DIELECTRONIC RECOMBINATION IN Li^+ IONS

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Dielectronic recombination[1] (DR) is an atomic process occurring in electron-ion collisions when the capture of an electron is accompanied by the simultaneous electronic excitation of the ion resulting in the formation of a doubly-excited intermediate state; subsequent deexcitation by photon emission completes the recombination of the ion. The DR process, which is mediated by the electron-electron interaction, is just the inverse of an Auger transition and is resonant for relative velocities corresponding to outgoing Auger-electron energies.

Over a broad energy range DR is the principal means by which free electrons recombine with ions. So DR has been of fundamental interest for many years.[2,3] In addition, DR is important to astrophysical studies[4] and to the development of nuclear fusion plasmas;[5] and DR can be an important diagnostic tool for ion-beam cooling in storage rings. Cross sections for DR have been calculated[2,3] extensively. Recently, powerful new experimental methods have provided good measurements[6-10] of DR for testing the theoretical predictions.

In this work, DR was investigated for $Li^+(1s^2) + e^- \rightarrow [Li^0(1sn\ell n'\ell')]^{**}$ using the electron cooler at IUCF. The present work is an extension of our previous work[11-12] at IUCF for He^+ ions. These light He^+ and Li^+ ions pose stringent tests of DR theory because the electron-electron interaction, which mediates DR, is stronger compared to electron-nucleus interactions than it is for heavier ions. Additionally, the electron coupling in two-electron Li^+ gives rise to angular momentum configurations different from those in He^+.

For $Li^+(1s^2)$ ions, DR is expected to occur for relative energies E_{rel} of 50-60 eV between the ion and the electron. However, the metastable beam component $Li^+(1s2s)$ can give rise to DR involving $2s \rightarrow 2p$ transitions for relative energies near zero (i.e., a few eV). Also, for $E_{rel} = 0$, a peak due to radiative recombination (RR) (inverse photoelectric effect) is expected.

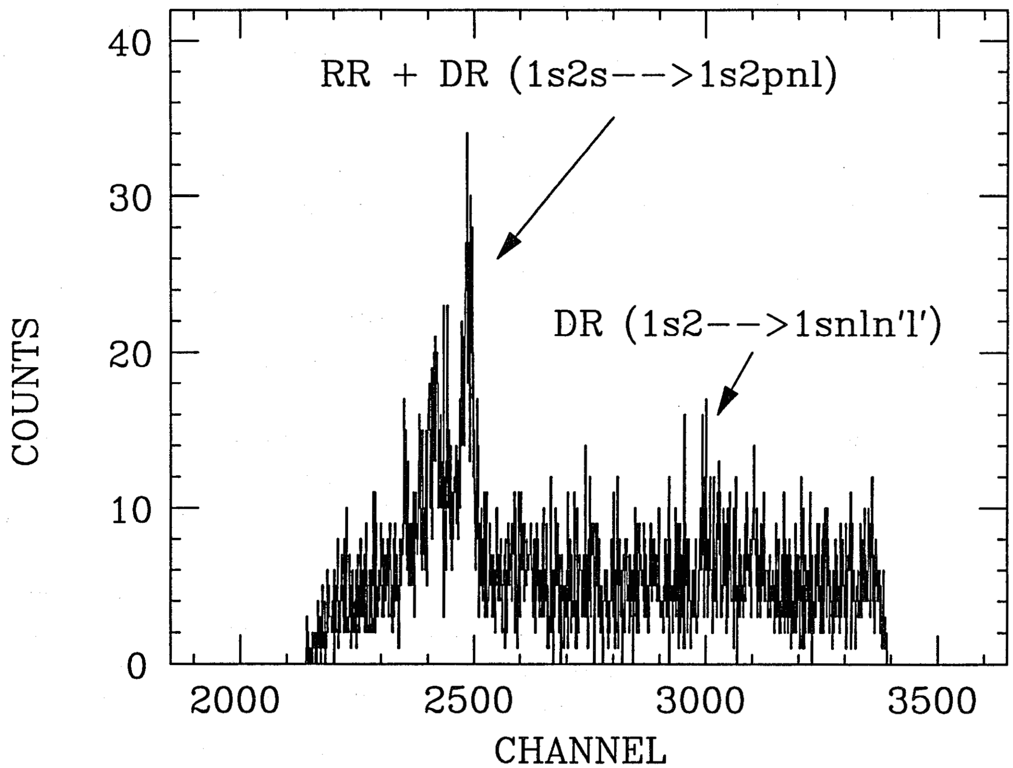

Figure 1. Measured intensity (counts) of neutral Li atoms resulting from collisions of 31 MeV Li^+ ions with electrons in the Cooler region. The channel number is proportional to the laboratory electron energy. The expected regions for dielectronic recombination (DR) and radiative recombination (RR) are indicated.

As for He^+, the Li^+ measurements were conducted in a "single-pass" mode in which the ions circled the storage ring, passed through the intense electron beam in the cooler region, and then those Li^+ ions not undergoing recombination were deflected by a ring dipole magnet and collected in a Faraday cup. Events resulting in DR were detected from the yield of neutral Li atoms formed in the cooler region; these atoms emerged through the 0° exit port following the electron cooler and were counted with a large area (2000 mm^2) silicon surface-barrier detector. For the measurements conducted here, a 31-MeV beam of Li^+ ions of current 10 nA was merged with the electron cooling beam of current $\sim$ 300 mA over the interaction length of 2.8 m.

In these measurements we did observe DR for Li^+, but the beam intensity was too low and the beam stability too erratic to give good results. A typical spectrum obtained is shown in Fig. 1. Some evidence of the expected DR peak due to $1s^2 + e^- \rightarrow 1s2\ell2\ell$ transitions in the range 50-60 eV is seen, but the data are not convincing. Also there is an indication of a DR contribution resulting from $1s2s + e^- \rightarrow 1s2pn\ell$ transitions in the metastable $Li^+(1s2s)$ ion. However, this latter contribution to DR occurs near zero relative energy where radiative recombination (RR) should be at a maximum. In the present work, the separate contributions from DR and RR cannot be clearly identified. Additional measurements with better beam conditions are planned.

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