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

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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. SXR imaging has been applied to high-temperature toroidal plasma experiments for the study of pressure fluctuations either in the core or at the periphery[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. Purpose of this study is comparative analyses of experimental observation of SXR images between at the LHD and at RELAX device[2].

Two dimensional (2-D) SXR imaging measurement has been a useful tool for understanding the plasma dynamics and instabilities. Therefore, we have already developed an SXR imaging diagnostic system that uses multiple pin-hole SXR cameras together with high-speed cameras to record the time evolution of the SXR images from the tangential and vertical directions simultaneously for studying the dynamic structures of 3-D SXR emissivity in RELAX[3]. We obtain SXR images under various configurations of RELAX plasmas making use of this system, and estimate magnetic structures. Moreover, we have developed a two-dimensional electron temperature diagnostic system for thermal structure studies[4]. The system consists of a SXR camera with two pin-holes for two-kinds of absorber foils, combined with a high-speed camera. We have succeeded in distinguishing T_e image in quasi single heilicty RFP from that in multi-helicity RFP states.

As a next step, in order to measure SXR emissivity distribution in LHD, a soft X-ray camera is being developed for technology development of a fast 2D measurement system[5]. The new camera can observe spatial structures of MHD modes with high frequency and high spatial resolution. The 6×8 photo diodes be aligned on the copper plate. Developed camera is applied for observation of Core Density Collapse (CDC) event at LHD. Figure 1 shows time evolution of the SXR emissivities obtained with developed array from vertical port in LHD.

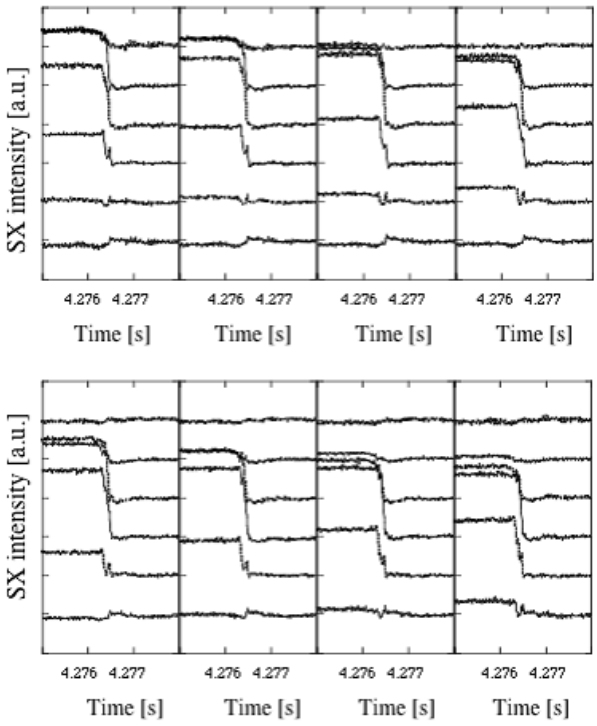

Fig. 1: Time evolution of SXR emissivity obtained with 6×8 ch vertical detectors at LHD.

In Fig. 1 we can observe a sudden changes of signals due to collapse in core region during CDC event. Moreover, increases of SXR signal in edge region appear.

The observed vertical SXR at LHD has things in common with the SXR images observed in sawtooth event and helical transition event at RELAX RFP plasmas. Analysis with various physical quantities, especially with magnetic fluctuations, will be attempted to understand of effect of MHD on transition phenomena. This comparative analyses would deepen our understanding of the helical transition phenomena in high-beta fusion plasma.

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3) A. Sanpei *et al.*, JPS Conf. Proc. **1** 015027 (2014).

4) K. Nishimura, et al. : Rev. Sci. Inst., **85**, 033502 (2014).

5) Y. Takemura *et al.*, Rev. Sci. Inst. **85** 11E410 (2014).