Asymmetries of the electron cusp in heavy-ion atom collisions

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Synopsis The well-known experimental technique of zero-degree cusp electron spectroscopy has been extended towards heavy-ion atom collisions at near-relativistic collision velocities, at which new effects of asymmetries in the electron cusp arise.

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 charge-transfer processes [1]. At the experimental storage ring ESR of the heavy-ion accelerator facility GSI, a dedicated magnetic electron spectrometer was installed downstream from the supersonic gas-jet target, which enables the measurement of high-energetic electrons emitted in ion-atom collisions, with electron velocities similar to the projectile velocity, emitted within a small cone in the forward direction (Figure 1). This technique provides the ability to extend the well known study of zero-degree cusp electrons towards heavy-ion atom collisions at near-relativistic projectile energies.

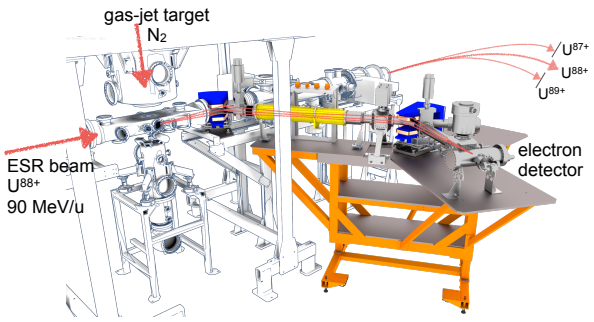

Figure 1. Magnetic electron spectrometer at the ESR

Through the electron-loss-to-continuum (ELC) cusp, double-differential cross sections of projectile ionization can be studied even for the heaviest few-electron projectiles [2]. But also a new channel opens up, the radiative electron capture to continuum [3], which can be directly compared to its non-radiative counterpart [4]. Using the electron spectrometer in combination with detectors for emitted x rays and charge-exchanged projectiles, the study of the collision system $U^{88+}(1s^2 2s^2) + N_2$ @ 90 MeV/u revealed all three processes, each characterized by a unique shape of the electron cusp [5].

Furthermore, the process of electron loss to continuum was investigated for multi-electron projectiles in the collisions of U^{28+} with gaseous targets of H_2, N_2, and Xe at collision energies of 30 and 50 MeV/u. The experimental data revealed a significant electron cusp asymmetry, which increases towards heavier targets. This observation is inconsistent with presently available theories [6].

As a next step, the electron spectra for $U^{89+}(1s^2 2s)$ ions colliding with gaseous targets of N_2 and Xe have recently been measured, at a projectile energy of 76 MeV/u, i.e. just above the threshold for electron impact ionization of the *L*-shell of uranium. In these measurements, the studied electron emission energy was extended considerably, stretching both over the full electron cusp and the binary-encounter peak. At the studied collision velocity, relativistic continuum-distorted-wave (CDW) calculations of projectile ionization show a deviation of the electron energy distribution from first-oder perturbation theory due to the effect, that the electron emitted by the projectile is attracted by the target nucleus. Preliminary experimental results for these collision systems will be shown, which motivate further developments of relativistic theories describing charge-changing processes in heavy-ion atom collisions.

References

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