§16. ICRF Mode Conversion Heating Experiments

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At ICRF heating experiments, the applied frequency was selected at f=25.6MHz, because the magnetic field strength was 1.5T in the 2nd cycle. In this situation, the ion cyclotron resonance and the mode conversion layer were located on the inner high field side: at half radius and at 0.65-0.75 of normalized radius, respectively. RF power is transmitted to each RF antenna by a high power RF generator via a liquid impedance matching system.

An ICRF heating was applied to the ECH-produced plasma at the power level of about 300kW for 0.2 seconds as shown in Fig.1[1]. The target plasma consisted of a majority of He ions and a minority of H ions. A pulse length of hydrogen gas has been able to change the ratio of H ions as shown in the bottom column of Fig.1. ICRF heating is started 0.15 seconds after ECH is started. The increase (in solid line) in the stored plasma energy was observed to be the same as with ECH only (dashed line) as shown in the top column. The maximal stored plasma energy was observed at the end of ECH power, which is at 0.42 seconds. ICRF heating shows the same performance as ECH. The ECH target plasma has an average electron line density, n_e=8.5x10^{18}m^{-3} with a central electron temperature, T_{e0}=400eV. The increase in the stored plasma energy is proportional to the applied ICRF power up to 300kW. The stored plasma energy with ECH only is 13kJ. The maximal increase is found to be 13kJ at P_{ICRF}=300kW, which has been obtained at a little longer overlay of ECH and ICRF heating than that in Fig.1.

A series of experiments about the results of changing the ratio of number of injected atomic hydrogen (H) to that of atomic helium (He) was carried out as shown in Fig.2. The number of H was changed by changing a pulse length of a hydrogen gas puffing at the constant flow rate of 0.82 Pam^3/sec as shown in the bottom column of Fig.1. The numbers of He were constant at 0.194 Pam^3 as shown in the middle column of Fig.1. The abscissa of Fig.2 is the minority ratio of H to He, H/(He+H). The increase in the plasma stored energy dW_p with the application of ICRF heating is plotted with solid circles in Fig.2. The maximal dW_p is observed at H/(He+H)=30%.

The increase in the stored energy of electrons, dW_e can be calculated by integrating a product of the electron density and the electron temperature measured by a 13 channel-HCN laser and 130-spatial-point Thomson scattering. Open circles indicate the increase in dW_e, which is also plotted in Fig.2. A subtraction of dW_e from dW_p shows an increase in the stored ion energy, dW_i, which is also plotted with open squares in Fig.2. The stored electron energy is small at the lower minority ratio of H/(He+H) and increases with the proportion of the minority hydrogen ratio. The maximal electron stored energy is observed at H/(He+H) =25%.

Reference
[1] R.Kumazawa et al., in the proceeding of 13th Topical Conference on Applications of Radio Frequency Power to Plasmas (1999).

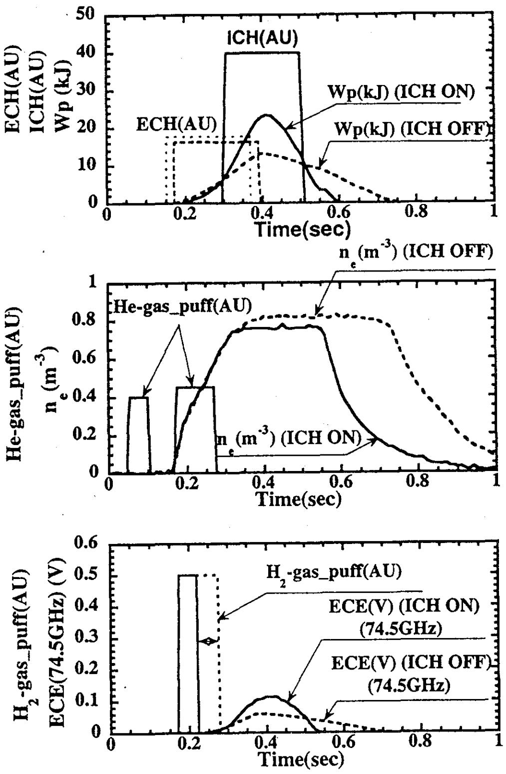

Fig.1 Time evolution of plasma parameters; at top column, ICRF heating power, ECH power, and plasma stored energy, at middle column, average electron density and He gas puffing and at bottom column, ECE signal and H_2 gas puffing with and without ICRF heating.

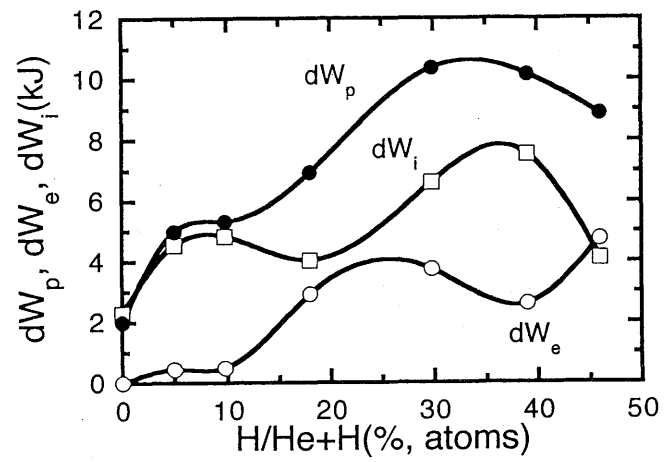

Fig.2 Dependence of increase in stored energies of dW_p, dW_e and dW_i on the gas puffing rate of H/H+He.