§9. Isotope Effect on Charge Transfer by Slow Lithium Ions from Hydrogen Molecules

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We have recently investigated isotope effect on charge transfer by slow hydrogen ions (H^+ and D^+ ions) from hydrogen molecules (H_2, HD, and D_2).[1,2,3] The cross section ratios of σ ($H^+ + D_2$) / σ ($H^+ + H_2$) and σ ($D^+ + D_2$)/ σ ($H^+ + H_2$) decrease to smaller value than unity below 1 keV/u, and reach a value of about 0.6 at the collision energy of 0.18 keV/u. Contrary to the case of H_2 and D_2, the experimental σ ($H^+ + HD$) / σ ($H^+ + H_2$) and σ ($D^+ + HD$) / σ ($H^+ + H_2$) ratios are found to be almost unity in the entire energy region from 0.18 keV/u to 1.5 keV/u investigated. The theoretical analyses based on the molecular-orbital expansion method have been applied to these collisions taking into account the deference of the vibrational energy of the product hydrogen molecular ions and the Frank-Condon principle.

The above charge-transfer processes at low collision energies are known to be important in a number of applications, especially in the controlled thermonuclear fusion research. In order to get more comprehensive understanding about the isotope effect on charge transfer in ion-molecule collisions of the hydrogen family, we have measured the charge-transfer cross sections of $^7Li^+$ ions colliding with the H_2, HD and D_2 molecules in the energy range of 1.4 to 4.0 keV.

The $^7Li^+$ ions were extracted from a surface ionization ion source. A platinum foil with the size of 2 × 2 × 0.03 mm spot-welded at a tungsten filament with 0.15 mm diameter was used as an anode for lithium ion emitter, which was coated with a mixed powder of Li_2CO_3, Al_2O_3 and SiO_2. The cross sections of charge transfer were determined by the initial growth rate method with a position sensitive micro-channel plate detector.

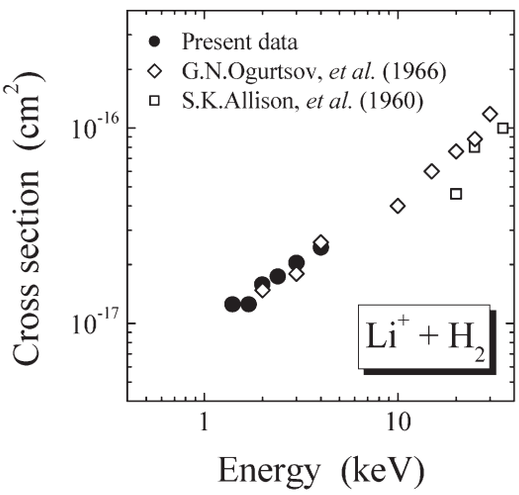

Fig. 1. Charge-transfer cross sections of Li^+ ions in collisions with H_2 molecules as a function of the collision energy.

Figure 1 shows the charge-transfer cross sections of Li^+ ions colliding with H_2 molecules. The present cross sections increase as the collision energy increases and are in good accordance with the previous data of Ogurtsov *et al.*[4] We tried to measure the charge-transfer cross sections at energies below 1.4 keV. However, charge transferred lithium atoms are found to be heavily scattered at large angle, so that the most charge transferred lithium atoms could not be passed through the exit aperture of the collision cell.

Both the present charge-transfer cross sections of Li^+ ions colliding with HD and D_2 molecules are found to be about 15% smaller than those of H_2 target.

The joint theoretical studies are now in progress for Li^+ ions colliding with the hydrogen family to obtain clear conclusive evidence.

Reference

1) Kusakabe, T. *et al.*:Phys. Rev. A **62** (2000) 062714.
2) Kusakabe,T. *et al.*:Phys. Rev. A **68** (2003) 050701(R).
3) Kusakabe, T. *et al.*:Phys. Rev. A **70** (2004) 052710.
4) Ogurtsov, G.N. *et al.*: Sov. Phys. - Tech. Phys. **11** (1966) 362.