§1. Hyperspherical Close-coupling Calculations for Positronium Formation Positron-helium Collisions

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Recently Igarashi and Toshima[1] have demonstrated that the hyperspherical close-coupling method is a powerful theoretical approach for the study of positronium formation in positron-hydrogen collisions. Later the method was successfully extended to the process of antihydrogen formation [2] and to muon transfer between hydrogen isotopes [3]. One of the merits of the hyperspherical coordinate method is that the Jacobi coordinate systems in the entrance and the rearranged channels can be unified into a common six-dimensional coordinate space and consequently the coupled scattering equations do not possess a nonlocal potential, which appears in the ordinary coupled-channel or close-coupling (CC) treatment of two-center rearrangement collision and makes it very difficult to solve the multichannel coupled-equations accurately.

In this study we use a model potential representation for the study of positronium formation from a helium atom. Hewitt *et al*[4] recently studied the same process using a model potential representation in the framework of the conventional CC approximation. Although satisfactory agreement was obtained with measured values for some of the processes, their basis set used for the expansion is not large enough to ensure that the expansion has well converged. In the previous studies [1-3] we showed that the hyperspherical CC method achieves much better convergence for rearrangement collisions than the conventional CC method based on the atomic-orbital expansion.

We apply the hyperspherical CC method to positron-helium scatterings in a collision energy range below 54.4 eV. The helium atom is treated as a single-electron atom in which the electron is moving under the influence of a central potential from the He^+ core.

$$V_e(r) = -\frac{1}{r} - \frac{a+br}{r}\exp(-\beta r), \qquad (1)$$

where $a = 1.0$, $b = 0.4143$, and $\beta = 2.499$. This potential gives satisfactorily accurate energies of the ground state and singly-excited states. The interaction between the positron and the He^+ core is approximated by a static potential that is an average of the sum of the Coulomb potentials from the passive electron and from the helium nucleus over a simple hydrogenic distribution of an effective charge $Z_{eff} = 27/16$.

In this quasi-three particle system, the hyperradius ρ and the five-dimensional grand angular momentum Λ can be defined similarly to those for positron-hydrogen collisions[1]. Further details of the calculations and the numerical results will be shown elsewhere.

References

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