A.3.3. Transfer Ionization to Single Capture Ratio for Fast Multiply Charged Ions on He-- *R. Unal,* M.J. Singh, A.L. Landers, H. Tawara, H. Aliabadi, I. Ben-Itzhak, C. L. Cocke, and P. Richard*

During the last grant period we built a COLTRIMS apparatus consisting of a two-stage supersonic jet and a spectrometer for coincidence measurements of the recoil ion and ejected electron. The gas jet consists of a 30-micron aperture and two 500-micron gas skimmers. The electric fields of the COLTRIMS spectrometer direct the recoil ions and ejected electrons toward two chevron microchannel plate position sensitive detectors (Abstract #23). Figure 1 shows a photograph of the spectrometer assembly excluding the recoil-ion detector, and Fig. 2 shows the recoil-ion detector. Figure 3 shows the beam line within the region of the gas jet and recoil ion – electron momentum analyzer, in which the coils generating the magnetic field confining the electrons can be seen.

In a recent series of experiments using this apparatus, we have measured the charge state and energy dependences of Transfer Ionization (TI) and Single Capture (SC) processes. The collision systems investigated to date are $F^{(4-9)+}$ ions interacting with helium at beam energies from 0.75 to 2.0 MeV/u and $O^{(4-8)+}$ at 1 MeV/u. The recoil ion momentum spectrometer is used to separate TI and SC by recording the longitudinal momentum transfer and time-of-flight of the recoil ions. A magnetic field is used to control the position of the recoil ions on the detector. The longitudinal momentum transfer is negligible for ionization in comparison to electron capture. This allows us to separate the helium recoil ions associated with electron capture from the random events due to single and double ionization by the contaminant q-1 beam, as shown in Fig. 4. As a result, the ratios of TI to SC are determined with better accuracy than in previous measurements [1,2]. Figure 5 shows the q-dependence of the ratio of TI to SC (denoted as R) for 1 MeV/u $O^{(4-8)+}$. The very strong charge state-dependence leads to a variation of R for this data from a low of ~0.6 to a high of ~1.8 (Abstract #104). Furthermore, we will compare this data to all of the previous measurements [2,3,4] on TI/SC ratios and Q-value determinations.

Due to downtime of the tandem accelerator because of the failure of the belt charging system and the conversion to the new Pelletron charging system, we have not yet completed the measurements of the TI/SC ratio for higher Z ions. This work on determining the ratio of TI to SC for the high-Z ions is presently in progress. The Q-value determinations in SC and electron momentum distributions in TI will be investigated in the near future (see Proposal Section A.1.2).

Figure 1. Recoil – Electron analyzer showing electron detector assembly (near flange) and the recoil momentum analyzer plates. The ion beam traverses between plates number 4 and 5 above the electron drift region (copper cylinder). Connection at plate number 16 begins the voltage step that provides the focusing of recoil ions of different momenta onto different positions on the recoil detector (see Fig. 2).

Figure 2. Recoil detector assembly showing the ground ring, grid, channel plate holder, the drift region and the position-sensitive backgammon board and holder.

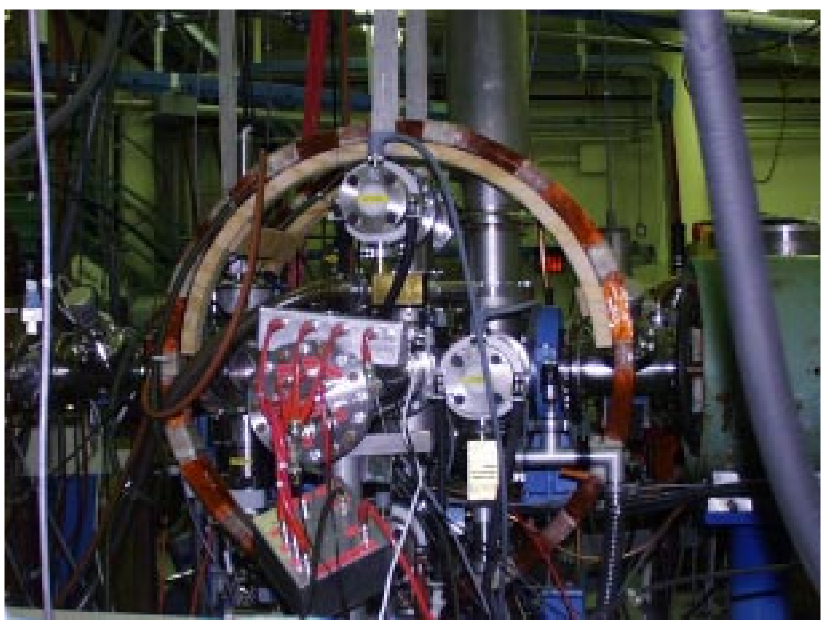

Figure 3. Chamber assembly with recoil detector mounting. The two large copper rings produce the magnetic field for guiding the electrons onto the electron detector.

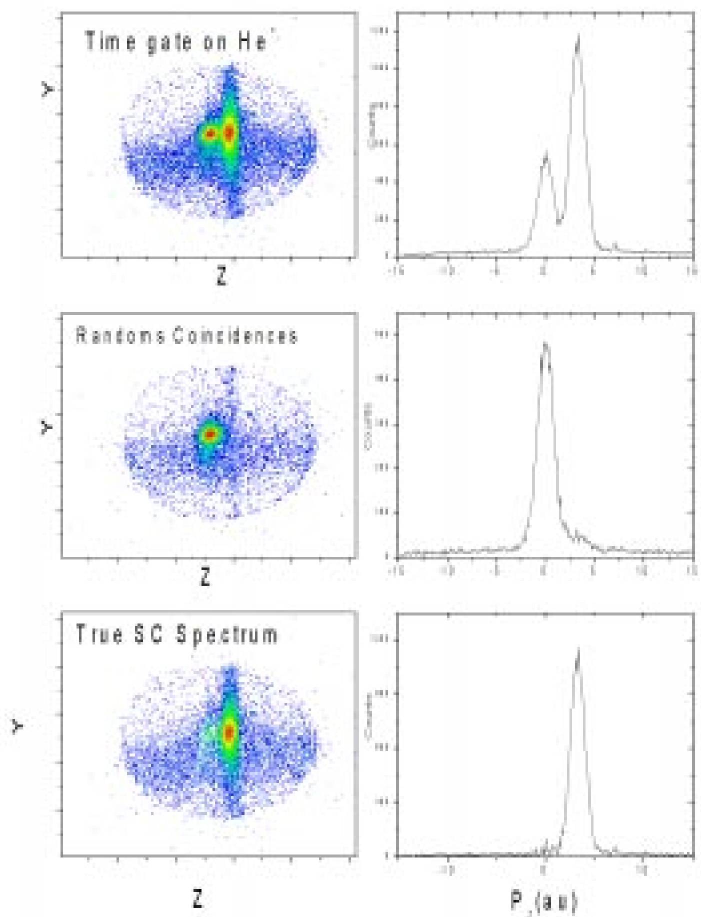

Figure 4. The 2-D recoil ion momentum spectrum of He^+ recoil ions from collisions with 1 MeV/u O^{5+} as observed on the position sensitive recoil-ion detector. In the leftmost figures the ordinate is the momentum parallel to the beam and the abscissa is one component of the momentum perpendicular to the beam. The three spectra are for coincidences with He^+: total coincidences (top), random coincidences (middle) and the true SC coincidences (bottom). The rightmost figures are the projections in the longitudinal direction.

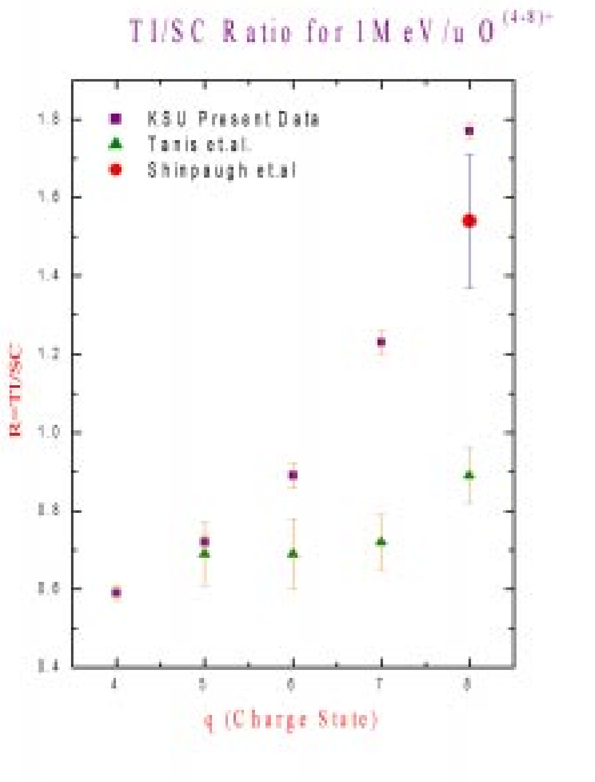

Figure 5. The ratio of TI to SC for $O^{(4-8)+}$ on He. The data obtained by time-of-flight measurements are shown for comparison.

Publications Related to Work:

Abs. #23: "Transfer Ionization to Single Capture Ratio for Multiply Charged Ions on He," by Singh, *et al.*

Abs. #104: "Transfer Ionization to Single Capture Ratio for Fast Multiply Charged Ions on He," by Unal, *et al.*

References

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1. E.C. Montenegro, K.L. Wong, W. Wu, P. Richard, I. Ben-Itzhak, C.L. Cocke, R. Moshammer, J.P. Giese, Y.D. Wang, and C.D. Lin, Phys. Rev. 55, 2009 (1997).
2. J.L. Shinpaugh, J.M. Sanders, J.M. Hall, D.H. Lee, H. Schmidt-Böcking, T.N. Tipping, T.J.M. Zouros, and P. Richard, Phys. Rev. A 45, 2922 (1992).
3. J. Tanis, M.W. Clark, R. Price, R.E. Olson, Phys. Rev. A 36, 1952 (1987).
4. W. Wu, K.L. Wong, C.L. Cocke, J.P. Giese, and E.C. Montenegro, Phys. Rev. A 51, 3718 (1995).