§7. Plasma Polarization Spectroscopy on GAMMA10 Tandem Mirror Plasma

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A departure from the Maxwellian velocity distribution of electron is observed. For example a plateau-shaped electron energy distribution function is observed in the plug region of GAMMA 10 tandem mirror, in the case the electron cyclotron resonance heating (ECRH) is adopted for formation of a plug potential with a thermal barrier[1]. Since the electrons are accelerated in the direction perpendicular to the magnetic field, the non-Maxwell characteristics may indicate that the electron by ECR microwave in the plasma. When the EVDF is anisotropic, the emission from atoms and ions in the plasma may be polarized.

Emission lines from impurity ions in standard ICH plasma of hydrogen gas were observed in the central region of GAMMA10. Figure 1 shows the schematic drawing of the polarization observation. Three line-of-sights equipped polarization separation optics were located at the height y = 90, 0, -68 mm. The orthogonal polarized components (extraordinary and ordinary rays) of the emission lines from the plasma were separated with a beam-splitting Glan-Thompson prism. Each of the e-ray and the o-ray was focused by a lens onto the entrance surface of an optical fiber having core diameter of 400 μm. The plasma areas viewed by the both rays were confirmed to be identical with the He-Ne laser light. The optical fiber of 8-meter transmitted the light to a Czerny-Turner-type spectrograph. The entrance slit was 75 μm. Spectra dispersed by the grating were recorded with an image intensifier coupled to a CCD (QImaging: Retiga1300R 1300x1030 of 7.4 μm square pixels). The high voltage applied to the image intensifier was adjusted from 6.3 to 8.0 kV. Normally the voltage of 6.4 kV is applied. The repetition frequency of the CCD data acquisitions was 40 Hz. The emission profile was observed during 250 ms discharge duration. The electron line density was about 1×10^{13} cm^{-2}.

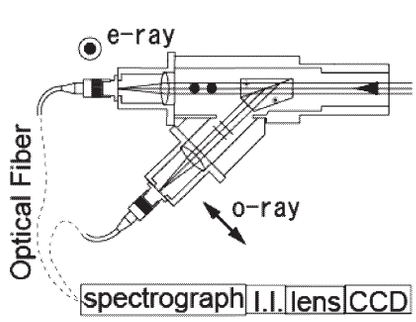

Fig. 1. Polarization separation optics used for the ion emission observation. Spectra dispersed by the grating were recorded with an image intensifier coupled a fast CCD

Figure 2 shows an example of the polarization resolved spectral profiles of O II $2p^23s\ ^4P_{1/2,\ 3/2,\ 5/2} \leftarrow 2p^23s\ ^4D_{1/2,\ 3/2,\ 5/2,\ 7/2}$ and C III $2s3s\ ^3S_1 \leftarrow 2s3p\ ^3P_{0,\ 1\ ,2}$ emission lines. For the purpose of reducing the noise of the image intensifier on the observed spectra, the time resolved spectra are averaged over seventeen discharges. Ten time-evolution spectra are obtained. In the first frame, 0-25 ms, the ion temperature is low and the lines are resolved. Nearby two emission lines from O II $2p^23s\ ^4P_{1/2} \leftarrow 2p^23s\ ^4D_{1/2}$ and C III $2s3s\ ^3S_1 \leftarrow 2s3p\ ^3P_0$ are never polarized. The sensitivity ratio is determined from these two line intensities. The uncertainty is, however, large owing to the low signal intensity of these two unpolarized lines.

The relative intensities of the π and σ components apparently change with the course of time. For example, for OII $2p^23s\ ^4P_{3/2} \leftarrow 2p^23s\ ^4D_{5/2}$ at λ464.18 nm, the intensity of the σ component is higher than that of the π component at the time range of 125 – 150 ms. While at 175 – 200 ms, the intensity of the π component is higher than that of the σ component. We first discuss the possibility that this 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 three different observed locations; z =90, 0, -68 mm, and no electron heating is applied in the observation time. We conclude that the apparent relative intensity variation is due to the statistical origin.

Various ECH (Plug ECH, Off-axis barrier ECH, central ECH) have been started in the GAMMA10 operation. We plan to observe the ECH overlapped plasmas.

Reference

[1] T. Cho, *et. al.*, Phys. Rel. Lett. **64**, 1373 (1990).

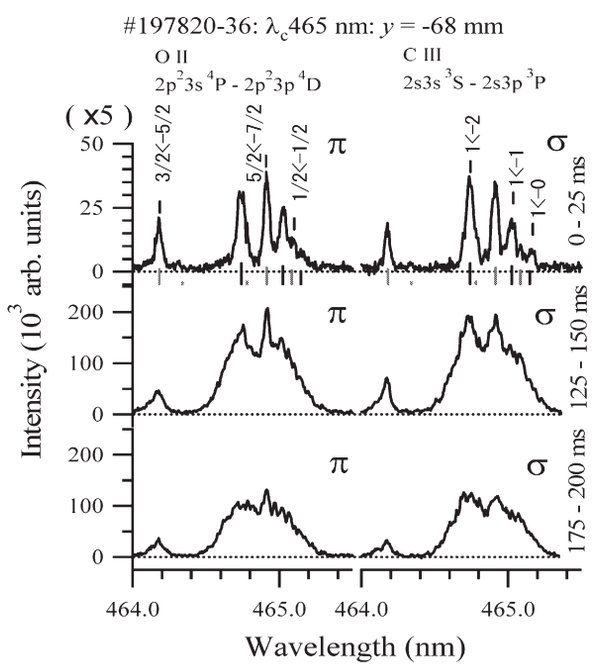

Fig. 2. The polarization separated line profiles: O II and C III emission. The π and σ components at different exposure times. Ten successive line profiles are obtained during 250 ms discharge. In the first frame intensity is scaled by a factor of 5.