# §11. Experimental Study about Spatial Structure of Short-wavelength Fluctuation Due to MHD Instability in High Beta Region

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A fast soft X-ray camera has been developed in LHD in order to investigate spatial structure of short-wavelength fluctuations due to MHD instability.

A steep pressure gradient is formed in the so-called super dense core plasma produced by intense fuel supply to the plasma core region. An abrupt flushing of the core density occurs when the central $\beta$ approaches the stability limit ($\beta$=plasma pressure/magnetic pressure) [1]. This is called the core density collapse (CDC) events. In previous work, precursor oscillations were observed just before the CDC. It is believed that the ballooning mode leads to the oscillation. However the measured structure of the precursor oscillation has not compared with the ballooning mode structure and has not been fully clarified yet. A fast two dimensional (2D) measurement system is required in order to study the structure of the precursor oscillation. If high response photo diode is aligned as a 2D array, the required system can be constructed.

The prototype of the fast pinhole-type camera was manufactured and is installed in LHD. The soft X-ray emission is detected by silicon photo diode array in the prototype. The prototype array has 8 diodes arranged in the toroidal direction. The direction from channel 1 to channel 8 is the counter direction. The diodes are pointed at the low magnetic field side of the plasma. The projected image length of the array is ~800 mm at the plasma location.

The specification of the prototype is introduced briefly. The silicon photo diode of model number S3590-09 manufactured by the Hamamatsu photonics are employed. The advantage of this diode is large sensor area of 10 mm×10 mm and small diode capacitance which enable us the short response time. According to the X-ray mass absorption coefficient of silicon, 0.3 mm thick silicon can absorb photon energy less than ~10 keV. The projected image size of a diode is ~126 mm at the plasma location when $L_{in}$=11182 mm, $L_{out}$=1775 mm, $a_d$=10 mm and $a_p$=10 mm. Here, $a_p$ is diameter of a pinhole, $a_d$ length of a diode, $L_{in}$ length between a plasma and a pinhole, $L_{out}$ length between a detector and a pinhole. The pinhole is sealed with a thin film of the high purity beryllium of 30 mm in thickness, which corresponds to the cut-off energy of 1 keV.

The CDC experiment was performed and the precursor oscillation excited before the event was measured by the prototype. Figure 1 shows a typical waveform in the CDC experiment. The plotted soft X-ray emission was measured by a diode of channel 4 with the chord through core region of horizontally-elongated plasma. The volume averaged beta value and the soft X-ray emission are reduced rapidly at ~4.4 s while H-alpha is increased. This suggests a visible light do not affect the measurement result.

Figure 2 shows time evolution of the soft X-ray emission. Phase difference of the precursor oscillations in the toroidal direction is found. The arrow indicates the wave propagates in the co-direction.

In the future, the poloidal array is added to the prototype. The detailed structure of the precursor oscillation is may be clarified by the upgrade 2D measurement system.

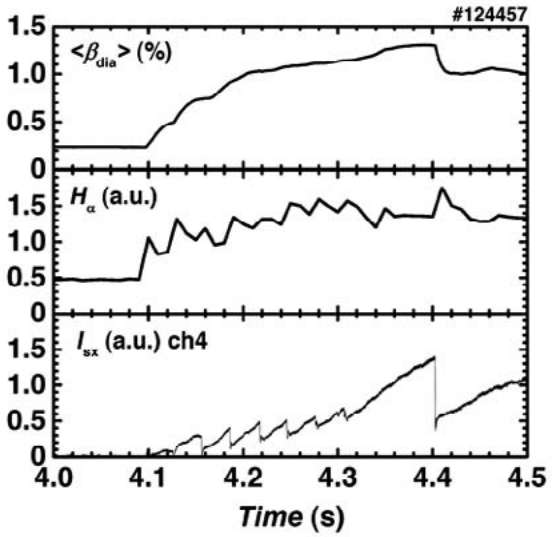


Fig. 1. A typical waveform in the CDC experiment. Minor collapse occurs at ~4.4 s.

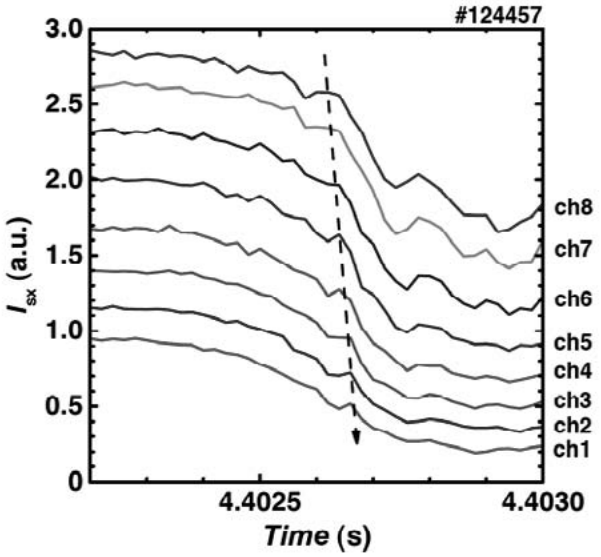


Fig. 2. Time evolution of the soft X-ray emission measured by photo diode array. The arrow indicates the propagation direction of waves.

1) Ohdachi, S. et al.: Contrib. Plasma Phys. **50** (2010) 552.