§12. Fast-framing VUV Camera System

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Physics of fluctuations in magnetically confined plasma are fairly complicated. If we resolve the spatial structure of them, our understanding of the fluctuations and related transports will be improved. Since the phase of the fluctuations on a magnetic field line are almost the same, we can obtain greater part of the information from two dimensional (2D) structure of the fluctuations in toroidally confined plasmas. Therefore, We have developed 2D imaging diagnostics, such as the tangentially viewing soft X–ray camera[1)].

The soft X–ray system we used so far had the advantage that the photons it detects are in the same energy range as those emitted by the plasma. The drawback is, that no lenses are available in this energy range and we have to use a pinhole for optical system. To improve the time resolution is then only possible if we increase the diameter of the pinhole. That means all sizes of the camera, including detector should be increased as much if we keep the spatial resolution. The size of the detector is, however, limited because of their availability; moreover, the camera becomes larger and needs more space on the experiment.

If we go to lower energy radiations, the first optical components we can use are mirrors made of Mo–Si layers, which can reflect photon of 13.5nm. The reflectivity of the material is up to 65 % and the mirrors available are close to the theoretical limit. The carbon VI line (n=4 – 2, 13.5 nm) falls into this energy range. Therefore, we expect to study 2D density fluctuations via carbon radiation in the boundary of LHD by the camera system with mirror optics. Inverse–Schwarzschild type mirror optical system is adopted. The radiation image is focused on the MCP plate for detection. The output image from the MCP is measured by the fast framing video camera[2)].

The system was mounted on a flange at 1-O port. This fiscal year, the system was moved to 10-O because a new NBI system will be installed on 1-O section. On this occasion, we have improved the system; (1) The size of the attached flange is extended to ICF253 from ICF203. Observing area is thereby increased by 20% (40cm diameter in the core plasma region now). (2) Thin Zn film (0.2 μm) is inserted in front of the MCP plate. The low-energy VUV light, which is slightly reflected by the multi-layer mirror, is cut by this. Before the insertion, we have observed the signal even after the main plasma disappears. Now, we are sure that we are observing purely light with energy of 13.5nm. Typical framing rate is several kHz to 10kHz. The spatial resolution is about 1cm in the plasma.

Figure 1 shows one example of measurements. 2D images are analyzed by the singular value decomposition (SVD) method. Time evolution of the image is separated by orthogonal components by this. Coherent oscillations are observed from 3.742s in the fluctuating component (Fig. 1 (a2)). It is consistent with other measurement for VUV light by AXUV diodes (Fig. 1 (c))[3)]. There are horizontal filaments in the corresponding spatial structure (Fig. 1 (b2)). That shape may caused by the magnetic field lines in the observing region. (Note that we are observing the plasma vertically from the outer port.) Therefore, 2D structure of the fluctuations localized in the peripheral region is measured by this system.

Detailed analysis including reconstruction of local emissivity from this line-integrated image is in progress. We will install the camera system at the tangential port in order to observe wider area of the plasma.

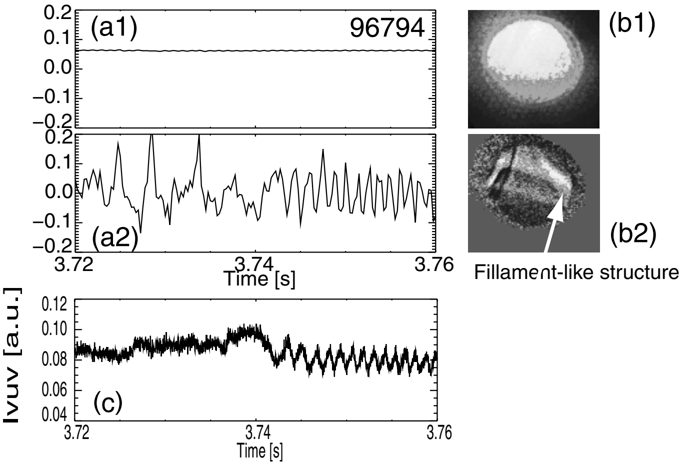

Fig. 1: *The 2D image is analyzed by the SVD method. Figures (a) and (b) show the choronos and topos from the SVD. Figures (a1) and (b1) indicate to the stational component. Figures (a2) and (b2) show one of the fluctuationg components. Figure (C) shows the time evolusion of the vuv radiation measured the AXUV diode array.*

1) S. Ohdachi, K. Toi, G. Fuchs, S. von Goeler, and S. Yamamoto, Rev Sci Instrum 74, 2136 (2003)

2) M. Takeuchi, S Ohdachi and LHD experimental group, Plasma Fusion Res. 5, S1037 (2010).

3) F. Watanabe et.al., Plasma and Fusion Research **2**, S1066 (2007).