01 Jul 2012

Four Body Charge Transfer Process in Proton Helium Collision

Uttam Chowdhury

Allison L. Harris

Jerry Peacher
Missouri University of Science and Technology, peacher@mst.edu

Don H. Madison
Missouri University of Science and Technology, madison@mst.edu

Recommended Citation

U. Chowdhury et al., "Four Body Charge Transfer Process in Proton Helium Collision," *Journal of Physics: Conference Series*, vol. 388, no. PART 8, IOP Publishing Ltd., Jul 2012.
The definitive version is available at https://doi.org/10.1088/1742-6596/388/8/082048

Four body Charge Transfer Process in Proton Helium Collision

U. Chowdhury* [1], A.L. Harris† [2], J. L. Peacher*, and D. H. Madison*

*Missouri University of Science and Technology Department of physics, Rolla, MO 65401
†Henderson state University. Arkadelphia, Arkansas, 71999

Synopsis: Recent advancements in experimental techniques now allow for the study of fully differential cross sections for 4-body collisions. Theoretical fully differential cross sections will be presented and compared with absolute experimental data for transfer-excitation in proton-helium collisions. The role of different scattering mechanism will be discussed.

For more than 50 years, the study of electron capture process have been an active field of atomic collisions. The simplest four-body problem is a charged particle collision with a helium atom, in which both atomic electrons change state. This type of collision can result in many different outcomes, such as double excitation, excitation–ionization, double ionization, transfer-excitation, transfer-ionization, and double charge transfer. We use the 4BTE (4-body transfer-excitation) model [1] which is a fully quantum mechanical, first order perturbative model that includes all relevant two particle interactions. Numerically, this requires a full nine-dimensional integral, and is quite computationally expensive.

In the transfer-excitation [1] case, a high energy proton collides with the helium atom and captures one electron and leaves as a hydrogen atom. The target becomes a helium ion the residual electron is excited to an arbitrary excited states. Since the experiments [2] do not determine which excited state, it is necessary to sum over all the excited states. We determined that summing over excited states with $2 \le n \le 4$ is sufficient. In this work we will present fully differential cross sections for transfer excitation by protons with energies of 25keV, 60keV, 75keV, 100keV, 150keV and 300keV.The theoretical results will be compared with the experimental data of Schöffler *et al.*[2] and Hasan *et al.* [3].

Figure 1 shows results for which the incident and scattered projectile wave function is a plane wave and the initial atomic wavefunction is a 20 term Hylleraas wavefunction [1] which has angular as well as radial correlation included. For this case, the theoretical cross section was a factor of v**4 larger than the experimental data where v is the velocity of the incident projectile which ranges from 2 a.u to 3.5 a.u for the energies of Fig.1.

[1]E-mail: ucxt4@mail.mst.edu

[2]E-mail: a.l.harris.01@gmail.com

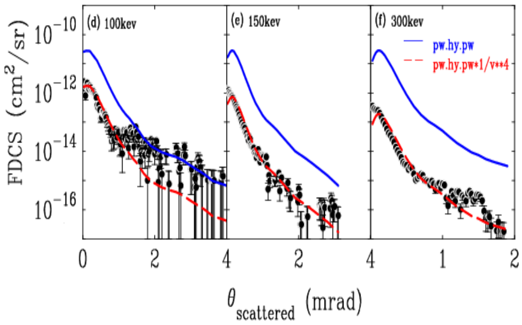

Fig. 1 FDCS as a function of the projectile scattering angle for proton + helium collisions for transfer excitation. The theoretical results are: Solid line 4BTE model with a plane wave for the incident projectile, Hylleraas wave function for the target atom (helium), and plane wave for the scattered projectile; Dash line 4BTE times 1/v**4.

Results for other energies and different scattering models will be presented and discussed.

Reference:

[1] A.L Harris, J. L. Peacher, and D.H Madison, *Phys Rev. A* **80,** 062707 (2009).

[2] M. S. Schöffler, Ph.D. thesis, *Univeristy of Frankfurt am Main*, (2006).

[3] A. Hasan, B. Tooke, M. Zapukhlyak, T. Kirchner, and M .Schulz, *Phys. Rev. A* **74,**032703 (2006).