§18. Accuracy Enhancement of a Millimeter Wave Interferometer for Study of Helical RFP Plasma Performance

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A spontaneous transition to the quasi-single helisity configuration is observed in the low aspect ratio reversed field pinch device RELAX[1, 2)]. Studies of its formation mechanism and confinement properties will provide important knowledge which is common among magnetically confined torus plasmas including helical system. Since the behavior of the electron density is necessary especially in the high density range (2-3 $\times$ 10^{19} m^{-3}), a millimeter-wave interferometer which uses a Gunn oscillator with a frequency of 140 GHz is developing.

We had already developed and installed a 60 GHz interferometer with a cross-detector via this research collaboration[3)]. The main target of the interferometer is low density plasmas, less than 10^{19} m^{-3}. For measurement of higher density plasmas, higher frequency is preferable to suppress the beam deviation in a plasma. Hence we start to develop the 140 GHz interferometer. Figure 1 shows a schematic view of the 140 GHz millimeter-wave interferometer on RELAX. As a first step, we installed a 140 GHz heterodyne interferometer with a frequency-swept Gunn oscillator. One of advantages of the method is that only one Gunn oscillator is necessary and the interferometer system becomes simple. However, the amplitude of the intermediate frequency (IF) signal was strongly modulated when the frequency was swept. Hence the phase evaluation with a phase counter was so perturbed. Then, we added another Gunn oscillator with a frequency difference of 1 GHz as shown in fig. 2. In addition to that, we optimized some amplifier components to avoid fringe jump in low density discharge. As a result of optimization of each components, we have succeed to reduce noise level with of 10 dB, and to gain signal intensity with of 14 dB. The improvement of signals-noise ratio permits the stable measurement of a time evolution of line averaged electron density n_e. The improved interferometer system have been adopted to RELAX. Figure 3 shows a sample of Lissajous figure and time evolution of and n_e measured using the developed interferometer in RELAX plasma. It is confirmed that the obtained signal corresponds with using the 104 GHz heterodyne.

1) S. Masamune *et al.*, 24th IAEA Fusion Energy Conf., (2012) EX/P4-24.

2) S. Masamune *et al.*, 25th IAEA Fusion Energy Conf., (2014) EX/P3-52.

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

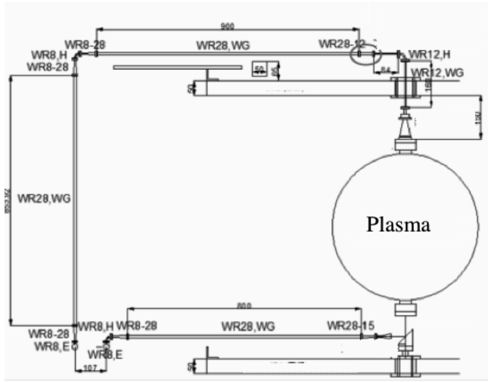

Fig. 1: A schematic view of a waveguide system of a 140 GHz heterodyne interferometer on RELAX.

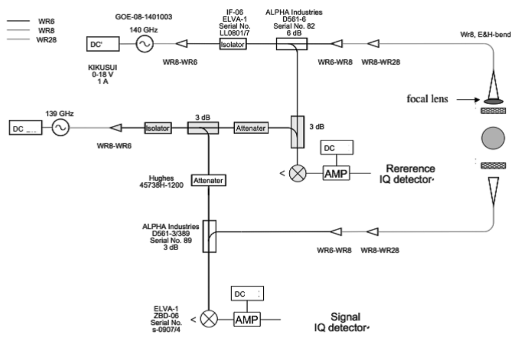

Fig. 2: A schematic view of a 140 GHz heterodyne interferometer with Gunn oscillators with a frequency of 140 and 139 GHz.

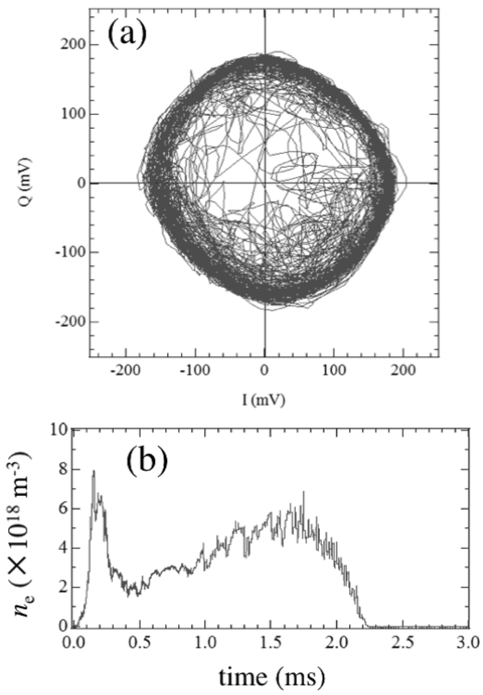

Fig. 3: Lissajous figure and time evolution of electron density obtained from RELAX discharge.