§55. Development of Evaluation Methods of Anisotropic Pressure Based on MHD Equilibrium Analysis in LHD

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In LHD high beta experiments with the $<\beta> > 3\%$, the typical operation magnetic field strength is less than 0.5T. And the typical high beta discharges are operated under the relatively low density with tangentially injected high power NB. According to a Monte Carlo Simulation, the beam pressure by NBI is expected more than 30% in the whole plasma stored energy in the LHD highest beta discharge [1]. To study the effects of the anisotropic pressure on the MHD equilibrium and the stability is considered an important subject on improving the accuracy of scientific predictions concerning the reactor performance based on the present LHD high beta study.

In LHD, an evaluation method of the anisotropy of the pressure has been developed [2]. In the previous work, the pressure anisotropy theoretically evaluated with the Mote Carlo simulation on the beam pressure by NBI was related with measured magnetic fluxes (the ratio between the diamagnetic flux and a saddle loop flux). By using the method, the relationship between the magnetic axis location and the pressure anisotropy were studied [3]. Recently, the three dimensional MHD equilibrium analysis code, VMEC, has been extended to apply the anisotropic pressure plasmas with a special distribution function based on the bi-Maxwellian, which is called ANIMEC [4]. Here we apply it to evaluate the relationship between the anisotropic pressure and the magnetic flux measurements. Figure 1 shows the saddle loop flux signal, Φ_{PS}, dependence on the equal weight volume averaged beta value, $<\beta_{eq}>$, (a) and the diamagnetic flux signal, Φ_{DIA}, dependence on the perpendicular component of the volume averaged beta value, $<\beta_{\perp}>$, (b) for a typical pressure profile and the LHD typical configuration, R_{ax}=3.6m, B_q=100%, γ=1.254. Here $<\beta_{eq}> \equiv (<\beta_{//}>+<\beta_{\perp}>)/2$ and $<\beta_{//}>$ denotes the parallel component of the volume averaged beta. In the figures, the solid lines correspond to the isotropic cases, and the symbols with "+" and "x" denote the anisotropic cases. It should be noted that the anisotropy is changed with the parallel temperature, $T_{//}$, and the perpendicular temperature, $T_{\perp}$, in the bi-maxwellian in addition to the change of the ratio between the high energy particles' pressure and the thermal pressure. Here the parallel pressure dominant cases are studied because our main concern is for the LHD high beta discharges. Fig.1(a) shows the saddle loop signals even in the anisotropic plasmas are only the function of the $<\beta_{eq}>$, which means that the ratio between the thermal pressure and the high energy particles' pressue. On the contrary, the diamagnetic flux signals are found not to be only the function of the $<\beta_{\perp}>$ in the much anisotropic cases. A theoretical analysis by Pustovitov [5] suggested that the perpendicular current depends on the parallel pressure gradient and the magnetic hill/well as well as the perpendicular pressure gradients. The confirmation of the effect on the diamagnetic flux signal is one of the future subject. Now it should be noted that the diamagnetic flux is still good index for the $<\beta_{\perp}>$ in the case that the pressure anisotropy is not so large, which means that we can evaluate the anisotropic pressure by using the magnetic fluxes' measurements in the case that the pressure anisotropy is not so large if we know the pressure profile.

As the next step, we will make a lot of calculations for the various pressure profile and distribution function, and we should confirm the properties mentioned in the above, and develop the identification method of the an isotropic pressure profiles.

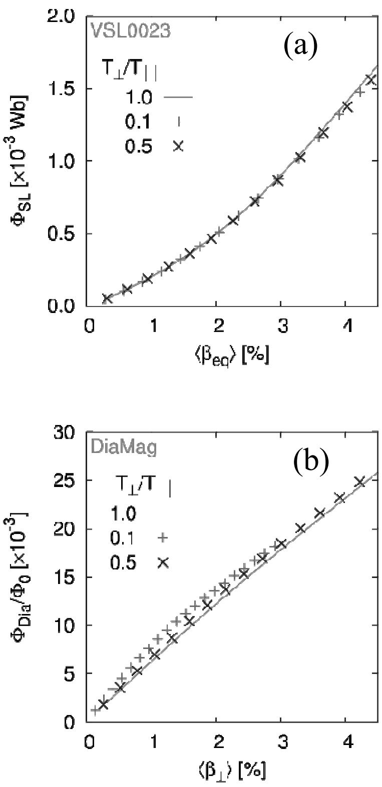

Fig. 1. (a) The saddle loop flux signal, Φ_{PS}, dependence on the equal weight beta value. (b) The diamagnetic flux signal, Φ_{DIA}, dependence on the perpendicular beta value.

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2) Yamaguchi, T. et al, Nucl. Fusion 45 (2005) L33.
3) Watanabe, K.Y. et al, in 19th ITC.
4) Cooper, W.A., Comp. Phys. Com. 180 (2009) 1524.
5) Pustovitov, Plasma Phys. Control. Fusion 52 (2010) 065001.