§17. Physics Study on 3-D Helical Equilibrium Plasmas with 2-D Imaging Diagnostics

Sanpei, A., Masamune, S., Himura, H., Oki, K.,
Nakamura, M., Higashi, A., Motoi, H., Fukahori, D.
(Kyoto Inst. Tech.),
Watanabe, K.Y., Suzuki, Y., Ming, T.F., Ohdachi, S.

The measurement of bremsstrahlung soft X-ray (SXR) radiation is one of the useful passive methods for diagnosing high-temperature plasmas, because contours of the SXR emissivity correspond to magnetic surfaces of the plasmas. Tangential SXR imaging has been applied to high-temperature toroidal plasma experiments for the study of pressure fluctuations either in the core or at the edge[1)]. The reversed field pinch (RFP) is a high-temperature and high-beta toroidal plasma. In the RFP, studies on the behavior of magnetic islands due to the tearing modes are quite important, because the RFP configuration is self-organized and sustained by nonlinear interaction of the tearing modes, which lead to magnetic chaos. One of the important issues of this study is the development of three dimensional (3-D) SXR measurement system, which will be applied for physics study on 3-D helical equilibrium on LHD.

Consecutive imaging measurement has been a useful tool for understanding the plasma dynamics and instabilities. We are therefore developing an SXR imaging system consisting of a SXR pin-hole camera and a high-speed CMOS camera (Photoron FASTCAM SA-4 500K-M1AS) for the study of time evolution of 3-D structure. A schematic drawing of the developing imaging system is illustrated in Fig.1. Plural unit is located tangential view of the plasma to have a view of nearly the entire plasma diameter and most of the vertical extent of the plasma. This SXR imaging system utilizes a microchannel plate (MCP) to record a higher-resolution distribution of two-dimensional (2-D) luminosity on a phosphor plate. The projected images strongly depend on the equilibrium magnetic field. As the A of RFP is lowered, the safety factor q on axis increases and n of dominant internally resonant mode is to be lower. In this sense, the core of a low-A RFP is favorable for this kind of tangential measurement.

In a low-A RFP machine RELAX[2)], ($R = 0.51$ m/$a = 0.25$ m ($A = 2$)), a quasi-periodic transition to quasi-single helicity (QSH) state has been observed[3)]. In this experiment, we have taken a series of tangential images of the plasma with 10 μ sec time intervals, to identify time evolution of SXR emissivity structure in the QSH state in RELAX. 2-D luminosity distributions corresponding to integrated SXR emissivity are measured with the high-speed camera with 320×192 pixels array and 12-bit of dynamic range. Raw images of SXR emission contain both the equilibrium and fluctuating component. To clearly illustrate the fluctuating component, we have applied the subtraction technique; we have obtained differential signals of two consecutive images. Figure 2 shows an example of the results. A simple helical structure has been observed clearly in the central part of the tangential viewing area. An equilibrium reconstruction has shown that the minor radial location of the $m=1/n=4$ resonant surface is consistent with the experimental observation; The simple helix is located at 0.10-0.14 m in a poloidal cross-section.

We successfully obtained time evolution of SXR images from tangential port.

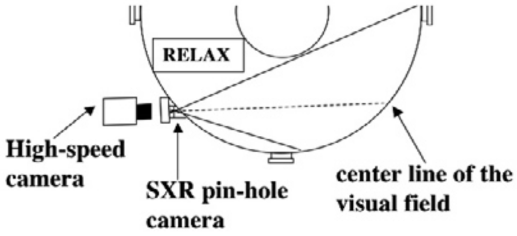

Fig. 1: Arrangement of the SXR pin-hole camera and the high-speed camera. Solid lines and a dashed line represent the limits of the visual field and the line sight of the center of the visual field, respectively.

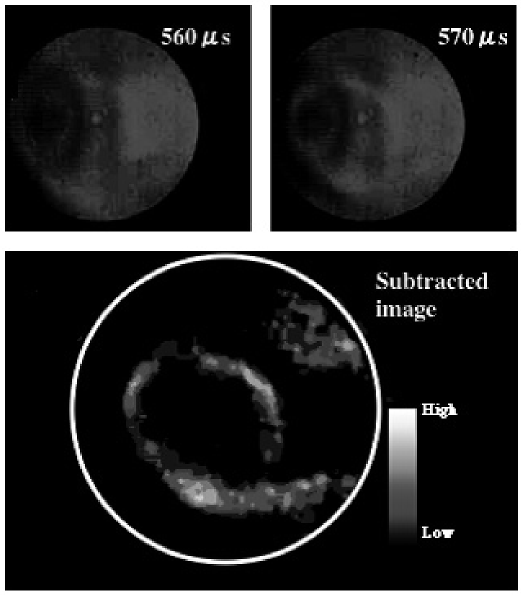

Fig. 2: Above two images are raw data. Below one is a result of subtraction.

1) S. Ohdachi, et al., Plasma Fusion Res. **2**, S1016 (2007)

2) S. Masamune *et al.*, J. Phys. Soc. Jpn. **76** (No.12) (2007) 123501.

3) R. Ikezoe, et al., Plasma and Fusion Res. **3**, 029 (2008)