§8. RF Plasma Production on CHS by Type III Antenna

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Radio frequency waves in the ICRF range have the notable feature of producing plasmas in a wide span of magnetic field strengths, which is important in the study of stellarator β limits. The plasma density as high as $\langle n_e \rangle = 5 \times 10^{12} cm^{-3}$ was produced by the Nagoya Type III antenna [1-2] and this density is suitable as a target for NBI heating. The detailed structure of the plasma production behavior versus magnetic field strength has been studied in CHS. When $\omega/\omega_{ci} < 1$ and $\omega/\omega_{ci} > 1$, slow waves (shear Alfven waves) and the Ion Bernstein waves (IBW) are effectively excited by the Nagoya Type III antenna, respectively. If the Alfven resonance,

$$N_{//}^2 = (ck_{//}/\omega)^2 = S \simeq 1 + \omega_{pe}^2/\omega_{ce}^2 - \omega_{pi}^2/(\omega^2 - \omega_{ci}^2), \quad (1)$$

is satisfied for the slow waves, plasma is expected to be produced through the electron heating of mode converted waves at the resonance. In Fig. 1, the resonance (1) is shown in density and toroidal magnetic field space, where the toroidal wave number, $k_{//}$, is determined by the toroidal eigen modes. If IBW is excited at the plasma edge where $\omega \leq (n+1)\omega_{ci}$, and propagates toward the center of the plasma ($\omega \geq n\omega_{ci}$), plasma is produced through electron Landau damping of the wave. The relations between density and toroidal magnetic field on axis, B, are shown in Fig.2. The plasma is produced above B~0.5T and the dependence of density on B behaves like the Alfven resonance curve for the toroidal eigen mode N~4, where N is a toroidal eigen mode number. The density drop at B~0.9T in Fig.2 is not obvious in the previous experiment with a higher rf power of ~500kW. The IBW is excited near the antenna where $\omega \leq 2\omega_{ci}$ and absorbed by electrons through Landau damping around $\omega \sim \omega_{ci}$ in the plasma, which exists in the region 0.4T<B<1T. This IBW heating is confirmed by the ray trace calculations. The plasma with the mixture of H(90%) and D(10%) is examined for the IBW heating. There is $3\omega_{ci}$ harmonics heating in the plasma when 0.4T<B<1T. The dependencies of the density on B for H and H+D plasmas are slightly different but further study is needed to explain the results.

Reference

1) Shoji, T., Nishimura, K, et al., Nagoya Univ. Ann.Report 6(1989)1
2) Nishimura, K., Shoji, T., et al., Fusion Tech. 17(1990)86

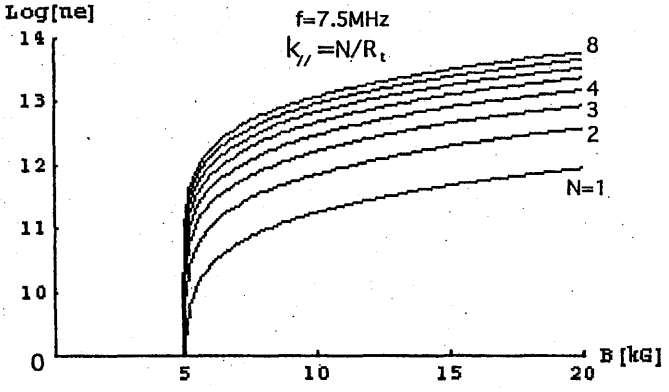

Fig. 1. Relation between density and toroidal magnetic field strength for Alfven resonance ($N_{//}^2 = S$) with different toroidal eigen modes.

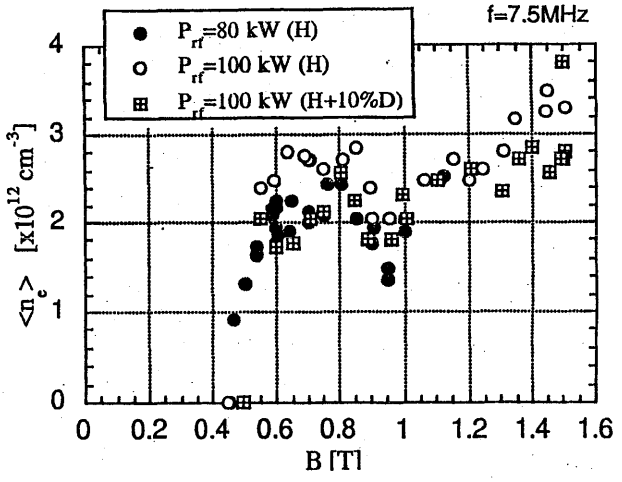

Fig. 2. Averaged plasma density as a function of B for H and H+D(10%) plasmas.