§22. Scaling Study of Beam Driven Current in CHS

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In CHS experiments, the toroidal current is observed for tangential NBI discharges and this current has been investigated based on 'Ohkawa' model. According to this model, the beam driven current is described as

$$I_{oh} = I_b\left(1 - Z_b / Z_{eff}\right),$$

$$I_b = J_b \times v_b \tau_{ie} / 2\pi R = P\sqrt{2e/m_b E} \times \tau_{ie} / 2\pi R.$$

In the previous analysis, it was found that the current depends on line averaged electron density ($\bar{n}_e$) and magnetic field (B_t) as is shown in Fig.1. The dependence of I_p on $\bar{n}_e$ could be explained with the model that the beam driven current is proportional to the slowing down time. But the beam driven current does not depend on B_t explicitly in Ohkawa model. However, if it was assumed that International Stellarator Scaling ISS95 could be applied to CHS, the electron temperature (T_e) was proportional to $B_t^{0.83}$, which could explain the dependence of I_p on B_t.

In the present analysis, the dependence of I_p on the absorbed beam power, electron temperature measured by Thomson scattering, and the effective charge number (Z_{eff}) of plasma is fully analyzed. It is predicted that the beam driven current is proportional to the injection power of NBI. In Fig.2 the dependence of I_p on the absorbed beam power divided by $\bar{n}_e\sqrt{E}$ (where E is the beam ion energy) is shown. The proportional dependence of I_p is clearly shown, but the proportional constant is different for the different B_t. When the dependence of I_p on T_e is included in the analysis as is shown in Fig.3 (where T_e measurement by Thomson Scattering is used), the proportional constant does not depend on B_t, which proves that the effects of B_t on I_p are due to the T_e difference. I_p is not much influenced by Z_{eff} in experimental results. The value of observed Z_{eff} in CHS when the toroidal current is saturated is between 3 and 6. If Z_{eff} is larger than 3, its difference causes only small effects on I_p according to Ohkawa model. In Fig.3 the solid line is a fitting line for experimental data and the dotted line shows the calculated value from Ohkawa model in which the parabolic profile of T_e and n_e and $Z_{eff} = 3$ are assumed.

The toroidal current in tangential NBI discharges of CHS can be explained by 'Ohkawa' current.

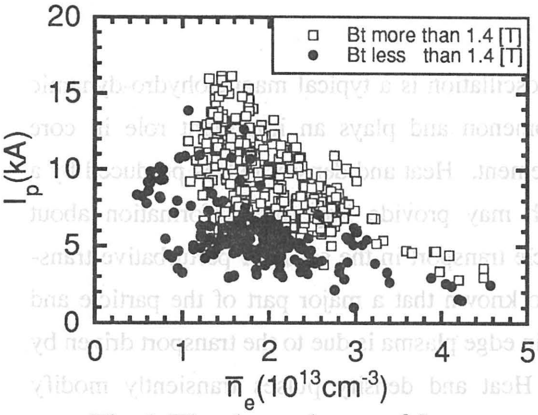

Fig.1 The dependence of I_p on $\bar{n}_e$

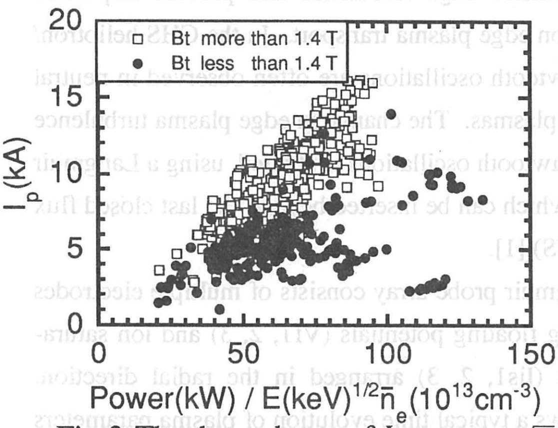

Fig.2 The dependence of I_p on $P/\bar{n}_e\sqrt{E}$

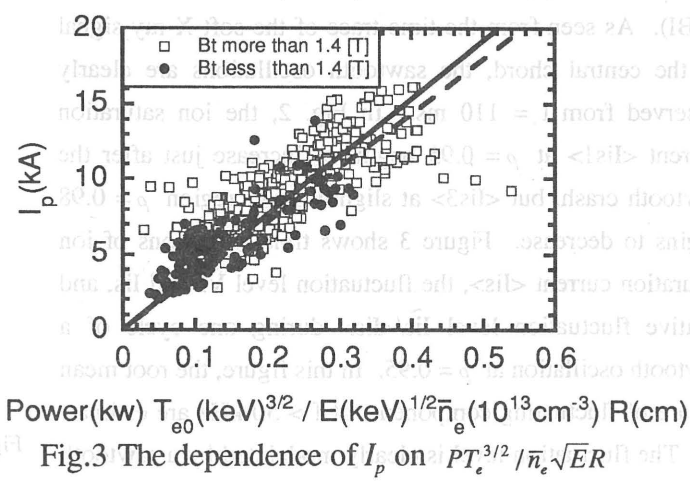

Fig.3 The dependence of I_p on $PT_e^{3/2}/\bar{n}_e\sqrt{E}R$