§69. Impurity Behavior during Radiation Collapse and Non Radiation Collapse

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Plasma impurities are important from the viewpoint of energy balance and particle transport in plasma simulation or modeling of many kinds of plasmas, including fusion plasmas, astrophysical plasmas and industrial plasmas. Impurities play a key role for plasma evolution. Spectroscopic measurements give a useful, quantitative way to study both plasma and impurity behavior. In this paper, we present EUV spectra from fusion plasma experiments in the Large Helical Device (LHD), and study the behavior of impurities in representative cases showing radiation collapse and non-radiation collapse.

Ionization and excitation processes are dominant in plasmas while the heating is on. These processes have often been studied. However the recombination processes have not been studied as well in experiments. In this paper we are interested in recombination processes when the plasma decays. We compare the behavior of carbon ions during radiation collapse with non-radiation collapse. In the case of radiation collapse, the temperature derived from intensity ratios decreases towards the end of plasma. However in the case of non-radiation collapse the derived temperature is found to increase after the heating is terminated. This suggests the radiating ions are closer to the plasma center.

Spectra were recorded on a Schwob-Fraenkel 2.0 m SOXMOS Spectrograph which gave an average resolving power of ~600 with a 600 mm^{-1} grating and ~ 300 with 130 mm^{-1} throughout the wavelength range of interest. It was possible to record spectra from both the centre of the discharge and also close to the edge or 24 cm from the centre. Generally the line of sight of the measurement is fixed through the center of the plasma. It includes the region from the lower temperature edge to the high temperature core.

We measured spectra in the wavelength range of 20 – 46A where the emission lines from He-like and H-like carbon ions are included. We used the intensity ratios of CV the intercombination lines (40.7 A, 1s2 – 1s2p 3P) to the resonance line (40.3 A, 1s2 – 1s2p 1P) for plasma diagnostics in this paper. We compared the observed intensity ratios and theoretical ones. Then we derived the electron temperature for C^{4+} ions. Theoretical calculations for the line intensities are obtained with the use of our collisional-radiative model for He-like ions[1]. In ionizing plasma, the singlet resonance line I_r(40.3A) is stronger than the intercombination line in the triplet system I_i(40.7A), whereas the intercombination line are stronger than the resonance line in recombining plasmas. The observed intensities of the resonance lines are always stronger than those of the intercombination lines even during radiation collapse and after the heating off. This indicates the ionization and excitation processes are dominant even in the phase of the plasma decay. We derived the electron temperature assuming the ionizing plasma; the derived temperatures show the lower limit values. In the case of radiation collapse, the electron temperature falls down much faster than the case of non radiation collapse. We can obtain the time evolution of the position of the C^{4+} ions comparing the derived temperatures and the radial distributions of the electron temperature measured by Thomson scattering. The time dependent positions of C^{4+} ions after the NBI heating off show the C^{4+} ions are moving towards the centre of the plasma faster than the recombination processes. We will investigate more about the transport of the impurity ions.

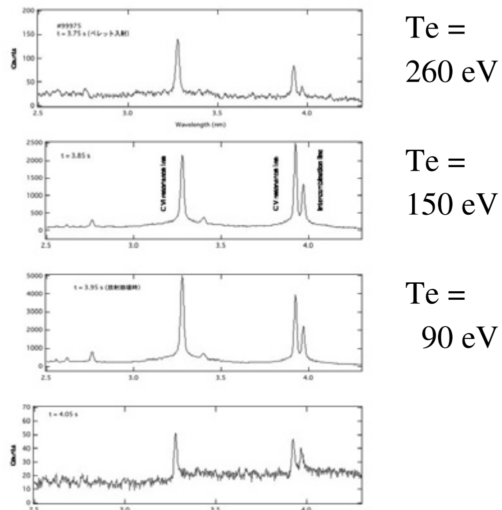

Fig. 1. The spectrum of H –like and He-like carbon ions during the radiation collapse. Te values indicate the temperatures in plasma where C^{4+} ions exist.

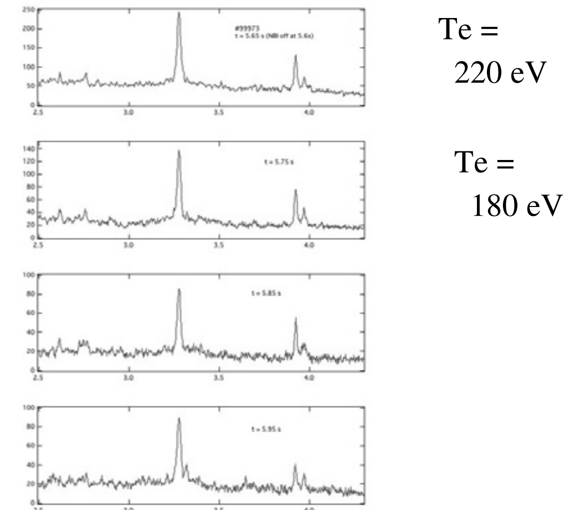

Fig. 2.. The spectrum of carbon ions for non radiation collapse after the NBI heating off.

1) T. Fujimoto and T. Kato, Phys. Rev. A **30**, (1984) 379.