Interactions between neoclassical effects and turbulence in toroidal momentum transport, and comparison between flux driven and gradient driven simulations

Y. Idomura

Japan Atomic Energy Agency, Kashiwa, Chiba 277-8587, Japan

In full-f gyrokinetic simulations, both turbulent/neoclassical transport and profile formations are self-consistently computed under fixed power, momentum, and particle inputs. By taking advantages of recent Peta-scale supercomputers, long time ITG turbulence simulations are performed, and the quantitative convergence of steady temperature and (intrinsic) rotation profiles is confirmed after an energy confinement time [1]. In the steady state, both heat and momentum fluxes exhibit active bursts propagating over significant radii. Even without momentum input, the steady turbulent momentum transport remains finite and produces non-diffusive fluxes depending on the radial electric field shear. In the steady state, the toroidal angular momentum conservation shows that the finite turbulent momentum flux is cancelled by the neoclassical (or magnetic drift induced) counterpart, which has not been considered in conventional delta-f approaches.

Another important difference between full-f and δf approaches is flux driven and gradient driven properties of turbulent heat transport. Earlier ρ^* scaling studies with fixed gradient simulations showed a transition from Bohm scaling to gyro-Bohm scaling in a local limit regime or $1/\rho^*>300$ [2]. From the viewpoint of power balance, Bohm scaling means increasing heating power with $1/\rho^*$, while gyro-Bohm scaling gives constant heating power regardless of ρ^*. However, it is well known that the tokamak confinement strongly depends on heating power, and therefore, the above ρ^* scaling argument may be implicitly affected by the power scaling. To clarify this point, systematic power scan is performed using full-f simulations, and the experimental power scaling of the energy confinement time is recovered. We then revisit the ρ^* scaling study with full-f simulations, where heating power is also scaled with $1/\rho^*$ [3]. In the ρ^* scan, the ion heat diffusivity shows the similar ρ^* dependency as Bohm scaling even in the local limit regime. Both the power scan and the ρ^* scan give similar T_i stiffness, which is produced by intermittent bursty transport [4]. These results show that the transport scaling in the local limit regime is strongly affected by the power degradation of confinement.

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