

Electron emission spectra of U^{28+} -ions colliding with gaseous targets

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Synopsis The electron-loss to continuum has been studied experimentally and theoretically for the collision systems $U^{28+} + H_2$ at a collision energy of 50 MeV/u, $U^{28+} + N_2$ at 30 MeV/u, and $U^{28+} + Xe$ at 50 MeV/u.

Projectile ionization in ion-atom collisions has a significant relevance for understanding one of the fundamental processes of atomic physics. Its analysis has been shown to be of great importance for the beam physics of heavy-ion accelerators, since their beam intensities are limited by space-charge effects. Highest particle beam intensities can thus only be achieved by decreasing the charge state of the accelerated ions at the expense of an increased magnetic rigidity required for the same energy. Here, the ionization of heavy medium-charged ions by atoms of the rest gas plays a crucial role, since charge-exchanged ions are lost during the acceleration process. In the heavy-ion accelerators of FAIR, U^{28+} -ions are planned to be accelerated consecutively in the synchrotrons SIS18 and SIS100 from an energy of 11.4 MeV/u to 2.7 GeV/u. The charge state of the accelerated ions is far from the equilibrium charge state. For those charge states *a priori* calculations of projectile ionization have encountered substantial difficulties.

Complementary to studying absolute ionization cross sections [1], this motivates the study of the mechanisms of differential cross sections for the ionization of U^{28+} in collisions with different gaseous atomic targets, presented in this contribution. The measurement of the energy spectra of cusp electrons for the collision systems $U^{28+} + H_2$ at 50 MeV/u, $U^{28+} + N_2$ at 30 MeV/u, and $U^{28+} + Xe$ at 50 MeV/u is shown. Unprecedentedly clean experimental conditions were facilitated by using the magnetic forward-angle electron spectrometer [2] installed in the experimental storage ring ESR of the heavy-ion accelerator facility GSI Helmholtzzentrum für Schwerionenforschung.

The experimental setup enabled the measure-

ment of differential cross sections by studying the cusp-electron peak, i.e., the energy distribution of electrons emitted under an angle of $\vartheta_e \approx 0^\circ$ with respect the projectile beam, having a velocity similar to the projectile velocity. These electrons are ionized from the projectile during the collision with the gaseous target atoms and form the electron-loss-to-continuum cusp. Remarkable deviations from a symmetric cusp shape measured in the laboratory frame-of-reference can be traced back to an anisotropic electron emission in the projectile frame, and asymmetries in the cusp shapes have been shown to be a clear messenger for the underlying charge-transfer mechanisms [2, 3, 4].

The measured spectra are compared with theoretical calculations based on the continuum-distorted-wave (CDW) approach, as a test for the description of ionization of heavy multi-electron projectiles in collisions with atomic targets [5]. The applied theoretical calculations required an extension of the approach used previously for the ionization of light neutral targets by dressed projectiles [6] towards the ionization of heavy dressed projectiles by neutral targets.

References

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