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Electron transfer processes in proton-atomic hydrogen excited states collisions

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Synopsis We have studied the collisions between protons and highly excited hydrogen atoms using the Classical Trajectory Monte Carlo method. We compare our numerical results for the electron transfer cross sections with those obtained by using semiclassical treatments. We present and discuss scaling laws for this process.

Proton-atom/molecule collisions have attracted considerable interest over the past few decades owing to their wide applications in plasma confinement, chemical reactive medium, ...and to the fundamental understanding of atomic structures and interactions [1]. The atomic processes of charge exchange (capture) in collisions between fully stripped ions and atomic hydrogen in its ground state have been extensively investigated both experimentally, e.g.[2,3], and theoretically, e.g.[4,5]. The case of H(n=2) initial state has also been analyzed by using Classical Trajectory Monte Carlo (CTMC)[6,8], semiclassical treatment [8] and Eikonal approximation (EA) [7].

The Classical Trajectory Monte Carlo has been proposed originally by Abrines and Percival [9] to study the collisions of protons with hydrogen atom in any excited state; these authors concluded that the CTMC method can be reliable for highly excited initial states. However this classical method has been used in numerous works, e.g.[4,5,6,7,8,9,10] to calculate ionization and electron transfer cross sections mainly for collisions involving ground state hydrogen and good agreement with experimental data were found in the intermediate energy range. Very recently CTMC calculations have also been performed on collisions between $N^{7+}$and $C^{6+}$with H(n=2) [10], with comparison with those obtained from semiclassical approaches, using atomic orbital (AOCC) and molecular orbitals close-coupling (MOCC) [11].

In the conference we present CTMC results, extending the study of $H^+ + H(n = 1)$ (compared with experimental data and other recent CTMC results [12]), to collisions between proton and highly excited states of atomic hydrogen, focusing on total and state-to-state capture cross sections. The advent of supercomputers and parallel programming facilities allow the treatment of such processes that have been out of reach before due to extensive CPU time consumption. The aim of our work is to reveal the behaviour of the cross sections in the case of excited hydrogen and check different scaling laws, as those of Foster [13] and Janev [14].

References

[1] Dörner et al. Adv. At. Mol. Opt. Phys. **48**,1(2002)
[2] J.E. Bayfield, Phys. Rev. **185**, 109 (1969)
[3]W.L. Fite et al., Phys. Rev. **112**, 1161 (1958)
[4] R. Abrines, andI.C Percival. Proc. Phys. Soc. ***88***, 861. (1966)
[5]R. E. Olson, and A. Salop. Phys. Rev. A ***16***, 531–541.(1977)
[6] C. O. Reinhold, and J. E. Miraglia. J. Phys. B: At. Mol. Phys. 20541-549 (1987)
[7] J. K. M. Eichler Phy. Rev. A **23** 498 (1981)
[8] M. J. Fitzpatrick, J. Fu , W. F. Smith, J. F. Reading, A. Dubois, and R. Gayet. Radiat. Phys. Chem. ***76***, 426–430. (2007).
[9]R. Abrines, and I.C Percival. *Proc. Phys. Soc.* **88** 861(1966)
[10] A. Jorge, L.F. Errea, C. Illescas, and L . Méndez. Eur. Phys. J. D ***68***, 1–11.(2014).
[11] K. Igenbergs, J. Schweinzer, A.Veiter, L. Perneczky, E. Frühwirth, M. Wallerberger, R.E. Olson, and F. Aumayr. J. Phys. B At. Mol. Opt. Phys. ***45***, 065203.(2012)
[12] I. D. Kaganovich,., A. Shnidman, H. Mebane, and R.C. Davidson. Nucl. Instrum. Methods Phys. Res. Sect. Accel. Spectrometers Detect. Assoc. Equip. ***606***, 196–204.(2009).
[13] A. Foster, Ph.D. thesis, University of Strathclyde, UK, (2008)
[14] R.K.Janev, D.Reiter, U.Samm: collision processes in Low-Temperature Hydrogen Plasmas JUEL 4105 (2003)

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