§32. Anisotropic Pressure Effect on the MHD Equilibrium in LHD

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In LHD high beta experiments with the $\langle\beta\rangle > 3\%$, the typical operation magnetic field strength is less than 0.5T [1]. And the typical high beta discharges are operated under the relatively low density. The achieved beta value increases with the decrease of the magnetic field strength, but the stored energy decreases. On the other hand, the increase of the beam energy due to the decrease of the operational density is superior to the degradation of the beam energy on the decrease of the magnetic field strength. Then the ratio of the beam energy to the thermal energy increases with the decrease of the magnetic field strength, which is expected to leads to the anisotropic pressure with the large parallel components due to the tangentially injected NB. 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 based on the magnetic flux loop measurement [2]. The diamagnetic flux loop detects dominantly the perpendicular component of the plasma stored energy, and the saddle loop does the PS current, which scales both the perpendicular and the parallel components. Based on the above property, the anisotropy of the pressure is evaluated. Fig.1 shows the magnetic flux measured by the diamagnetic flux loop and the saddle loop (Φ_{DIA}(a), Φ_{PS}(b)), the magnetic axis position evaluated by the electron temperature profile (c) as the function of the electron density for the plasmas heated by tangential NBs. The data with almost same diamagnetic flux, pressure profile and the NBI power are extracted from a LHD experimental dataset. The Φ_{PS} decreases as the electron density decreases in spite of almost same diamagnetic flux, which suggests the anisotropy of pressure decreases. This behavior is understandable from the speculation that the parallel beam pressure component due to the tangentially injected NB decreases with the density increases and the sum of the parallel and the perpendicular pressure decreases. In contrast, the kinetic component is expected dominant in the perpendicular pressure, then the Φ_{DIA} does not change as the density increases. Moreover, the Shafranov shift becomes small as the density increases, which is consistent with the behavior of the ratio between Φ_{DIA} and Φ_{PS}. Fig.2 shows the measured Shafranov shift as the function of the anisotropy of the pressure. It should noted that the anisotropy of the pressure is evaluated by using a method proposed in ref.[2]. A goal of this study is to establish the method and/or the model to evaluate the MHD equilibrium configuration and some equilibrium parameters in the anisotropic pressure plasmas. Here a model for the relationships between the anisotropy and the Shafranov shift is compared with the experimental ones. The model is that the Shafranov shift scales $(\beta_{//}+\beta_{perp})/2$ in stead of β in the anistropic pressure plasmas [3], which is shown by the closed squares. As the references, 2 models are shown. A model is that the Shafranov shift scales $(\beta_{//}+2\beta_{perp})/3$ (closed diamonds), which corresponds to the total b in the anisotropic pressure, and the other is that the Shafranov shift scales $3\beta_{perp}/2$ (closed triangles), which corresponds to the total b under the isotropic pressure. The model proposed in ref.[3] is not conclusive to reproduce the experimental data yet. We need more systematical study to get the conclusive model for the relationship between the Shafranov shift and the anisotropy. This is one of our future subjects.

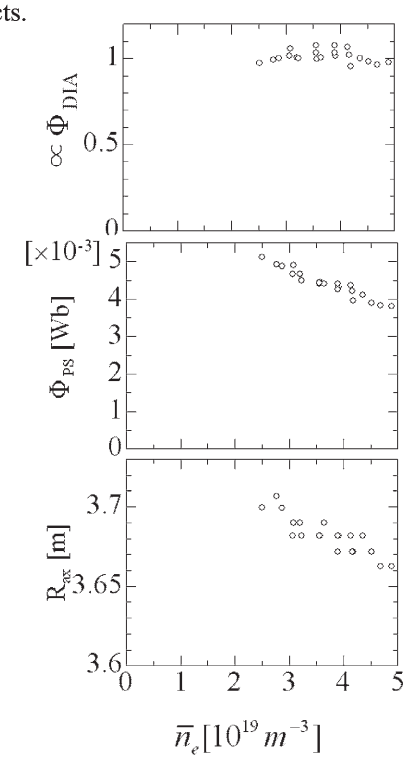

Fig. 1. the magnetic flux measured by (a) Φ_{DIA}, (b) Φ_{PS} and (c) the magnetic axis position evaluated by the electron temperature profile as the function of the electron density.

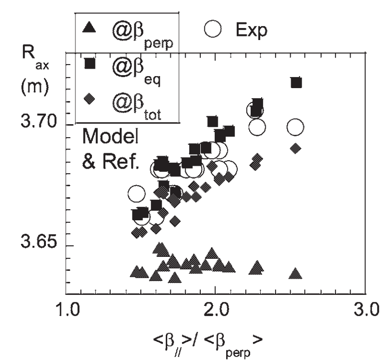

Fig. 2. The measured Shafranov shift as the function of the anisotropy of the pressure.

1) Watanabe, K.Y. et al, in Proc. of Joint Conf. of 18th ITC.
2) Yamaguchi, T. et al, Nucl. Fusion 45 (2005) L33.
3) Hichon, W.N.G., Nucl. Fusion 23(1983)383.