§15. The Effect of the Elongated Configurations on Shafranov Shift

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To reduce the magnetic axis shift (Shafranov shift) due to vertical field created by Pfirsch-Schluer currents is useful technique to achieve high beta of plasma. The reduction of the magnetic axis shift can be realized by elongate plasma vertically. The effects of oblate magnetic configuration on the reduction of magnetic axis shift are investigated. The magnetic axis shifts measured with the soft x-ray CCD camera system[1] are compared with those calculated with three-dimensional free boundary code, VMEC[2]. The toroidal averaged ellipticity of cross-section of flux surface, κ, are set by controlling the quadrupole field produced by helical coils using quadrupole field produced by the axisymmetric poloidal coils

The effect of plasma ellipticity on the Shafranov shift is studies in the NBI heated plasma with vacuum magnetic axis $R_{ax}{}^{v}$ = 3.60 m and various quadrupole components; κ = 0.8 (prolate configuration), κ = 1.02 (standard configuration) and κ = 1.4 (oblate configuration). Since the cross section of flux surface over one field pitch length on the magnetic configuration with κ = 1.02 at $R_{ax}{}^{v}$ = 3.60 m becomes approximate circle, this magnetic configuration is referred as the 'standard configuration'.

Figure 1 shows the Shafranov shifts measured with the soft x-ray CCD camera as a function of volume averaged beta estimated with diamagnetic loop, <β_{dia}>, for plasma with κ = 0.8, 1.02 and 1.4 at $R_{ax}{}^{v}$ = 3.60 m during NB injection. The figure shows that the Shafranov shifts measured increase linearly as <β_{dia}> for all κ, and the shift of magnetic axis in the prolate configuration (κ = 0.8) is larger than that in the standard configuration (κ = 1.02) and the shift in oblate configuration (κ = 1.4) is smaller than that in the standard configuration. The reduction of the Shafranov shift due to the vertical elongation is clearly demonstrated in this experiment.

The Shafranov shifts are calculated from pressure profile using VMEC code for three experiments. The electron density and temperature profiles used in this calculation are $n_e \sim n_0(1-\rho^8)$ and $T_e \sim T_0(1-\rho^2)$, that are consistent with measurements with FIR interferometer and YAG Thomson. These magnetic axes are shifted greatly as averaged beta increase. The shift of the magnetic axis for the plasma with the prolate configuration (κ = 0.8) is much larger than that in oblate configuration (κ = 1.4) by a factor of 5 at <β_{dia}> = 0.5 %. Although the Shafranov shift has a difference quantitatively between the measured and calculated results, it is qualitatively in agreement.

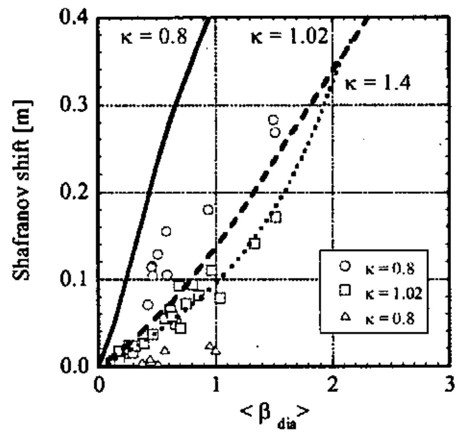

Fig. 1 Comparison the Shafranov shift measured (symbols) with theoretical prediction (lines) calculated by VMEC code for the plasma with different ellipticity of κ = 0.8, 1.02 and 1.4.

1) Y. Liang *et al.* Plasma Phys. Control. Fusion 44 (2002) 1383
2) S.P. Hirshman, Phys. Fluids 26 (1983) 3553