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Evaluation of time evolution of 3-D Structure in Low-Aspect-Ratio RFP RELAX with SXR Imaging Technique
軟X線イメージングを用いた低アスペクト比RFPにおける三次元構造時間発展の計測

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In a low-*A* RFP machine RELAX (R = 0.51 m/a = 0.25 m (A = 2)), a quasi-periodic transition to quasi-single helicity (QSH) state has been observed. We have developed a two-dimensional electron temperature diagnostic system for thermal structure studies. The system consists of a soft X-ray (SXR) camera with two pin-holes for two-kinds of absorber foils, combined with a high-speed camera. We have succeeded in distinguishing Te image in QSH from that in multi-helicity (MH) RFP states. The most recent results using above techniques will be presented, together with discussion on possible reconstruction methods from 3-D imaging.

1. Introduction

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].

In the reversed field pinch (RFP), toroidal pitch of the equilibrium field is relatively short and fluctuation component resulting from internally resonant global instabilities forms three-dimensional (3-D) helical structure. Equilibrium analyses have shown that the innermost mode rational surface can be located away from the axis in a lower aspect ratio ($A = R/a$) RFP configuration, where R (a) is the major (minor) radius of the plasma column. Therefore, growth of a single mode to a higher amplitude can be expected in a low-*A* RFP than in medium- and high-*A* RFPs, which may allow easier access to quasi-single helicity (QSH) state, in which the internally resonant single tearing mode grows significantly larger than other modes.

In a low-*A* RFP machine RELAX [2], (R = 0.51 m/a = 0.25 m (A = 2)), a quasi-periodic transition to QSH state has been observed [3]. During the QSH state, the fluctuation power is concentrated to the dominant single m = 1 mode. We have developed SXR imaging diagnostics using multiple SXR cameras, which are constructed with microchannel plate (MCP) and fluorescent plate, for the identification of structures of dominant MHD instabilities in the QSH state in the RFP [4,5]. Detailed design of the SXR camera has been reported in ref.[6]. Moreover, we have constructed a fast successive SXR imaging system. As a preliminary experiment, we have taken SXR pin-hole pictures with time resolution of 10 micro sec, to identify time evolution of a simple helix structure in RELAX plasmas [7,8,9]. As a next step, we have applied a high-speed (10-microsecond time resolution) dual SXR imaging diagnostic system to take SXR images from tangential and vertical directions simultaneously to observe 3-D dynamic structures of the SXR emissivity. The magnetic field topology for the QSH RFP phase in RELAX plasmas are identified with obtained dual SXR images and results of external magnetic measurements [10]. Recently, we have developed a two-dimensional electron temperature diagnostic system for thermal structure studies [11]. 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 QSH from that in multi-helicity (MH) RFP states.

2. Experimental Set-up and Results

A schematic drawing of the two-color imaging system is illustrated in Fig. 1. We have installed the system to observe the 2D *T*e image from outboard side on the equatorial plane. The pinhole is located at 170 mm away from the plasma edge. Since the decay time of the fluorescence from phosphor plate is 0.5-microsecond, we can follow time evolution of the two SXR images on the phosphor plate by using a high-speed camera (Photoron FASTCAM SA-4) with 50 kfps.

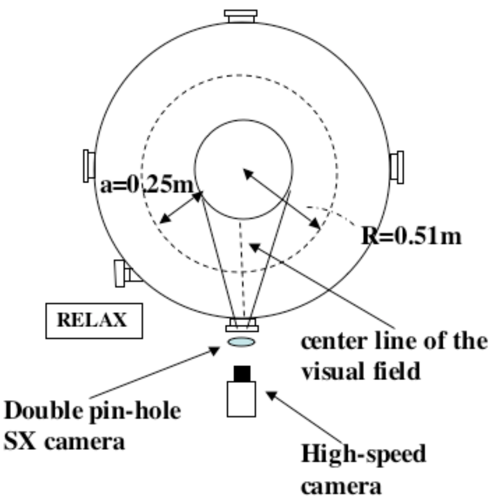

Fig.1 Top view of two-color imaging system.

Figure 2 shows time evolution of plasma current *I*p, spectrum index *N*s and 2-D *T*e profile in shallow reversal discharge obtained from vertical port in RELAX with 50kfps of time resolution. We can recognize that tilted high temperature region is observed quasi-periodically. It is consistent with the result obtained with edge magnetic measurements.

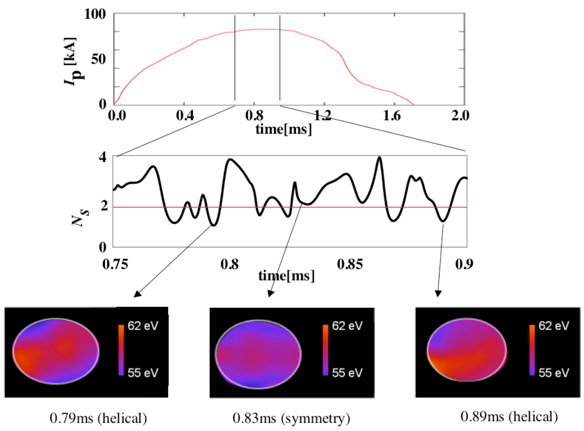

Fig.2 Time evolution of *I*p, *N*s and 2-D *T*e profile in shallow reversal discharge.

The most recent results using two-color imaging technique will also be presented, together with discussion on possible reconstruction methods for 3-D imaging.

Acknowledgments

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