§11. The Analysis of Beam Driven Current in CHS

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The beam driven current in CHS is analyzed. The database, which comprises 530 recent NBI discharges in CHS, is examined in detail to reveal the dependence of the beam driven current on plasma parameters. Due to the Ohkawa's theory the toroidal current induced by a tangential NBI is determined by the following plasma parameters: Z_{eff}, j_b and τ_s . Z_{eff} is the effective charge number of plasma and τ_s is the slowing down time of beam ion. Of course τ_s is proportional to $T_e^{3/2}/n_e$, so the beam driven current also depends on the plasma temperature and density. In the torus system as CHS, the beam ion injected by NB revolves around the torus axis. That revolving number is expressed by $v_b\tau_s/2\pi R$ so the toroidal current also depends on the major radius and on the velocity of the beam ion. The above things are taken into account, and in the analysis we use experimental results of the following plasma parameters: T_e[keV], $\bar{n}_e$[10^{13}cm^{-3}], P_{abs}[kW], E_b[keV], R_{ax}[cm], and Z_{eff}. When T_e and n_e profiles are assumed to be parabolic, the Ohkawa current is calculated as follows.

$$I_{oh}[kA] = 232\cdot\left(1 - Z_b / Z_{eff}\right)\cdot T_e^{3/2}P_{abs} / R_{ax}\bar{n}_e\sqrt{E_b}$$

The observed current I_{ex} is shown as a function I_{oh} in Fig.1. Open circles are for 479 co-injection shots, and closed rectangles are for 51 counter-injection shots. The dependence of I_{ex} on plasma parameters may be same as that of I_{oh}, but the magnitude is smaller. The proportional constant of the fitting line is 0.32, which indicates that the magnitude of the observed beam driven current can not be explained by the above simple model.

Next, from the database the scaling low of the beam driven current is obtained with a square minimum scheme. The effective charge number Z_{eff} has little effect because the value in CHS is usually larger than 3, so this parameter is excluded from scaling parameters. The scaling function of toroidal current is assumed to be expressed as follows,

$$I_{scale} = \alpha_{const}\left(P_{abs} / E_b\right)^{\alpha_P}\bar{n}_e^{\alpha_n}T_e^{\alpha_T}\left(\sqrt{E_b} / R_{ax}\right)$$

The function in the first bracket corresponds to the current injected by a neutral beam. The function in the last bracket corresponds to the revolutional frequency of a beam ion in CHS, whose range in our database is narrow. So the proportion to this parameter is simply assumed. The square minimum scheme is applied to database, and then the scaling function is obtained as follows,

$$I_{scale} = 37\cdot\left(P_{abs} / E_b\right)^{0.82}\bar{n}_e^{-0.79}T_e^{0.52}\left(\sqrt{E_b} / R_{ax}\right)$$

In Fig.2 the observed toroidal current I_{ex} as a function of I_{scale} is shown. Compared with the function of I_{oh}, the dependence on T_e is very weak. It is considered that this is one reason for the observed current being smaller than the Ohkawa current.

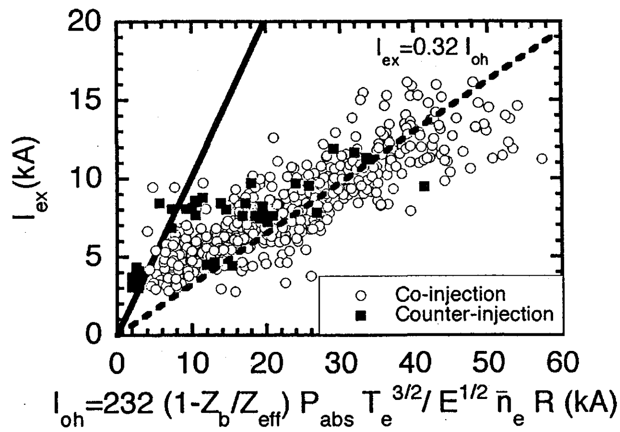

Fig.1 The observed toroidal current as a function of Ohkawa current.

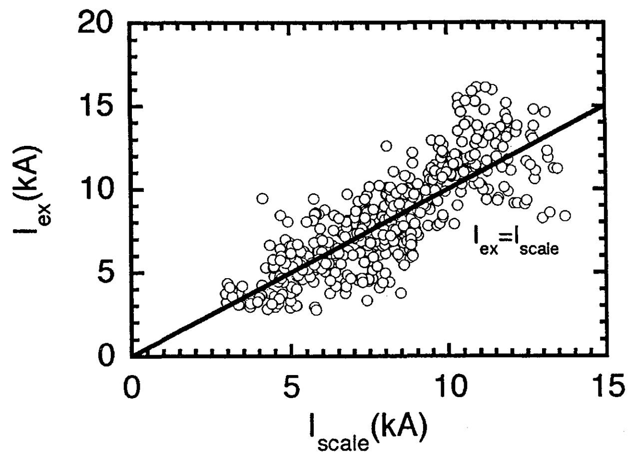

Fig.2 The observed toroidal current as a function of I_{scale}.