§19. Charge Transfer Cross Sections in Slow Impurity Ion — Molecule Collisions Relevant to Fusion Edge Plasmas

Kusakabe, T. (Dept. Nucl. Engng. Kinki Univ.)
Nakai, Y. (At. Energy Res. Inst. Kinki Univ.)
Tawara, H., Sasao, M.

Charge transfer collisions of low charge state ions with molecules are important at low temperature edge plasma region and play a key role in determining properties of high temperature plasmas at the core region. Therefore we systematically measured the charge transfer cross sections of C^+ and O^+ ions in collisions with some of carbon-containing molecules, which are relevant to the edge plasma in devices with carbon-coated or graphite-lined walls. In this work, as a contineing study, we have measured the charge transfer cross sections of H^+ ions in collisions with H_2, CO, CO_2, CH_4, C_2H_6 and C_3H_8 in the energy range between 0.2 and 4 keV.

Among them, collision systems of H^+ - CH_4, C_2H_6 and C_3H_8 for the ground state - ground state transition are exoergic. Figure 1 shows the present cross sections for the charge transfer into H^+ ions from C_2H_6 molecules, together with theoretical calculation. The experimental cross sections for H^+ ions decrease gradually as the collision energy increases.

Two curves on Fig. 1 are the calculated results based on the Olson-Demkov theory [1] applied to the following reaction channnels of charge transfer

$$H^+ + C_2H_6(v=0) \rightarrow H(^2S) + C_2H_6^+(v'=0) \quad (1)$$

$$\rightarrow H(^2S) + C_2H_6^+(v' \neq 0) \quad (2)$$

where v and v' are the vibrational quantum numbers of target molecules and product molecular ions. The theoretical curve for reaction channel (1), which are exoergic, shows the energy dependence different from experimental data, namely this curve increases as the incident energy increasing and reaches a maximum.

The reaction channel (2) means "charge transfer with vibrational excitation of product molecular ions". The energy defect ΔE for this charge transfer reaction can be zero, so that this channel corresponds to so called "resonant charge transfer". The calculated result for the channel (2) satisfactorily reproduces the energy dependence of the present data as can be seen in Fig. 1. A similar trend was previously obtained in some exothermic collision systems of C^+ and O^+ ions.

Therefore, the charge transfer accompanied vibrational excitation of product molecular ion can be dominant at low energies even if the ground state - ground state reaction channels are exoergic.

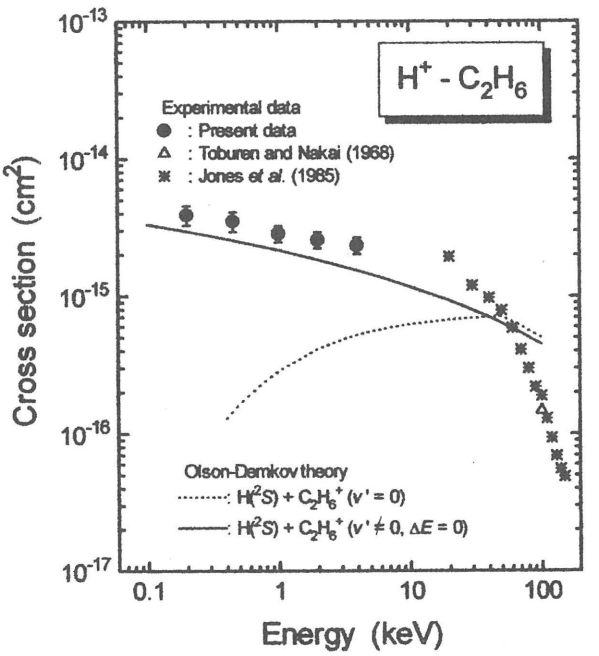

Fig. 1. Charge transfer cross sections for H^+ ions colliding with C_2H_6 molecules.

References
1) Olson, R. E., Phys. Rev. A6 (1972) 1822.