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Forward-angle electron spectroscopy in heavy-ion atom collisions studied at the ESR

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Synopsis For the collisions system $U^{88+} + N_2$ @ 90 MeV/u the emitted cusp electrons have been studied, and the three processes contributing to the electron cusp were compared to individual theoretical calculations.

In collisions of heavy highly-charged projectile ions with atomic targets, the energy distribution of the emitted electrons is a characteristic observable for the underlying elementary processes. At the experimental storage ring ESR of the heavy-ion accelerator facility GSI, a dedicated magnetic electron spectrometer was built downstream from the gas-jet target, which enabled the measurement of high-energetic electrons emitted in ion-atom collisions within a small cone in the forward direction. Using this electron spectrometer in combination with detectors for emitted x rays and charge-exchanged projectiles, the study of the collision system $U^{88+} + N_2$ @ 90 MeV/u revealed three processes resulting in the emission of electrons with a velocity similar to the projectile velocity, i.e., cusp electrons:

(a) The process of **electron loss to continuum** (ELC) corresponds to the ionization of an electron from the projectile into the projectile continuum during the collision with the target,

$$U^{88+} + N_2 \rightarrow U^{89+} + [N_2]^* + e^- .$$

For the ELC, the measured spectrum was compared to first-order perturbation theory using fully-relativistic Dirac wavefunctions [1].

(b) The process of **electron capture to continuum** (ECC) corresponds to the capture of a target electron into the projectile continuum, while the excess energy is carried away by the recoil of the generated target ion:

$$U^{88+} + N_2 \rightarrow U^{88+} + \left[N_2^+\right]^* + e^- .$$

For the ECC, the measured spectrum was compared to calculations in the impulse approximation using semi-relativistic Sommerfeld-Maue wavefunctions, and to calculations in the continuum-distorted-wave approach [2].

(c) The process of **radiative electron capture to continuum** (RECC) corresponds to the capture of a target electron into the projectile continuum, while the excess energy is carried away by a photon:

$$U^{88+} + N_2 \rightarrow U^{88+} + \left[N_2^+\right]^* + e^- + \gamma .$$

This latter process can be seen as the high-energy endpoint of bremsstrahlung studied in inverse kinematics. For the RECC, the measured spectra were compared to calculations in the impulse approximation using semi-relativistic Sommerfeld-Maue wavefunctions, and to calculations using fully-relativistic Dirac wavefunctions [3].

Within this study it was shown that each of the three processes is characterized by a unique electron cusp shape, being a clear messenger for the underlying charge-exchange mechanism.

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