§8. Cross Sections of Charge Transfer by Slow Helium Ions in Collisions with Water Molecules

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Water molecule is main components of comets and one of the typical impurities in almost all laboratory plasmas. Recent observations of X-ray emission from comets have been modeled using the charge transfer processes. The fully and partially striped solar wind ions captured orbital electrons from cometary gases produce the X-ray emissions.[1] In the large thermonuclear fusion devices, adsorbed water molecules are released from the inner wall of the vacuum vessel and some electrodes. It is considered to have affected the character of plasma through various collision processes. On the other hand, a helium atom is one of the common elements in the solar wind plasmas and the fusion product in the next day large fusion devices. Therefore, cross section measurements are important for charge transfer of slow He^+ and He^{2+} ions colliding with water molecules. But the previous cross section measurements in these collision partners are scarce. 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 He^+ and He^{2+} ions colliding with water molecules at low keV energies.

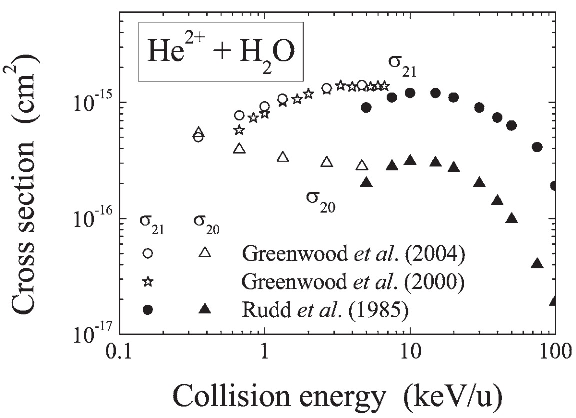

Fig. 1. Charge-transfer cross sections for He^{2+} ions in collisions with H_2O molecules.

As a first step of this study, the previous cross section data have been surveyed. Figure 1 shows the cross sections for charge transfer in He^{2+} + H_2O collisions. Only two data sets are available till now. Rudd *et al.* measured both single- and double-charge transfer cross sections (σ_{21}, σ_{20}) at above 5 keV/u in energy.[2] There data shows that the cross section values for the single-charge transfer were entirely larger than those for the double-charge transfer in their investigated energy range. Greenwood *et al.* have presented two articles concerning the cross section data at energies below 7 keV/u.[1,3] Reliability of these data should be verified.

Figure 2 shows the cross sections for charge transfer in He^+ + H_2O collisions. Only two data sets are also available. The cross section data of Koopman, which were measured in the energy range between 0.04 to 1.2 keV, gradually decrease with increasing collision energy,[4] while the recent experimental data of Greenwood *et al.* measured in the energy range of 1.2 to 6.6 keV are almost constant.[3] However, the data of Koopman are found to be extreamly smaller by a factor of about 10 at 1.2 keV in energy than the recent measurements of Greenwood *et al.* Reliability of these data should be also verified.

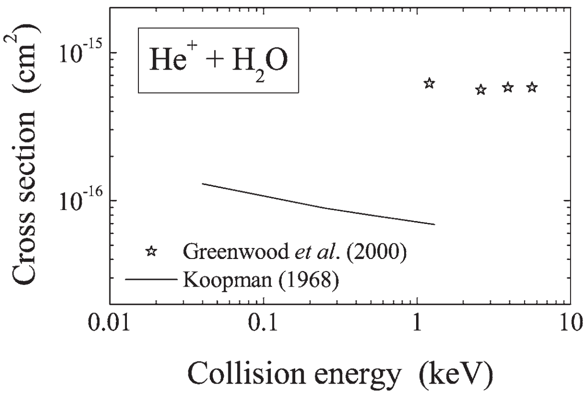

Fig. 2. Charge-transfer cross sections for He^+ ions in collisions with H_2O molecules.

In the present experiment, He^+ and He^{2+} ions will be extracted from an electron impact ion source and introduced into a 4 cm long collision cell filled with high purity water molecules. In order to avoid the contamination of the He^{2+} ions by H_2^+ ions, the isotope ^3He gas will be supplied to the ion source. After collisions, fast ions and product fast neutral particles are detected with a position sensitive micro-channel detector. The cross sections of charge transfer are determined by an initial growth rate method. In this year, we constituted the introducing system of water vapor with water reservoir, which can be cooled by liquid nitrogen in order to remove the air absorbed into water. In the present theoretical calculation, the molecular-orbital close-coupling method (MOCC) will be applied to these specific processes.

The further studies are now in progress for He^+ and He^{2+} ions colliding with H_2O molecules to establish more precise cross section data.

1) Greenwood, J.B., *et al.*, Phys. Scripta, **T110** (2004) 358.
2) Rudd, M., *et al.*, Phys. Rev. A, **32** (1985) 2128:
3) Greenwood, J.B., *et al.*, Astrophys. J., **529** (2000) 605.
4) Koopman, D. W., Phys. Rev., **166** (1968) 57.