Single electron transfer in the collision of He^+ ion with Hydrogen atom

Sh Azizan[1], R Fathi[2], F Shojaei[3], MA Bolorizadeh[4]

[*] Faculty of Physics, Shahid Bahonar University of Kerman, Kerman, Iran

Synopsis: The four body Born distorted wave approximation with correct boundary condition is used for single electron transfer in He^+-H collision. The post and prior total cross sections are obtained while their discrepancy is observed. Making use of two different wave functions, the sensitivity of the results with respect to the choice of final helium-like wave function is investigated.

Here the collisions between two hydrogen-like atomic systems are investigated and the four-body Born distorted wave (BDW-4B) approximation is used. A four-body process is considered in which a hydrogen-like system as a projectile captures one electron from another hydrogen-like system, i.e

$$(Z_P, e_1)_{1s} + (Z_T, e_2)_{1s} \rightarrow (Z_P, e_1, e_2)_{1s^2} + Z_T \,. \qquad (1)$$

The prior and post form of the transition amplitudes in the BDW-4B model are given by

$$T_{if}^{-} = \left\langle \phi_f^c \middle| U_i \middle| \chi_i^+ \right\rangle \text{ and } T_{if}^{+} = \left\langle \chi_f^- \middle| U_f^\dagger \middle| \phi_i^c \right\rangle, \qquad (2)$$

respectively. Here $U_{i,f}$ and $\chi_{i,f}^{\pm}$ are the perturbation potentials and the distorted waves, respectively, which are obtained in detail [1,2], previously. Applying the potentials and wave functions the primary nine dimensional integrals of the post and prior versions of the transition amplitudes are obtained [1,2]. Taking the advantage of analytical calculation, the post and prior transition amplitudes are reduced to two and five dimensional integrals respectively. The three additional integrals in the prior form are due to the presence of the electron-electron interaction.

Presently numerical calculations for the total post and prior cross sections are carried out in terms of the Gauss-Mehler and Gauss-Legendre quadrature's for the reaction $^4He^+(1s) + H(1s) \rightarrow {}^4He(1s^2) + H^+$ at the intermediate and high energies. The one-parameter Hylleraas [3] and the two-parameter Silverman [4] wave function are used here to describe the final helium atoms. The post and prior total cross sections with Silverman wave function are presented in Fig. 1 and comparison with experimental data is also made. It is clear from Fig. 1 that there is a significant post-prior discrepancy at lower energies. The theory and the experiment agree at higher energies. In Fig. 2 the total post and prior cross section, obtained via two different wave functions, are compared. One can observe from Fig. 2 that the total cross sections calculated making use of the two wave functions are close enough to conclude that the results are not sensitive with respect to the choice of final bound state wave function.

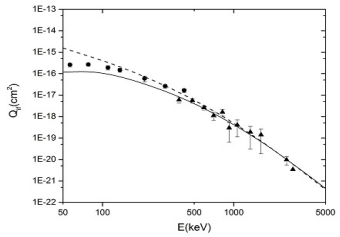

Figure 1. Total cross sections as a function of energy. The prior (post) cross section is represented by full (dashed) curve. Final state of He wave function: Silverman [4]. Experimental data: ● Olson et al. [5]; ▲ Hvelplund and Andersen [6].

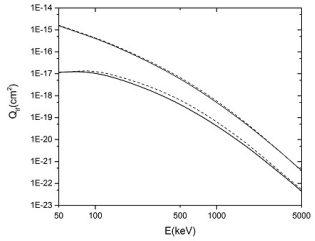

Figure 2. Total cross sections as a function of E. Upper (Lower) pair of curves: solid line represents the present results of the post (prior) form with the wave function of Silverman et al. [4]; dashed line shows the post (prior) results with the Hylleraas [3] wave function. The values of the lower curves should be multiplied by 10.

References

[1] SH. Azizan, F. Shojaei, R. Fathi 2016 J. Phys. B **49**, 085201

[2] SH. Azizan, F. Shojaei, R. Fathi, 2016 J. Phys. B **49**, 135201

[3] E. Hylleraas 1929 Z. Phys. **54**, 347

[4] J. N. Silverman, O. Platas, F. A. Matsen, 1960 J. Chem. Phys. **32**, 1402

[5] Olson R E et al. 1977 *Phys. Rev*. A **16** 1867-72

[6] Hvelplund P and Andersen A 1982 *Phys. Scr*. **26** 375

[1] Email: sazizan@sci.uk.ac.ir

[2] E-mail: rfathi@uk.ac.ir

[3] E-mail: fshojaei@uk.ac.ir

[4] E-mail: mabolori@uk.ac.ir