§90. Impurity Behavior for Non Radiative Collapse

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We measure 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-radiative 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-radiative 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-radiative 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 lines in the triplet system I_i(40.7A), whereas the intercombination lines are stronger than the resonance line in recombining plasmas. The observed intensities of the resonance line are always stronger than those of the intercombination lines even during radiation collapse and after the heating turns off. This indicates that ionization and excitation processes are dominant even in the plasma decay phase. We derived the electron temperature assuming an ionizing plasma for the non-radiative collapse case; the derived temperatures show the lower limit values. In the case of radiation collapse, the electron temperature falls much faster than the case of non-radiative collapse. We can obtain the time evolution of the position of the C^{4+} ions by comparing the derived temperatures and the radial distributions of the electron temperature measured by Thomson scattering for non radiative collapse case.

We show the time evolution of the intensity ratios and the electron temperature derived from the intensity ratios in Fig.1 for the shot #106505 which is a case of non radiative collapse. We can divide the results into three phases; i) before carbon pellet injection, ii) after carbon pellet injection, iii) after the heating is terminated. In phase i), the electron temperature Te derived from the intensity ratios is rather high, 200 – 250 eV. In phase ii), Te decreases to 100 eV and gradually increases to 150 eV. In phase iii), Te is almost constant 130 eV for about 0.5 sec and then decreases to 60 eV. We show the time variation of the position of C^{4+} ions in Fig.2. From Fig.2, the radiating C^{4+} ions move towards outside about 10 cm in 0.2 sec after the pellet injection. However the position gradually shifts towards the center in 0.4 s and comes back to the initial position. After the heating is terminated the C^{4+} ions stay the same position for 0.3 s and then shift to the plasma center by about 42 cm in 0.3 s. It is not possible to explain this last behaviour through the recombination process of C^{5+} to C^{4+}, because Te is too high for recombination. We will further investigate the transport of impurity ions.

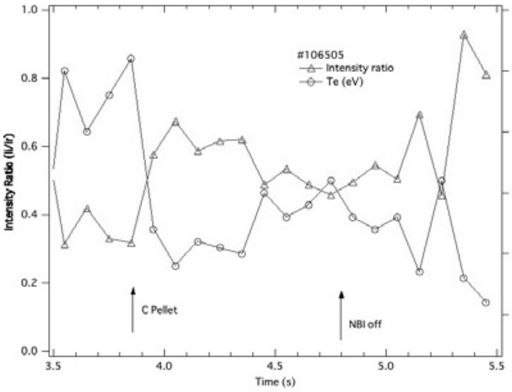

Fig. 1. The time evolution of the intensity ratios and the electron temperature.

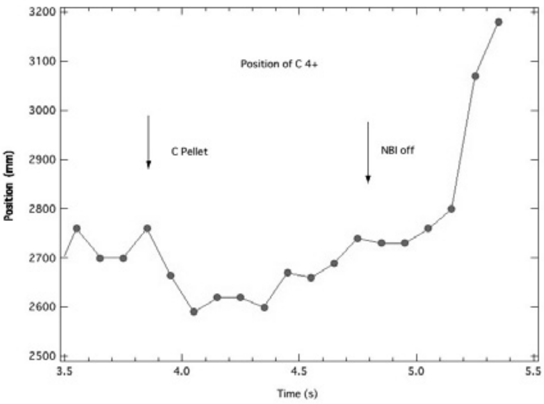

Fig. 2. Time behavior of the position of C4+ ions.

1) T. Fujimoto and T. Kato, Phys. Rev. A (1985)