§20. Study on High Z Ions in Magnetosphere Plasma RT-1

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Impurities with high Z ions exist in LHD and other fusion plasmas, and are modeled to understand their behaviors in plasmas. The ring trap 1(RT-1) at the University of Tokyo simulates an impurity ion production in the magnet sphere plasmas, and then the results of impurity introduction experiments in RT-1 can be analyzed by using the atomic and molecular database, the program package HULLAC, and the ADAS database.

We had estimated the atomic process of high Z impurity ion (carbon) in RT-1 from the spectroscopic measurement and the electron temperature from the line ratio of HeI spectrum. For these analyses, the ADAS program is used to evaluate these processes in plasmas.

The charge states of the carbon impurity in plasmas are evaluated from the rate equation based on the ADAS database and compared with the results of spectroscopic measurement in Fig. 1. We usually observe the low charge states of carbon ions (C^+ and C^{2+}), so that a process to reduce the high charge states more than 3 exists. To explain the observation, the influence on the charge exchange process of carbon ions ($C^{2+} + H \rightarrow C^+ + H^+$) is included in the calculation. The result shows that the effect on the charge exchange process of carbon ions is necessary to explain the experimental result. On the other hand, the high energy electron with more than a few ten keV does not show the clear difference in charge states of less than +4. This is explained by the lower cross section with high energy electrons, and it does not contribute to the ionization process.

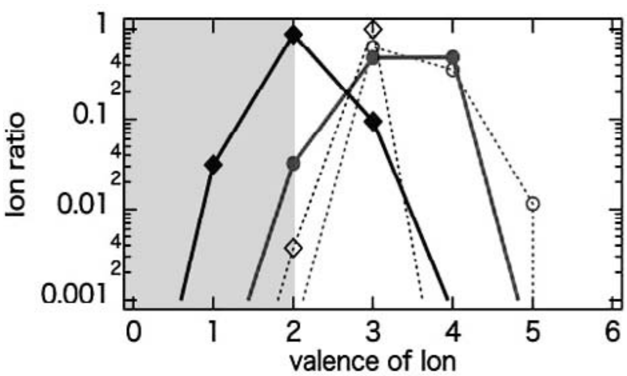

Fig. 1 The charge state of impurity carbon calculated with (solid line) and without (broken line) the charge exchange reaction. The hatched region indicates the observed charge states in RT-1. The charge states are measured at the filling gas pressures of 1 mPa (circles) and 13 mPa (diamonds).

The basic parameters for electrons and ions are important to discuss the plasma production by electron cyclotron heating and ion cyclotron heating and their plasma transport phenomena. The ion temperature is measured by the Doppler broadening of the line emission, and the electron temperature is evaluated by the measured HeI line ratio (728 nm/706 nm) and the ADAS database. From the result in Fig. 2, we found that the ion temperature increased linearly as a function of the electron temperature. This result explains the experimental charge states of ions, which was mentioned in Fig. 1.

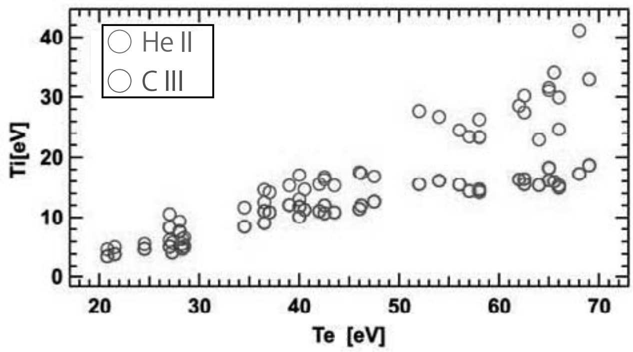

Fig. 2 The relation between the electron temperature and the ion temperature.

The confinement time and the charge exchange time are estimated from the following equations;

$$\tau_c = \frac{T_i}{T_e - T_i}\tau_{eq} \quad ,$$

and

$$\tau_n = \frac{1}{C_n N_n}, \text{ respectively.}$$

Here τ_{eq} is the energy relaxation time. These τ_c and τ_n estimated from HeII and CIII lines do not behave reasonably at high pressure region. This would be caused by the overestimate of the neutral density and/or the accuracy spatial profile of the spectroscopy. We should solve these problems to discuss the transport physics in RT-1.

We studied the atomic processes for high Z ion (carbon), the effect on the high energy electron, the relation between the ion temperature and the electron temperature. The production condition for higher charge state ions and the seeding of the heavy impurities (W and Mo) to the plasmas would be studied to understand the impurity transport in plasmas.