.06 | 10.83 ± 0.06 |
| 2M00413621+3757173 | 10.400904 | +37.954819 | 368219984511758016 | 3.9 | 6 | 13.264 ± 0.037 | 80.13 ± 0.07 | 5.03 ± 0.05 | 7.38 ± 0.08 |
| 2M00415938+3946340 | 10.497458 | +39.776131 | 369021906445473024 | 6.1 | 3 | 10.982 ± 0.023 | 122.19 ± 0.25 | -13.85 ± 0.26 | 13.3 ± 0.31 |
| 2M00425211+1416557 | 10.717128 | +14.282163 | 2779442009197270016 | 3.9 | 5 | 11.369 ± 0.032 | 165.79 ± 0.04 | -111.98 ± 0.03 | 20.47 ± 0.03 |
| 2M00440889+0143590 | 11.037056 | +1.733068 | 2549540316877960192 | 3.7 | 4 | 11.993 ± 0.03 | 25.46 ± 0.06 | 19.07 ± 0.05 | 8.18 ± 0.05 |
| 2M00443289+1853533 | 11.137077 | +18.898144 | 2783170178249789952 | | 3 | 11.908 ± 0.017 | 48.9 ± 0.09 | -21.04 ± 0.05 | 8.53 ± 0.07 |

Note – The astrometry, proper motions, and parallaxes are compiled from *Gaia* EDR3 (*Gaia* Collaboration et al. 2021).

Note – The full table is presented in a machine-readable table format.

C Binary Candidate Orbital Fit

In Section 3.4.5, we presented the orbital fits for our binary candidates identified in our sample below.

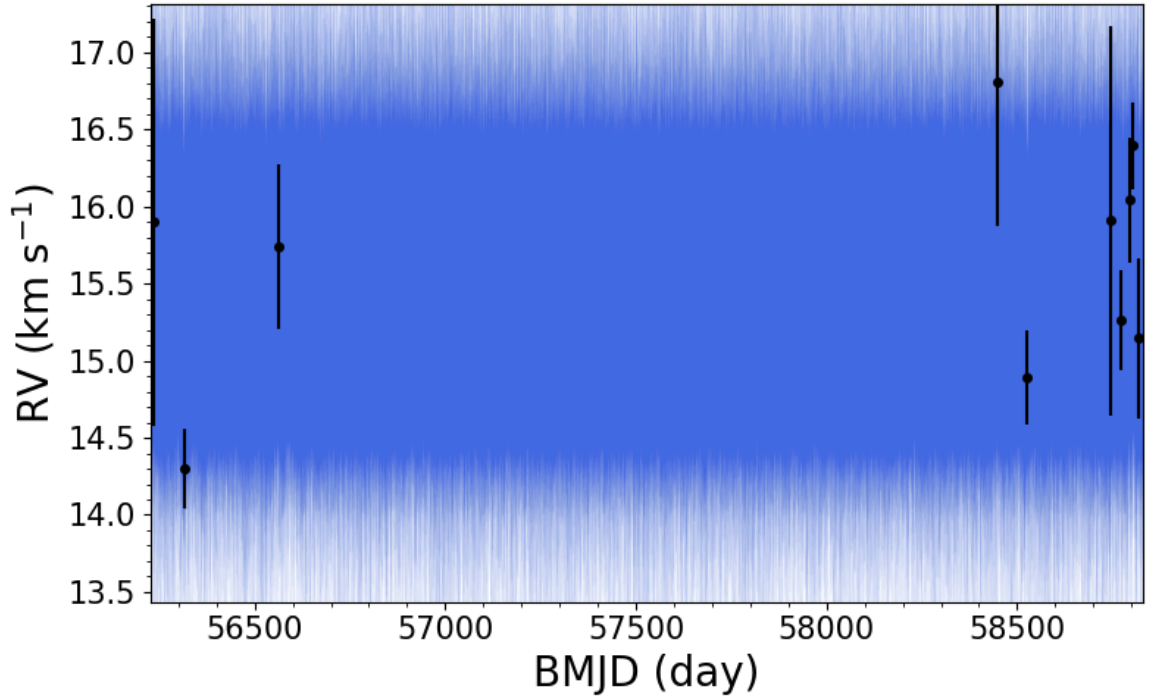


Figure C.1: Binary orbital fit for 2MASS J03282839+3116273. The best-fit orbital parameters are $P_{\text{fit}} = 24.1^{+86.9}_{-21.8}$ day, $K_{\text{fit}} = 1.0^{+0.3}_{-0.2}$ km s⁻¹, and $e_{\text{fit}} = 0.175^{+0.245}_{-0.132}$.

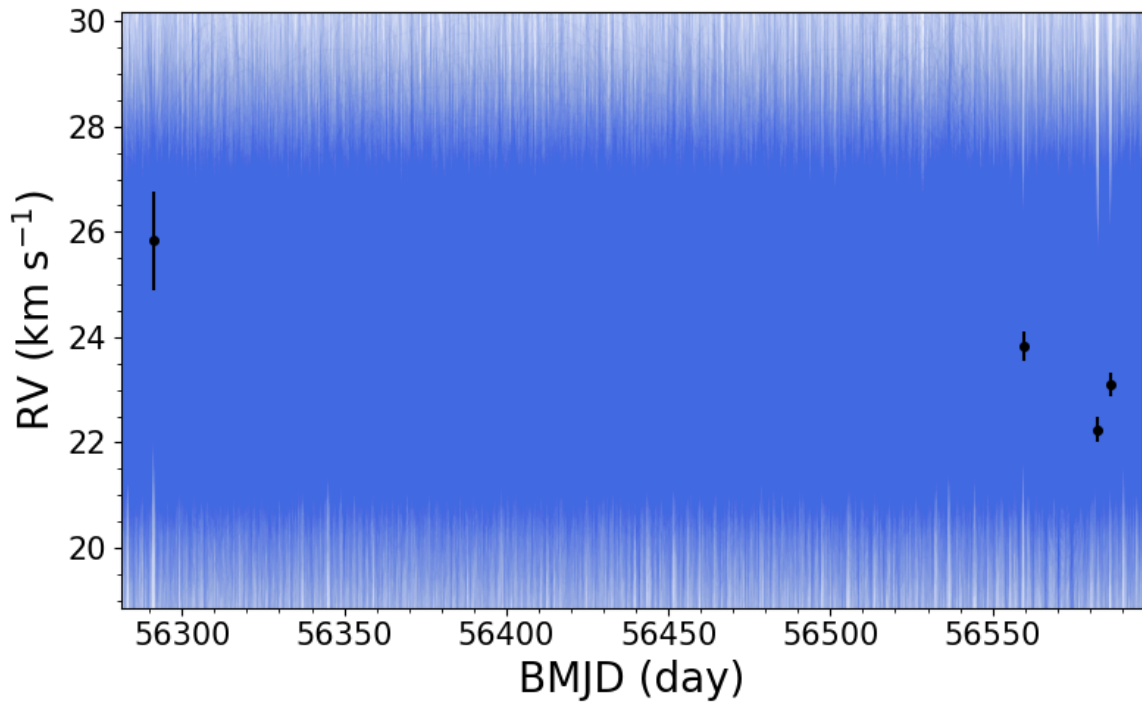


Figure C.2: Binary orbital fit for 2MASS J05402570+2448090. The best-fit orbital parameters are $P_{\text{fit}} = 27.8^{+49.5}_{-24.8}$ day, $K_{\text{fit}} = 2.3^{+1.2}_{-0.9}$ km s⁻¹, and $e_{\text{fit}} = 0.186^{+0.268}_{-0.143}$.

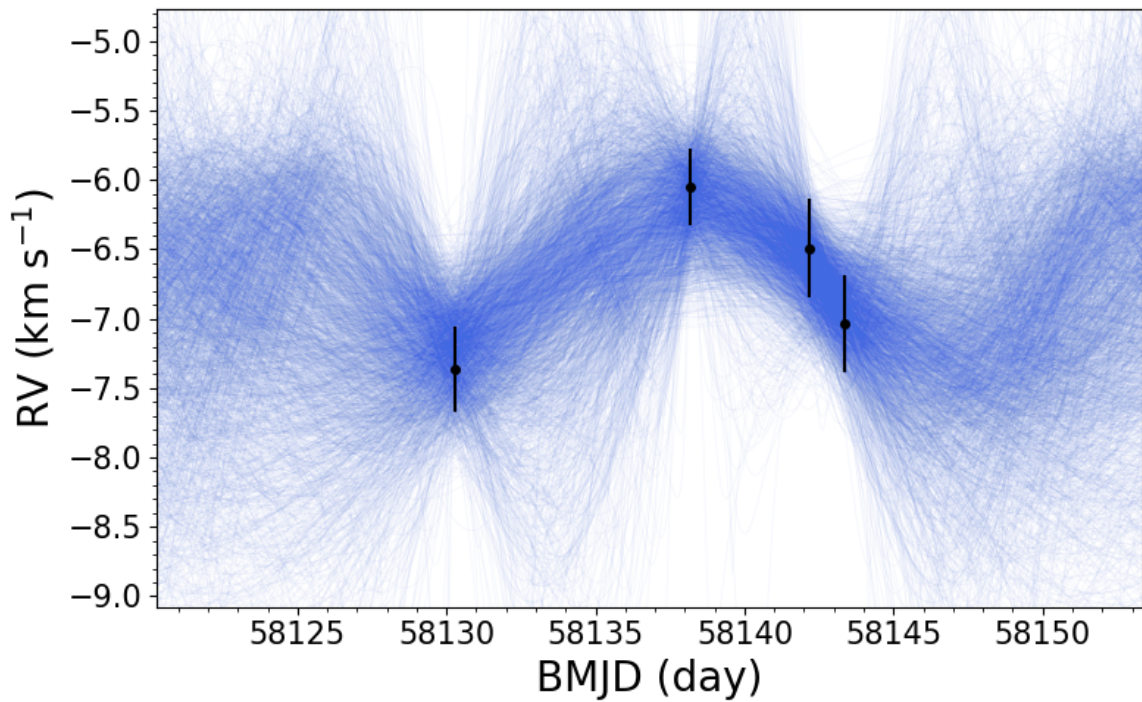


Figure C.3: Binary orbital fit for 2MASS J08092892+3235226. The best-fit orbital parameters are $P_{\text{fit}} = 17.7^{+11.9}_{-4.6}$ day, $K_{\text{fit}} = 0.9^{+0.5}_{-0.3}$ km s⁻¹, and $e_{\text{fit}} = 0.199^{+0.255}_{-0.151}$.

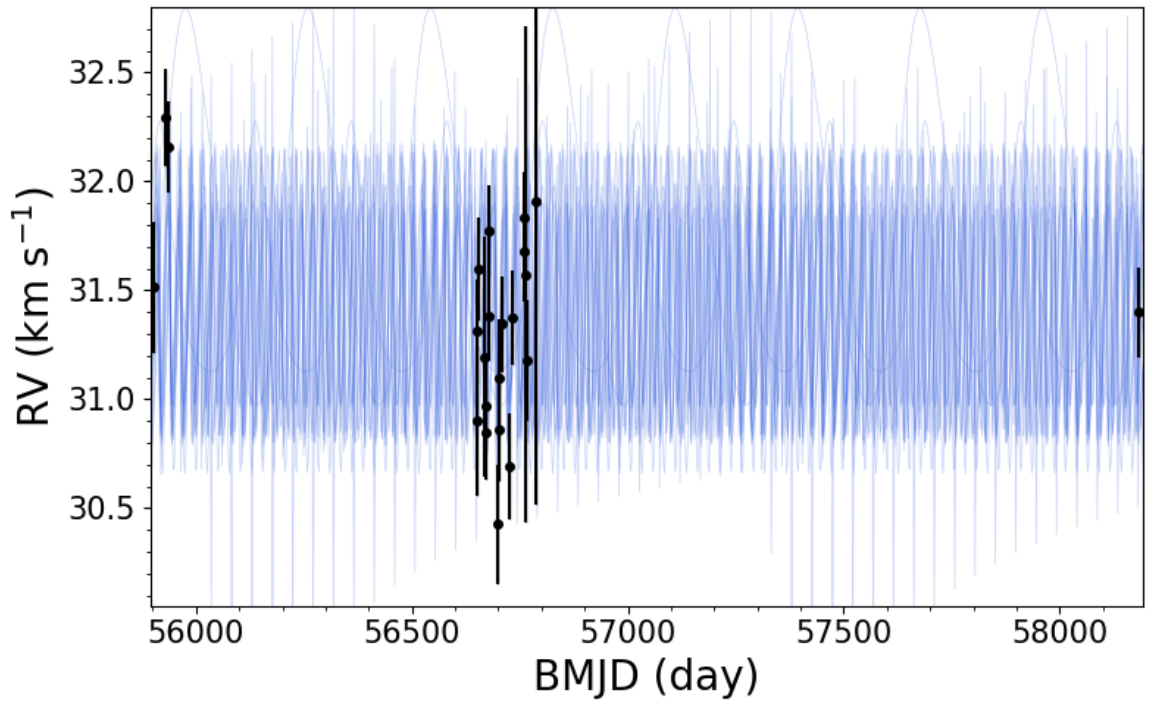


Figure C.4: Binary orbital fit for 2MASS J08501918+1056436. The best-fit orbital parameters are $P_{\text{fit}} = 26.0^{+17.4}_{-24.0}$ day, $K_{\text{fit}} = 0.7^{+0.3}_{-0.1}$ km s $^{-1}$, and $e_{\text{fit}} = 0.365^{+0.43}_{-0.232}$.

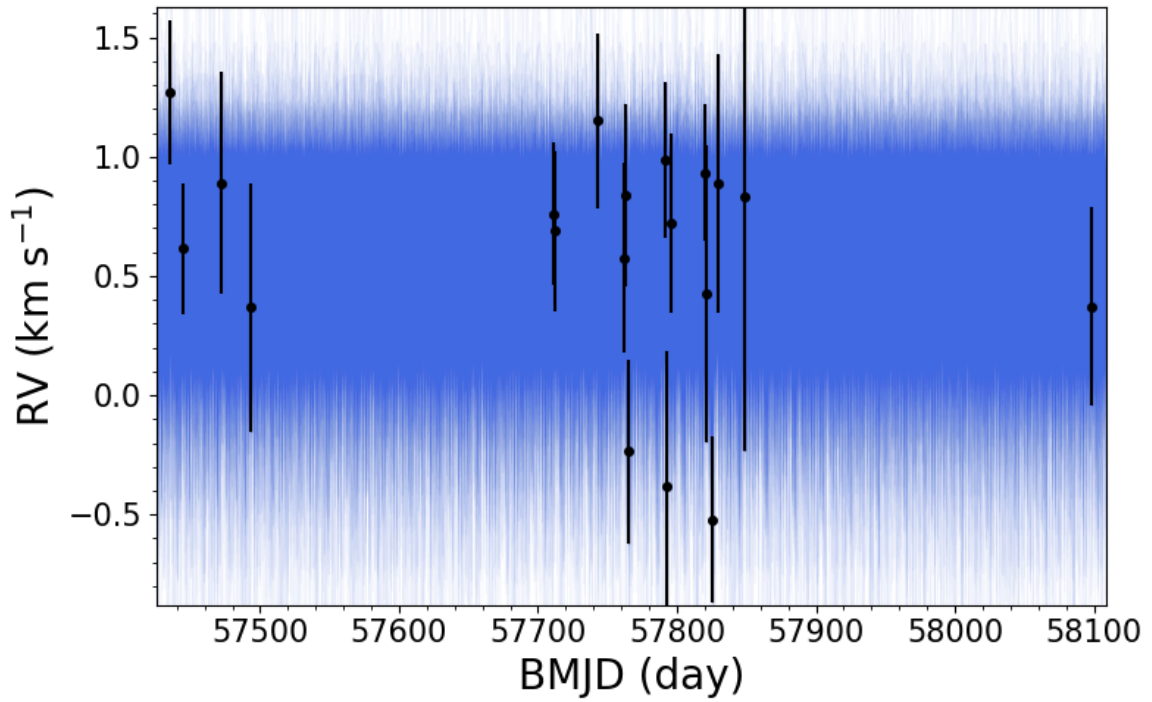


Figure C.5: Binary orbital fit for 2MASS J09373349+5534057. The best-fit orbital parameters are $P_{\text{fit}} = 5.7^{+13.5}_{-3.9}$ day, $K_{\text{fit}} = 0.4^{+0.3}_{-0.2}$ km s $^{-1}$, and $e_{\text{fit}} = 0.271^{+0.297}_{-0.199}$.

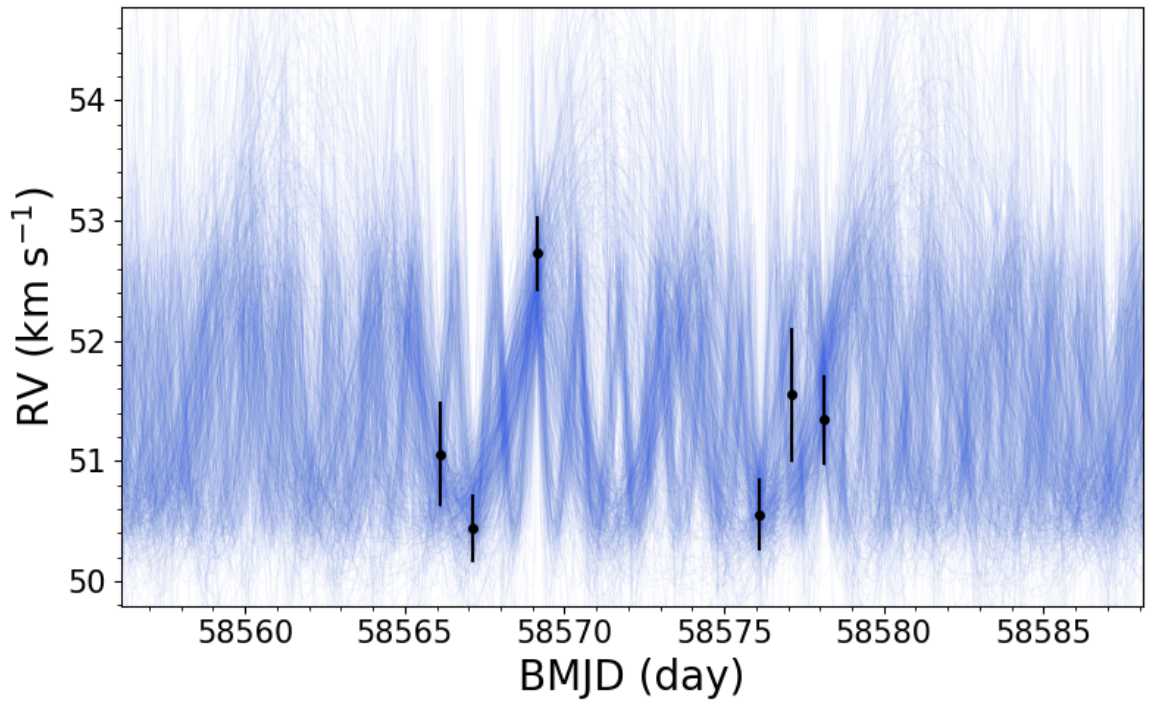


Figure C.6: Binary orbital fit for 2MASS J09442625+3521233. The best-fit orbital parameters are $P_{\text{fit}} = 4.8_{-3.4}^{+5.2}$ day, $K_{\text{fit}} = 1.2_{-0.3}^{+0.5}$ km s $^{-1}$, and $e_{\text{fit}} = 0.227_{-0.179}^{+0.273}$.

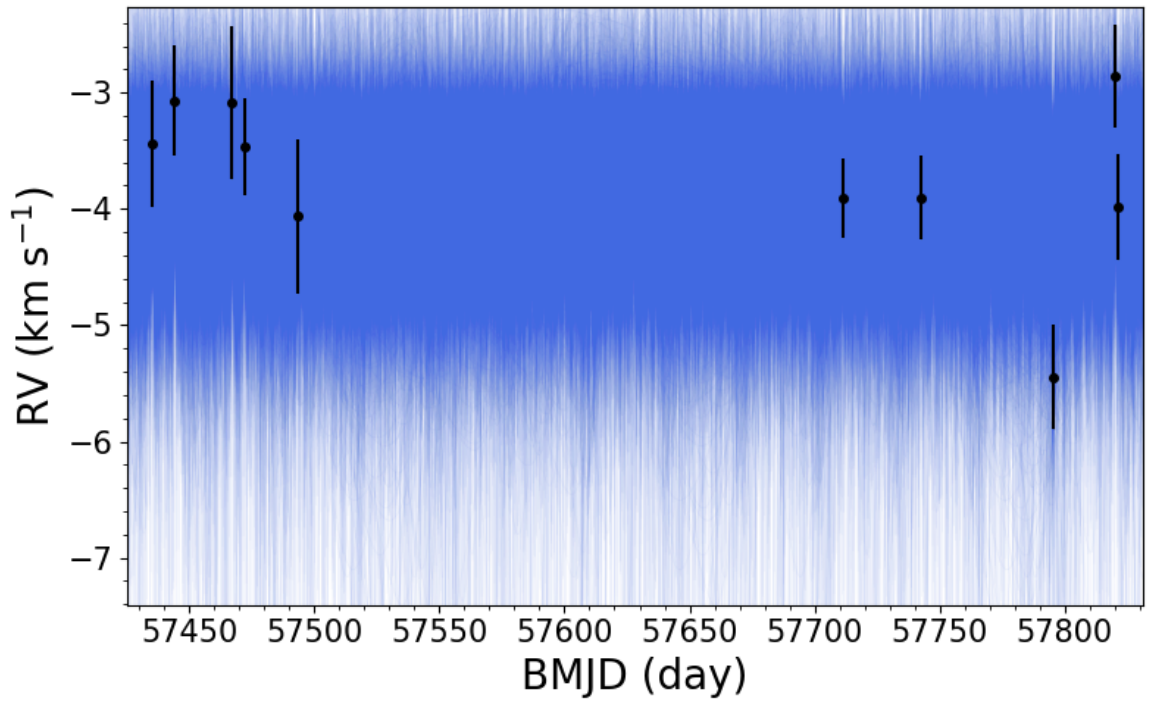


Figure C.7: Binary orbital fit for 2MASS J09453388+5458511. The best-fit orbital parameters are $P_{\text{fit}} = 15.1_{-12.7}^{+119.8}$ day, $K_{\text{fit}} = 1.0_{-0.5}^{+0.5}$ km s $^{-1}$, and $e_{\text{fit}} = 0.315_{-0.244}^{+0.298}$.

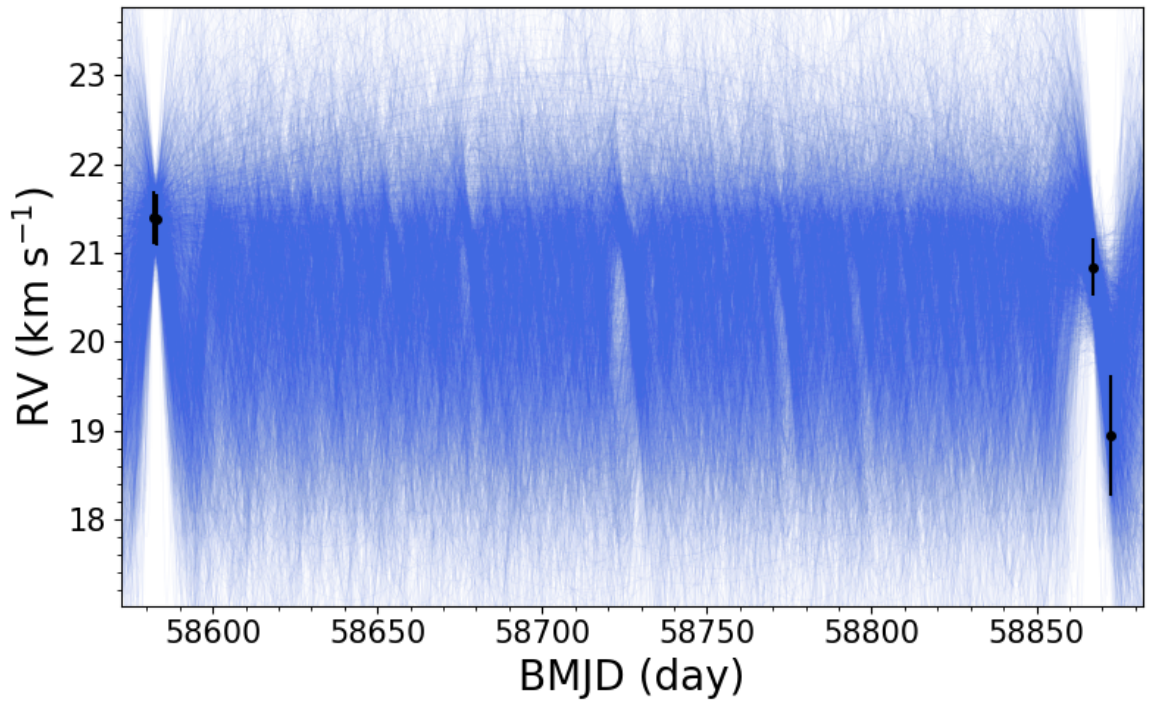


Figure C.8: Binary orbital fit for 2MASS J09560888+0134128. The best-fit orbital parameters are $P_{\text{fit}} = 47.1^{+188.3}_{-25.4}$ day, $K_{\text{fit}} = 1.4^{+0.7}_{-0.7}$ km s $^{-1}$, and $e_{\text{fit}} = 0.177^{+0.262}_{-0.14}$.

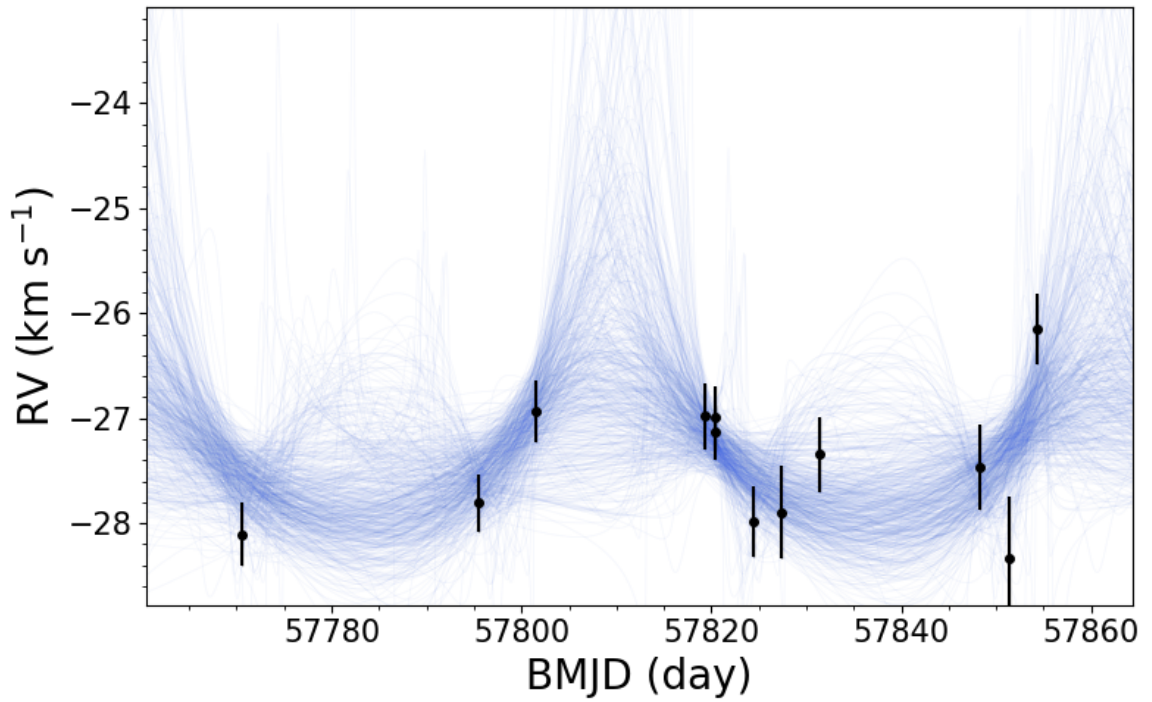


Figure C.9: Binary orbital fit for 2MASS J13202007+7213140. The best-fit orbital parameters are $P_{\text{fit}} = 52.6^{+4.1}_{-16.0}$ day, $K_{\text{fit}} = 0.9^{+0.6}_{-0.5}$ km s $^{-1}$, and $e_{\text{fit}} = 0.338^{+0.268}_{-0.213}$.

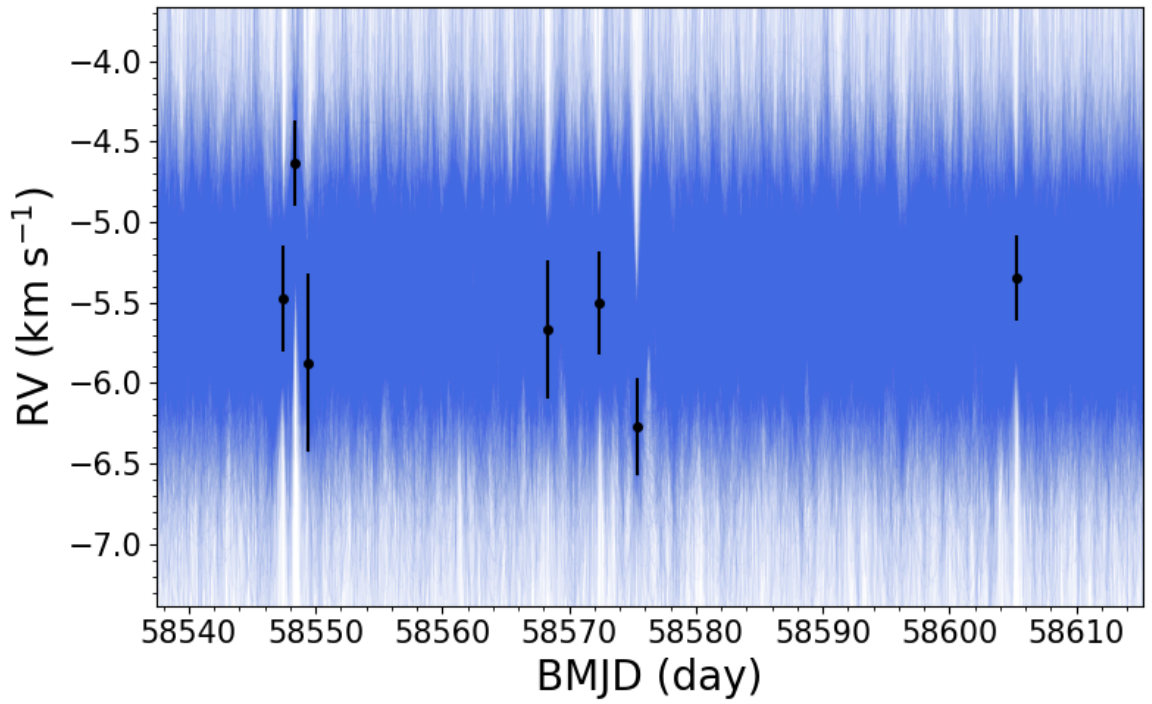


Figure C.10: Binary orbital fit for 2MASS J13232423+5132272. The best-fit orbital parameters are $P_{\text{fit}} = 3.6_{-2.0}^{+8.0}$ day, $K_{\text{fit}} = 0.7_{-0.3}^{+0.4}$ km s $^{-1}$, and $e_{\text{fit}} = 0.207_{-0.154}^{+0.332}$.

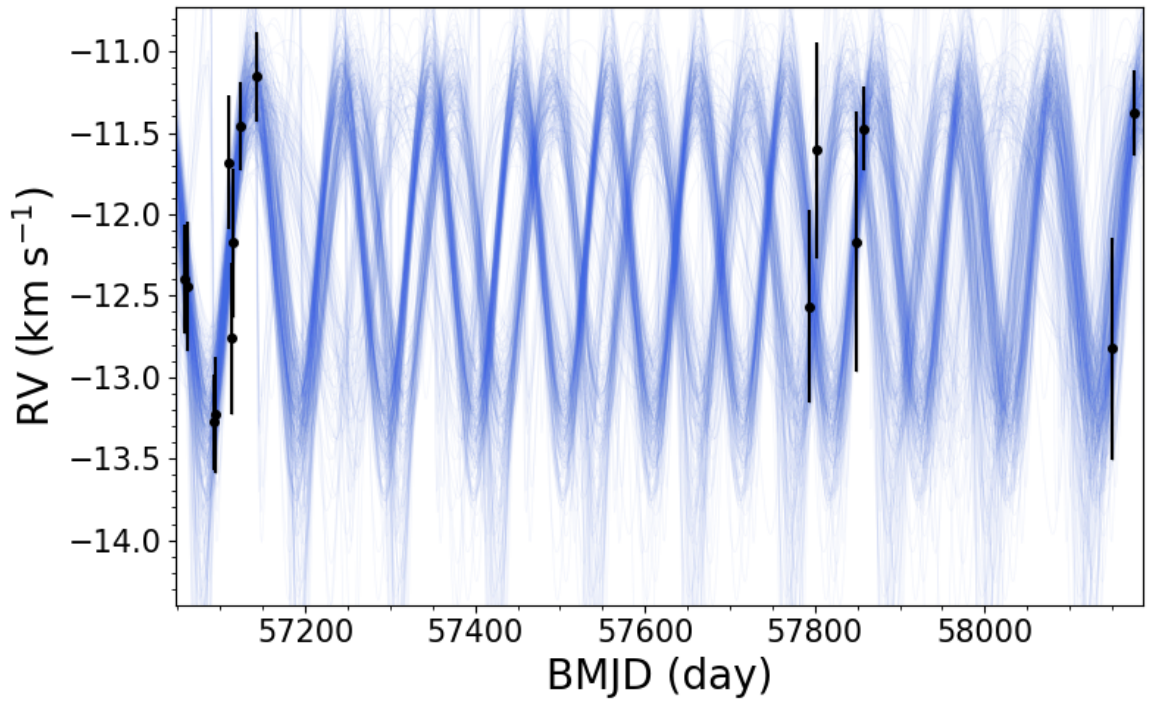


Figure C.11: Binary orbital fit for 2MASS J13430646+0038442. The best-fit orbital parameters are $P_{\text{fit}} = 106.7_{-2.0}^{+40.4}$ day, $K_{\text{fit}} = 1.1_{-0.2}^{+0.2}$ km s $^{-1}$, and $e_{\text{fit}} = 0.124_{-0.096}^{+0.207}$.

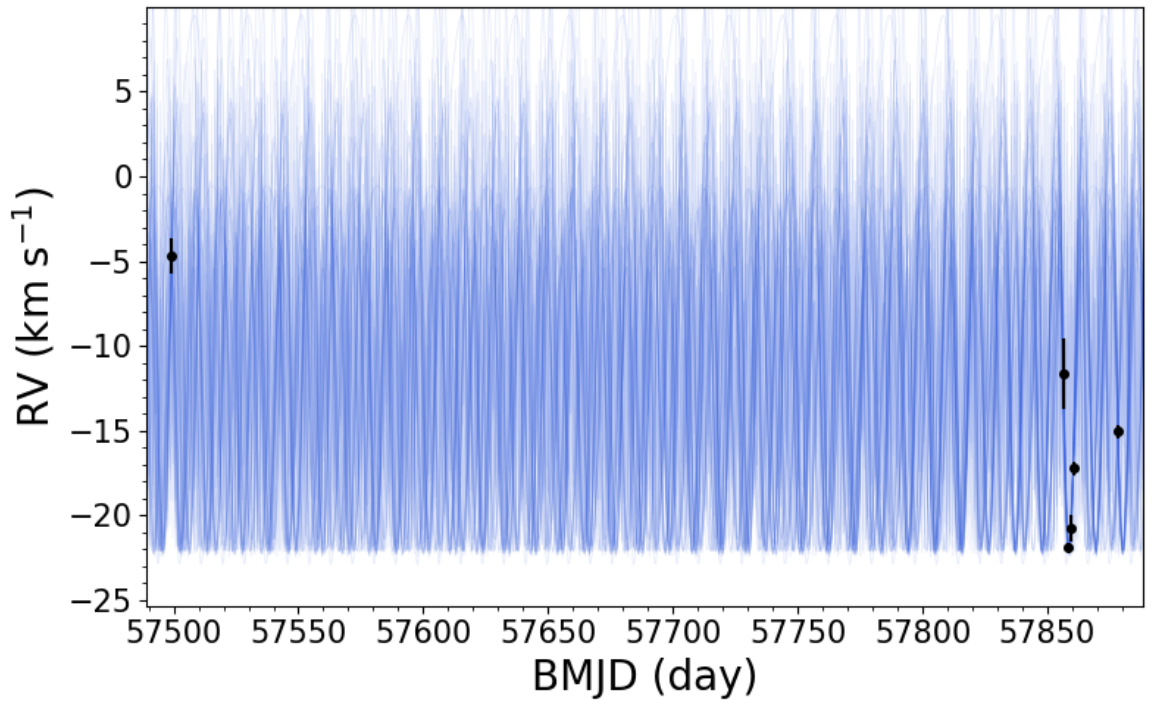


Figure C.12: Binary orbital fit for 2MASS J13482307+3321508. The best-fit orbital parameters are $P_{\text{fit}} = 10.7^{+0.1}_{-3.4}$ day, $K_{\text{fit}} = 10.8^{+3.6}_{-1.6}$ km s⁻¹, and $e_{\text{fit}} = 0.101^{+0.182}_{-0.066}$.

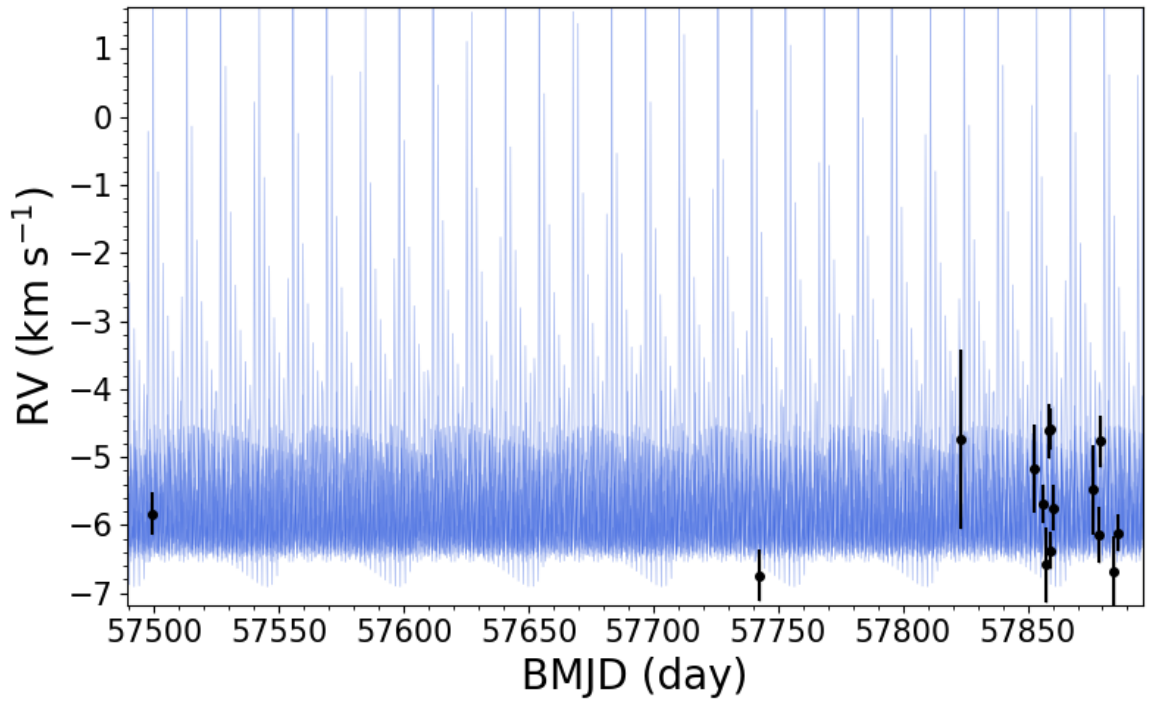


Figure C.13: Binary orbital fit for 2MASS J13500476+3207596. The best-fit orbital parameters are $P_{\text{fit}} = 1.7^{+0.2}_{-0.7}$ day, $K_{\text{fit}} = 1.1^{+0.9}_{-0.2}$ km s⁻¹, and $e_{\text{fit}} = 0.655^{+0.093}_{-0.177}$.

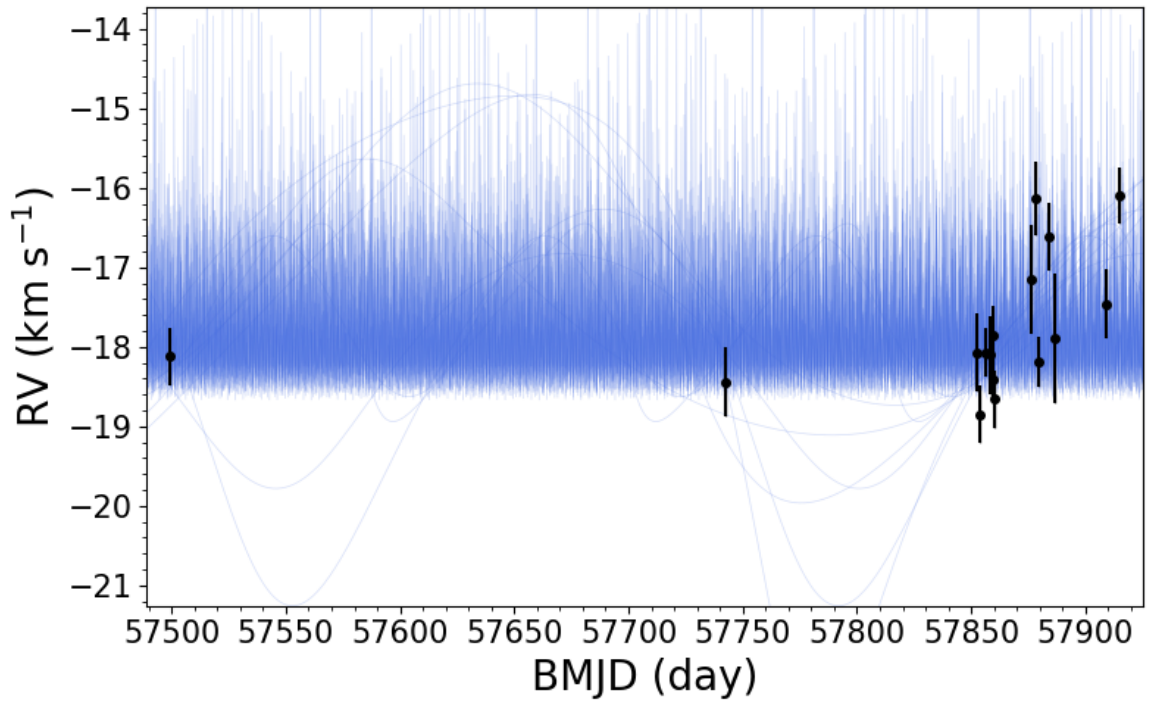


Figure C.14: Binary orbital fit for 2MASS J14005977+3226109. The best-fit orbital parameters are $P_{\text{fit}} = 1.4^{+321.0}_{-0.3}$ day, $K_{\text{fit}} = 1.5^{+1.0}_{-0.4}$ km s⁻¹, and $e_{\text{fit}} = 0.419^{+0.258}_{-0.255}$.

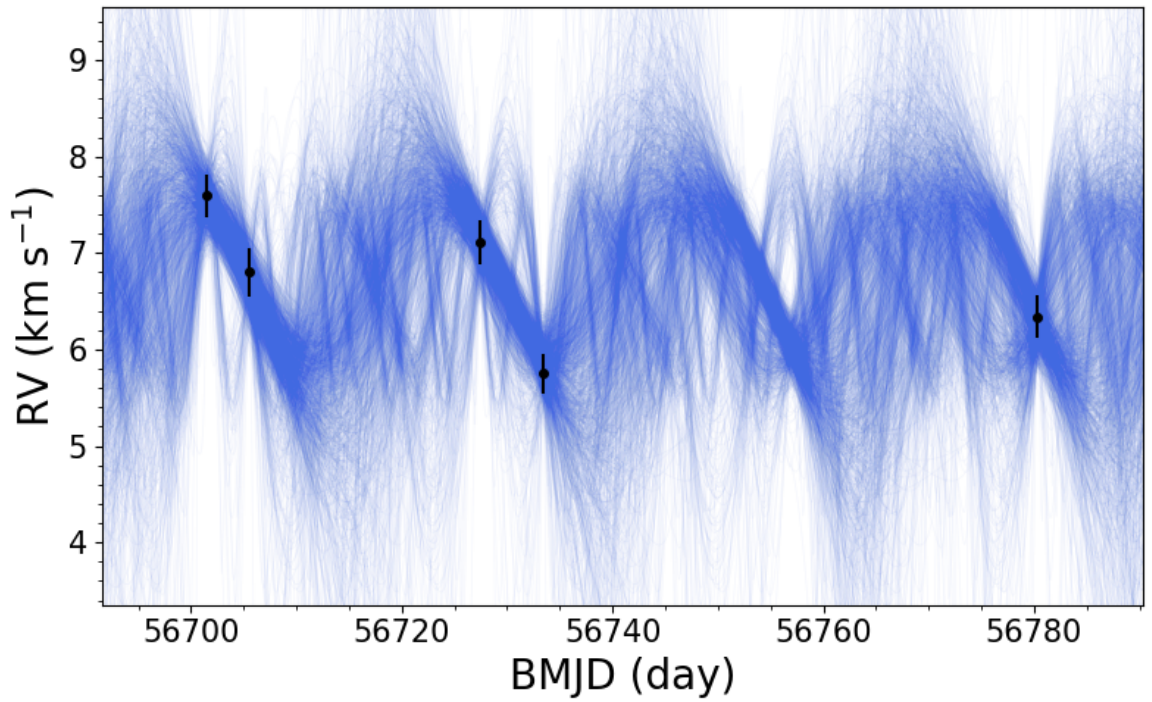


Figure C.15: Binary orbital fit for 2MASS J15010818+2250020. The best-fit orbital parameters are $P_{\text{fit}} = 23.3^{+1.3}_{-11.0}$ day, $K_{\text{fit}} = 1.2^{+0.7}_{-0.3}$ km s⁻¹, and $e_{\text{fit}} = 0.189^{+0.284}_{-0.142}$.

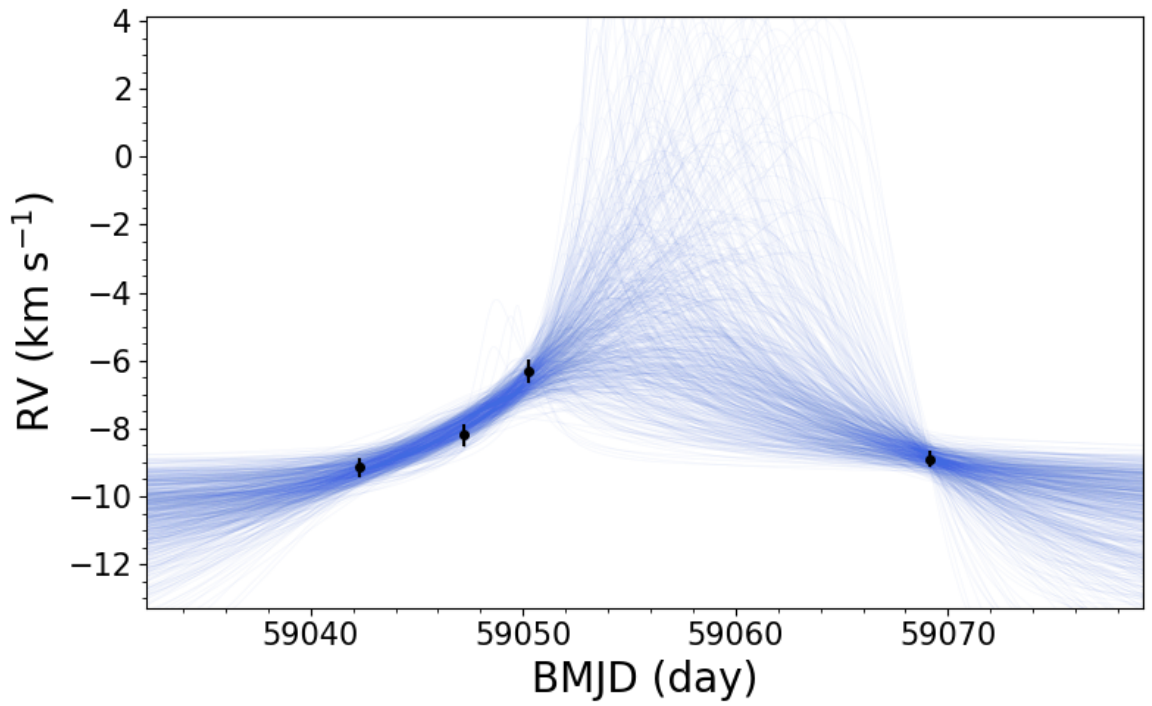


Figure C.16: Binary orbital fit for 2MASS J16271825+3538347. The best-fit orbital parameters are $P_{\text{fit}} = 69.7^{+17.6}_{-7.4}$ day, $K_{\text{fit}} = 3.4^{+2.1}_{-1.3}$ km s $^{-1}$, and $e_{\text{fit}} = 0.524^{+0.175}_{-0.238}$.

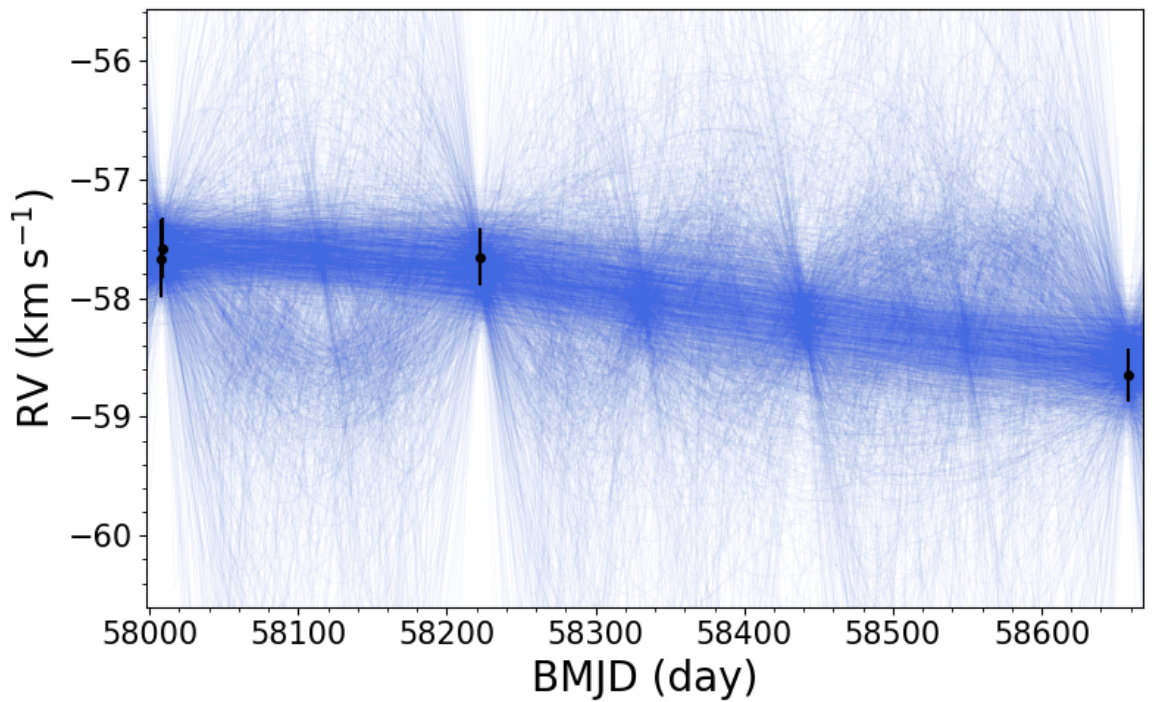


Figure C.17: Binary orbital fit for 2MASS J16572919+2448509. The best-fit orbital parameters are $P_{\text{fit}} = 989.0^{+1158.0}_{-800.9}$ day, $K_{\text{fit}} = 0.8^{+0.6}_{-0.3}$ km s $^{-1}$, and $e_{\text{fit}} = 0.195^{+0.29}_{-0.15}$.

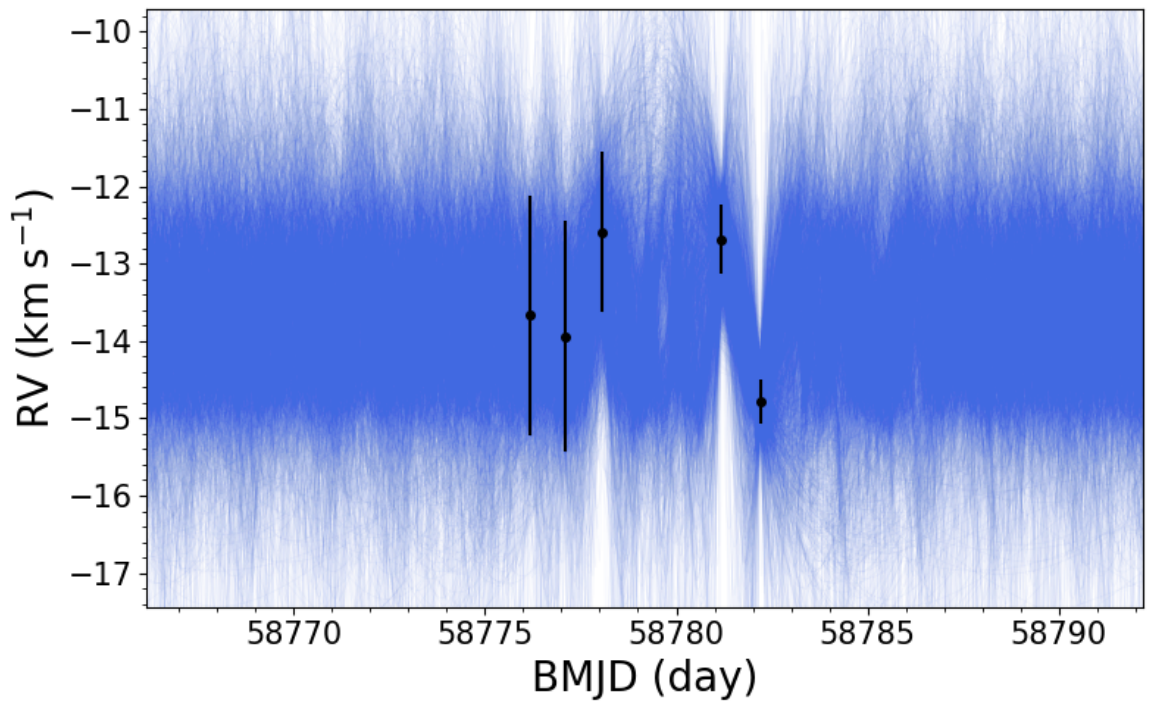


Figure C.18: Binary orbital fit for 2MASS J22551142+1442456. The best-fit orbital parameters are $P_{\text{fit}} = 2.8^{+4.8}_{-1.1}$ day, $K_{\text{fit}} = 1.6^{+0.9}_{-0.5}$ km s⁻¹, and $e_{\text{fit}} = 0.178^{+0.256}_{-0.135}$.

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