Radiative Double Electron Capture for 2.21 MeV/u $F^{9+,8+} + N_2$, Ne

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Radiative double electron capture, for which two electrons are captured along with the simultaneous emission of a single photon, has been observed for 2.21 MeV/u F^{9+} (and F^{8+}) projectiles colliding with nitrogen and neon targets. For an ion-atom system, RDEC can be considered the inverse of double photoionization. The investigation of RDEC for fully-stripped ions is particularly advantageous because of the difficulty of observing double photoionization for two-electron ions, which has been studied only for two-electron helium atoms. In the present work, cross sections for RDEC for both projectile charge states and targets were determined and are compared with theory and with previous results for thin-foil carbon targets. This is the first successful observation of RDEC for gas targets

This experiment was performed at Western Michigan University (WMU) using the tandem Van de Graaff accelerator. Projectile ions collided with target atoms under single-collision conditions in a differentially pumped gas cell. A Si(Li) x-ray detector positioned at 90^{o} to the collision chamber observed x rays, while separate silicon surface barrier detectors were used to observe charge-changed projectile ions following magnetic analysis. Coincidences between the detected x rays and singly and doubly charge-changed projectile ions were detected using a time-to-amplitude converter (TAC). Due to the small cross sections involved, the measurements required significant amounts of beam time for each charge state and target (about a month for each).

Successful observations of RDEC were previously performed at WMU using fully-stripped oxygen [1] and fluorine [2] projectiles incident on thin-foil carbon targets. Preliminary upper limit RDEC results for gaseous N_2 [3] and Ne [4] targets have also been reported. The use of gas targets avoids the multiple-collision effects of the foil targets and contaminants do not play a role. Coincidence techniques allowed the data to be sorted such that specific emitted x rays can be assigned to their respective charge-changed particles as shown in Figure 1 for the N_2 target, or vice-versa as shown in Figure 2, also for N_2. The x ray-sorted particle spectrum (Figure 2) shows clearly that RDEC has taken place and provides a reasonable estimate of the RDEC cross section. The present results for N_2 and Ne indicate that the RDEC cross sections for F^{8+} are about 6 and 4 times smaller, respectively, than for F^{9+}. A reduction in the cross section would be expected as capture of both electrons to the K shell is not possible for F^{8+} ions.

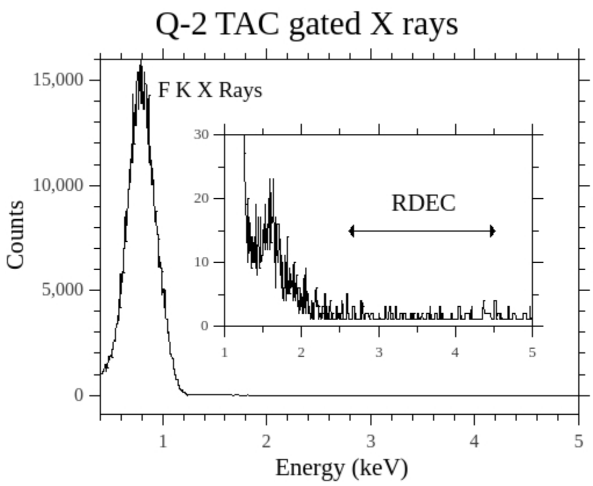

Fig. 1 X-ray spectrum associated with double charge exchange (Q-2) for 2.21 MeV/u $F^{9+} + N_2$ (8 mTorr).

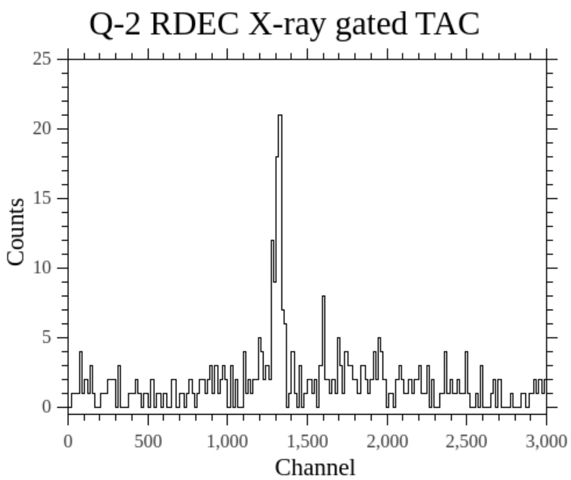

Fig. 2 Double charge exchange (Q-2) time spectrum from x rays in the RDEC energy region for 2.21 MeV/u $F^{9+} + N_2$ (8 mTorr).

References

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