§40. Accuracy Enhancement of Simple System of Millimeter-wave Interferometer for Low Density Plasmas

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Measurement of electron density profile of the edge and divertor plasma is very important issue for study of fusion plasma physics. In 2008, we had developed a prot-type homodyne interferometer system to measure the electron density distribution in the diverter region. The homodyne interferometer system is simpler than standard heterodyne systems and can be developed at a reasonably low cost. One of the important issues of this study is the development of multi channel measurement system, which will be applied for low density regime such as diverter plasma of LHD. Developed a prot-type interferometer system was applied for a low aspect ratio (A) reversed field pinch (RFP) plasma, then obtained a preliminary experimental result. However, an analysis from the obtained experimental result is less-accurate because fringe jump is more likely to occur with much number of fringes. In order to accurize our system, in this study, we have adopted a cross detector which simultaneously detects reference and transmitted waves from two ports. The use of cross detector has lead to improved accuracy in the phase shift measurement. All data are obtained from the low-A RFP device, REversed field pinch of Low Aspect eXperiment (RELAX)[1, 2], which has low electron density $\sim 10^{18-19}$.

The schematic of developed system is shown in Fig.1. Microwave frequency for the probing beam has been carefully selected. Beam frequency must be much higher than the cut off frequency of the plasmas at the center since refraction by a plasma density gradient may become a serious problem at low frequencies. In this study, we choose 60 GHz microwave oscillator[3]. The microwave oscillator is IMPATT diode (HUGES, 47174H-1280), which has maximum power 25.4 dBm, and a cross detector which simultaneously detects reference and transmitted waves from two ports. In order to protect the oscillator from reflected wave, an isolator is inserted on circuit. A directional coupler (HUGES, 45324H-1210) splits the microwave to probe and reference signals. This system is simple and the use of cross detector has lead to improved accuracy in the phase shift measurement.

Here, we show a experimental result. The experiment is carried out the typical discharge of the low-A RFP device RELAX. Figure 2 shows the time evolution of (a) the plasma current I_p and (b) the line averaged electron density n_e measured using developed interferometer in typical RELAX plasmas. The density evolves and reaches a maximum value in the current rising phase.

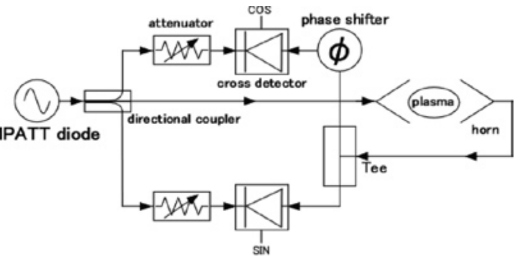

Fig. 1: Schematic of the developed interferometer system.

After that, the density decays to a steady state value in the current flat-top phase. The rapid decay of the density is called density pump out, which results from imbalance of sufficient ionization and insufficient confinement caused by insufficient formation of the RFP configuration. It is typical density behavior in RFPs, and we have observed the similar density behavior in RELAX.

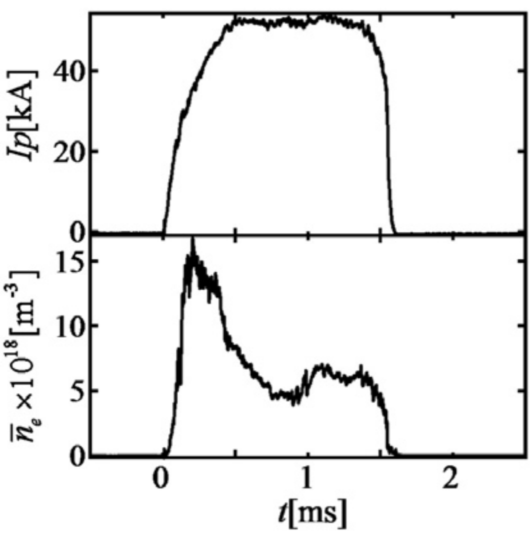

Fig. 2: Time evolution of (a) the plasma current I_p and (b) the line averaged electron density n_e measured using developed interferometer in typical RELAX plasmas.

The newly developed 60 GHz homodyne interferometer, characterized by simplicity and low cost, has been shown to be applicable to RELAX particularly in the low density regime.

1) S. Masamune *et al.*, Trans. of Fusion Sci. Technol. **51** (No. 2T) (2007) 197.

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

3) I. H. Hutchinson, *Principle of Plasma Diagnostics* (2002).