Radiative Double Electron Capture for 2.11 MeV/u $F^{9+,8+} + N_2, Ne$

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Synopsis The first successful observation of radiative double electron capture for gas targets is reported. RDEC was observed for 2.11 MeV/u $F^{9+,8+}$+N_2, Ne collisions. Cross sections for both projectile charge states and targets were determined and compared with previous results for thin-foil carbon targets and with theory.

Radiative double electron capture is a fundamental atomic process where two electrons are captured from a target to bound states in a projectile simultaneous with emission of a single photon [1]. RDEC can be considered the inverse of double photoionization for ion-atom collision systems, a process that has been observed only for two-electron helium atoms and not for two-electron ions. RDEC is related to the well-known process of radiative electron capture [2], in which a single electron is captured to a bound state with the simultaneous emission of a photon. Cross sections for RDEC for 2.11 MeV/u $F^{9+,8+}$+N_2, Ne have been determined [3].

This work was performed using the tandem Van de Graaff accelerator facility at Western Michigan University (WMU). A beam of F^{9+} or F^{8+} ions was directed toward a differentially-pumped gas cell with target pressures set to the single-collision regime (8 mTorr for N_2 and 15 mTorr for Ne). A Si(Li) x-ray detector mounted at 90° to the beamline collected photons and separate silicon surface-barrier detectors collected the charge-changed projectiles. Analog-to-digital converters for the x rays and time-to-amplitude converters (TACs) for the coincidences, as well as an event-mode data acquisition system, were employed to assign the measured x rays to the corresponding single (Q-1) or double (Q-2) charge-changed particles, or vice versa. Typical spectra obtained are shown in Fig. 1.

The first successful observations of RDEC were performed at WMU using 2.38 MeV/u O^{8+} [4] and 2.11 MeV/u F^{9+} [5] projectiles incident on thin carbon foils. Unavoidable multiple-collision effects were present in these measurements causing RDEC events to be observed in both the Q-2 and Q-1 channels. These previous measurements thus provide the motivation for the present single-collision gas target work. Also, contaminants are avoided with high-purity gases. As seen, approximately 70 RDEC counts for $F^{9+} + N_2$ were obtained in nearly three weeks of round-the-clock beamtime.

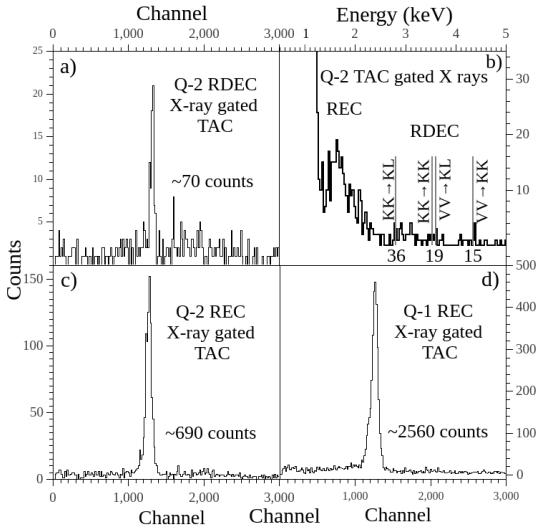

Figure 1. Spectra for 2.11 MeV/u F^{9+}+N_2: (a) Q-2 TAC spectrum associated with RDEC energy photons, (b) x-ray spectrum associated with Q-2 particles, (c) Q-2 and (d) Q-1 TAC spectra associated with REC energy photons.

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References

[1] Miraglia J and Gravielle M. S. 1987 *ICPEAC XV: Book of Abstracts* p. 517 Brighton, U.K.
[2] Stöhlker T *et al.* 1995 *Phys. Rev. A* **51** 2098
[3] La Mantia D *et al.* 2019 Submitted to *Phys. Rev. Lett.*
[4] Simon A *et al.* 2010 *Phys. Rev. Lett.* **104** 123001
[5] Elkafrawy T *et al.* 2016 *Phys. Rev. A* **94** 042705

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