

§8. Measurement of Shafranov Shift with Soft X-ray CCD Camera on LHD

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The soft x-ray CCD camera system was installed on a tangential port in LHD after preliminary measurements in CHS [1]. As a measurement of soft x-ray imaging for long pulse discharge, the soft x-ray CCD camera system has been developed with an air-controlled shutter to prevent x-ray photons coming to CCD surface during the readout of image data. The minimum pulse width of shutter trigger is about 0.3s.

The tangential soft x-ray image has been measured during the 3rd LHD experiment campaign. The plasma magnetic axis was derived by best fitting of calculated images of soft x-ray emission to that measured with soft x-ray CCD camera with β scan or pressure profiles scan [2]. The shifts of magnetic axes due to vertical field and plasma pressure (Shafranov shift) are measured.

Figure 1 shows the χ^2 profiles for plasmas with different vacuum magnetic axes of 3.6m and 3.75m. The plasma, with vacuum magnetic axis of 3.6m and magnetic field of 2.893T, is heated by ICRF from 0.3s to 10.5s. Another plasma, with magnetic axis of 3.75m and magnetic field of 1.5T, is heated by NBI from 0.3s to 9.22s. Line-averaged electron density are $0.5 \times 10^{19} \text{m}^{-3}$ and $3.5 \times 10^{19} \text{m}^{-3}$, and the $\langle \beta_{\text{dia}} \rangle$ measured with diamagnetic loop is 0.1% and 0.45%, respectively. The duration of integrating time of soft x-ray images measured using soft x-ray CCD camera with 50-mm-thick Be filter and 0.2-mm-diameter pinhole are from 6.0s to 6.75s. The magnetic axes derived by minimizing χ^2 are 3.61m and 3.81m, respectively. The shift of magnetic axis due to vertical field is 20 cm as shown in Fig. 1.

The tangential soft x-ray image was also measured during high beta experiment in LHD. The vacuum magnetic axis is 3.6m and magnetic field is 0.75T. The NBI was injected to the ECH target plasma from 0.4s to 1.7s. The store energy reach the top value of 182.2kJ at 1.011s, then decreased slowly to 140kJ at 1.2s and keep this value up to the timing of NBI injection finished. The soft x-ray image is measured from 1.008s to 1.448s and the diamagnetic beta, $\langle \beta_{\text{dia}} \rangle$, measured in this duration is 2.0%. The χ^2 profile with magnetic axis scan from 3.603m to 4.071m corresponding to the plasma pressure, β , from 0.0% to 3.61% is shown in Fig. 2. The Shafranov shift measured with CCD camera is 19 cm, which agrees with that estimated from equilibrium code ($R_{\text{ax}}=3.835\text{m}$) within 20%

error. On the other hand, there is no anisotropy was observed in LHD plasma, where the beam slowing down time of neutral beam is comparable to the energy confinement time, because of large size of plasma.

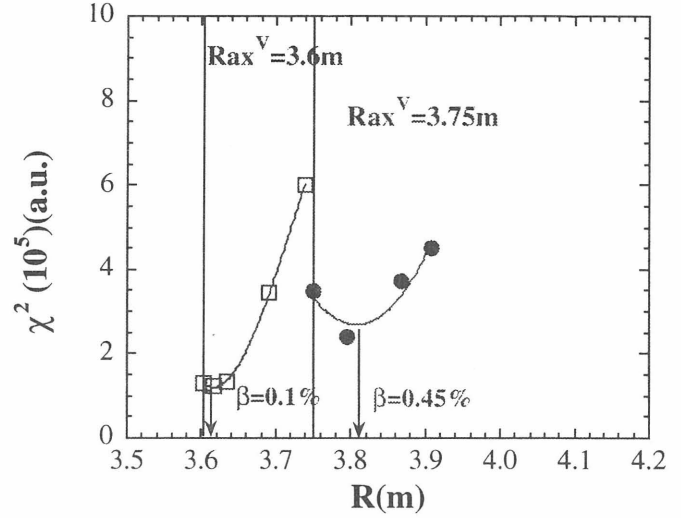


Fig. 1 χ^2 profiles for plasmas with different vacuum magnetic axes of 3.6m and 3.75m.

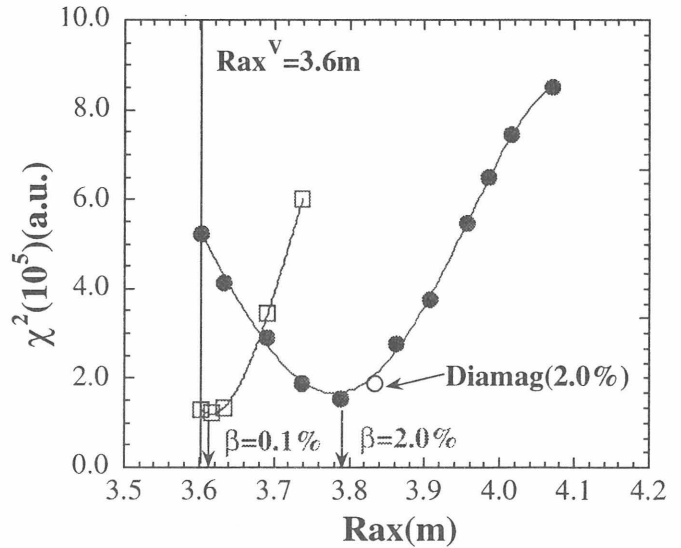


Fig. 2 χ^2 profiles for plasmas with different plasma pressure of $\beta=2.0\%$ and $\beta=0.1\%$. The vacuum magnetic axis is 3.6m.

References

- [1] Liang, Y., Ida, K., et al., : Proc. of the 10th International Toki Conference on Plasma Physics and Controlled Nuclear Fusion (ITC-10). Toki-city, Japan, 18-21st January 2000
- [2] Liang, Y., Ida, K., et al. : Plasma Phys. Control. Fusion (To be submitted).