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Comparison of bootstrap current calculation in helical plasmas among different types of approximations in drift-kinetic equation

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In toroidal plasma, neoclassical (NC) theory describes radial NC flux and the bootstrap current. The bootstrap current depends on Magnetohydrodynamics (MHD) equilibrium and collisionality. The bootstrap current is unessential for MHD equilibria of helical plasma. However, in high-beta and high-temperature plasma, the bootstrap current could be large enough to affect equilibrium field. Therefore, a self-consistent method is required to track MHD equilibrium and bootstrap current. For example, Wendelstein 7-X (W7-X) is optimized to have good MHD instabilities and low bootstrap current in order to improve NC confinement.[1] Here W7-X design fellowed the local NC code.[2] Conventionally, mono-energy and local approximation are employed to reduce computation time and resource. Here, "local" means neglecting the higher order magnetic drift terms in the drift-kinetic equation. The recent NC studies[3][4] indicate that conventional local approximations are deficient for some conditions in radial neoclassical transport. It shows that keeping tangential magnetic drift terms leads to large differences in the radial NC flux where $\mathbf{E}\times\mathbf{B}$ rotation is small. The tangential magnetic drift effect on bootstrap current is still an open question. This work performs the benchmark between conventional and new local code with the tangential magnetic drift and discusses its contribution on bootstrap current in LHD and W7-X.

References

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