

ATOMIC PHYSICS

DIELECTRONIC RECOMBINATION IN Li^+ IONS

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

In this work, DR was investigated for Li^+ ions using the electron cooler at IUCF. The present work is an extension of our previous work^{1,2} at IUCF for He^+ ions. As with 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 neutral atoms emerged through the 0° exit port following the cooler and were counted with a large area silicon surface-barrier detector. For the measurements conducted here, a 31 MeV beam of Li^+ ions with a current of 50 nA was merged with the 500-mA electron cooling beam over the 2.8-m interaction length. To investigate DR, the electron beam energy is scanned over the energy region where DR is expected to occur.

For two-electron Li^+ , DR can occur for the $1s^2$ ground-state electron configuration and also for the $1s2s$ metastable-state configuration (lifetime about 50 s). For ground-state $\text{Li}^+(1s^2)$, DR is expected to occur via $1s^2 + e^- \rightarrow 1sn\ell n'\ell'$ transitions for relative energies E_{rel} of 50-60 eV between the ion and the electron. The metastable beam component $\text{Li}^+(1s2s)$ can give rise to DR via $1s2s + e^- \rightarrow 1s2pn\ell$ transitions for E_{rel} near 1 eV. Also, for $E_{rel}=0$, a peak due to radiative recombination (RR) (inverse photoelectric effect) is expected.

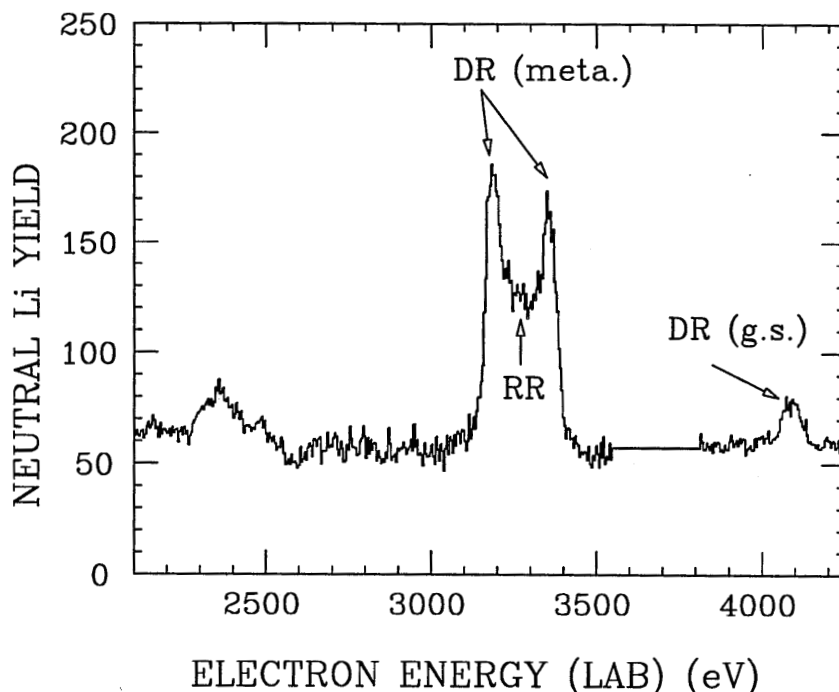


Figure 1. Measured yield of neutral Li atoms resulting from collisions of 31-MeV Li^+ ions with electrons in the cooler region as a function of the laboratory electron energy. The positions of ground-state [DR(g.s.)] and metastable [DR(meta.)] dielectronic recombination are indicated, as well as the position of the radiative recombination (RR) maximum.

We have observed DR in Li^+ for both the ground-state and metastable configurations, and, additionally, there is an RR contribution near zero relative energy as shown in Fig. 1. The DR contribution resulting from transitions in metastable $\text{Li}^+(1s2s)$ is not fully resolved from the radiative recombination (RR) maximum at zero relative energy, however. Theoretical calculations³ are presently underway to compare with these measurements. Li^+ (and He^+) ions pose stringent tests of DR theory because the electron-electron interaction 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^+ .

To date, accurate absolute cross sections for DR in Li^+ have not been obtained. Because Li^+ is an important system for which to study DR (its low Z and two-electron configuration provide stringent tests of theory), new measurements will be conducted for this system. Additionally, the long-lived (50 s) metastable state of Li^+ enables the investigation of DR for excited states not easily accessible to this process.

This work was supported in part by the U.S. Department of Energy, Office of Basic Energy Sciences, Division of Chemical Sciences; the National Science Foundation; and the Science and Engineering Research Council (Great Britain).

1. J.A. Tanis, *et al.*, Nucl. Instrum. & Methods **B56/57**, 337 (1991).
2. R.R. Haar, *et al.*, Phys. Rev. A **47**, R3472 (1993).
3. N. Badnell, private communication.