

## Collision between two atoms including Positronium and Muonium

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Recently Ray [1-5] has solved a four-body Coulomb problem exactly in the center of mass frame and introduced two new codes: the SEM and the MSEM to study cold-atomic collision following a coupled-channel methodology. The SEM include the non-adiabatic short-range effect due to electron exchange. The MSEM include the effect due to long-range van der Waals interaction in addition to the short-range non-adiabatic effect. Both these effects dominate at cold energies. The SEM code is applied to study the Ps-H, Ps-Ps, Ps-Mu, Ps-D, Ps-T, Mu-Mu, Mu-H, Mu-D, Mu-T, H-H, H-D, H-T, D-D, D-T and T-T systems. Here Ps, Mu, H, D, T symbolize the Positronium, Muonium, Hydrogen, Deuterium and Tritium respectively. The MSEM code was used to study the variation of scattering length with the variation of the strength of attractive long-range van der Waals interaction controlling the minimum interatomic distances ( $R_0$ ) as  $2a_0$ ,  $3a_0$ ,  $4a_0$ ,  $5a_0$ ,  $6a_0$ ,  $7a_0$ ,  $8a_0$ ,  $9a_0$ ,  $10a_0$ ,  $11a_0$ ,  $12a_0$ ,  $15a_0$ ,  $20a_0$ . The systems studied were Ps-H [1] and H-H [5]. It was found that at larger interatomic distances e.g. at  $R_0=20a_0$ , the MSEM and SEM data nearly coincide. In the present study, I reinvestigate thoroughly both the codes and reproduced exactly the same data to strengthen the earlier findings. Figures 1 and 2, briefly describe the results.

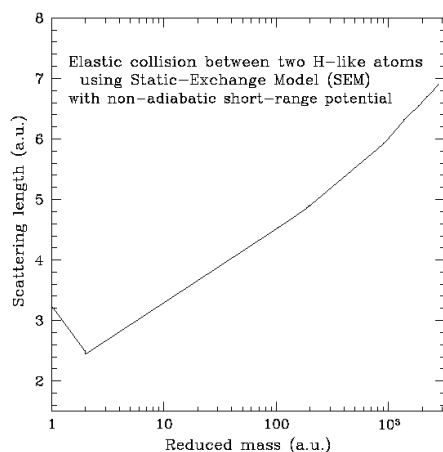


Fig. 1. Dependence of scattering length on reduced mass of the system.

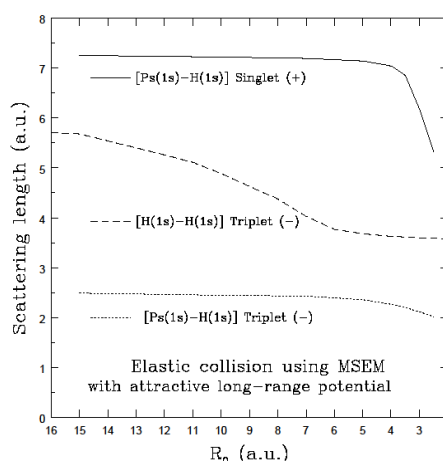


Fig. 2. Dependence of scattering length on the strength of van der Waals interaction.

- [1] H. Ray, Pramana J. Phys. 83, 907 (2014).  
 [2] H. Ray and R. De, J. Phys. B Conference Series 618, 012008 (2015).  
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 [5] H. Ray, Pramana J. Phys. Rapid communication 87, 8 (2016).