Faddeev three-body approach to high-energy positronium formation

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Three-body interaction is of interest in many areas of physics and technology. Faddeev, Watson and Lovelace (referred to as the FWL method [1]) developed one of the most successful fully quantum mechanical three-body theories which is particularly applicable at moderate and high scattering energies. Alston [2], Alt et al [3] and Ghanbari Adivi et al [4] applied the method to electron transfer in the collision of simple and complex atoms by ionic projectiles. A double scattering mechanism suggested by Thomas for forward electron transfer at high impact velocities, classically, is evident in all of these approaches. The existence of such a process has to show a peak, Thomas peak, about the Thomas angle, $\theta_T \cong \sqrt{3}\, m/M_P$, relative to forward direction, where m and M_P are the electron and projectile masses, respectively. The angular distributions are different in shape and relative magnitude around the critical angle 0.47 *mrad*. The methods used and developed are especially applicable at small angles.

Positronium is formed in the collision of poitrons with atomic species. This is also a three body interaction [5]. The Faddeev-Watson-Lovelace (FWL) scattering formalism is generalized to large scattering angles by applying to the positronium formation in the collision of positron with the atomic hydrogen at high impact energies as a three-body problem. In a second-order approximation, the integral forms of the five nuclear-electronic and inter-nuclear partial amplitudes are derived. The Coulomb two-body off-shell transition matrices are used to evaluate the closed forms of the amplitudes. Differential cross sections for positronium formation based on the quantum-mechanical FWL theory in the positron-hydrogen collisions are presented to confirm the presence of the Thomas peak. The results are shown in figure 1 for positron energies of 1.0 keV to 3.0 keV. As it is expected, the Thomas peak appears at about 60^o angle which is the evidence of a double mechanism.

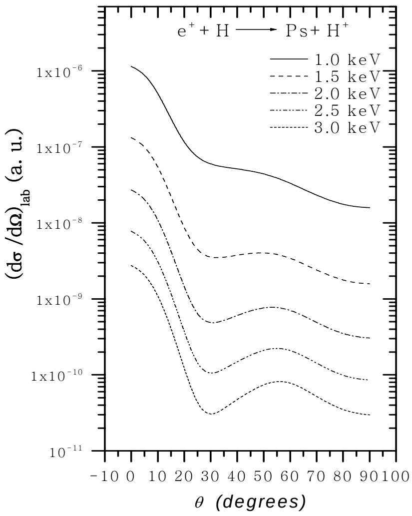

Figure 1. Differential cross sections calculated for the positronium formation in the collision of positron with atomic hydrogen.

References

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