The analysis of ICRF antenna with controllable toroidal wavenumber in LHD

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Sheath loading in front of ion cyclotron range of frequencies (ICRF) antenna is related to impurity production and penetration, and the reduction is achieved using a double-strap antenna with the phase difference (0-pi) in tokamaks. On the helical plasma, ion cyclotron heating (ICH) experiment using single-strap antennas has been carried out in Large Helical Device (LHD), and in short pulse operation (less than 300 s) significant impurity penetration is not observed. In steady-state operation using ICH, plasma discharge is terminated by sudden impurity penetration (mainly iron) after local hot spots with large intensity are observed at several local places. High-energy particles accelerated in front of ICRF antenna impact to several local points, and hot spots are consistent with the impact point for orbit-tracking calculation [1].

In order to reduce sheath loading in front of ICRF antenna, ICRF experiments using double strap excitation are planned in LHD, and the ICRF antenna design for controllable toroidal wavenumber (see Fig. 1) has been forward using high frequency structure simulator (HFSS) [2]. In order to reduce calculation time and save working memory, a simplified squared-shape antenna model is calculated, and a fresh-water and the modified fresh-water with the relative permittivity of 1000 as imaginary plasmas are used, because HFSS could not calculate the actual plasma model. Though antenna loadings are not large in these materials, these conditions are similar to ICH experiment with low heating efficiency. Comparing large antenna loading with small antenna loading, the sheath loading is strong in the small antenna loading due to produce large RF voltage around ICRF antenna, and these materials are suitable to study sheath loading effects.

For simplified antenna model calculations with the phase difference of 0-pi, the reduction of excited RF-field between ICRF antennas are clearly observed, and the surface losses on the carbon protector to avoid plasma contacts are weaker rather than the model with that of 0-0. The wave excitation with that of 0-pi could make the sheath loading reduction, and the wave number to toroidal direction is larger than that of single strap antenna excitation. The excited large wavenumber could be damped to electron in large electron beta region through electron Landau damping and transit-time magnetic pumping, and this heating method is one of the candidate for high density plasma heating like super dense core and high beta plasma ($\beta_e \sim 5$ %) heating in LHD.

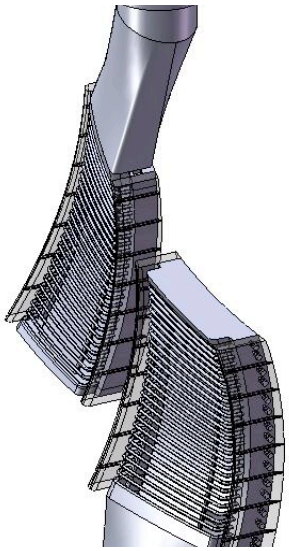

Fig. 1 New designed double strap ICRF antenna in LHD

[1] H. Kasahara, et al., Fusion Eng. and Des. **83** (2008) 253-255.

[2] Ansoft Corp., 2007 HFSS TM V11.0, Pittsburgh, PA, USA