Title

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We have used the foil-excitation technique recently employed by Kay[1] and Bashkin et al.[2] to measure directly the average of the lifetimes of the $1s^2 2p(^2P^o_{1/2})$ and $1s^2 2p(^2P^o_{3/2})$ states of C IV, N V, O VI, F VII, and Ne VIII ions in the lithium-like isoelectronic sequence. In each case a beam of ions accelerated to an energy of 0.97 MeV/nucleon by the Berkeley heavy-ion linear accelerator (Hilac) was further ionized and excited in an aluminum foil. The decay of radiation from the ^2S-$^2P^o$ transitions was then measured as a function of position downstream from the exciting foil; a vacuum-uv monochromator with a sodium-salicylate-covered photomultiplier was used as a photon detector.

Ions C^{+2}, N^{+3}, O^{+3}, F^{+3}, or Ne^{+3} were accelerated to $\beta = 0.0457$ by the "prestripper" section of the Berkeley Hilac. The ion beam was collimated, passed through a 140 $\mu g/cm^2$ Al foil, and monitored by two concentric Faraday cups. The foil was attached to a moveable shaft that permitted 35-cm displacement along the beam line. The central Faraday cup, 1.9-cm in diameter, received most of the beam (typically 80 to 90% for the greatest foil-cup separation). The other cup gave an indication of the angular spread of the beam.

The ions emerged from the foil with an equilibrium charge distribution and in various states of electronic excitation. The radiation from these excited states was observed with a vacuum-uv scanning monochromator (McPherson 0.5-meter Seya-Namioka) with 1.0 by 20 mm entrance and exit slits. The monochromator collected light from 1 cm of beam path and had a roughly triangular bandpass 32 Å wide at half maximum. The detector was a photomultiplier tube (Amperex XP 1010) coated with sodium salicylate and cooled to -40°C to reduce thermal noise. Current pulses due to individual photons were registered by a scaler circuit; to correct for photomultiplier noise, data were also recorded on a second scaler for an equivalent time interval between beam pulses.

The monochromator was scanned in wavelength at a given foil position to locate the center of the doublet, and the photon counts were then recorded as a function of foil position. Peak counting rates were about 4000 counts per minute for a beam current of 1 μA. Figure 1 shows the number of counts as a function of foil position for the F VII doublet at 890.8 and 883.1 Å. The foil comes into the field of view of the monochromator at about 4.8 cm and leaves it at about 5.8 cm; beyond this position the intensity of the doublet is seen to decay exponentially with distance. Results for other ions in the lithium-like isoelectric sequence were similar.

The transition probabilities were obtained by least-squares fitting the data points with a computer program to an exponential plus a constant background. In every case a single exponential fitted the data very well, and the computer-selected background was consistent with estimates derived from the observed counting rate before the foil came into the field of view of the monochromator. Whether the data were normalized to the total charge collected by only the central Faraday cup or to the total charge collected by both Faraday cups made, on the average, a difference of only 2% in the value of the transition probability. In the final results these two values were averaged and an uncertainty of 3% assigned, sufficient to include both the uncertainty in normalization and the uncertainty in curve fitting. The only other source of uncertainty is the calculation of the velocity from the accelerator parameters and the calculated energy loss in the foil ($\Delta E/E \approx 0.05$). An uncertainty of ± 1.5% is assigned to the calculated velocities.

The average transition probabilities for the $1s^2 2s(^2S_{1/2}) - 1s^2 2p(^2P^o_{1/2,3/2})$ transitions of C IV, N V, O VI, F VII, and Ne VIII are shown in Table I. Also shown are theoretical values calculated by Varsavsky[3] (screening approximation), Griem[4] (Coulomb approximation), Heroux[5] (Coulomb approximation), and Weiss[6] (Hartree-Fock method, a, and a presumably more accurate method, b, employing 45-term configuration interaction wave functions). The wavelengths and the various authors' estimates of the reliability of their values are included.

Within the estimated uncertainties, all the theoretical values, even those derived from the Coulomb approximation, agree well with our measurements.

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FOOTNOTE AND REFERENCES

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Table I. Average transition probabilities for $1s^2 2s(^2S_{1/2}) - 1s^2 2p(^2P^o_{1/2, 3/2})$.

Spectrum	λ(Å)	Transition probability × 10^{-8} (sec^{-1}) Measured	Theoretical Varsavsky	Griem	Weiss[a]	Weiss[b]	Heroux
C IV	1550.7 1548.2	2.97 ± 0.11	2.78	2.64	2.681	2.645	2.6
N V	1242.8 1238.8	3.34 ± 0.12	3.46	3.40	3.416	3.373	4.0
O VI	1037.6 1031.9	3.94 ± 0.14	4.37	4.14	4.144	4.055	4.2
F VII	890.8 883.1	4.48 ± 0.16	5.07	---	4.872	---	---
Ne VIII	780.3 770.4	5.55 ± 0.19	5.94	---	5.591	---	5.75
Estimated uncertainty		3.5 %	≥ 10 %	≥ 20%	5 - 15%	2 - 4%	

[a] Hartree-Fock method

[b] 45-term configuration interaction wave functions

FIGURE CAPTION

Fig. 1. Counts vs foil position for the F VII doublet at 890.8 and 883.1 Å. The line is the computer result for the best fit to the data.

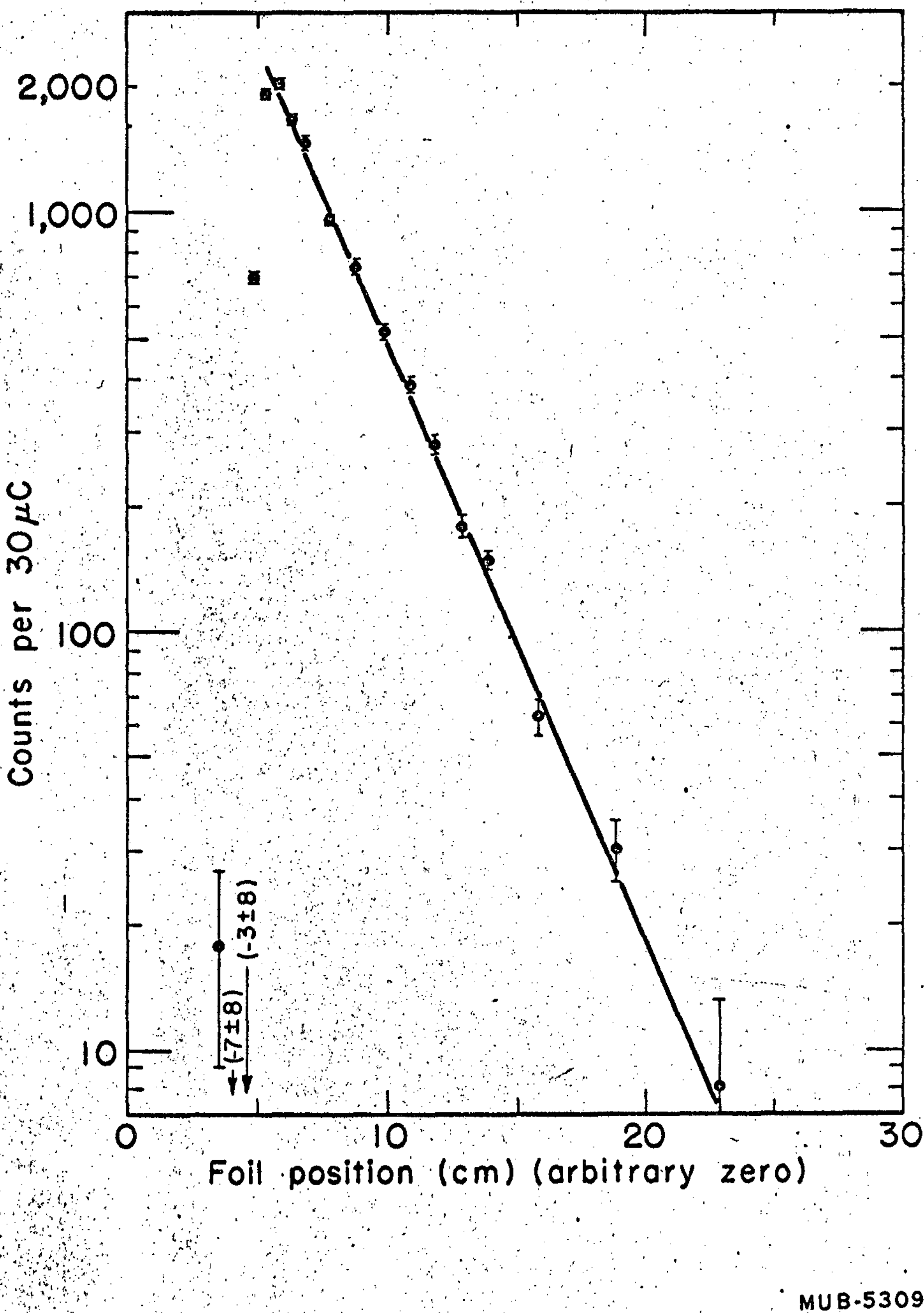
2,000
1,000
100
10
Counts per 30 μC
(-7±8)
(-3±8)
0
10
20
30
Foil position (cm) (arbitrary zero)
MUB-5309

Fig. 1.