§3. Polarization Separated Spectra of C III and O II emission lines in the GAMMA10 Plasma

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Electron cyclotron resonance heating (ECH) is adopted for formation of a plug potential with a thermal barrier in the plug region of GAMMA 10 tandem mirror[1]. Electrons in the plasma during ECH are accelerated in the direction perpendicular to the magnetic field by the ECH microwave. Non-Maxwell characteristics may be induced in electron velocity distribution function (EVDF) in the plasma. When the EVDF is anisotropic, emission lines from atoms and ions in the plasma can be polarized[2].

Emission lines from impurity ions in the hydrogen plasma during ion cyclotron radio frequency (ICRF) heating and ICRF+ECH were observed in the central region of the GAMMA10 Tandem Mirror device. Two line-of-sights equipped polarization separation optics were located at the height y = 90 and -40 mm. The orthogonal polarized components (π and σ components) of the emission lines from the plasma were separated with a beam-splitting Glan-Thompson prism. The polarization direction of the π light is parallel to the magnetic field direction. Each of π and σ polarized light was focused by a lens onto the entrance surface of an optical fiber having core diameter of 400 μm. The optical fiber bundle of eight-meter transmitted the polarized components of emission lines to a Czerny-Turner-type spectrograph. Spectra dispersed by the grating were recorded with an image intensifier coupled to a CCD. The high voltage of 6.8 kV was applied to the image intensifier. The emission profile was observed during 250 ms discharge duration. The repetition frequency of the CCD data acquisitions was 40 or 50 Hz. The exposure time was 18 ms for 50 Hz or 20 ms for 40 Hz. The plasma was generated from 50 to 250 ms with the ICRF injection. The barrier-ECH was additionally injected from 161 to 163.5 ms superposed with ICRF.

Figure 1(a) shows an example of the polarization separated spectral profiles of O II $2p^2 3s\ ^4P_{1/2,\ 3/2,\ 5/2} \leftarrow 2p^2 3s\ ^4D_{1/2,\ 3/2,\ 5/2,\ 7/2}$ (3/2←5/2: 464.18 nm, 5/2←7/2: 464.91 nm, 1/2←1/2: 465.08 nm) and C III $2s3s\ ^3S_1 \leftarrow 2s3p\ ^3P_{0,\ 1\ ,2}$ (1←2: 464.74 nm, 1←1: 465.03 nm, 1←0: 465.15 nm) emission lines in the ICRF discharges. For the purpose of reducing the noise of the image intensifier on the observed spectra, the time resolved spectra are averaged. At the last frame exposed at t = 241 ms, C III $2s3s\ ^3S_1 \leftarrow 2s3p\ ^3P_{0,1,2}$ emission lines are mainly observed.

Figure 1(b) shows the time evolution of the polarization separated spectra for the ECH plasma at the sixth frame. An increase of the intensities of the impurity lines can be seen. Nearby two emission lines from O II $2p^2 3s\ ^4P_{1/2} \leftarrow 2p^2 3s\ ^4D_{1/2}$ and C III $2s3s\ ^3S_1 \leftarrow 2s3p\ ^3P_0$ are never polarized. The sensitivity ratio can be determined from these two line intensities. The uncertainty is, however, large owing to the low signal intensity of these two unpolarized lines. he relative intensities of the π and σ components apparently change with the course of time. For example, for O II $2p^2 3s\ ^4P_{5/2} \leftarrow 2p^2 3s\ ^4D_{7/2}$ at λ464.91 nm and C III $2s3s\ ^3S_1 \leftarrow 2s3p\ ^3P_2$ λ464.74 nm lines in Fig. 1(a), the intensity of the π component is higher than that of the σ component at the time 161 ms. Then the intensity of the σ component becomes higher than that of the π component at 221 ms. We discuss the possibility of the polarization this variation is due to the effect of statistical fluctuation of photons and electrons in the imaging intensifier. Since there is no correlation of the polarization separated spectra among the different observed locations; y =90 and -40 mm. We conclude that the apparent relative intensity variation is due to the statistical origin in the ICCD system. In Fig. 1 (b), electron heating is applied in the observation time at 161 ms. During the ECH duration the EVDF can be anisotropic. The observed intensities of the π and σ components of O II $2p^2 3s\ ^4P_{5/2} \leftarrow 2p^2 3s\ ^4D_{7/2}$ at λ464.91 nm and C III $2s3s\ ^3S_1 \leftarrow 2s3p\ ^3P_2$ λ464.74 nm lines are nearly equal at 161 ms. The duration of the ECH pulse 2.5 ms is rather shorter than the exposure time 20 ms. Plug-ECH, barrier-ECH and central-ECH have been injected in the GAMMA10 plasma. In the experimental campaign of FY2007, the barrier-ECH will be injected for 50 ms at maximum duration. The plug-ECH and central-ECH pulses will be 20 ms. We plan to observe the ECH overlapped plasmas.

References

1) T. Cho, *et. al.*, Fusion Sci. Tech. **51**-2T, 11 (2007).
2) A. Iwamae, *et al*., Plasma Phys. Control. Fusion **47** L41 (2005)

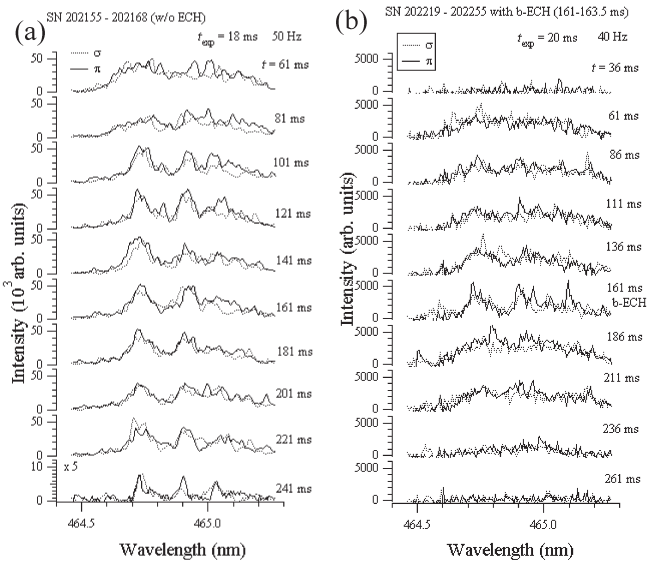

Fig. 1. The polarization separated line profiles: O II and C III emission at y = 90 mm. (a) ICRF discharge, (b) ICRF + barrier-ECH (161-163.5 ms). The π and σ components at different exposure times are plotted with solid and dotted curves, respectively. Ten successive line profiles are obtained during 250 ms discharge.