New phenomena observed in transfer ionization at intermediate energy ion-atom collisions

D. L. Guo∗, X. Ma†, S. F. Zhang∗, X. L. Zhu∗, W. T. Feng∗, R. T. Zhang∗, Y. Gao∗, B. Hai†, M. Zhang†, D. B. Qian∗, S. Yan∗, and P. Zhang∗

∗Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China
†University of Chinese Academy of Sciences, Beijing 100049, China

Synopsis We have performed a kinematically complete experiment for transfer ionization for 50-100 keV p-He collisions using a reaction microscope. It was found that the electron momentum distribution projected onto the scattering plane is consistent with the prediction of an independent two-step mechanism involving a binary encounter. The important effect of the explicit electron-electron Coulomb interaction was revealed by the comparison with classical trajectory Monte Carlo calculations.

Studies of the fundamental ionization and electron transfer processes occurring in ion-atom collisions are of great importance for understanding the dynamics of these processes and for practical applications. In view of the few studies of transfer ionization (TI) at intermediate energies, the understanding of this process is far from satisfactory. In this work, we performed a kinematically complete experiment on TI for 50-100 keV p-He collisions [1]. The momentum vectors of both the recoil ions and the emitted electrons were reconstructed from the time of flight and the impact positions on the detectors.

Figure 1 shows the electron momentum distribution projected onto the scattering plane for 50 keV projectile energy. The distribution shows that the electrons are preferably emitted into the forward direction and opposite to the transverse component of the projectile momentum. A further inspection of the electron momentum distribution in the other planes indicates that the momentum exchanges between the projectile and both the recoil ion and the electron dominate in this process (see details in Ref. [1]). We attribute the typical electron momentum distribution projected onto the scattering plane to the contribution of a binary encounter between the projectile and one target electron. This observation might be the signature of an independent two-step mechanism involving a binary encounter between the projectile and the target electron which gives rise to the electron emission, accompanied by independent capture of the second electron by the projectile.

In order to shed more light on the collision dynamics as well as the importance of the electron-electron correlation effects, we performed calculations using the CTMC method. Our results indicated that the calculations including the electron-electron interaction are in much better agreement with the experimental measurements (Figure 2), which strongly suggests that electron-electron correlations play an important role in this two-electron process.

References