

§17. Development of a Millimeter Wave Interferometer for Study of Helical RFP Plasma Performance

Sanpei, A., Kazuaki, D., Himura, H., Masamune, S., Oki, K., Fukahori, D. (Kyoto Inst. Tech.), Ejiri, A. (Univ. Tokyo), Akiyama, T., Suzuki, C., Kawahata, K.

Measurement of electron density profile of the edge and divertor plasma is very important issue for study of fusion plasma physics. A 60GHz interferometer with up-converter mixer has been developed for measurement in low density regions where $n_e \leq 1 \times 10^{19} \text{ m}^{-3}$. 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 divertor plasma of LHD. Developed an interferometer system was applied for a low aspect ratio (A) reversed field pinch (RFP) plasma, REversed field pinch of Low Aspect eXperiment (RELAX)^{1, 2)}, then obtained a preliminary experimental result³⁾.

Now our interest is focused on spontaneous helical deformation of RFP plasma. In shallow-reversal regions, soft-X ray (SXR) imaging diagnostics and magnetic diagnostics have revealed the attainment of helically deformed RFP configuration. Some preliminary analysis have shown the possibility of attaining helical non-planar axis RFP configuration with helically deformed hot or dense core region, similar to the Single Helical Axis (SHAx) state observed in RFX-mod. It has thus become important to measure electron density in high-density region ($n_e \sim 2 - 3 \times 10^{19} \text{ m}^{-3}$), for the detailed study on self-organization to helical RFP state and its confinement performance. Development of a 140GHz millimeter wave interferometer has been started as a NIFS collaboration program because of the general interest of higher-order self-organization to helical state from toroidal plasma physics.

For FY 2011, operation of a gun oscillator and frequency modulation using a saw-teeth signal generator has been tested. In this year, we have developed frequency sweep heterodyne interferometer. The schematic of developed system is shown in Fig.1. We have obtained an adequate intensity of the transmitted wave with 20 μW on position of detecting horn antenna. However, interference signal becomes unstable due to large amplitude modulation during sweeping of the oscillator.

Then, we have switched from heterodyne system to homodyne interferometer system which has fixed frequency, and measured electron density of RELAX. Figure 2 shows a sample of time evolutions of plasma current I_p and interference signal $A\cos\phi$, obtained from a low ohmic current discharge. We have succeeded to obtain a valid wave form of $A\cos\phi$ for the time evolution of the I_p . In higher ohmic current operation, however, it

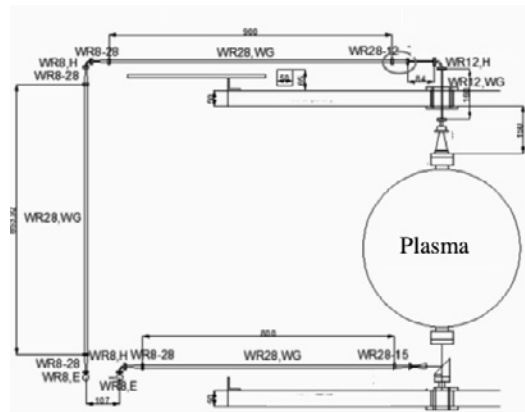


Fig. 1: Schematic of the developed frequency sweep heterodyne system with 140 GHz gun oscillator applied to RELAX.

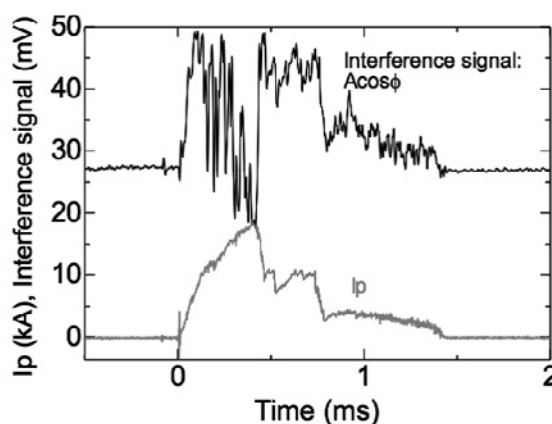


Fig. 2: Time evolution of plasma current I_p and interference signal $A\cos\phi$. Because f exceeds 90 degrees, inverted feature of time evolution has been observed in $t = 0.1 \sim 0.47 \text{ ms}$.

is observed that S/N ratio falls below unity. Therefore, protections against noise have been under development.

- 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) M. Sugihara *et al.*, Plasma Fusion Res., **5**, S2061 (2010).