§12. Charge Transfer Cross Sections of Singly Charged Lithium Ion in Collisions with Noble Gas Atoms in the Energy Range below 4.0 keV

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Lithium (Li) is sometimes used for plasma diagnostic purposes in fusion devices. Therefore, cross section data and any knowledge of collision dynamics for these atoms and ions are known to be important and useful in controlled thermonuclear fusion research. In order to establish the plasma modeling in the low-temperature boundary and edge plasmas which took in the behavior of Li ion more accurately, cross section data of the charge transfer for Li^{q+} (q = 1, 2, 3) ions in collisions with various atoms or molecules are essential.

However these cross section data are still sparse, particularly at low collision energies. In this study, therefore, we have measured the charge transfer cross sections of singly and multiply charged Li ions colliding with noble gas atoms and hydrogen molecules.

As a first step of the present project, the charge transfer cross sections of $^7Li^+$ ions have been measured for He, Ne, and Ar atoms in the energy range below 4.0 keV. The singly charged lithium ions were extracted from a surface ionization ion source. The $^7Li^+$ ion beam was mass-separated with a Wien filter, and was introduced into a 4 cm long collision cell, where target gases of high purity were filled. The Li^+ ions and energetic neutral Li atoms emerging from the cell after the collisions were charge-separated by using electrostatic parallel plates and detected with a position-sensitive micro-channel plate detector (MCP-PSD). The charge transfer cross sections were derived based on a so-called growth rate method. The target gas pressure was measured in the present study with an MKS-Baratron capacitance manometer, and ranged from 0.05 to 2 Pa. The back pressure was less than about 2×10^{-5} Pa in the vacuum chambers which were evacuated by 500, 50, and 300 l/s turbo-molecular pumps.

Figure 1 shows the present charge-transfer cross sections of $^7Li^+$ ions colliding with Ar atoms together with the previous data.[1-5] The present preliminary cross sections increase as the collision energy increases and are the orders of 10^{-17} cm^2. The experimental data of Ogurtsov *et al.*[1] is approximately a quarter of the present data, and these of Klaus[2] is even smaller. While the data of Kikiani *et al.*[3] are larger than the present data, and are flat to the incident energy.

In the $^7Li^+$ + Ar collision system, the charge transfer process is endothermic,

$$^7Li^+ (^1S) + Ar (^1S) \rightarrow {}^7Li (^2S) + Ar^+ (^2P) - 10.36 \text{ [eV]}, \quad (1)$$

and it is, therefore, expected to have a simple increasing curve in the low collision energies. The theoretical results by Dubrovskiĭ *et al.*[6] and the present model calculations based on the simple two state model by Rapp and Francis[7] just show this energy dependence.

We tried to measure the charge transfer cross sections at energies below 2 keV. However, charge transferred lithium atoms are found to be heavily scattered at large angle as pointed out by Ogurtsov *et al.*[1], so that the considerable portion of charge transferred lithium atoms could not pass through the exit aperture of the collision cell. Therefore, the absolute cross sections of Li^+ ions colliding with Ar atoms cannot be determined at energies below 2 keV. The peak profile of the charge transferred lithium atoms in the charge spectrum measured with the MCP-PSD is having structure like a ring. The diameter of this ring becomes large along with decrease in collision energy.

We have similar results for He and Ne atoms. The charge transfer cross section of $^7Li^+$ ions colliding with Kr and Xe atoms are under measurement. As a second step of the present project, the charge transfer cross section of $^7Li^{2+}$ ions colliding with noble gas atoms and H_2 molecules are under preparation.

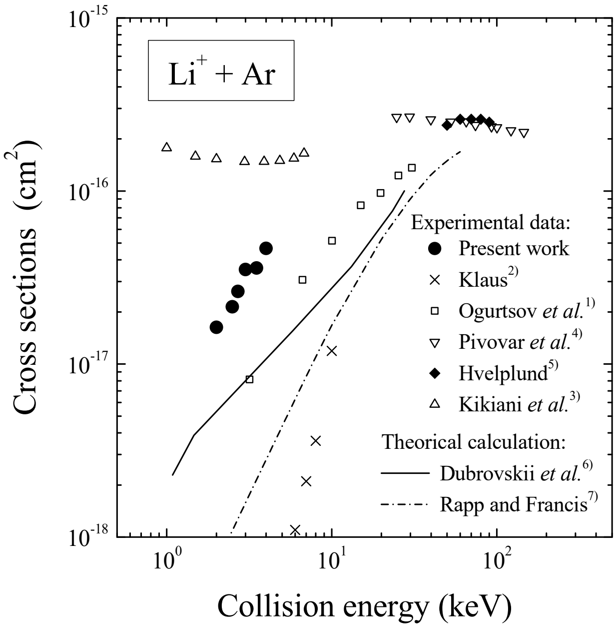

Fig. 1. Charge transfer cross sections of $^7Li^+$ ions colliding with Ar atoms.

1) Ogurtsov, G. *et al.*: Sov. Phys. Tech. Phys., **11** (1966) 362.
2) Klaus, B.: Zeitschrift für Physik, **162** (1961) 34.
3) Kikiani, B. *et al.*: Sov. Phys. JETP, **71** (1990) 51.
4) Pivovar, L. *et al.*: Sov. Phys. JETP, **30** (1970) 236.
5) Hvelplund, P.: J. Phys. B, **9** (1976) 1555.
6) Dubrovskiĭ, G. *et al.*: Sov. Phys. JETP, **22** (1966) 1264.
7) Rapp, D. and Francis, W. E.: J. Chem. Phys., **37** (1962) 26 31.