§21. Confinement and MHD Stability of a Plasma in a New Magnetic Configuration with Very Low Rotational Transform

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Deep magnetic well can be generated by large Shafranov shift in heliotron/torsatron such as LHD. Large Shafranov shift may be realized by substantial reduction of the rotational transform. Two important questions are posed. One is whether the plasma confinement is degraded or not, following the ISS95-scaling that has a dependence on $[\iota/2\pi\ (\rho=2/3)]^{0.4}$. The other is whether the MHD equilibrium and stability are ensured or not. We have numerically investigated the MHD equilibria of a plasma in a magnetic configuration with zero-rotational transform [1]. When the ratio of the plasma current for the toroidal field I_p/B_t reaches -100 kA/T (negative for reversed Ip), the rational surface of zero rotational transform appears in the plasma core region and n=0 axisymmetric island structure is formed there. In this case, the rotational transform is reversed around the plasma center.

Substantial reduction of the rotational transform was attempted by inducing a large amount of beam driven current with counter neutral beam injection (NBI). In order to get a large beam driven current, line averaged electron density is adjusted to be relatively low ($\sim 1\times10^{19}$ m-3). Moreover, strong neon gas puffing is applied to enhance absorbed NBI power. The ratio I_p/B_t up to - 120 kA/T has been achieved. In Fig.1, typical time evolutions of electron density and electron temperature at various radial locations are shown, together with reversed beam driven current by counter NBI. With the increase in Ip toward reversed direction|, edge electron density and temperature gradually increase. This clearly indicates that the reduction of the central rotational transform does not degrade the global confinement, but even improve it. The electron temperature profile becomes broad with the decrease in central $\iota/2\pi$, and has an asymmetric shape in the core region for the range of Ip/Bt $\leq$ -90 kA/T. If we assume the current density profile $j = j_0(1-\rho^2)^s$, the total rotational transform at the center reaches to zero for S = 0.47 in the case of Ip/Bt= -120 kA/T. In this case, $\iota/2\pi$ at ρ=2/3 is reduced from ~0.56 (at Ip=0 kA) to ~0.17. As seen from Fig.1, the global confinement is not degraded. This suggests that the confinement time would be improved by about 50% or more, compared with the net current free case. Moreover, very interesting magnetic fluctuations having m=0/n=0 (m, n: ploroidal and toroidal mode numbers) suddenly grows in the phase of Ip/Bt < -70 kA/T , and then gradually decays, as shown in Fig.2. The fluctuations may be related to the generation of the zero rotational surface and n=0 island. Note that edge MHD modes excited around $\iota/2\pi$=1 are stabilized in the latter half of the discharge with large reversed Ip, presumably due to decrease in the pressure gradient and increase in the magnetic shear there.

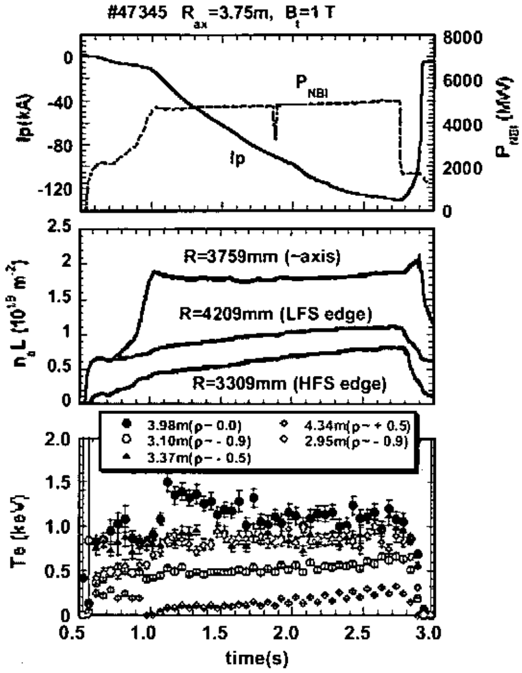

Fig.1 Time evolution of electron density and electron temperature at various radial location with large reversed current Ip up to 130 kA, where Bt=1T , magnetic axis position Rax=3.75m, and absorbed NBI power is 5MW. Neon puff is applied at t=0.9s.

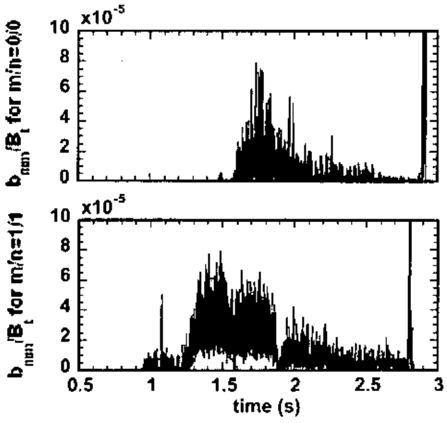

Fig.2 Time evolutions of magnetic fluctuations with m/n=0/0 and 1/1 mode structure in the shot shown in Fig.1.

Reference

[1] R. Kanno, K. Toi, K.W. Watanabe et al., J. Plasma Fus. Res. 79, 839 (2003).