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Erratum: "Giant Outer Transiting Exoplanet Mass (GOT 'EM) Survey. II. Discovery of a Failed Hot Jupiter on a 2.7 yr, Highly Eccentric Orbit" (2021, AJ, 162, 154)

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In the original analysis by Dalba et al. (2021) to confirm and characterize the Kepler-1704 system, an erroneous offset of 0.53878357713256 day was accidentally subtracted from the time stamps of the photometric measurements of this star acquired by the Kepler spacecraft. This photometry was then used in the comprehensive system modeling that yielded the final ephemeris of this exoplanet. As a result, parameters describing the timing of this planet's orbit, most notably its conjunction (transit) time, were erroneously offset. This erratum serves to correct this error and the ephemeris of Kepler-1704 b.

We added the 0.53878357713256 day offset to the time stamps of the Kepler photometry that was used in the original analysis. The corresponding flux values were unchanged. Besides the time stamps, we did not alter any other data product.

We then conducted the joint modeling of the stellar and planetary parameters of the Kepler-1704 system using EXOFASTv2 (Eastman et al. 2019) exactly as described in Section 3 of Dalba et al. (2021). All priors and EXOFASTv2 settings were left as described in the original analysis. This new fit converged following the same criteria applied in the original analysis. We again observed a bimodality in mass and age of Kepler-1704 as described in Section 3.1 of Dalba et al. (2021). We selected the lower stellar mass solution just as before and calculated the updated stellar and planetary parameters, which are listed in Tables 1 and 2, respectively.

The only parameter values in Tables 1 and 2 that changed significantly between Dalba et al. (2021) and this analysis are conjunction time (T_C), periastron time (T_P), and eclipse time (T_S). This is expected given that the only change to the inputs to the EXOFASTv2 fit were the time stamps of the Kepler photometry. Changes for other parameters other than those listed above were only due to rounding error or small statistical variations in the Markov chain Monte Carlo analysis, and were all well within the 1σ uncertainties.

Figure 1 shows the Kepler light curves with the updated time stamps and the updated best-fit models. This figure is analogous to Figure 5 of Dalba et al. (2021). Table 3 shows the updated predictions for the timing of future transits and periastron passages. As expected, the time of these events are shifted forward by the value of the time stamp offset relative to the corresponding times published in Table 4 of Dalba et al. (2021).

We conducted two consistency checks of the new ephemeris for Kepler-1704 b. First, we accessed the Kepler Pre-search Data Conditioning Simple Aperture Photometry (PDCSAP; Jenkins et al. 2010; Smith et al. 2012; Stumpe et al. 2012) photometry of Kepler-1704 from Quarters 2 and 13 via the Mikulski Archive for Space Telescopes but we did not conduct any additional detrending. We inserted the unaltered PDCSAP transit light curves into the exact same EXOFASTv2 fit, which proceeded until convergence. The resulting orbital elements are consistent this with those listed in Table 2. Second, we accessed the Transit and Ephemeris Service on the NASA Exoplanet Archive[15] and predicted future transit times of Kepler-1704 b using the planet candidate solution from the Kepler Quarter 1–17 Data Release 25 Supplemental Kepler Object of Interest Table. The resulting transit times for the four events spanning the years 2023–2031 agreed with the transit times listed in Table 3 to within 1 minute.

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[15] https://exoplanetarchive.ipac.caltech.edu/cgi-bin/TransitView/nph-visibletbls?dataset=transits

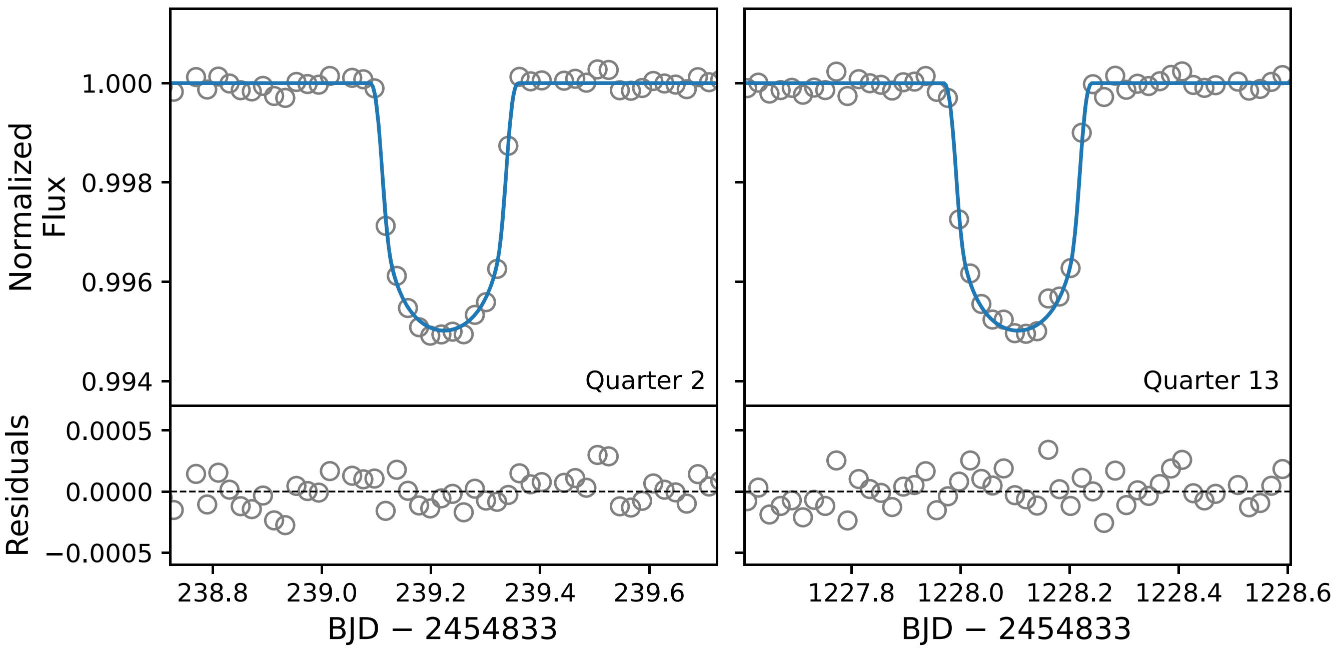

Figure 1. Detrended Kepler photometry of both transits (gray circles) and the best-fit EXOFASTv2 model (blue line).

Table 1
Median Values and 68% Confidence Intervals for the Stellar Parameters for Kepler-1704

Parameter	Units	Values
Informative Priors:		
$T_{\rm eff}$	Effective Temperature (K)	$\mathcal{N}(5772, 115)$
[Fe/H]	Metallicity (dex)	$\mathcal{N}(0.2, 0.06)$
ϖ	Parallax (mas)	$\mathcal{N}(1.213, 0.016)$
A_V	V-band extinction (mag)	$\mathcal{U}(0, 0.2902)$
Stellar Parameters:		
M_*	Mass ($M_\odot$)	$1.132^{+0.040}_{-0.050}$
R_*	Radius ($R_\odot$)	$1.697^{+0.059}_{-0.058}$
L_*	Luminosity ($L_\odot$)	$2.83^{+0.17}_{-0.19}$
$F_{\rm Bol}$	Bolometric Flux (cgs)	$1.336 \times 10^{-10}{}^{+7.1\times10^{-12}}_{-8.6\times10^{-12}}$
ρ_*	Density (g cm^{-3})	$0.325^{+0.036}_{-0.032}$
$\log g$	Surface gravity (cgs)	$4.031^{+0.031}_{-0.032}$
$T_{\rm eff}$	Effective Temperature (K)	5746^{+87}_{-88}
[Fe/H]	Metallicity (dex)	0.196 ± 0.058
$[{\rm Fe/H}]_0$	Initial Metallicity[a]	$0.219^{+0.053}_{-0.056}$
Age	Age (Gyr)	$7.4^{+1.5}_{-1.0}$
EEP	Equal Evolutionary Phase[b]	$452.9^{+4.5}_{-5.7}$
A_V	V-band extinction (mag)	$0.190^{+0.067}_{-0.091}$
$\sigma_{\rm SED}$	SED photometry error scaling	$1.05^{+0.43}_{-0.26}$
ϖ	Parallax (mas)	1.213 ± 0.016
d	Distance (pc)	824 ± 11

Notes. See Table 3 in Eastman et al. (2019) for a detailed description of all parameters and all default (noninformative) priors beyond those specified here. $\mathcal{N}(a, b)$ denotes a normal distribution with mean a and variance b^2. $\mathcal{U}(a, b)$ denotes a uniform distribution over the interval $[a, b]$.
[a] Initial metallicity is that of the star when it formed.
[b] Corresponds to static points in a star's evolutionary history. See Section 2 of Dotter (2016).

Table 2
Median Values and 68% Confidence Interval of the Planet Parameters for Kepler-1704 b

Parameter	Units	Values
P	Period (days)	988.88112 ± 0.00091
R_p	Radius (R_J)	$1.066^{+0.044}_{-0.042}$
M_p	Mass[a] (M_J)	$4.16^{+0.29}_{-0.28}$
T_C	Time of conjunction (BJD_{TDB})	$2{,}455{,}072.22337^{+0.00063}_{-0.00064}$
a	Semimajor axis (au)	$2.027^{+0.024}_{-0.030}$
i	Inclination (deg)	$89.00^{+0.56}_{-0.26}$
e	Eccentricity	$0.920^{+0.010}_{-0.016}$
ω_*	Argument of periastron[b] (deg)	$82.4^{+4.5}_{-5.1}$
T_{eq}	Equilibrium temperature[c] (K)	$253.8^{+3.7}_{-4.1}$
τ_{circ}	Tidal circularization timescale[d] (Gyr)	$80{,}000^{+160{,}000}_{-48{,}000}$
K	RV semiamplitude (m s^{-1})	190^{+17}_{-16}
$\dot{\gamma}$	RV slope[e] (m s^{-1}day^{-1})	$0.0031^{+0.0029}_{-0.0027}$
R_p/R_*	Radius of planet in stellar radii	$0.0644^{+0.0016}_{-0.0011}$
a/R_*	Semimajor axis in stellar radii	$256.4^{+9.1}_{-8.7}$
τ	Ingress/egress transit duration (days)	$0.0173^{+0.0041}_{-0.0022}$
T_{14}	Total transit duration (days)	$0.2503^{+0.0035}_{-0.0026}$
T_{FWHM}	FWHM transit duration (days)	0.2325 ± 0.0017
b	Transit Impact parameter	$0.37^{+0.16}_{-0.22}$
b_S	Eclipse impact parameter	$7.6^{+2.4}_{-4.5}$
ρ_P	Density (g cm^{-3})	$4.07^{+0.55}_{-0.49}$
$\log g_P$	Surface gravity (cgs)	3.938 ± 0.040
$\langle F \rangle$	Incident Flux (10^9 erg s^{-1} cm^{-2})	$0.000465^{+0.000027}_{-0.000028}$
T_P	Time of periastron (BJD_{TDB})	$2{,}455{,}071.88 \pm 0.19$
T_S	Time of eclipse (BJD_{TDB})	$2{,}454{,}760^{+100}_{-110}$
Wavelength Parameters		Kepler
u_1	Linear limb-darkening coefficient	$0.453^{+0.039}_{-0.040}$
u_2	Quadratic limb-darkening coefficient	0.264 ± 0.048
Telescope Parameters		Keck-HIRES
γ_{rel}	Relative RV Offset[e] (m s^{-1})	$34.1^{+3.4}_{-3.6}$
σ_J	RV jitter (m s^{-1})	$6.7^{+4.3}_{-4.2}$

Notes. See Table 3 in Eastman et al. (2019) for a detailed description of all parameters and all default (noninformative) priors. The coordinates of the planet are barycentric.
[a] The value and uncertainty for M_P were determined using the full posterior distribution.
[b] ω is the argument of periastron of the star's orbit due to the planet.
[c] Calculated with Equation (3) of Dalba et al. (2021), which assumes no albedo and perfect redistribution. Between apastron and periastron, T_{eq} varies from 180 to 900 K. See the text for a discussion.
[d] The tidal circularization timescales is calculated from Equation (4) of Dalba et al. (2021).
[e] The reference epoch is $BJD_{TDB} = 2{,}457{,}429.435011$.

Table 3
Future Transit and Periastron Timing Predictions

Epoch[a]	Conjunction (Transit) Time BJD_{TDB}	Conjunction (Transit) Time UTC	Periastron Time BJD_{TDB}	Periastron Time UTC	JWST Visibility[b]
5	2460016.6290 ± 0.0046	2023-03-13 03:06	2460016.29 ± 0.19	2023-03-12 18:51	None
6	2461005.5109 ± 0.0055	2025-11-26 00:15	2461005.17 ± 0.19	2025-11-25 16:00	Partial
7	2461994.3912 ± 0.0064	2028-08-10 21:23	2461994.05 ± 0.19	2028-08-10 13:09	Full
8	2462983.2723 ± 0.0073	2031-04-26 18:32	2462982.93 ± 0.19	2031-04-26 10:18	Partial

Notes. The times listed here do not account for possible uncertainty owing to yet undiscovered TTVs (see Section 5.3 of Dalba et al. 2021).
[a] Epoch = 0 is defined as the first transit observed by the Kepler spacecraft.
[b] JWST visibility after 2023 December 31 is based on previous years' visibility. Epochs for which the full periastron passage of Kepler-1704 b partially falls outside of the predicted visibility windows are labeled as "Partial" (see the text).

In summary, the correction of the Kepler-1704 b ephemeris is critically important as the erroneous offset was longer than the transit duration itself. However, it is also important to note that this error and its correction has had no other impact on the interpretations or discussion presented by Dalba et al. (2021).

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