Rapid Communications

Visible Imaging of Edge Fluctuations in Heliotron J

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High-speed 2-D imaging of edge fluctuations has been made by a C-MOS camera in Heliotron J. The camera monitored a limiter head, which was inserted into the peripheral plasma. In high-density ECH experiments it was found that the striped patterns of H_α emission near the limiter head periodically shifted along the poloidal direction. The typical spatial length and frequency of this shifted pattern were 8 cm and 5-6 kHz, respectively.

Keywords:

edge fluctuations, fast visible camera, plasma rotation, Heliotron J

Fast video-camera images of visible light emission from plasma provide much information on plasma behavior [1]. This technique was applied to the edge plasma study in Heliotron J [2].

An experimental setup is shown in Fig. 1. In order to localize the observation area, a movable cannonball-shaped carbon limiter was used. The diameter of the limiter head is 9 cm, and the limiter is inserted into the peripheral plasma from a bottom port. Retractable Langmuir probes are installed at a top of the limiter head. Figure 2(a) shows a top view of the limiter. A fast visible light video camera (Photron Inc., Fastcam Ultima-SE) [1] with an optical filter monitors the limiter head from the opposite side of the limiter. A half-mirror splits the light in order for the spectra of H_α or impurity lines to be measured by spectrometer.

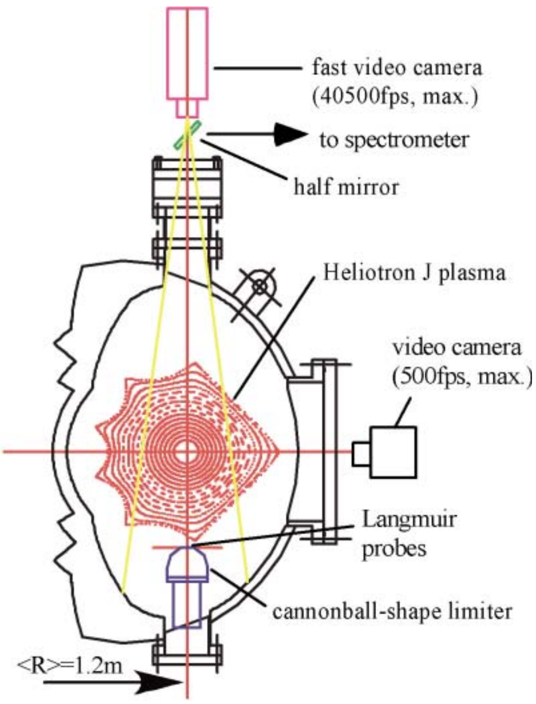

Fig. 1 Experimental setup in Heliotron J for new limiter experiments.

In this experiment, the limiter head was located 2 cm outer from the outermost magnetic surface. A frame speed of the fast camera was 40,500 s^{-1}, and a view size at this speed was 64×64 pixels.

In high density ($n_e \geq 1.8 \times 10^{19}$ m^{-3}) ECH (70 GHz) experiments [3], it was observed that the striped patterns of H_α light near the limiter shifted periodically during a certain period of a discharge. An analysis of the intensity of each pixel of each frame showed that the striped patterns shifted along the poloidal direction at 5-6 kHz. Typical spatial wavelength was 8 cm. Figures 2(b)-(e) show the two-dimensional contour images at a typical frequency (~ 5.7 kHz) component obtained by FFT during the fluctuation period.

The striped patterns of H_α light moving along the poloidal direction were seen clearly. The waveform of the ion saturation current measured by the Langmuir probe at the limiter head and the intensity of H_α light in the pixel corresponding to the probe position in the fast camera images are shown in Fig. 3 (a) and (b).

According to the fast camera data, the fluctuations began at 237 ms, and ended at 244 ms. The time behavior of the both signals is quite similar. This suggests that the H_α light intensity from the fast camera images is almost proportional to the ion flux. Thus, the observed fluctuations suggested that

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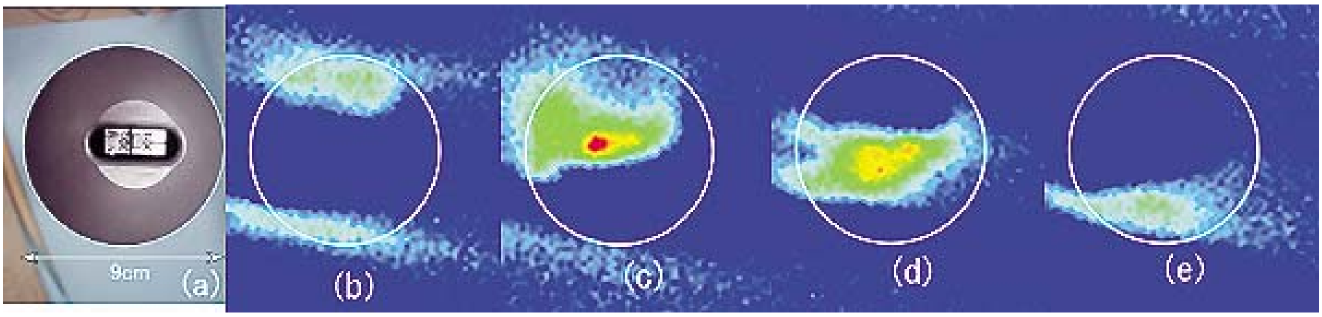

Fig. 2 (a) Top view of carbon limiter, in central region there are 4 Langmuir probes; each two is separated by a block of SiC. (b-e) Two-dimensional contour images at a 5.7 kHz frequency spectral power obtained by FFT during fluctuation period. Each frame continues in this order at every 49.4 μsec. In (b-e) the white circle shows the outline of the carbon limiter.

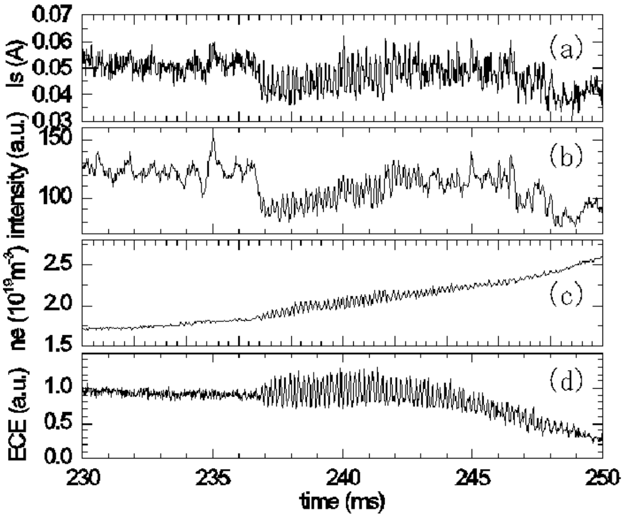

Fig. 3 (a) Ion saturation current of the Langmuir probe on the limiter head, (b) H_α signal of pixel data at the probe position in the fast camera images, (c) Line-average electron density, (d) ECE signal from the plasma central region.

the flux from the peripheral plasma moved along the poloidal direction. It was observed that the line-average electron density and ECE signals from several spatial points oscillated at the same frequency as the peripheral plasma fluctuations of the corresponding period. The waveforms of these signals are shown in Fig. 3 (c-d). The floating potentials of the edge plasma observed by the other Langmuir probes at different toroidal sections were also oscillating at the same frequency during this period (not shown in the figure). These observations suggest that the plasma rotated along the poloidal direction during this period. However, at present, we have no information regarding the toroidal rotation. During this fluctuation period, the diamagnetic signal increased (not shown in the figure). Therefore, it is thought that the fluctuations do not degrade energy confinement.

We are planning to confirm the edge plasma rotation by using multi-channel Langmuir probe arrays. Also, spectroscopic measurement of the toroidal rotation of the core plasma is in preparation.

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