§10. Estimate of Confinement Properties in a Low-Aspect-Ratio RFP Using Interferometer

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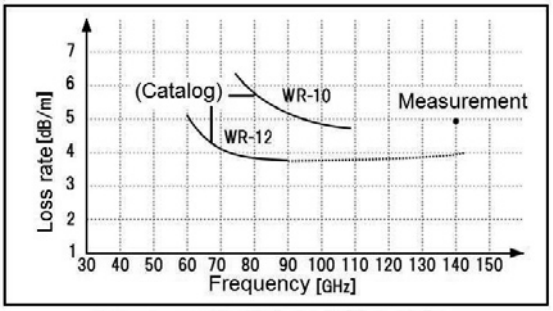
The objectives of this research include estimating confinement properties of a low-aspect-ratio RFP plasma in RELAX from density measurement using an interferometer. In RELAX, it has been shown that the operational regions in (Θ, F) space are extended in low-A RFP configurations. There have been observed two characteristic regions which have importance in confinement improvement in the RFP. 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. On the other hand, in extremely deep reversal discharges where F can be lowered down to -2.5, the discharges are sustained with lower magnetic fluctuation level without discrete dynamo events. and lower magnetic fluctuation level than in the normal reversal discharges. In both of these discharges, SXR emission intensity is enhanced, which implies the improved plasma performance.

It has thus become important to measure electron density in high-density region (n_e=2 - 3 x 10^{19} 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.

RELAX is a low-A RFP machine operated at Kyoto Institute of Technology. The discharge and plasma parameters attained to date are: toroidal plasma current Ip up to 100 kA, toroidal loop voltage V_{loop} down to 30V, electron density n_e from 0.2 to 2.0 x $10^{19}m^{-3}$ (with interferometer), and electron temperature around 50eV. A 60GHz interferometer with up-converter mixer has been developed for measurement in low density regions where n_e<1x$10^{19}m^{-3}$. In the present research, our interest is focused on 140GHz interferometer for the study of higher density regions. For FY 2010, operation of a gun oscillator and frequency modulation using a saw-teeth signal generator has been tested. Measurements of attenuation characteristics of an over-sized waveguide (WR-12) have been performed, and power attenuation in the designed interferometer system has been estimated. Measurements of radiation pattern from horn antennas have also been made. As shown in Fig.1, attenuation coefficient of WR-12 for 140GHz millimeter wave was found to be 4.9dB/m, from which we have estimated that the power attenuation is 15dB in the designed interferometer. In Fig.2, three-types of horn antennas are shown, where the length L and the area S are chosen as parameters characterizing the radiation pattern. Table I summarizes the radiation pattern (HWHM).emitted from the tree types of horn antennas.



Frequency dependence of Loss rate

Fig.1. Frequency dependence of loss rate for WR-10 and WR-12 (over-sized for 140GHz).

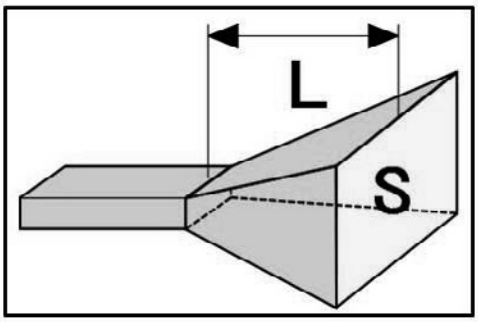


Fig.2. Dimension of horn antenna. The length L and the area S are the parameters.

Table I Radiation patterns from three tyoes of horns.

HORN	S[mm^2]	L[m^2]	HWHM [mm]
horn1	314	47	43.4
horn2	1590	80	non-measurable
horn3	7396	135	42.2

1) Ikezoe, R. et al., Plasma Phys. Control Fusion **53**(2011) 025003.
2) Sugihara, M. et al., Plasma Fusion Res. **5** (2010) S2061.