§23. The Effect of Coil Misalignment on Particle Transport in Quasi-Axisymmetric Systems

Shimizu, A., Isobe, M., Okamura, S., Suzuki, C., Nishimura, S., Akiyama, T., Matsuoka, K., Nemov, V. (Institute of Plasma Physics, Ukraine)

An advanced stellarator, CHS-qa [1], is an experimental device being planned to investigate the good neoclassical confinement property of a quasi-axisymmetric configuration and to study the reduction of anomalous transport by plasma rotation and maximum-J configuration. Its magnetic configuration is produced by modular coil system, which consists of total of 20 coils [2]. In this article, the effect of the error in the position of these coils on the neoclassical transport is reported. This estimation is important for determining the acceptable level for error in placing modular coils.

The property of neoclassical transport in $1/\nu$ regime of helical device is determined by effective helical ripple, ε_{eff}, and the neoclassical diffusion coefficient is proportional to $\varepsilon_{eff}^{3/2}$. In order to evaluate this quantity numerically, the NEO code [3] is used. The advantage of this code is that, 1) it can calculate the effects from trapped particles in any magnetic field ripples therefore it can take the bumpy ripples from discrete coils into account. 2) Since the code uses the solution for the distribution function of the bounce averaged kinetic equation, the calculation time is shorter than Monte Carlo method. In order to evaluate the effect of error in the position of coils, modular coils are moved artificially and the change in ε_{eff} is analyzed.

The reference configuration of CHS-qa, "2b32" version, is selected, of which major radius is 1.5 m, aspect ratio 3.2, maximum magnetic field strength 1.5 T. Here, two cases of displacement are considered. In case A, COIL 2, 4, 8, 12, 14, 18 are moved in the positive direction along the z axis by the distance of Δz, and COIL 3, 7, 9, 13, 17, 19 are moved in the negative direction. In case B, COIL 2, 4, 7, 9, 12, 14, 17, 19 are moved in the positive radial direction by the distance of ΔR, and COIL 3, 8, 13, 18 are moved in the negative radial direction. These displacements put on coils are schematically shown in Fig.1.

The calculation result of NEO code for case A is shown in Fig.2. Δz is changed from 0 to 10 cm. If the displacement is smaller than 2 cm, its effect on ε_{eff} is not seen clearly. However for Δz = 10 cm, ε_{eff} is one order larger than standard configuration. The local maximum appears at averaged minor radius of 0.1 m for Δz = 6 cm, and at 0.2 m for Δz = 10 cm. These come from effects of n/m = 2/5 islands of which position are moved with the change in rotational transform. In Fig.3, the change in ε_{eff} profile for case B is shown. If the displacement is smaller than 2 cm, its effect on ε_{eff} is small, which is same as case A.

Thus, the effect of the displacement of modular coils on neoclassical transport is small when it is below 2 cm for CHS-qa. By the way, the displacement of coils by the electromagnetic force in the magnetic field strength of 1.5 T is below a few millimeters. Therefore this can be neglected from the point of view of neoclassical transport. The study of effect of error on the high-energy particle transport, as discussed in Ref. 4, is a future issue.

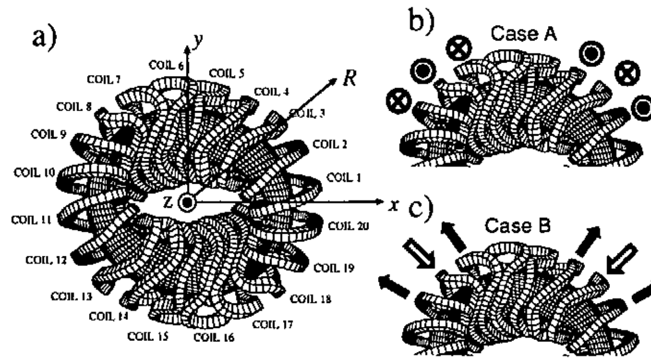

Fig.1 a) modular coils for CHS-qa b) artificial displacement of case A and c) case B

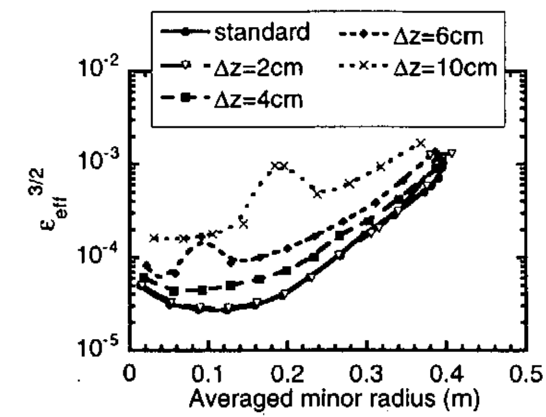

Fig.2 Profile of $\varepsilon_{eff}^{3/2}$ when the displacement of case A is assumed.

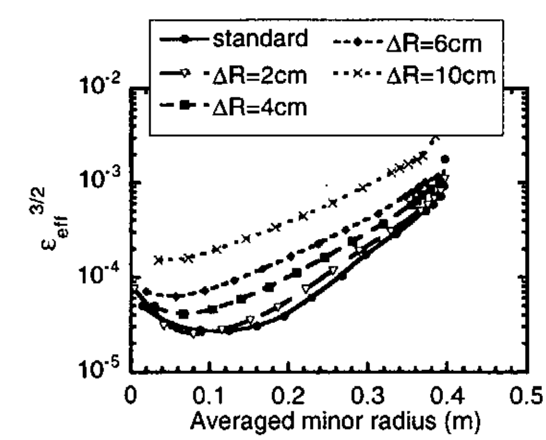

Fig.3 Profile of $\varepsilon_{eff}^{3/2}$ when the displacement of case B is assumed.

[1] Okamura, S., *et. al.*, Nucl. Fusion **41** (2001) 1865.
[2] Shimizu, A., *et. al.*, Fus. Eng. and Des. **65** (2003)109.
[3] Nemov, V., *et. al.*, Plasma Phys. Control. Fusion **45** (2003) 1829
[4] Isobe, M., *et. al.*, to be published in J. Plasma Fusion Res. SERIES (2004)