§26. Alpha Particle Confinement Optimization for CHS-qa

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The most important process to determine the neoclassical transport property of the quasi-axisymmetric stellarator is the stochastic ripple losses of toroidal banana particles. The orbit losses of helical ripple particles are almost negligible because of the sufficient level of quasi-axisymmetry of the configuration. The dependence of the banana particle losses on each non-axisymmetric Boozer component is not obvious. For example, the amplitude is largest for the mirror term with zero poloidal mode number. This component usually remains with almost unchangeable amplitude for any optimization process. But fortunately, this component is not an important one to influence the losses of banana particles. A smaller component with higher poloidal mode number is affecting the losses more strongly.

The confinement property of the high energy particles is basically determined by the axi-symmetry of the configuration. The optimization to reduce non-axisymmetric Boozer components was therefore the fundamental method to improve the confinement. However because of the more complicated effects of the residual non-axisymmetric components, a new optimization procedure was introduced with the direct evaluation of high-energy particle collisionless confinement.

In the orbit calculation, the particle energy is chosen at 3.5 MeV and the magnetic field at 5 T with the plasma volume of 1000 m^3. These choices are just to simulate alpha particle confinement in the reactor scale. Particles are launched at both 1/4 and 1/2 minor radii and followed for 1 sec without collision.

Figure 1 shows the vacuum magnetic surfaces of one solution (2a36) of such an optimization procedure. The confinement time of the high energy particles is dramatically improved (more than two orders of magnitude) approaching to 1 sec which is the nominal slowing down time of alphas in the reactor.

Figure 2 shows the Boozer spectrum of 2a36 configuration. Non-axisymmetric components (except the mirror term) are suppressed below 1.5% at the edge in this new configuration. Relatively large amplitude of the mirror term might be a key of good confinement of high energy particles.

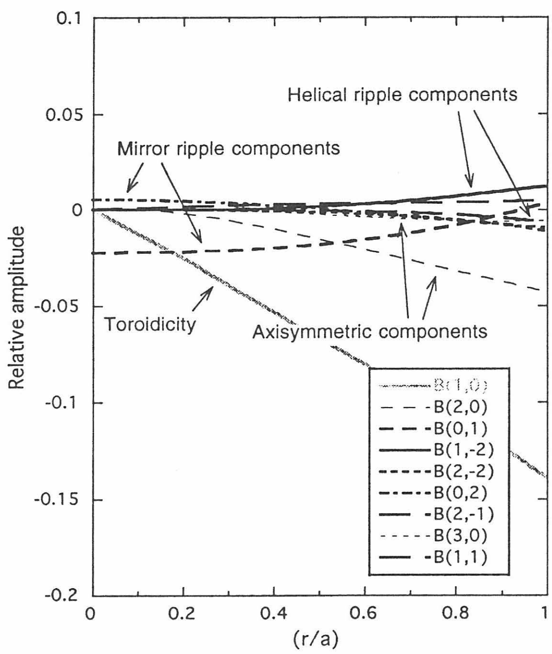

Fig. 2. Boozer spectrum of magnetic field structure of 2a36 configuration

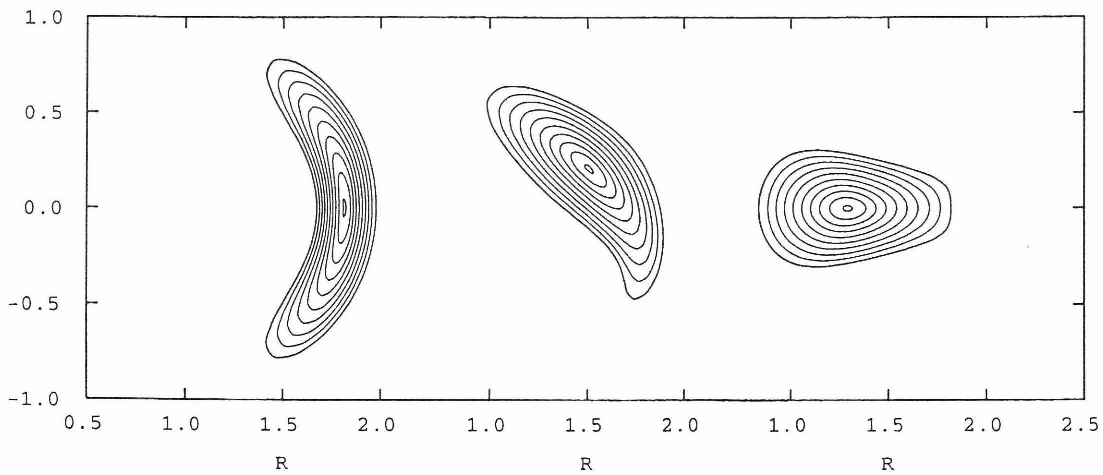

Fig. 1. Vacuum magnetic surfaces of alpha particle confinement optimized configuration 2a36