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Time evolution of Soft-X ray emission profiles in RELAX
RELAXにおける軟X線放射強度分布の時間発展

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In a low-aspect-ratio (low-A) reversed field pinch (RFP) configuration, it has been demonstrated that the magnetic configuration tends to relax to the quasi-single helical (QSH) state easily, and helical hot or dense core is formed with soft-X ray (SXR) imaging. In order to study time evolution of the magnetic flux surfaces, we have developed a SXR emissivity profile using AXUV photo diode array and an aluminium thin foil. Initial measurements using a single array has provided peaked profiles and the peak position oscillates during the QSH period. Tomographic imaging system is being developed for the detailed study of time evolution of magnetic island and /or hakical shape of the core region.

1. Introduction

The reversed field pinch (RFP) is one of the magnetic confinement systems for high-beta plasmas. Relatively weak external magnetic field is enough to confine the RFP plasma, and therefore, the magnetic field outside the plasma is mostly due to the plasma current. Thus engineering beta is quite high, which is a great advantage of the RFP reactor concept.

In order to realize good confinement in the RFP, it has been demonstrated that magnetic flux surfaces have to be formed (or recovered) in otherwise stochastic field lines resulting from MHD relaxation to from or sustain the RFP configuration. One of the methods for realizing nested flux surfaces is to allow a single dominant mode to grow to a saturation level (quasi single helical or QSH state), to form nested flux surfaces inside the dominant magnetic island.

When the aspect ratio is lowered, more space becomes available between the dominant mode rational surfaces in the core region, where the single mode can grow to a larger amplitude than in standard medium- or high-A RFP configuration.

RELAX is a low-A RFP machine (R=0.5m/ a=0.25m) which aims to study the MHD behavior in low-A RFP. The plasma parameters attained to date are as follows: plasma current Ip from 40 to 100 kA, the electron density from 0.1 to $2.0\times10^{19}\mathrm{m}^{-3}$, the electron density around 50eV from SXR intensity, and the discharge duration around 2 ms.

Operational regions of RELAX plasmas have been studied in (Theta, F) space, and we have found two important regions for confinement improvement[1]. In RELAX, magnetic fluctuation level and SXR emission intensity are used as indications of plasma performance. The shallow reversal regime where external reversed toroidal field is very weak or almost zero is one of the characteristic discharge regimes, where the QSH states tends to be realized rather easily without specific control of magnetic boundary conditions. In such QSH state RFP plasmas, SXR pin-hole imaging has revealed formation of a single helical hot or dense core where SXR emission is higher than the surrounding area.

In addition to the SXR pin-hole camera system, we have developed a SXR array using the AXUV photo-diode array. Figure 1 shows a photo of the whole detector. The system can be inserted into the vacuum vessel through a ICF070 gate valve. We will use two arrays simultaneously from the top and the horizontal diagnostic ports in a poloidal plane for SXR tomographic diagnostic.

Fig.1: A soft-X ray array detector using AXUV photo-diode array and aluminum thin foil.

2. Measurement system

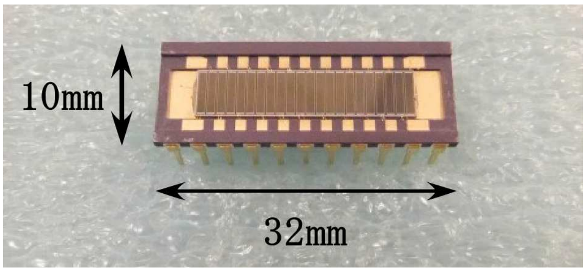

Fig.2: AXUV photodiode array used in our SXR diagnostic system shown in Fig.1.

In RELAX, some SXR diagnostics have been developed to provide two-dimensional profile of SXR emissivity[2]. One is a SXR pin-hole camera together with a high-speed camera to obtain tangential and/or vertical 2-D images. These imaging diagnostics have worked well to identify the helical hot or dense core in the QSH regime RELAX plasmas. Time resolution of this system, however, is limited by the frame rate of the high-speed camera, and we need sufficient MCP gain to obtain SXR image of relatively low temperature plasmas.

We have developed a SXR array diagnostic system for the study of MHD mode dynamics with high time resolution. Figure 2 shows the AXUV photo diode array used in our present SXR diagnostic system. 20 radial chord can be measured using a single detector array of rather small size. We have used aluminum fliter to minimize the effect of visible light and low-energy photons.

Figure 3 shows an example of the time evolution of radial profile of the SXR emission in QSH regime RFP plasmas[3]. We can identify clear oscillations in the SXR contour evolution, with a slight shift of the peak position. The oscillation frequency agrees with the experimental observation of magnetic fluctuation frequency, and therefore, the oscillation is closely related to the toroidal rotation of the dominant m=1/n=4 mode, or, helically deformed structure in the core region. In order to identify the time evolution of the cross sectional shape of the hot or dense core region, a second SXR detector array has developed, and the simultaneous measurement using two arrays will make it possible to apply tomographic imaging technique.

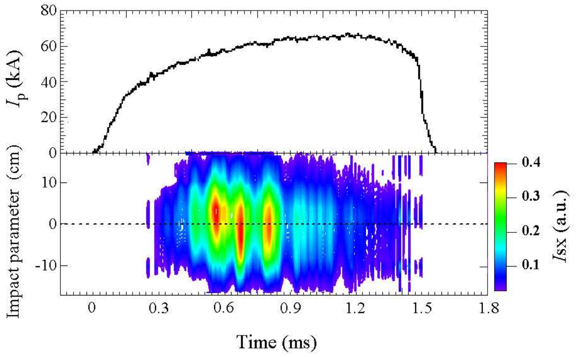

Fig.3: Time evolution of radial profiles of SXR emissivity in QSH tyoe discharge.

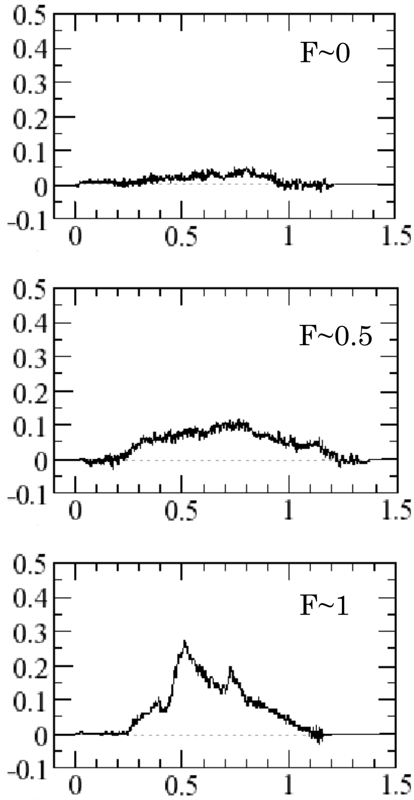

Fig. 4: Increase in SXR emission intensity by deepening the toroidal field reversal.

Figure 4 shows the dependence of the SXR emission intensity on the toroidal field reversal. As described in ref.[1], the SXR emission increases when the deep reversal discharge is realized, the lowest trace case in Fig.4. In spite of the fact that the electron density is lower in these discharge regions than in the QSH discharge regimes, the SXR emission intensity is almost the same as that in QSH regions. It may suggest high electron temperature in these discharge regions, if the impurity concentration is not increased so much. We have to carry out more detailed characterization of the RFP plasmas in these rather new discharge regions.

Acknowledgments

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