Kinematically complete scattering cross sections in positron and hydrogen atom collisions

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Synopsis A three-body classical trajectory Monte Carlo (CTMC) method is used to describe positron and hydrogen atom collisions. The total and multi-differential ionization and charge exchange cross sections are calculated and compared with experimental data and other theoretical results.

Understanding the elementary scattering processes during atomic collisions is of fundamental importance both from the experimental and theoretical points of view. Ionization by positron impact has been extensively studied in recent decades. In most cases noble gas atoms were used as the target. For designing new experiments, such as production of antimatter, ionization cross sections for other atoms are also necessary. During the last two decades more and more studies also became available for positronium impact.

The classical treatment of various collision problems has been quite successful for the calculation of the ionization and charge exchange cross sections when the collision energy is sufficiently high. In particular the classical trajectory Monte Carlo (CTMC) method is widely used. It is a non-perturbative method and hence all the interactions between colliding particles can be taken into account exactly within the framework of the classical dynamics.

In this work a three-body classical trajectory Monte Carlo technique is used to calculate the total and multi-differential scattering cross sections in collision between positrons and hydrogen atom. Our system consists of three particles, the positron as projectile, and the electron and proton as the target atom. The classical equations of motion for three-body system are solved numerically for large number of trajectories. The initial conditions are the impact parameter, the position and the velocity of the target electron. These are selected randomly for each trajectory. The initial conditions of the individual collision system were selected at a relatively large internuclear separation from the collision center in such a way that an initial binding energy of the H(1s) level (E_b=0.5 a.u.) was constrained. For given initial parameters, the Newton's equations of motion were integrated with respect to time as independent variable by the standard Runge-Kutta method.

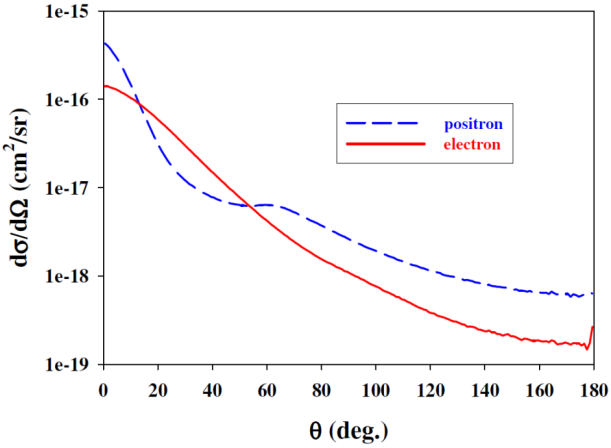

Figure 1. Present CTMC results for angular differential ionization cross sections of hydrogen atom at 50 eV primary positron energy.

In this work we present singly differential as well as kinematically complete triply differential scattering cross sections for ionization and charge exchange processes at 50 and 100 eV positron impact energies. Fig. 1 shows the present CTMC results for angular differential ionization cross sections of hydrogen atom at 50 eV primary positron energy.

We find that the classical treatment of the scattering problem for light projectile impact describes reasonable well the various cross sections. Our results are compared with experimental data and other theoretical values.

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