Relativistic coupled-channel calculations of differential ionization cross sections

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Synopsis A relativistic method for calculation of differential cross sections for ionization in ion-atom collisions is developed. It is applied to ionization of the atomic hydrogen by antiproton impact, where several discrepancies in available predictions are resolved. The relativistic effects are studied for ionization of hydrogenlike xenon ion under impact of carbon nucleus.

Recent progress in experimental technique of the recoil-ion and electron momentum spectroscopy [1] stimulates theoretical studies of the fully differential cross sections (FDCS) for ionization in ion-atom collisions.

In this contribution, we present a semiclassical relativistic method for calculation of FDCS for ionization in ion-atom collisions. The method can be applied for collisions involving heavy targets, since the Dirac equation is used to describe electron dynamics. The active-electron approximation is implied for the target description, and the projectile is assumed to be a bare ion. The method is based on the finite-basis-set expansion of the Dirac wave function of the active electron. The basis functions are constructed within the dual-kinetically-balanced *B*-spline approach. The Fourier transform is employed to extract the FDCS for a defined projectile momentum transfer.

As a first application, the method is utilized to calculate FDCS for antiproton-impact ionization of atomic hydrogen. This collisional system is very convenient for theoretical study, since it is a pure three particle system without charge-exchange and many-electron processes. Experimental investigation of FDCS for ionization in this collision is not possible at the moment. Nevertheless, ionization cross sections have already been extensively studied theoretically by various non-perturbative methods [2, 3, 4, 5]. The results are in overall agreement. However, several ionization cross sections, predicted by these methods, considerably differs. Within our independent calculation [6], we can give preference to the results of certain approaches.

Secondly, the impact-parameter dependencies of the total ionization probabilities from the *K*- and *L*-shells have been calculated for the 100 MeV/u C^{6+}-Xe^{53+} collision. In order to explore the relativistic effects induced by a large target charge, we also carried out the calculation in the non-relativistic limit, where the standard value of the speed of light c was multiplied by a factor of 1000. The comparison of the results of both calculations is shown in the figure. The total ionization probabilities averaged over the magnetic quantum number of the initial state are plotted.

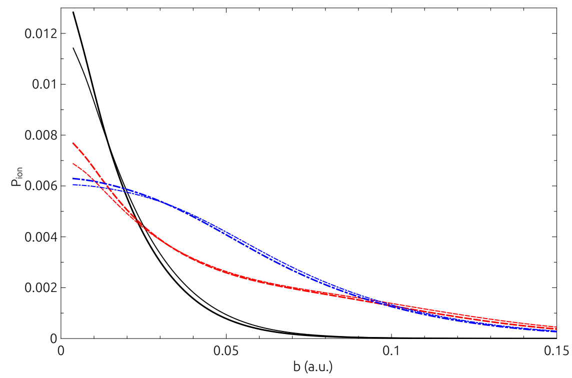

Figure 1. Impact-parameter dependence of the total ionization probability in the 100 MeV/u C^{6+}-Xe^{53+} collision for various initial states. Solid line, $1s$; dashed line, $2s$; dash-dotted line, $2p$. Thick (thin) lines are for the relativistic (non-relativistic) calculation.

In future, we plan to apply the developed approach to study ionization processes at the differential level in collisions involving heavy targets, where relativistic effects are of high importance.

This work was supported by SPSU-DFG (Grant No. 11.65.41.2017) and RFBR-NSFC (Grant No. 17-52-53136). A.I.B. acknowledges support from the FAIR-Russia Research Center.

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