§81. Fast Wave Frequency Broadening for the Poloidal Array Antenna and the Toroidal Array Antenna

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Two types of ICRF antennas are installed in the LHD, and these two antennas have two single loop coils in each other. Geometrical instllation of these antenna are different, and then excited wave-field patterns of radio-frequency(RF) are different. One is the poloidal array antenna (PA), which is vertically installed along to magnetic field line, and the other is the toroidal array antenna, which is installed along to magnetic field line. The antenna shape for toroidal array antenna is similar to hand-shake form, and the antenna is named as "the HAS antenna" (HAS). Mainly excited wavenumber for the PA is approximately zero with broadeing wavenumber to 5 m^{-1}, and the other of the HAS with dipole phase has the peak wavenumber of 6-8 m^{-1}. Initial Hydrogen minority heating experiments in Helium majority plasma for the HAS is carried to evaluate heating efficiency by using amplitude modulation method [1], and heating efficiency is over 90 % with dipole phasing [2]. The heating efficiency by the PA is approximately 70 %, and it is similar to the heating efficiency by the HAS with monopole phase.

In order to distinguish heating efficiency on two antennas, propagated frequency spectrum are measured by magneto-sonic probes with wide-band frequency range [3]. Figure 1 shows a schematic view for ICRF antennas at 3.5 port and 7.5 port and measument probes at 5.5 port and 6.5 port in the LHD, and there are two magneto-sonic probles in the each ports. Although there are four magneto-sonic probes in the LHD, we can not use two probes at the same time because of the limitation for fast data aquisiton system. Figure 2 shows a discharge waveform in various plasma parameters, and plasma is sustained by only ICRF heating except at plasma start-up phase. Favorabel heating efficiency by the HAS is achieved on the Hydrogen minority ratio of 10 %, and in this experimental codition the heating efficiency is poor for the HAS. For observed intensity of pump-wave, these propagtion distance to probes are different between the excitation antenna and the measurement probe close to the antenna. In order to study wave absorption on plasma propagation, a wave-power dercrement ratio is compared. The wave-power decrement ratio of the HAS is approximately 10^{-2} on the steady-state condition after 3 sec, and that is approximately 10^{-1} for the PA. The decrement ratio for the HAS is 10 times smaller than that for the PA, and it indicates that fast wave by the HAS is easily damped through the propagation than that by the PA. Figure 3 shows the frequency broadening between tha HAS and the PA, and the nearest probe is differenet between the HAS and the PA. On the HAS case, the HAS antenna is installed at 3.5 port, and the nearest probe is probe B at 5.5 port. On the other hand, the nearest probe for the PA is probe D at 6.5 port. In this minority heating experiments, pump-wave frequency is 38.5MHz, and peak frequencies of 38.5MHz are observed for all probes. For the frequency spectrum of the HAS, the spectrum pattern is not clearly different between the probe B and the probe D, and the peak intensity of the pump-wave is decreased as propagation distance is increased. For the frequncy spectrum of the PA, frequncy broadening is observed for both probes, and strongly freqnecy broadening is carried out around the PA. In previous theoritcal works, frequency boradeing for fast wave is carried out around plasma edge around two ion-ion hybrid resonance [4], and the fast wave by the PA is easly propagating around plasmsa edge around the PA antenna than the HAS.

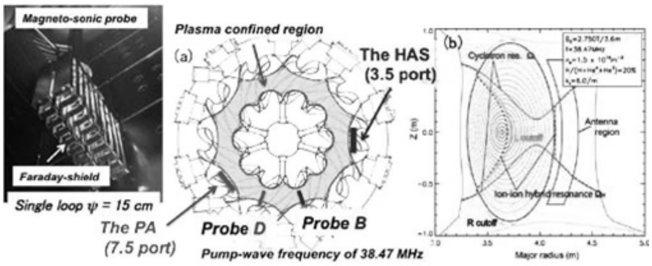

Fig. 1. The picutre of magneto-sonic probe and a schematic view for ICRF antennas and magneto-sonic probes in the LHD. Hydrogen cycyltron resonances in front of ICRF antennas in Fig. 1(b).

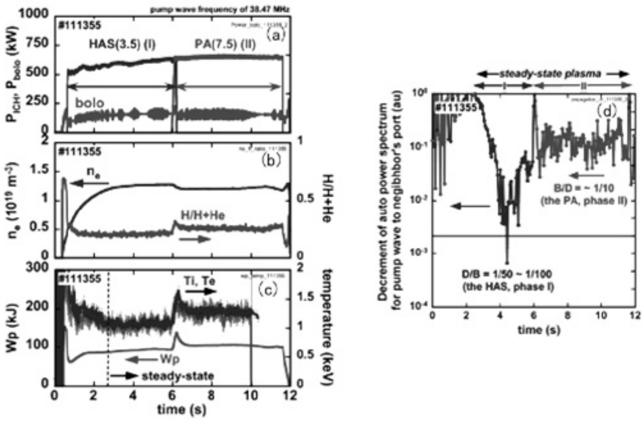

Fig. 2. Discharge waveforms in vairous plasma parameters. Figure 2(d) show A wave-power decrement ratio for fast wave propagation through one port.

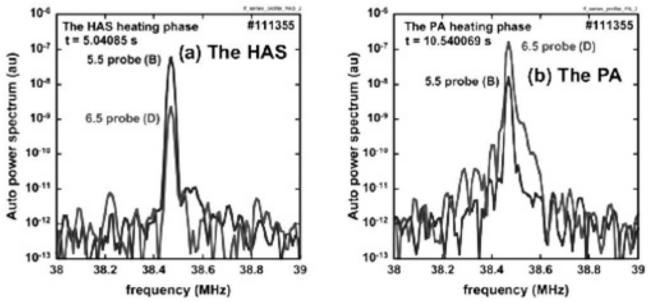

Fig. 3. Frequency broadening by using the HAS and the PA , these plasma are sustained by only each ICRF antennas.

[1] Y. Tori, et al., *Plasma Phys Ctrl. Fusion* **43**, 1191 (2001).
[2] T. Seki, et al., J. Plasma Fusion Res. Submitted (2011).
[3] K. Saito, et al., *Plasama Sci. and Technol.* submitted (2011). [4] M. Ono, *Phys. Fluids* **20**, 990 (1982).