§31. Cross-Sections of Charge Transfer by Slow Protons in Collisions with Noble Gas Atoms

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Charge transfer of low energy H^+ ions (protons) colliding with noble gas atoms (He, Ne, Ar, Kr, and Xe) is important as one of the most fundamental atomic collision processes as well as in various applications. For example, these collisions play a key role in cooling and diagnostics of low temperature edge plasmas in the current controlled thermonuclear fusion devices with a gas puffing system.[1] Theses collisions are very fundamental, so that there have been extensive experimental investigations of such processes.[2-4] Since these data sets were found to be closely consistent with each other, it was believed so far that the cross section data for charge transfer in this collision system were well established and understood. But theoretical calculations for He and Ne atoms become smaller than the experimental cross section as the collision energy decreases. To obtain precise and reliable cross section data and a detailed understanding of the collision dynamics, therefore, we have carried out a joint experimental and theoretical study for charge transfer of H^+ ions colliding with noble gas atoms at low keV energies.

In the present experiment, H^+ ions were extracted from an electron impact ion source and introduced into a 4 cm long collision cell filled with high purity noble gas atoms. The cross sections of charge transfer were determined by an initial growth rate method combined with a position sensitive micro-channel detector. In the present theoretical calculation, the molecular-orbital close-coupling method (MOCC) is applied to these specific processes. The observed cross sections are compared with the present calculations and other previously published both experimental and theoretical results.

The present cross sections for charge transfer in H^+ + Ne collisions are shown in Fig. 1. The present cross sections increase steeply as the collision energy increases, and the previous data are found to be larger by a factor of about five at 0.6 keV and about three at 0.8 keV, respectively, than the present observed cross sections.[5] The theoretical calculations by Kirchner *et al.*[6] are in general accordance with the present measurements at energies above 2 keV, but become gradually smaller than the present experimental results below 2 keV. The present MOCC calculations are closer to the present data than them.

The present cross sections for charge transfer in H^+ + Ar collisions are shown in Fig. 2. The present cross sections increase as the collision energy increases. The previous data are found to be larger by a factor of about three at 0.2 keV. The energy dependence of the theoretical calculations by Kirchner *et al.* are in general reproduced as the present experimental cross sections, but their calculations are found to be larger by a factor of about two.

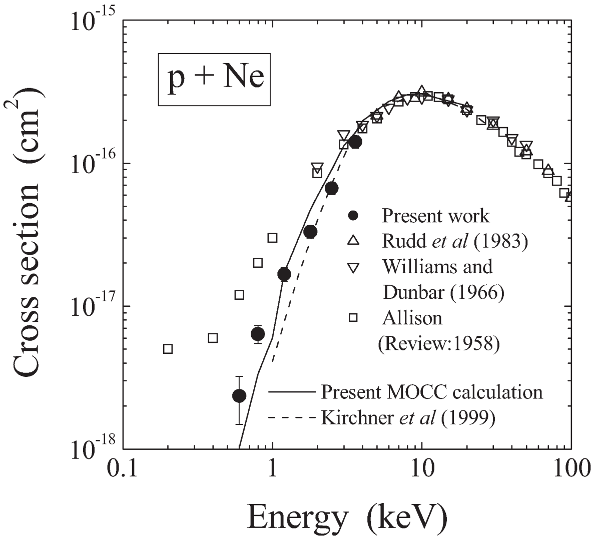

Fig. 1. Charge-transfer cross sections for H^+ ions in collisions with Ne atoms.

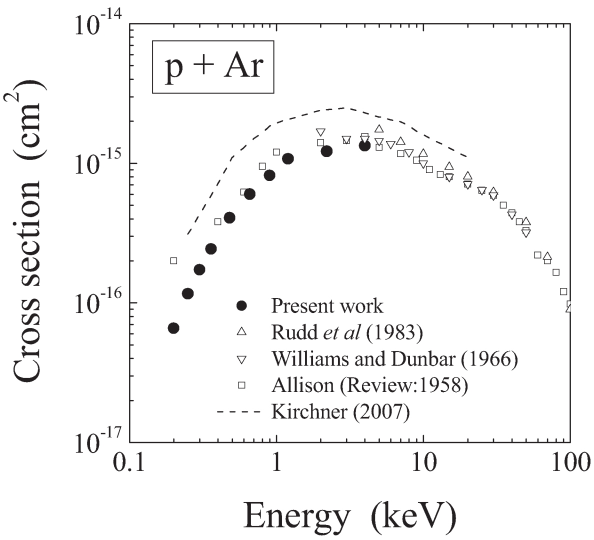

Fig. 2. Charge-transfer cross sections for H^+ ions in collisions with Ar atoms.

The joint theoretical and experimental studies are now in progress for H^+ ions colliding with He, Kr, and Xe atoms to establish more precise cross section data.

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5) Kusakabe, T., *et al*., Phys. Rev. A **75** (2007) 044701.
6) Kirchner T., *et al*., Phys. Rev. A **61**, (1999) 012705.