§26. Electron Heating and Plasma Production by Whistler Wave and Microwave Discharges in Low Toroidal Field

Shoji, T. (Dept. Energy Eng. and Sci. Nagoya Univ.),
Suzuki, C., Takeuchi, M., Ikeda, R., Toi, K.

Introduction

Whistler wave discharges in MHz range of frequency studied in CHS have the notable feature of producing plasmas in a low magnetic field strengths of kG range, which is important in the high beta and some Alfven wave related studies of helical systems. We compare the density and electron temperature profiles of the plasma production by the Whistler wave discharge and 2.45GHz microwave discharges[1-3].

Electron temperature and density profiles

Rf (9MHz, 10ms) and microwave (2.45GHz, 200ms) powers of 500kW and 30kW are used, respectively. The Whistler wave of parallel refractive index $N_{//}$~38 which is excited by Type III antenna in CHS can propagate deep in the plasma when $B_t < 400G$ and n_e~$10^{18\sim19}$ m^{-3}. Electron density n_e and temperature T_e are measured by the scanning Langmuir probe. Examples of n_e and T_e behaviors in time and radial profiles of helium plasmas are shown in Fig. 1, where pressure, toroidal field, rf and microwave powers of $3.3x10^{-5}$torr, B_t=175G, 117kW and 30kW, respectively. Figure 1(a) shows that the time evolutions of n_e and T_e at radius ρ=0.2 which is normalized by the radius of outmost closed flux surface. While the rf power creates the low n_e plasma at start-up phase, the density increases up to $10^{18}m^{-3}$ with the additional microwave power. This density exceeds more than 10 times larger than the density cut-off for the microwave and such a high density is kept even after the rf power is shut off. The microwave power without the rf can not ignite the plasma in this power level at low B_t. The n_e profife is hollow at the initial rf phase and then peaked at the center in the following combined microwave. The ne is decreased and the profile becomes a littler flatter in the centeral region after the rf is shut off (Fig. 1(b)). It is observed form the T_e profiles (Fig. 1(c)) that the electrons are heated mostly at surface in the rf start-up phase and the center Te increases with the additional microwave power. The edge T_e is reached to ~23 eV while the central one is ~10 eV in this phase. After the rf is shut off the edge T_e decreases more than the central one but the hollow T_e profile is kept. The rf frequency closes to lower hybrid one at B_t=275G at plasma center and the increase in central T_e is observed in the experiment. The comparison of these results with the Ray trace calculations of the rf waves is now under way.

References

1) Shoji, T, Sakawa, Y, Suzuki. C., Matsunaga, G., Toi, K. Ann. Rev, NIFS, (2003) 283
2) Toi, K. , Matsunaga, G., Ikeda. R, Takeuchi, M., Suzuki. C., Shoji, T. Ann. Rev, NIFS, (2003) 281
3) Shoji, T, Sakawa, Y, Suzuki. C., Takeuchi, M., Ikeda. R, Toi, K. Ann. Rev, NIFS, (2005) 296

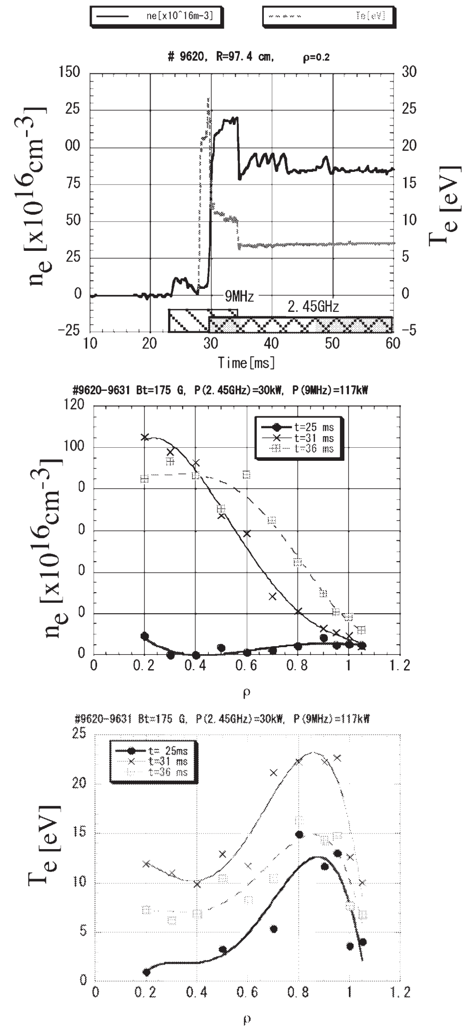

Fig. 1 (a) time evolution of electron density n_e and temperature T_e at ρ=0.2 for micro wave + whistler discharges. Radial profiles of (b) n_e and (c) T_e at t=25, 31, 36 ms. B_t= 175G, P_μ=20kW, Prf=117kW