§9. Use of DKES Code III: Application to the LHD

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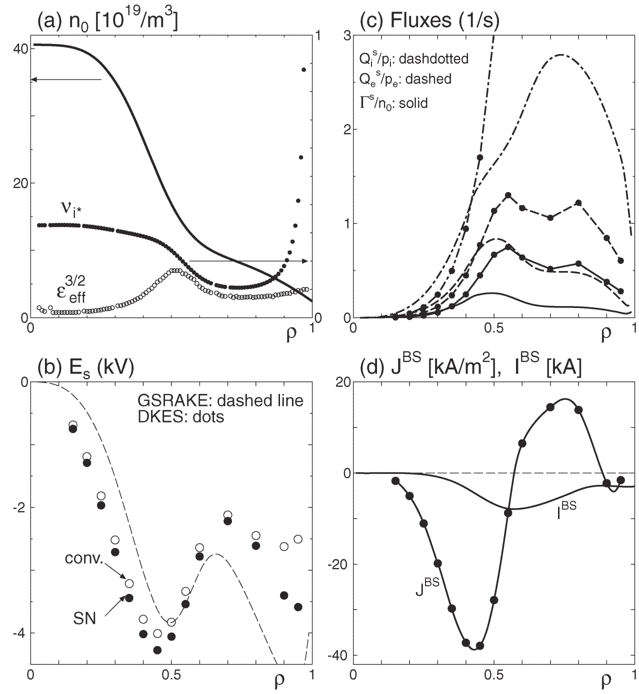
The DKES code [1] is applied to obtain the ambipolar radial fluxes, flows, currents, electric field, and in the SDC-IDB LHD plasmas, and the results are compared with the results by the GSRAKE code [2]. The assumed density profile is shown in Fig.(a), where $n(0)=4\times10^{21}/m^3$, $T/T(0)=1-\rho^4$ with $T(0)=0.8keV$, $B_0=2.5T$ so that $\beta(0) \sim 4\%$. These are used as inputs of the VMEC [3] to obtain the MHD equilibrium. In Fig.(a), the effective collision frequencies $\nu_{i*}/(v_{thi}/qR_0)$ and the effective asymmetric ripple $\varepsilon_{eff}^{3/2}$ are also shown. Due to the high density, the collisionarity is in the plateau regime in the entire radial region.

In Fig.(b), the ambipolar electric field of ion root is shown, obtained by DKES (marks) and GSRAKE (dashed line). Although the collisionarity is plateau, the electric field profiles are not so different. Since the GSRAKE assumes a few toroidal modes which are excited to be connected with the equilibrium B spectrum, so that the complicated B spectrum near the edge will make the difference large. Also two DKES results obtained by the conventional method (open) and S-N method [4] (closed) are shown. Here for the conventional method, D_{11} only is used for the energy integral. It can be seen that for the usual helical systems without symmetry, the E_s is not so strongly modified by the S-N method.

The particle and energy fluxes are plotted in Fig.(c). The results of DKES (lines with marks) are typically 2-3 times larger than those of GSRAKE (lines only). Thus it should be careful when the diffusion coefficients like χ, D is estimated from the fluxes simply. The ion energy flux is about 2-3 times larger than the electron energy flux, and this tendency is common for the DKES and GSRAKE. This can be explained such that the 1/ν contribution for ions is larger than that for electrons because of $\nu_{e*}/v_{the}\sim2\nu_{i*}/v_{thi}$. This indicates that the SDC-IDB plasmas are still strongly affected by the ripple transport despite the plateau regime. As a result, we can confirm that the neoclassical cross-field fluxes normalized by the density are not changed significantly when the temperature is fixed. From this, the neoclassical transport is expected to have no significant effects when the density increases while the temperature is fixed (or reduced), as in the pellet fueling phase. On the other hand, in the phase that the temperature is tried to increase, it is expected that both the temperature and the density will be deteriorated in the heat deposition region.

In Fig.(d), the bootstrap (BS) current density obtained self-consistently by the S-N method is shown. Corresponding current is of several kA, and this would be only small effects when recalculating the MHD equilibrium with the BS current. Since the current is in (env) dimension, this result for the SDC plasma would not be intuitive. This may be because the collisional friction (and viscosity) which enforces the parallel ion and electron flows to approach is stronger in the dense plasmas, and the mean velocity is reduced. It is noted that this is a result by not only the change of the forces, but both the calculated diffusion coefficient and the forces consistent with the MHD equilibrium in the S-N method.

In conclusion, the cross-field fluxes in the SDC plasmas factored by n and radial electric fields are as the same order as in the usual plasmas with comparable T, by the 1/ν contribution. The higher order BS current is relatively weak. The latter conclusion would be changed in case by case, and more detailed analysis will be needed.



1) S.P.Hirshman, K.C.Shaing, et al., Phys. Fluids **29**, 2951 (1986): W.I. van Rij and S.P.Hirshman, Phys. Fluids **3**, 563 (1989)
2) C.D.Beidler and W.D.D'haeseller, Plasma Phys. Control. Fusion **37**, 463 (1995)
3) S.P.Hirshman, Phys. Fluids **26**, 3553 (1983)
4) H.Sugama and S.Nishimura, Phys. Plasmas **9**, 4637 (2002)