Exploratory Experiments: Photodetachment of Negative Ions by Energetic Photons

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**Abstract**

One of the current investigations in Atomic Physics is the electron-electron interaction in atoms by placing atoms in "exotic" states. A unique opportunity exists to perform a series of experiments which will probe this interaction by examining continuum states in various atomic species by photodetaching negative ions. Synchrotron radiation is useful in providing a continuously tunable source of photons over the energy range of interest. Various theories [1, 2] predict the photodetachment cross sections are rich in features (both minima and resonances) in this photon energy range. This situation makes these studies ideally suited for providing stringent tests of our current understanding of atomic structure. The specific experiments listed in this abstract are representative of the types of experiments possible and are only the first in an extended series of experiments that are currently of great interest in atomic physics.

The first series of experiments that are proposed will probe the photon energy region from 4eV to 20 eV in a variety of relatively light elements. Gribakin, et al. [1] predicted the photodetachment cross sections for the outer np and nearby ns subshells of C- 2p3 4S, Si- 3p3 4S, and Ge- 4p3 4S. The np photodetachment cross sections have minima around 5eV above the negative ion ground states and then rise to maxima at around 8 eV before gradually falling again. The minima have widths of order of 0.5 eV, whereas the maxima have widths of several eV. By contrast, most of the predicted [2] resonances in Be (4Po, 4Do, and 4So) have widths of order of 10-50 meV.

These proposed experiments complement previous photodetachment experiments of the authors at lower photon energies. With an estimated photon flux of $10^{12}$ photon/s, an ion current of 100 nA, and the predicted photodetachment cross sections, we expect a photoelectron current of approximately 10-1000 e-/s. An apparatus (PHOTO-2) has been constructed for conducting this series of photodetachment experiments (see Figure).

Briefly, it consists of: a 0 - 50kV negative ion accelerator; a dodecapole chamber for merging the ion and photon beams; an interaction chamber of approximately 30 cm long; and data acquisition chamber. Photodetached electrons are energy analyzed by a hemispherical energy analyzer located...
in the data acquisition chamber. The various residual ion, neutral, and photon beams exit through
an aperture in the outer hemisphere of the analyzer and are detected by a Faraday cup detector. The
interaction region has magnetic field coils to null the earth's magnetic field throughout this region.

The predicted continuum state structure (energy locations, widths, and magnitudes) are very
sensitive to specific atomic structure theory approximations, and experimental measurements such
as the ones currently proposed will provide stringent tests of our understanding of the electron-
electron and electron-nucleus interactions that occur in atoms and ions.

References
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