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WAVELENGTHS AND OSCILLATOR STRENGTHS OF TRANSITIONS IN Kr XXXIII AND Kr XXXIV

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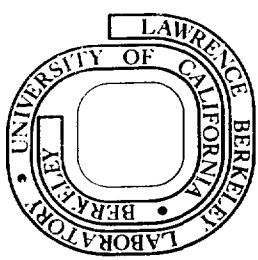

WAVELENGTHS AND OSCILLATOR STRENGTHS OF TRANSITIONS IN Kr XXXIII AND Kr XXXIV

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ABSTRACT

We have used the beam foil technique to measure the wavelengths and meanlines of the upper levels of: 1) the $2s\ ^2S_{1/2}$-$2p\ ^2P^\circ_{1/2,3/2}$ resonance transitions in lithium-like Kr XXXIV and 2) the $2s^2\ ^1S_0$-$2s2p\ ^3P^\circ_1$ intersystem transition in berylium-like Kr XXXIII. Preliminary analysis of the data indicates good agreement between experimental values and results of recent relativistic oscillator strength calculations.

INTRODUCTION

We report preliminary experimental values of the wavelengths and mean lives of the lowest lying resonance transitions ($2s\ ^2S_{1/2}$-$2p\ ^2P^0_{1/2,3/2}$) in lithium-like krypton and the intersystem transition ($2s^2\ ^1S_0$-$2s2p\ ^3P^0_1$) in Berylium-like krypton. Members of these isoelectronic sequences appear prominently in the spectra of hot plasmas [1], their wavelengths are used to identify the ions present and their oscillator strengths are used to determine the ion concentration [2] and the electron temperature and density [3]. Further, since krypton is the highest z system for which measurements of this type have been made, these data provide an excellent test of relativistic effects [4]-[7] and extrapolation techniques [8].

EXPERIMENTAL ARRANGEMENT

A schematic diagram of the apparatus used to perform the beam-foil mean life and wavelength measurements is shown in Fig. 1. A 714 MeV krypton beam from the Lawrence Berkeley SuperHILAC is passed through a carbon foil mounted on a moveable support. Adequate collimination upstream insures that any light detected through the spectrometer is emitted by ions which are subsequently collected in the Faraday cup. The spectrometer is a McPherson 247 grazing incidence monochromator with stepping motor drive and 2.2 meter 600 ℓ/mm or 1200 ℓ/mm grating. With an 82° angle of incidence the blaze wavelengths are 210 Å and 105 Å respectively. The photon detector is a shielded Bendix Channeltron (Model 4700). And various gases are leaked into an

ion-gauge mounted across the chamber from the entrance slits to establish calibration constants for the spectrometer. Calibration lines are checked before and after wavelength measurements to establish the stability of the instrument.

DATA

A wavelength scan from about 165 Å to 190 Å is shown in Fig. 2. All three features of interest are included in this region. Actual wavelength measurements were made with repeated scans over single lines with 100 micron slits and approximately 10 points above F.W.H.M. instead of the 200 micron slit scan shown here. These wavelengths include, besides the transverse doppler shift, about a one percent linear doppler shift which was determined using the well known lines in lithium-like Fe. In particular, the one at 192.03 Å (established by solar flare observations [9]) is quite close to our region of interest.

Typical decay curves from which the mean lives of the $2p\ ^2P^0_{1/2,3/2}$ levels in lithium-like krypton were obtained are shown in Fig. 3. A similar decay curve was obtained for the $2s2p\ ^3P^0_1$ level in Berylium-like krypton. These data were obtained by getting a background reading at each coil position. Also, the amount of time spent collecting each data point and the amount of beam collected were monitored so that these curves have the background and dark current subtracted and are normalized to the beam current. All of the decay curves were fitted with a single exponential. Any effects of cascading

are assumed to be negligible in any case points close to the foil are omitted in the fitting process.

RESULTS

The preliminary results for the wavelengths measured are: 1) $2s^2\ {}^1S_0$-$2s2p\ {}^3P^0_1$, 170 ± 0.5 Å, 2) $2s\ {}^2S_{1/2}$-$2p\ {}^2P^0_{1/2}$, 174.1 ± 0.2 Å, and 3) $2s\ {}^2S_{1/2}$-$2p\ {}^2P^0_{3/2}$, 91.1 ± 0.1 Å. The latter two results for the lithium-like krypton compare very favorably with values due to Edlén [8] of 174.3 Å and 91.13 Å respectively. The preliminary results for the mean lives measured are: 1) ${}^3P^0_1$, 2.3 ± 0.3 nanoseconds, 2) ${}^2P^0_{1/2}$, 312 ± 19 picoseconds, and 3) ${}^2P^0_{3/2}$, 51 ± 3 picoseconds, again the latter two numbers are for lithium-like krypton. The errors quoted for the wavelengths are approximately twice the statistical uncertainties associated with the fitting procedures. For the mean lives, the uncertainty in the beam velocity (1%) and an estimate of possible systematic uncertainty (4%) are added in quadrature to twice the statistical uncertainties associated with the fitting procedures.

Oscillator strengths derived from these measurements are compared to theory in Fig. 4a for the lithium-like isoelectronic sequences. It should be noted that a previous relativistic "length" calculation by Kim and Desclaux [5] agree with Armstrong's results. It is apparent that the relativistic calculations in the dipole "length" gauge are in excellent agreement with our results. Fig. 4b shows a similar comparison for the $2s^2\ {}^1S_0$-$2s2p\ {}^3P^0_1$ transition in the Berylium isoelectronic sequence. Again, excellent agreement is obtained.

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FIGURE CAPTIONS

Fig. 1. Schematic diagram of experimental arrangement used for the meanlife and wavelength measurements.

Fig. 2. Spectral scan of the post foil beam for a 714 MeV Kr^{+21} beam incident on a 600 μgram/cm^2 carbon foil taken with 200 micron slits. The lines are; (1) $2s^2\ {}^1S_0$-$2s2p\ {}^3P^0_1$ intersystem transition in Be-like krypton, 170 Å, 2) $2s\ {}^2S_{1/2}$-$2p\ {}^2P^0_{1/2}$ resonance line in Li-like krypton, 174.1 Å, and 3) $2s\ {}^2S_{1/2}$-$2p\ {}^2P^0_{3/2}$ resonance line in Li-like krypton in second order, 182.1 Å.

Fig. 3. Measured decay curves for determination of the mean lives of $2p\ {}^2P^0_{1/2,3/2}$ levels of lithium-like Kr.

Fig. 4. Comparison of theoretical and experimental oscillator strengths of (a) the $2s\ {}^2S_{1/2}$-$2p\ {}^2P^0_{1/2,3/2}$ resonance transitions for ions of the Li isoelectronic sequence (the middle dashed line through the origin is nonrelativistic theory, the remainder of the curves are relativistic theory [4] [5]). The experimental points are S^{+13} [10], Fe^{+23} [11] and Kr^{+33} (this work), and (b) the $2s^2\ {}^1S_0$-$2s2p\ {}^3P^0_1$ intersystem transition for ions of the Be isoelectronic sequence (theoretical curves are from [6]). The experimental points are Fe^{+22} [11] and Kr^{+32} (this work). The subscript V and L denote results of "velocity" and "length" gauge calculations respectively. (Z = atomic number.)

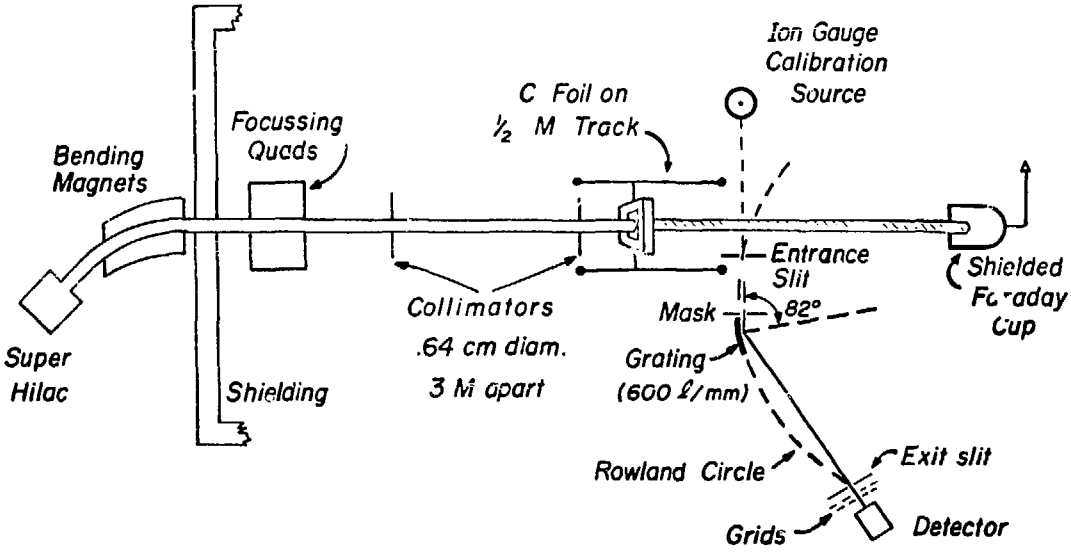

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Figure 1

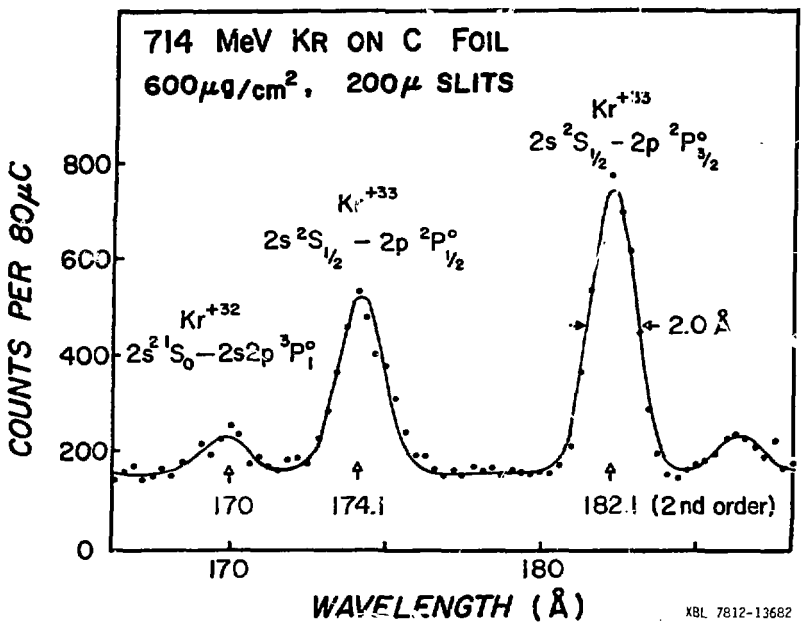
714 MeV KR ON C FOIL
600μg/cm², 200μ SLITS
Kr+33
2s ²S1/2 – 2p ²P°3/2
Kr+33
2s ²S1/2 – 2p ²P°1/2
Kr+32
2s² ¹S0 – 2s2p ³P°1
2.0 Å
170
174.1
182.1 (2nd order)
COUNTS PER 80μC
800
600
400
200
0
170
180
WAVELENGTH (Å)
XBL 7812-13682

Figure 2

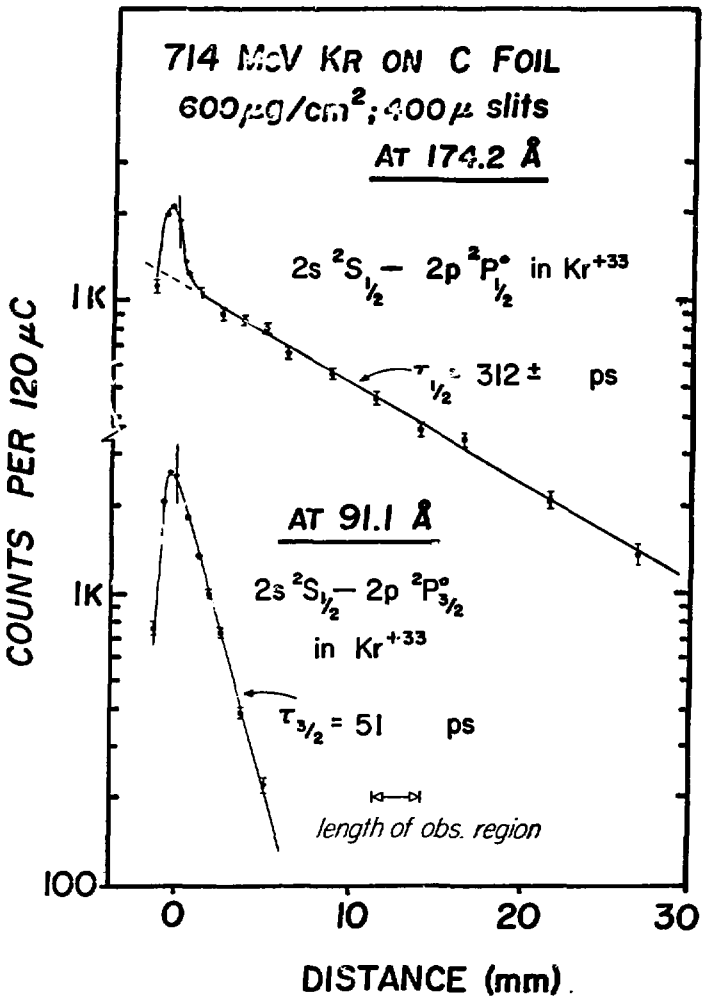

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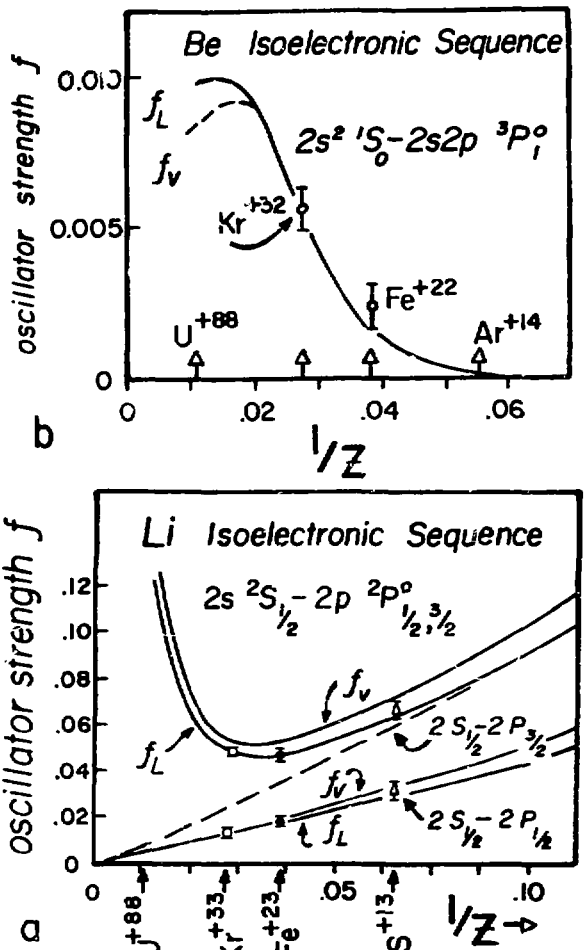
Figure 3


Be Isoelectronic Sequence
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0.005
0
f_L
f_v
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Kr^{+32}
Fe^{+22}
U^{+88}
Ar^{+14}
0
.02
.04
.06
b
1/Z
Li Isoelectronic Sequence
oscillator strength f
.12
.10
.08
.06
.04
.02
0
$2s\ ^2S_{1/2} - 2p\ ^2P^o_{1/2,3/2}$
f_v
f_L
$2\ S_{1/2} - 2\ P_{3/2}$
$2\ S_{1/2} - 2\ P_{1/2}$
0
.05
.10
U^{+88}
Kr^{+33}
Fe^{+23}
Sn^{+13}
a
1/Z →

Figure 4