§5. Direct Electron Heating in Ion Cyclotron Range of Frequency

Kumazawa, R., Jaeger, E.F., Rasmussen, D.A., Hoffman, D.J., Lyon, J. (Oak Ridge National Laboratory)
Nishimura, K., Minami, T., Masuda, S. (Grad. Univ. for Advanced Studies)
Mutoh, T., Shimpo, F., Seki, T., Watari, T., CHS Group

ICRF heating succeeded to sustain and heat a plasma in the mode conversion regime, where minority(hydrogen) ratio is about 30%. Scientists of Oak Ridge National Laboratory joined ICRF heating experiments in US-Japan collaboration program. They proposed a direct electron heating via. transit-time magnetic pumping(TTMP). In ion cyclotron range of frequency, a single absorbed power fraction by electrons was calculated using a slab plasma with various electron beta values in several applied frequencies. Figure 1 shows calculated single pass electron damping for parallel wave numbers in three various applied frequencies. Here we selected plasma parameters as follow; a central electron density and electron temperature are $4 \times 10^{13} cm^{-3}$ and 150eV in the magnetic field strength, B_0=0.7T, respectively. The ion temperature was assumed same as electron. The electron beta is 0.5% at the axis. The maximum single pass damping is 10% at $k_{//}=20m^{-1}$ for 26MHz. Generally the single pass electron damping increases with the electron beta. The wave phase velocity is nearly same as the electron thermal velocity in this $k_{//}$. When increasing applied frequency to 40MHz or 60 MHz, $k_{//}$ for the maximum single pass damping becomes larger as shown in Fig.1 and the single pass damping slightly increases.

We modified U-port antenna(single strap) to double strap antenna. The width of the antenna strap is 5cm and the separation between central positions of two straps is 11.5cm. The radiated RF power spectrum has its maximum at $k_{//}$, $18m^{-1}$. The target plasma was produced by neutral beam injection(NBI with hydrogen, co-injection and 0.8MW of port-through power at 39keV). The average electron density and the electron temperature on axis were $2 \times 10^{13} cm^{-3}$ and 270eV at B_0=1T, respectively, where the electron beta was 0.44% at the axis. In this target plasma, 130kW of RF power was transferred to the new U antenna(double strap antenna), however, only 60kW of RF power was radiated from U-port antenna as shown in Fig.2. The plasma loading resistance was about half that in old U-port antenna due to decrease in RF radiated power in smaller $k_{//}$. Then we could not observe an increase in the stored plasma energy as shown in Fig.2 neither in the electron temperature by Thomson scattering within +-10% accuracy. The absorbed power by electrons from high energy ions of NBI was estimated 450kW with assuming 70% of NBI port through power to be absorbed. On the other hand, we observed the toroidal eigen mode in the radiated RF power during increasing electron density as shown in Fig.2, which suggests poor RF power absorption by plasma. The increase in the electron temperature should have been observed if all the RF power were absorbed by electrons. These experimental results indicated that multi-path absorption of fast wave did not occur on CHS and that successful electron heating via. TTMP requires higher electron beta such as a few %.

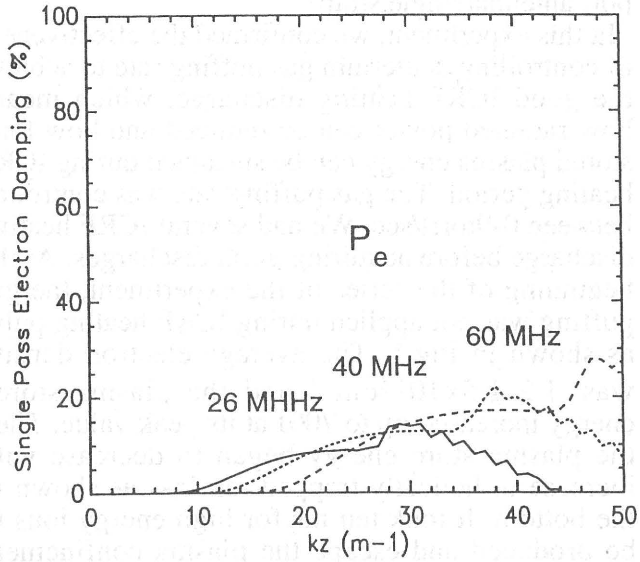

Fig.1 Single pass electron damping for various parallel wave number at electron beta, 0.5% on CHS.

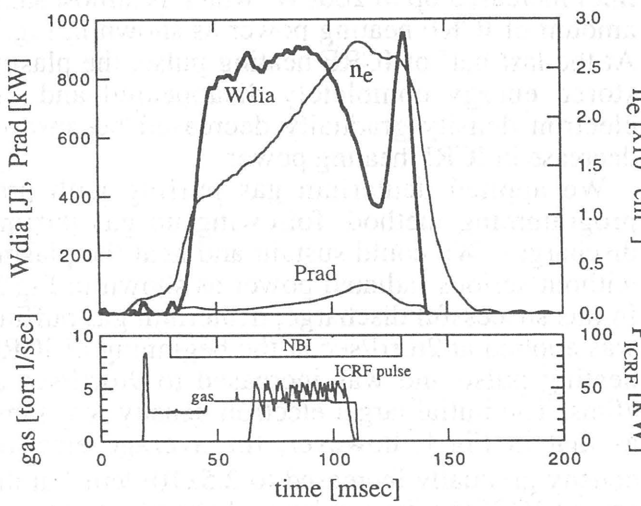

Fig.2 Time evolution of stored energy and electron density and radiated power with injected RF power, 60kW in direct electron heating.