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

D. S. La Mantia[*1], **P. N. S. Kumara**[*], **A. Kayani**[*], **A. Simon**[†], **J. A. Tanis**[*]

[*] Department of Physics, Western Michigan University, Kalamazoo, MI 49008-5252 USA
[†] Department of Physics, University of Notre Dame, Notre Dame, IN 46556-5670 USA

Synopsis Preliminary cross sections for RDEC, as well as total single and double electron capture, were measured for 40 MeV F^{9+} + He and Ne targets. Emitted x rays and charge-changed particles were measured using coincidence techniques.

Radiative electron capture (REC) is a one-step process by which a target electron is captured to a projectile with the emission of an x ray and can be considered the time-inverse of photoionization. Double photoionization and the effect of electron correlation can be investigated through the process of radiative double electron capture (RDEC), in which two electrons are captured with the simultaneous emission of a single photon. Preliminary RDEC cross sections, as well as those for total single and double capture, for F^{9+} + He and Ne were measured.

This work was performed using the tandem Van de Graaff accelerator at Western Michigan University. A 40 MeV beam of fully-stripped fluorine ions was collided with helium (40μ) and neon (25μ) targets inside a differentially pumped cell. A Si(Li) x-ray detector was positioned at 90° to the beamline on the gas cell. The ion beam was charge state analyzed using a dipole magnet and detected using silicon surface-barrier particle detectors. The x-ray and particle detector data were collected using an event-mode data acquisition system to assign the measured x rays to the corresponding charge-changed particles.

Previous RDEC experiments using high Z, high energy projectiles on gas targets [1][2] were performed and did not find evidence for the process. Theoretical predictions [3] suggest mid-Z projectiles in low energy collisions will give larger RDEC cross sections. Successful observations of RDEC were performed at WMU using bare oxygen [4] and fluorine [5] projectiles incident on thin carbon foil targets.

The events that can result in RDEC are the capture of two electrons to the projectile K shell ($1s^2$) or the capture of one electron to the K and L shells ($1s^1 2s^1$). X rays coincident with single (Q-1) and double (Q-2) electron capture for F^{9+} + Ne (25μ) can be seen in Fig. 1. In the Q-1 spectrum, beyond the characteristic x rays for F, REC dominates. In the Q-2 spectrum the counts at the high energy end of the REC region can be due to RDEC from target KK $\rightarrow$ projectile KL transitions, with the higher energy counts being due to target KK $\rightarrow$ projectile KK transitions.

Preliminary analysis gives $\sigma^{Ne}_{RDEC} \sim 110$ mb (10^{-27} cm^2), which is 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. At least an additional two months of continuous beam time is needed to obtain reliable statistics for each target.

[*]Supported in part by NSF Grant No. PHY-1401429.

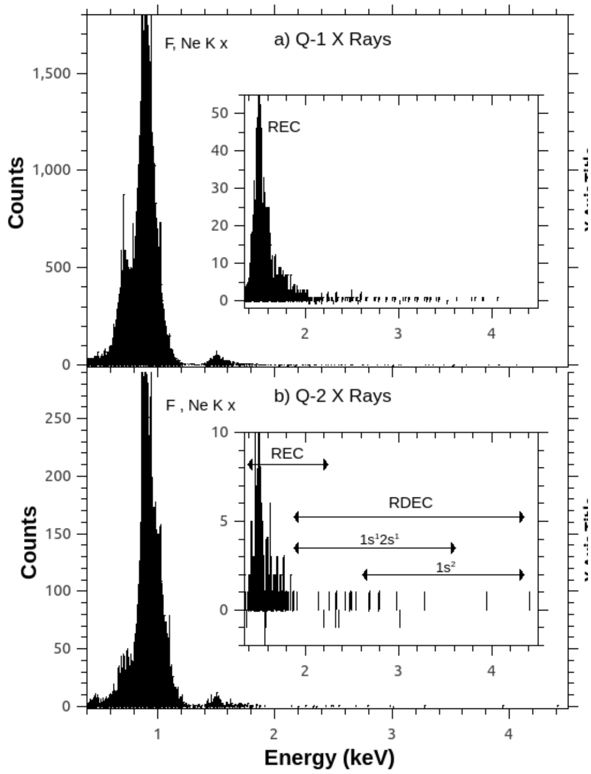

Figure 1. Spectra for x rays coincident with (a) single and (b) double capture for 40 MeV F^{9+} + Ne collisions.

References

[1] Bednarz *et al.* 2003 Nucl. Instrum. Meth. B **205** 573

[2] Winters *et al.* 2013 Phys. Scr. **T156** 014048

[3] Nefiodov *et al.* 2005 PLA **346** 158

[4] Simon *et al.* 2010 PRL **104** 123001

[5] Elkafrawy *et al.* 2016 PRA **94** 042705

[6] Mistonova and Andreev. 2013 PRA **87** 034702

[1]E-mail: david.s.lamantia@wmich.edu