§15. Deduction of Ratio of Stored Energy of High Energy Ion to That of Bulk Plasma

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The plasma pressure ratio of high energy ions to that of the bulk plasma is deduced in the plasma discharge with modulated ICRF heating power. In the low electron density n_e=2~4x$10^{18}m^{-3}$, the RF power modulation experiment was carried out at the standard magnetic configuration of R_{ax}=3.75m. The RF power was P_A=180kW and the modulation rate was 30%. Time evolutions of plasma parameters of the electron density n_e, the plasma stored energy W_p, the electron temperature T_e and the radiated RF power P_A are traced in Fig.1(a). Three phase differences of θ_A, θ_p and θ_b from a sinusoidal waves are calculated with time using data of measured δP_A, δW_p and δW_b in the following equations.

$$S_A = \int \left\{\delta P_A(t) - \delta P_{A0} \sin(\omega t - \theta_A)\right\}^2 dt,$$

$$S_p = \int \left\{\delta W_p(t) - \delta W_{p0} \sin(\omega t - \theta_p(t))\right\}^2 dt,$$

$$S_b = \int \left\{\delta W_b(t) - \delta W_{b0} \sin(\omega t - \theta_b(t))\right\}^2 dt.$$

θ_p and θ_b varies with time due to the change of plasma parameters. θ_A is a constant with time; θ_A=c_A. A quadratic function with time was employed in θ_p and θ_b; $\theta_p = a_p t^2+b_p t+c_p$ and $\theta_b = a_b t^2+b_b t+c_b$. Seven numerical factors, c_A, a_p, b_p, c_p, a_b, b_b and c_b were determined by minimizing summations of the square of the residual. θ_{pA} and θ_{tb} are θ_{pA}=θ_A-θ_p and θ_{pb}=θ_p-θ_b. Time evolutions of θ_{pb} and θ_{pA} are plotted in Fig.1(b). They are also plotted in R_{tb}-θ_{pA} plane as time evolution from t=1.0s to 2.0s as shown in Fig.2. There are two solutions for R_{tb} and they merges at θ_{pb}=11°. In this plasma discharge the electron density gradually increased with time; therefore it is thought to be natural that R_{tb} was reduced with time. R_{tb} changed from 0.36 to 0.18.

On the other hand, high energy tail fraction is calculated using ISS95 and the transfer efficiency, which was experimentally determined from the measured tail temperature in the previous section. In this calculation the absorbed RF power by high energy ions is constant of P_A=180kW. The electron density is varied from n_e=5x$10^{17}m^{-3}$ to n_e=5.0x$10^{18}m^{-3}$ and the average electron temperature is calculated using τ_E=τ_E^{ISS95}/2 and the transfer efficiency. Figure 3 shows plasma parameters as a dependence of the electron density n_e; the tail plasma stored energy W_t, the bulk plasma stored energy W_b and their ratio of R_{tb} are plotted. The pressure ratio R_{tb} varies from 0.4 to 0.2 as the electron density is increased from n_e= 2.0x$10^{18}m^{-3}$ to n_e=4.0x$10^{18}m^{-3}$. This figure agrees well with R_{tb} deduced experimentally from the phase measurement as shown in Fig.1(b).

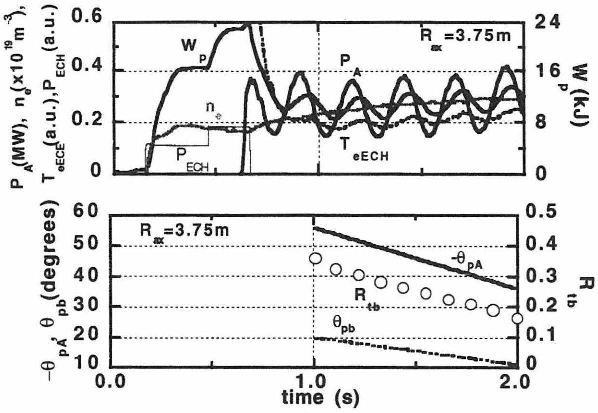

Fig.1 (a) Time evolutions of plasma parameters and the injected RF power.
(b) Measured phase difference, θ_{pA} and θ_{pb}, and the pressure ratio of R_{tb}.

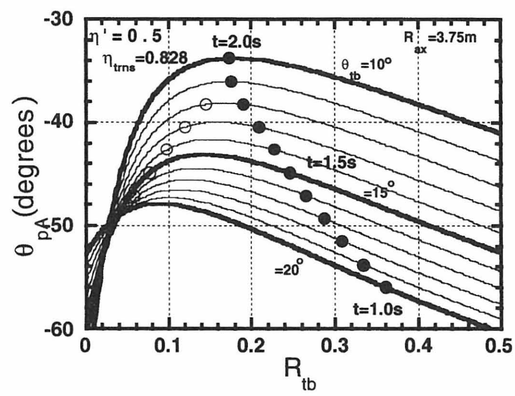

Fig.2 Determination of R_{tb} from measured phase difference of θ_{pA} and θ_{pb}.

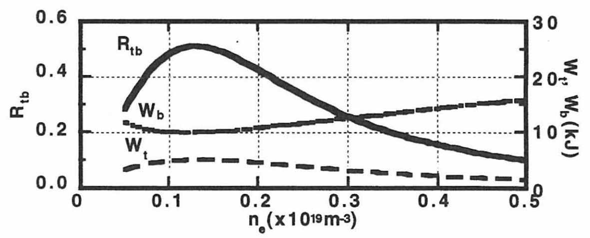

Fig.3 Dependence of R_{tb} on the electron density in the case of P_A=0.18MW and R_{ax}=3.75m.