§25. Optimization of Magnetic Configuration Using Additional Trim Coils

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Helical devices including heliotrons and stellarators can confine steady state plasmas in principle because their three-dimensional magnetic field for plasma confinement is mainly produced by external coils. However, the lack of symmetry would lead to the degradation of plasma confinement and optimization aiming at improvement of neoclassical and anomalous transport, and MHD stability is needed.

In order to improve the magnetic configuration of helical-axis heliotron which has a simple l=1 helical coil, we tried to optimize the magnetic configuration of Heliotron J using the stellarator optimizer "STELLOPT" suite developed by ORNL group [1]. STELLOPT can take into account several physics such as neoclassical transport, energetic particle confinement and MHD stability, and engineering requests. In this study, we mainly target on the confinement of trapped particles in the helical mirrors. In the previous calculation results and experimental results show higher harmonics of Fourier spectrum of magnetic field by helical coil breaks quasi-omnigeneity of magnetic configuration and disturbs the good particle confinement. First of all, we explored the possibilities to optimize the magnetic configuration of Heliotron J using modulation of Fourier harmonics of last closed flux surface (LCFS), that is fixed boundary optimization. The way to improve the bulk particle confinement is to minimize the differences of contour of the second adiabatic invariant J and B minimum with magnetic flux surface. Fig. 1 shows the good alignment of the J contour, which corresponds to the reflection point of trapped particles, with magnetic flux surfaces in the optimized configuration. We can expect that improvement of trapped particle confinement because B minimum contour also agree well with flux surface.

Fig. 2 shows the radial profile of effective helical ripple with regard to neoclassical transport of Heliotron J standard configuration (red broken line) and optimized configuration (blue solid line). Optimization of particle confinement slightly decreased the neoclassical transport of non-collisional particle.

As a result of this study, optimized magnetic configuration has clear quasi-omnigenous structure, which has a well-balanced combination with three Fourier components of toroidal, helical and mirror ripple, as shown in Fig. 3. Fig. 3 is the contour plot of magnetic field strength at normalized minor radius ρ = 0.6. Our next plan are further optimizations taking into account both particle confinement and neoclassical transport, and design of additional trim coil to reform magnetic configuration.

[1] D. Spong, et al., Nucl Fusion **41**, 711 (2001).

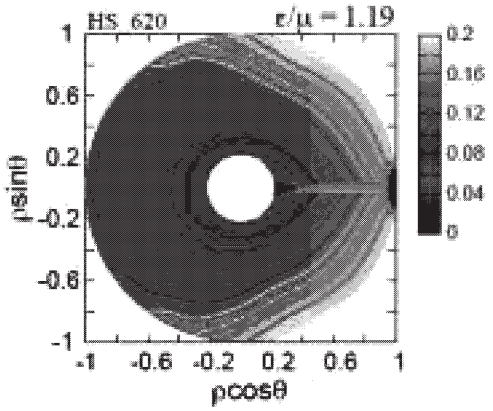

Fig. 1. J contour of optimized configuration

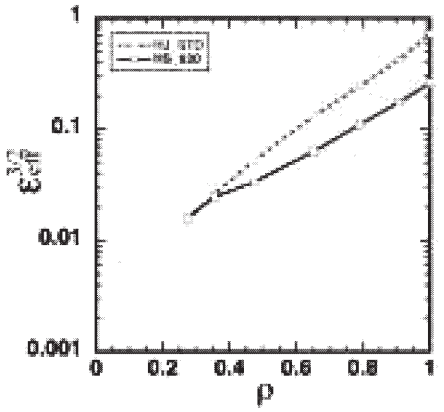

Fig. 2. Profile of effective helical ripple of Heliotron J and optimized configuration

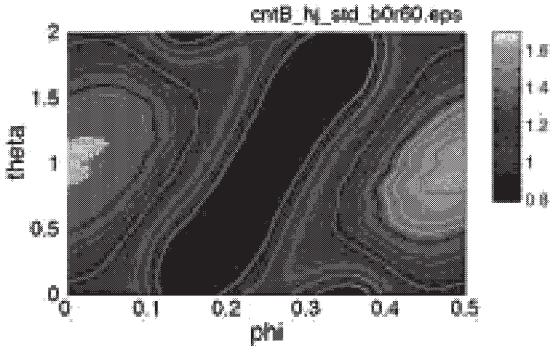

Fig. 3. Contour of magnetic field strength of optimized configuration.