Radiative Double Electron Capture (RDEC) in F^{9+} + N_2, Ne, He Collisions

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Synopsis RDEC has been investigated for 40 MeV F^{9+} + N_2, Ne, and He targets. Using coincidence techniques to record emitted x rays and charge-changed particles, preliminary cross sections were determined for RDEC.

Radiative electron capture (REC) is a process that occurs when a target electron is captured to a bound state of a projectile accompanied by the simultaneous emission of an x ray. REC can be considered the time inverse of photoionization. Radiative double electron capture (RDEC), which can be considered the time inverse of double photoionization, is the process of capturing two electrons to projectile bound states accompanied by the emission of a single photon. In this work, preliminary RDEC cross sections for 40 MeV F^{9+} + He, Ne, and N_2 have been determined.

The measurements were done using the tandem Van de Graaff accelerator at Western Michigan University. A 40 MeV beam of F^{9+} ions collided with N_2, Ne, and He targets inside a differentially pumped cell. A Si(Li) detector positioned at 90^o to the beamline detected the x rays. The ion beam was subsequently charge-state analyzed using a dipole magnet and observed with silicon surface-barrier detectors. Coincidences between x rays and particles were collected using an event-mode data acquisition system.

Previous RDEC experiments using high Z, high energy projectiles on gas targets [1][2] performed at GSI, Darmstadt did not find evidence for the process. Theoretical predictions [3] suggested mid-Z projectiles with lower energies should give larger RDEC cross sections. Successful observations of RDEC were performed at WMU using O^{8+} [4] and F^{9+} [5] projectiles incident on thin carbon foil targets. The theoretical predictions and these carbon experiments provided the motivation for the present work.

X rays coincident with double electron capture (Q-2) for F^{9+} + (a) N_2 and (b) Ne are shown in Fig. 1. In the region higher than the characteristic F K x rays, REC dominates. Above the REC energies scattered RDEC events can be seen, with more counts occurring at the lower end of the RDEC energy regions. These events are most likely due to the capture of target K-shell electrons. Preliminary analysis gives $\sigma^{N_2}_{RDEC}$ ~120 mb and σ^{Ne}_{RDEC} ~110 mb, which are in reasonable agreement with the theory of Mistonova and Andreev [6]. For He a single event was seen in the RDEC region, corresponding to $\sigma^{He}_{RDEC} \sim$ 3 mb. It is estimated that at least two additional months of continuous beam time are needed to obtain reliable statistics for each target.

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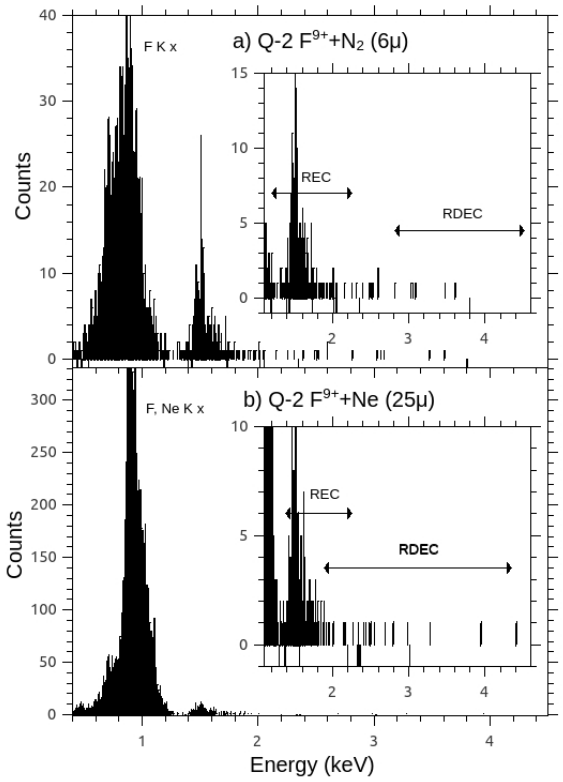

Figure 1. Spectra for x rays coincident with double capture for 40 MeV F^{9+} + (a) N_2 and (b) Ne collisions.

References

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