§5. Antenna Loading Resistance of ICRF Loop Antenna in LHD

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To inject the high power into the plasma in the ion cyclotron range of frequencies (ICRF) heating, high antenna loading resistance is required for reducing the voltage of the transmission line to prevent the arcing. It is important to build the high loading resistance antenna and operate the antennas in the experimental condition that the high loading resistance is achieved. The loading resistance of LHD ICRF antenna was investigated in the various plasma heating experiments. These results will contribute to the operation scenario for the high power injection.

A tremendous amount of data was collected for the six antennas. However, analysis of data was concentrate to the one antenna, 3.5U, in order to find out the characteristics clearly. Figure 1 shows the frequency dependence of the loading resistance. Various conditions such as density range and with and without NBI heating are included. The gap between the front of the Faraday shield of the antenna and the LCFS of the plasma is 8 to 11 cm. If you look at the lower boundary of the data, the peek can be found out around 50 MHz. Similar characteristics are found by the calculation assuming the simple antenna model and the simulation using the electromagnetic analysis code, HFSS. Expanding of data to the higher loading resistance region shows the possibility of the improvement. In 28.4 MHz, it was very difficult to inject the high power during the plasma experiments. High voltage was required at the transmission line and the voltage reached the threshold of the interlock level frequently when the injection power was increased.

It is required to operate the antenna far from the plasma for the steady state operation in order to reduce the heat load from the plasma. Dependence of the gap between the antenna and the plasma is shown in Fig. 2. The wave frequency is 38.47 MHz and the line-averaged electron density is from 0.5 to 1.5 x 10^{19} m^{-3}. NBI heating is not applied in these data. The loading resistance decreases with the antenna gap distance as expected. For the steady state operation, the antenna gap was set to 12 cm. The loading resistance of 4 Ω is possible in this case. If the voltage of the coaxial line of 35 kV is allowed, the injection power of 1 MW is possible.

Figure 3 shows the dependence on the line-averaged electron density with and without NBI heating. The lower boundary of data shows the density dependence of the loading resistance. The loading resistance increases with the plasma density. With NBI heating, lower boundary moves upward and higher loading resistance is obtained easily. This suggests the modification of the plasma boundary condition by the NBI heating. The density in the front of the antenna may be increased. This enhancement of the loading resistance is also found with the ECH case. It is preferable for the high power heating to inject the ICRF power with the other additional heating.

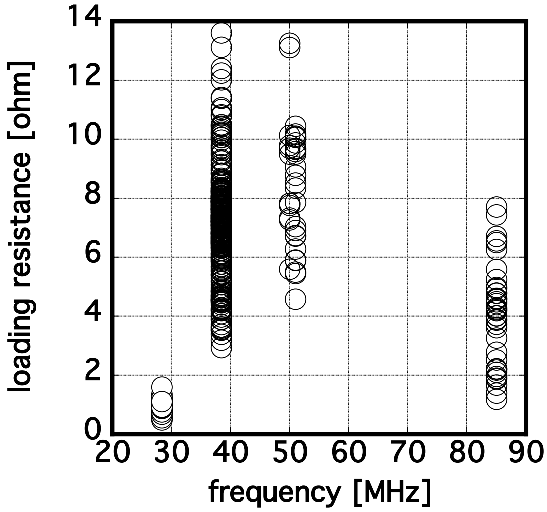

Fig. 1. Dependence of loading resistance on wave frequency.

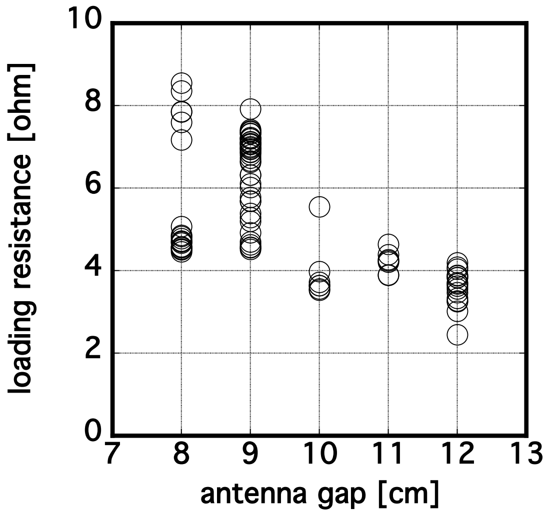

Fig. 2. Loading resistance as function of the gap between the antenna surface and the LCFS.

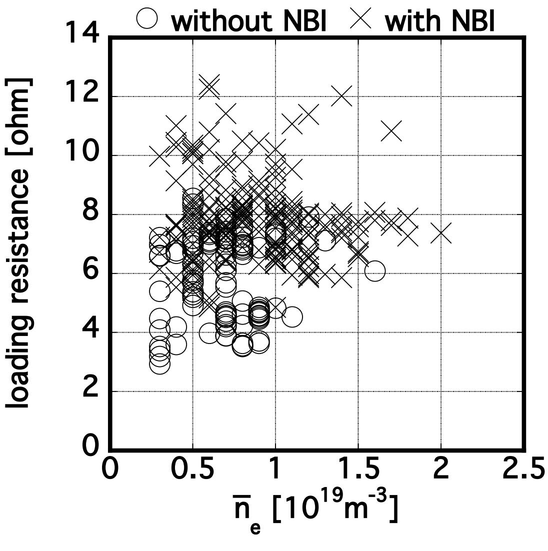

Fig. 3. Loading resistance as function of line-averaged electron density.