§14. Quasi-axisymmetric Stellarator (CHS-qa) with Reduced Shafranov Shift

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In the optimization procedure of designing a quasi-axisymmetric stellarator configuration, it is possible to include any physical characteristics by including the steps of evaluation for that quantity. The magnetic well depth has been used so far as a measure of MHD stability in the configuration design of CHS-qa. The evaluation of the ballooning stability is now included. The ballooning equation with the eikonal transformation is solved and the optimization is made to push away the second zero point of the solution to the positive infinity of the field line variable. Therefore the evaluation is for the high-n local ballooning mode. Although the local mode analysis can be made for any number of magnetic surfaces, single point in the radius is selected presently (r/a = 0.72) for the evaluation of the stability. The pressure profile is fixed as $(1+\Psi)^{1.5}$ in the optimization.

Three toroidal cross sections of magnetic surfaces with 3 % average beta are shown in Fig. 1. Clear differences between the boundary shapes of old and new configurations are the larger elongation and indentation in the ϕ = 0 cross section. More important improvement is the reduced Shafranov shift. The physical mechanism of the reduction of the Shafranov shift in Wendelstein VII-AS is the cancellation of the P-S current from the toroidal and helical curvature. Because there is no helical curvature in CHS-qa, another mechanism of reducing the Shafranov shift must be considered. The new configuration gives a stable 3 % beta equilibrium which was not possible for the old configuration because of the larger shift and the drop of the rotational transform which accompanies the large Shafranov shift.

Figure 2 shows the dependence of the Shafranov shift on the average beta for the new and old configurations. Relative positions of the magnetic axis between the inboard and outboard side positions of the boundary are plotted for two toroidal cross sections. The reduction of the Shafranov shift is clearer for the ϕ = 0 cross section where the shift for the 1 % average beta equivalent is reduced.

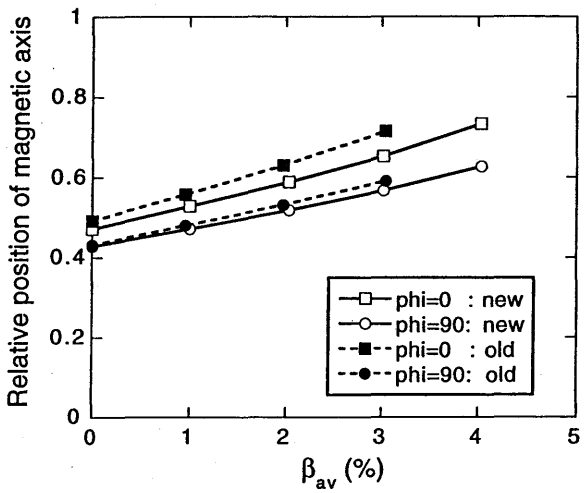

Fig. 2. Relative position of magnetic axis for two toroidal cross sections

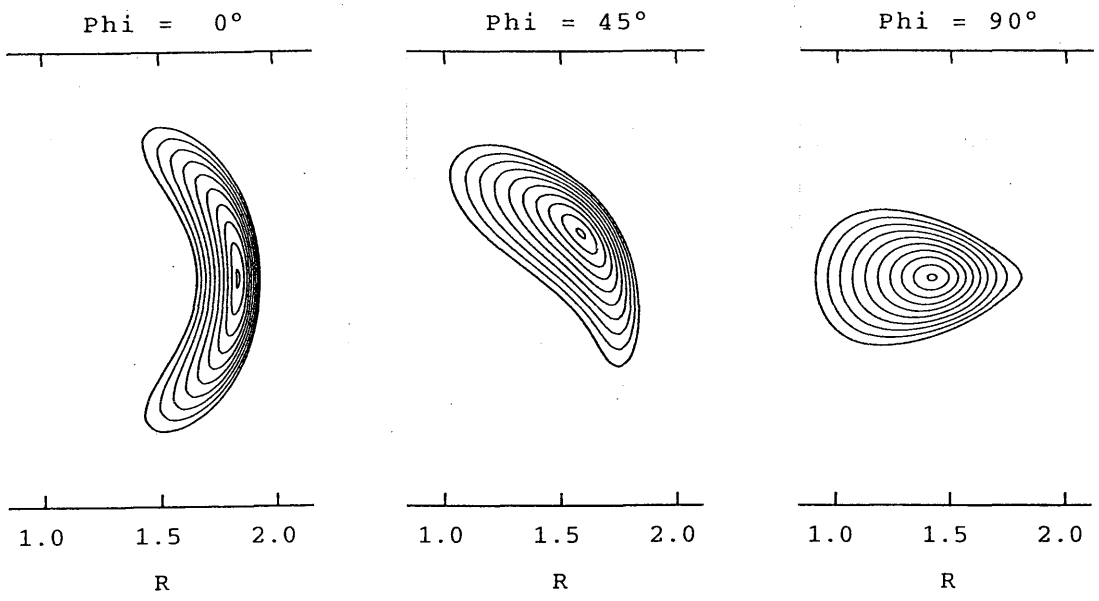

Fig. 1. Plasma cross sections of reduced Shafranov shift configuration with 3 % average beta