トカマクプラズマ内部磁気シア測定のための反射計開発

7P82 Development of a reflectometry for measuring magnetic shear inside tokamak plasma

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1. Introduction

Reconstruction of internal magnetic field profile is essential to control the equilibrium state and to evaluate the confinement performance of tokamak-type fusion reactor. For accurate reconstruction, we propose an application of magnetic shear profile information. Reflectometry has been widely used to measure the electron density and turbulent fluctuations in fusion plasmas since the 1980s. In this research, we are developing a novel technique to derive a magnetic shear profile from the mode-conversion ratio that can be measured by a reflectometry, which has several advantages for fusion devices such as compact size, easy operation, low cost, spatial resolution, etc.

2. System schematic

Consider linear approximate mode conversion between X and O modes, mode conversion ratio α can be derived as

$$\alpha_{XO,forward} \equiv \int_{edge}^{R=0} -\phi\left(\frac{k_X}{k_O}\right)^{1/2} \exp\left(i\int^{x'}(k_O - k_X)dx''\right)dx' \quad (1)$$

where ϕ is the magnetic shear. By simultaneously incident X&O mode waves with different frequency, mode-conversion ratio can be obtained as a function of frequency and then the spatial distribution of magnetic shear can be solved as an inverse problem.

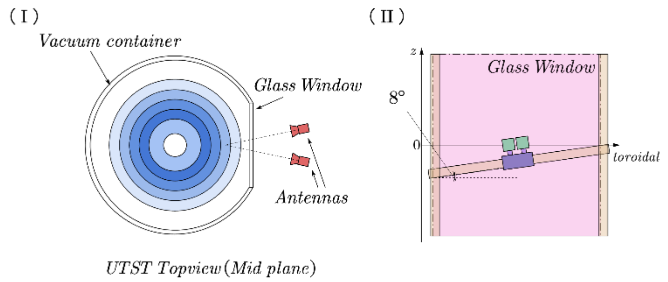

Fig.1 System with a pair of horn antennas placed on mid plane from top (I) and front (II) view.

Fig.1 shows the structure schematic of the system. The angle in Fig.1(I) between two dual polarized antennas was adjusted with regard to the location of cut-off layers. To match the magnetic field direction at plasma edge, the inclination of the horizontal direction of antennas was set to approximately 8 degrees as shown in Fig.1(II).

3. Experimental result

Fig. 2(II) shows the time evolutions of (a) plasma current, (b-e) amplitude of the reflected waves that are divided into four components corresponding to the polarities of injection-reflection waves, e.g. O mode (injection) to X mode (reflection), etc. Sharp increase of reflected waves was observed at t ~ 9.5ms when the ST plasma was formed in front of the antennas. Four cases of different carrier frequencies are shown in each panel. The amplitude of the reflected waves varies according to the frequency due to the change in the location of the cut-off layer. The mode-conversion ratio will be derived from the ratios of the reflected wave amplitudes, but the present experimental results show abnormally large value of O-to-X component (compared to the prediction from calculation shown in Fig.2(I)) possibly due to the unexpected path by the reflection on the vessel wall, etc. Dual directional couplers may be a good choice to improve the signal quality.

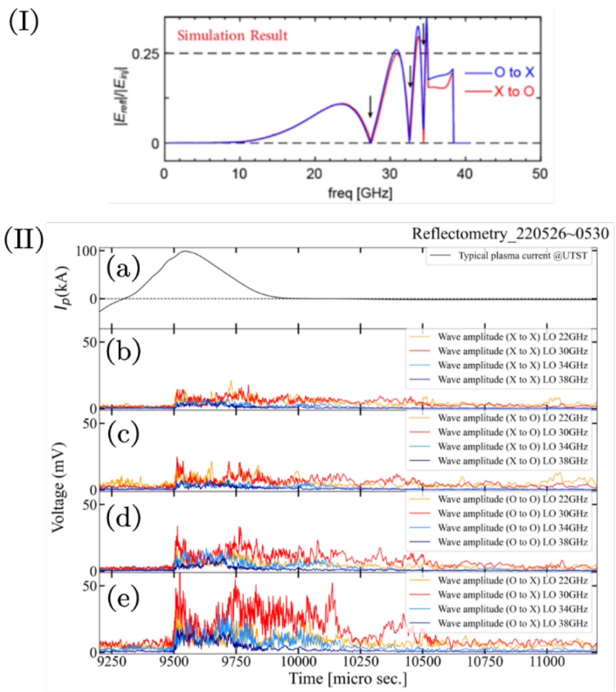

Fig2. Simulation (I) and experimental (II) result of reflected waveform from UTST charge. Measurement (II) starts from 9200us to 11200us with 1G/s sampling speed and a local carrier of 22/30/34/38GHz.