Ionization of Noble Gases by Charged-Particle Impact

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Charged-particle impact-ionization of noble gases has been investigated for many decades. Experimentally, much work has been done on electron collisions, but advances in the generation of intense positron beams has made such experiments possible for positron impact as well [1]. Experiments for heavy-ion impact, such as C^{6+} on He, have recently yielded very surprising results [2], and now experiments with anti-protons are underway [3]. The latter type of experiment is very appealing to theorists, since the reaction channels of positronium formation and charge exchange do not have to be considered.

Computational methods to attack this problem are generally classified as either perturbative, i.e., based upon the Born series, or non-perturbative, i.e., based the close-coupling expansion. For positron impact, the former includes work by Campeanu *et al.* [4] for direct ionization and by Gilmore *et al.* [5] for positronium formation, while positronium formation was also calculated in the coupled static-exchange approximation by McAlinden and Walters [6].

Over the past years, we have developed a general computer code [7] for charged-particle impact ionization of arbitrary atoms and ions, based upon the original work by Bartschat and Burke [8]. In this method, the projectile is described by a distorted wave while the initial bound state and the interaction between the residual ion and the ejected electron is described by an R-matrix (close-coupling) expansion. It is now possible to account, at least approximately, for second-order effects in the projectile−target interaction [9]. Such effects have been shown to be very important in highly correlated processes such as ionization plus simultaneous excitation [10] or electron-impact ionization in “out-of-plane” kinematics [11].

After summarizing the basic ideas of the computational model, we will present results for direct ionization of the noble gases He, Ne, Ar, Kr, and Xe by positron impact and compare the results with those for electron projectiles. We are currently developing a heavy-particle impact theory *beyond* the plane-wave approximation for the projectile. This method will make it possible to account for distortion effects on the heavy particle, which might be responsible for the surprising effects seen in experiments such as [2].

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