5D full-*f* gyrokinetic simulation with HPC infrastructures

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Gyrokinetic full-*f* simulation is considered to be an essential tool to study turbulent transport and profile evolutions self-consistently under the power balance between external source/sink. It directly solves the gyrokinetic Vlasov equation coupled with the field equation in 5D phase space so that the numerical cost becomes expensive, which requires sophisticated code development with high-efficient numerical algorithms and parallelization techniques with the aid of HPC infrastructures. Our full-*f* gyrokinetic code GKNET [1] has installed 3D MPI decomposition with communication and computation hiding optimization by OpenMP parallelization, however, it is necessary to do more improvement for larger-scale simulations, especially in the case with kinetic electrons [2, 3].

In this talk, we address our recent progress of numerical techniques to perform such larger-scale simulations. One is the implementation of field-aligned coordinate, which reduces the discretized mesh number along the magnetic field line while keeping numerical accuracy to reproduce ballooning-type ion-scale turbulence. Since the convergence for solving the field equation is also improved by introducing field-aligned coordinate, the total cost can be reduced by 1/4~1/8. The other is the GPU parallelization by using MARCONI 100. By installing the OpenACC parallelization and utilizing the asymptotic communication and calculation, the GPU acceleration efficiently works, reducing the total cost by 1/14.

As the achievement of large-scale simulation, we also report the spontaneous Internal Transport Barrier (ITB) formation in reversed magnetic shear plasmas. It is found that a strong mean E_r shear is formed near q_{min} region in flux-driven ITG turbulence, leading to spontaneous reduction of ion turbulent thermal diffusivity. In the presence of electron heating, a counter-intrinsic rotation by TEM turbulence is selectively driven in negative magnetic shear region, leading to steeper E_r shear and resultant larger reduction of ion turbulent thermal diffusivity. These results indicate that the co-existence of different modes can trigger the discontinuity near q_{min}, leading to spontaneous ITB formation.

References

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