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Beam-Foil Spectroscopy at Argonne National Laboratory

H. G. Berry
Argonne National Laboratory, Argonne, Illinois 60439

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Our present fast ion-beam atomic physics program consists of three major parts, two of which are investigations in atomic structure, and one of which involves collision physics. The first involves work mainly at the Argonne tandem accelerator (30-100 MeV ion energy) and will soon be extended to use of the superconducting linac post accelerator at energies up to 300 MeV. The other parts involve the Argonne dynamitron accelerator (0.5-5.0 MeV ion energy) and a low energy test bench facility.

We have completed a set of precision wavelength measurements of the transitions $1s2s\ ^3S_1 - 1s2p\ ^3P_{0,2}$ of the helium-like ions of silicon, sulfur, and chlorine. We have calculated the wavelengths of these transitions for $Z = 2-50$ using a nonrelativistic 1/Z expansion, one-electron Dirac energies, plus relativistic corrections in first-order perturbation theory, plus one-electron QED or Lamb-shift corrections. By comparisons of measurements of $Z = 4-26$ and theory, we find a discrepancy which is approximately $0.015\ Z^3\ cm^{-1}$. We have shown that this arises from a first-order screening correction to the one-electron Lamb shift and we have obtained an ab initio estimate of the correction (Fig. 1).

Optical emission from negative ions formed by the beam-foil interaction had not been considered feasible prior to the recent theoretical assignment of the observed emission at 348.9 nm to the $1s2s2p^2\ ^5P - 1a2p^3\ ^5S^o$ transition of Li^-. By alternately applying an electric field parallel and anti-parallel to the beam, the intensity of the emitted light, as a function of distance from the foil, assumes a signature unique to the ionic charge. Using such a technique we have confirmed that the radiation is emitted from the negative lithium ion.

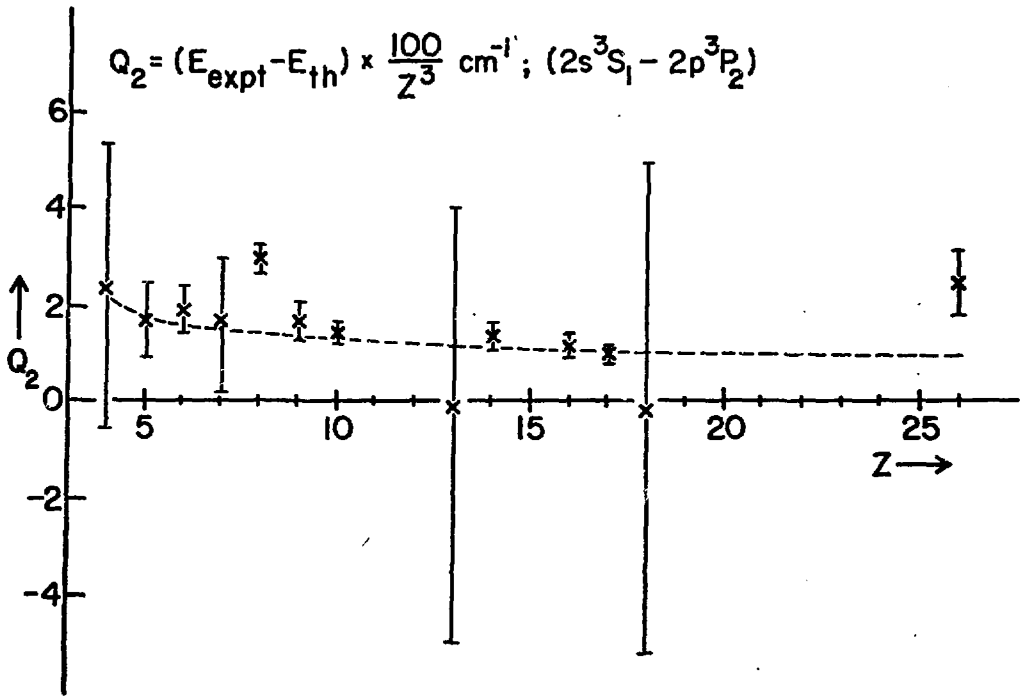

Fig. 1. Scaled differences of the experimental and theoretical energies of the transition $1s2s\,^3S_1 - 1s2p\,^3P_2$ in helium like systems. The measurements of Z = 14,16,17 are from ANL-Notre Dame work. The dashed line is our calculation of the two-electron QED corrections (R. DeSerio, Ph.D. thesis)

Supporting evidence is offered by the zero polarization measured with the foil tilted to 50°. In addition, we have established the cascade-free nature of the decay curve whose lifetime is 2.28 ± 0.05 ns. We have identified the transition in heavier isoelectronic ions up to fluorine.[1]

Searches for photon emission from H^- and O^- are also underway, so far without success.

We are continuing our measurements of alignment and orientation production in thin foils.[2] We have used both alignment and total light-yield measurements[3] to study the molecular break-up and transmission in thin carbon foils of light ions such as H_2^+, H_3^+, and HeH^+. Quantum beat studies of ^{3}HeI n ^{1}D states are also in progress.

REFERENCES

1. R. L. Brooks, J. E. Hardis, H. G. Berry, L. J. Curtis, K. T. Cheng, and W. Ray, Phys. Rev. Lett. 45, 1318-1322 (1980).

2. R. M. Schectman, R. D. Hight, S. T. Chen, L. J. Curtis, H. G. Berry, T. J. Gay, and R. DeSerio, Phys. Rev. A 22, 1591-1599 (1980).

3. T. J. Gay and H. G. Berry, J. Phys. B 13, 1199-1204 (1980).