§18. ICRF Antenna Coupling to Low Density Plasma

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Initial ICRF experiment using loop antenna has started from the 2nd cycle of LHD experiment. We study the antenna-plasma coupling for evaluating performance of the antenna. The antennas are inserted from the top and bottom ports of LHD and designed to launch the fast magnetosonic wave in ion cyclotron range of frequency. The shape of radiating section is twisted to fit the last closed flux surface (LCFS) in order to bring antenna close to plasma. Position of the antenna is changed by 16 cm in radial direction. We can move the antenna away from the plasma when the ICRF heating experiment is not performed. High loading resistance is desirable for injecting the high RF power.

Plasma loading resistance is estimated from forward and reflected power by the directional coupler which is located at the output of transmitter and voltage at the transmission line by the voltage probes. Figure 1 shows the plasma loading resistance as a function of antenna position. In this experiment, the frequency of RF wave is 25.6 MHz, magnetic field at R_{ax} = 3.75 m is 1.5 Tesla, line averaged electron density is 0.8×10^{19} m^{-3}, and gas puff ratio of H/(H+He) is 0.3. The loading resistance is large when the antenna approaches to the LCFS and it gradually decreases when antenna moves away from the LCFS. The difference of the loading resistance in the case between nearest and farthest antenna position is about factor two. Vacuum loading resistance is about half of that of the nearest antenna position case. Thus, it is thought that about 60-70 % of launched power couples with plasma. The reason why magnitude of the loading resistance is small is thought that the plasma density is low. The loading resistance of the U antenna is different from that of the L antenna. The reason of the difference is not clear. The grounding structure of the antenna may affect on the loading resistance.

Loading resistance is calculated analytically by Dr. Okada. The antenna geometry is three-dimensional as shown in Fig.2 and the angle between the antenna and magnetic field is taken into account. The current strap of antenna is a flat plate and Faraday shield is considered. Return conductor of the current strap and vacuum vessel wall are the same plate. The plasma parameters have the dependence on the x-direction only. Figure 3 is the calculation result of the plasma loading resistance as a function of the gap between the antenna and plasma. It has the same qualitative feature as the experimental result (Fig.1). This suggests that the antenna launches fast waves.

Further analysis is required for the magnitude of the resistance. It depends on the plasma parameters near the antenna.

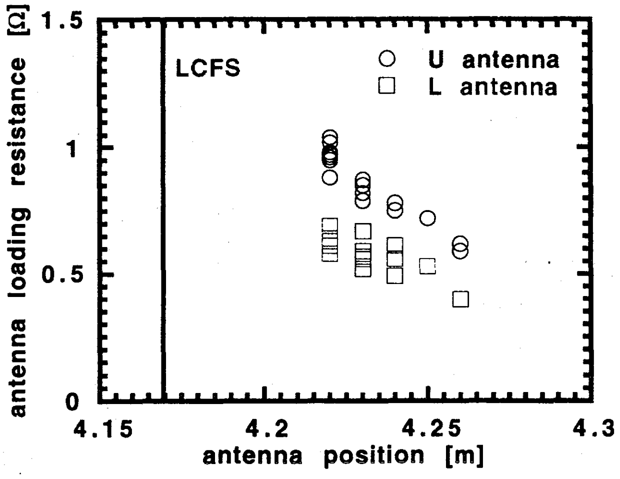

Fig.1 Measured loading resistance as a function of antenna position.

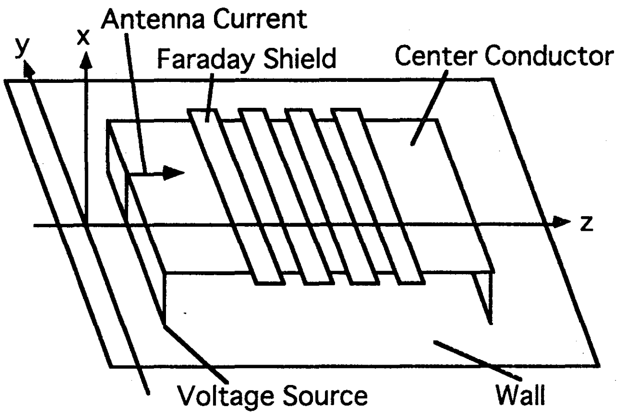

Fig.2 Antenna model used for loading calculation.

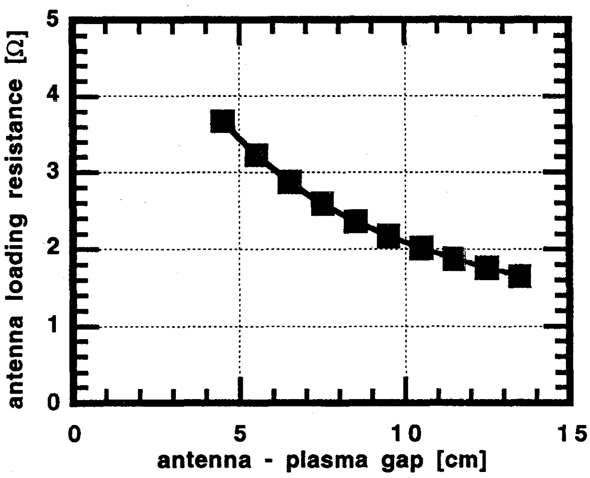

Fig.3 Calculated loading resistance as a function of antenna-plasma gap.