§ 20. Plasma Production with 2.45GHz Electron Cyclotron Waves

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Energy and particle transport in high temperature plasma is very complicated and the basic understanding is still insufficient. One reason is caused by difficulty of measurements of turbulent fluctuations in such plasma. Transport in high temperature plasma may be simulated with low temperature plasma if these plasmas have similar following dimensionless parameters[1]. That is, they are electron-ion collision frequency normalized by transit frequency, normalized ion gyro-radius evaluated with electron temperature (T_e), and the toroidal beta value evaluated with electron pressure:

$$\nu^* = \frac{\nu_{ei}}{v_{the}/Rq} ,$$

$$\rho_s^* = \frac{\rho_s}{\langle a \rangle} \quad \text{, and}$$

$$\beta_t = \frac{\langle p_e \rangle}{B_t^2/2\mu_0} ,$$

where B_t, n_e, q, R, <a>, ν_{ei}, v_{the}, μ_0, and $<p_e>$ are respectively the toroidal field, electron density, safety factor, major radius, averaged minor radius, electron-ion collision frequency, electron thermal velocity, vacuum magnetic permeability, and averaged electron pressure. In CHS, the simulation experiment is proceeded using a plasma produced by 2.45 GHz electron cyclotron wave (ECW) and 9MHz whistler waves at low toroidal field B_t<0.1T. A key issue of this project is to demonstrate that low collisionality plasmas are routinely produced having high ionization degree. In the experiment, radial profiles of T_e, n_e and so on were measured with the triple-Langmuir probe (LP). In order to calibrate the LP data, the line average electron density (n_e^{2mm}) was measured with 2mm microwave interferometer with high precision phase counter.

ECW was injected into filled hydrogen gas for 180ms in the magnetic configuration of R_{ax}=92.1cm, where B_t ($R=R_{ax}$) ≃ 612G. A typical time evolution is shown in Fig. 1. In this shot, T_e rises continuously during the ECW pulse and reaches about 18eV at the radial location of ρ=0.7. On the other hand, electron density(n_e) at ρ=0.7 stays almost constant after 100ms. In the latter half of the discharge, T_e and n_e fluctuations are considerably enhanced.

The radial profiles of T_e, n_e and space potential (V_s) are shown in Fig. 2 at three timings. Note that both Te and ne profiles tend to become peaky toward the end of the discharge. The above-mentioned dimensionless parameters at t=200ms are as follows: β_t =0.02%, ρ_s^* =0.05 and ν^*=0.05, where the last two parameters are evaluated at ρ=0.7. The achieved range of T_e and n_e^{2mm} for hydrogen plasma is shown in Fig. 3, where Te is evaluated at ρ=0.7. These data were taken by the B_t-scan from 612G to 1050G. This graph shows that the plasmas in this experiment are expected to go into the plateau to $1/\nu$ −helical ripple transport regime.

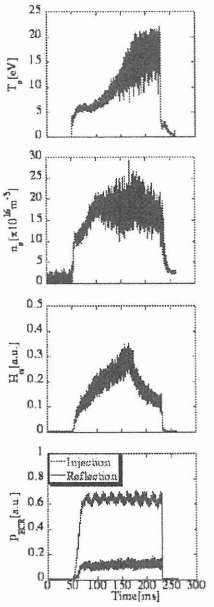

Fig. 1 Time evolution of T_e , n_e , H_α and the ratio of incident and reflected ECW power in R_{ax}=92.1cm, B_t=612G, the probe position ρ_{Lp}=0.7, P_{ECR}=8.7kW, and gas filling pressure p_{H2}= 3.6x10^{-5}Torr.

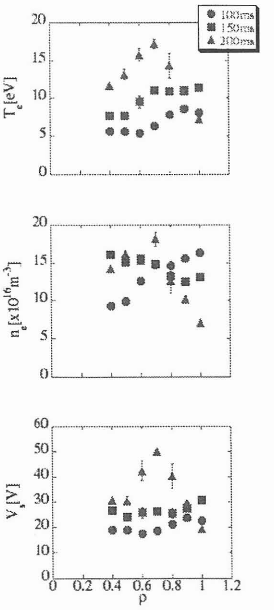

Fig. 2 Radial profiles of T_e, n_e and V_s at 100ms, 150ms, and 200ms.

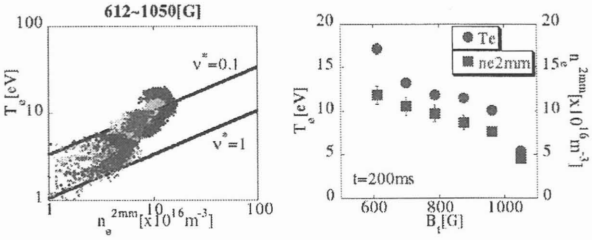

Fig. 3 The generation regime of the plasma obtained by B_t-scan.

[1] K. Toi et al., 29th EPS on Plasma Physics and Controlled Fusion, Montreau, 2001, paper No. P4-061.