Multiple ionization of atoms and molecules by impact of light charged ions at the intermediate energy range

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The ionization of multi-electron atoms and molecules by dressed and bare charged projectiles in the intermediate energy range regime which corresponds to the Bragg peak, where the stopping power of projectiles in matter reaches its maximum, is an important regions of the projectile trajectory for many applications. The understanding of the collision dynamics is essential to obtain the local damage in matter. Bare projectiles give a key benchmark to study the role of projectile screening in collision involving dressed projectile ions.

We report experimental and theoretical ionization and electron-capture cross sections for single, and multiple-electron removal from Ne atoms and H_2O molecules by He^{2+}, B^{2+}, C^{3+} and Li^{3+} ranging from 100 to 1000 keV/u. The experiment was carried out at the Tandem Pelletron accelerator facility of the Physics Institute at the Rio de Janeiro Federal University. Both the final state of the projectile and of the ejected recoils ions or fragment-ions were measured in coincidence to obtain cross sections associated with the pure ionization and electrons-capture channels. By using standard growth-rate method and time of flight mass spectrometry, absolute total and partial cross sections were obtained. These absolute cross sections are needed for comparison and aid to the development of theoretical methods for the collision dynamics over a wide range of projectile velocities as well as for providing reliable input data in simulation of penetration and damage of heavy ions in matter.

The average effective charge of the dressed charged ions along the ionization path and the effectiveness of its electrons in shielding its nucleus was investigated by comparing the cross sections of the multiple ionization of Ne and H_2O targets by B^{2+} and C^{3+} with the bare He^{2+} and Li^{3+} projectiles, respectively. The measurements have shown a strong screening effect for all n-fold recoil ion charge states in the ionization channels at the same velocities. The total ionization cross sections divided by the squared projectile charge as function of the impact energy show a universal, charge-independent scaling law at high energies (above 1000keV/u). On the other hand, at lower energies, the scaling is no longer fulfilled and more sophisticated theoretical approaches must be applied.

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[1] J. S. Ihani, H Luna, W Wolff and E C Montenegro, J. Phys B: At. Mol. Opt. Phys. 46 (2013) 115208

[2] W Wolff, H Luna, A C F Santos, E C Montenegro, R D DuBois, C C Montanari and J E Miraglia, Phys. Rev. A 84 (2011) 042704

[3] H Luna, W Wolff, E C Montenegro, A Tavares, H J Lüdde, G Schenk, M Horbatsch and T Kirchner, Phys Rev. A 93 (2016) 052705

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