§11. Gyrokinetic Simulations of Electromagnetic Plasma Turbulence

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In this project, we plan to perform simulation study using the electromagnetic gyrokinetics code `AstroGK`[1] to investigate energy conversion and transport mechanisms during magnetic reconnection. We have been studying the magnetic reconnection process of magnetized plasmas under the strong guide magnetic field, and have shown the significance of various kinetic effects on tearing instabilities[2] and plasma heating[3]. We will extend our study to include turbulence induced by external forces, inhomogeneity of background plasmas, or three-dimensional effects, and to elucidate effects of turbulence on magnetic reconnection and its energy conversion processes.

In this year, we have ported our `AstroGK` code on Plasma Simulator (PS), and have carried out performance test.

Since `AstroGK` has been tested on many supercomputers, the porting has been easily done. We have done i) the Fujitsu Fortran compiler support, ii) the SSL2 library support for the calculation of the special functions (e.g. Bessel functions), iii) installation of common libraries, such as FFTW2, NetCDF, and HDF5 with the support of the PS working group. The porting work has been verified by reproducing the past results. We note that the sister code `GS2`[4], mainly used for analyses of fusion plasmas having various magnetic configurations, becomes available on PS by this porting work.

The performance test result of `AstroGK` on PS is shown in Fig. 1. We used a magnetic reconnection simulation in the 4-dimensional phase space: 2 dimensions (N_x, N_y) in position space and 2 dimensions (N_λ, N_E) in velocity space. Two sets of the number of grid points are used: $(N_x, N_y, N_\lambda, N_E) = (256, 128, 64, 64)$ [small], $(256, 128, 128, 128)$ [large]. The graph shows calculation time per step for the fixed problem sizes against the number of cores [the strong scaling]. For comparison, we also show the same measurement result on Helios at IFERC-CSC, and Hyonosen at the University of Hyogo (decommissioned). Although the calculation speed of PS is slightly slower than that of Helios with less cores, PS shows better scalings at large number of cores than Helios.

We plan to continue this project for the next year. We will perform gyrokinetic simulation of magnetic reconnection using `AstroGK`, and also code improvement to obtain higher performance on PS.

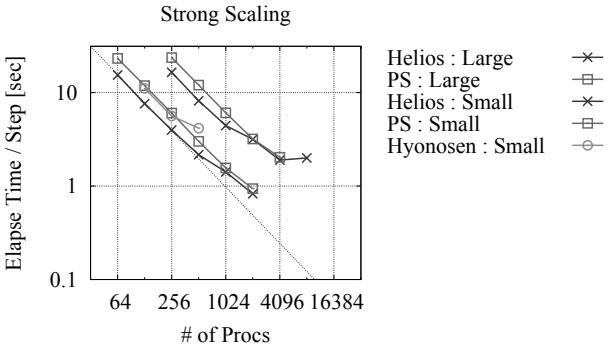

Fig. 1: Performance scaling of `AstroGK` at Plasma Simulator.

1) Numata, R. et al.: J. Comput. Phys. **229** (2010) 9347.

2) Numata, R. et al.: Phys. Plasmas **18** (2011) 112106.

3) Numata, R. and Loureiro, N. F.: J. Plasma Phys. **81** (2015) 305810201.

4) Kotschenreuther, M. et al.: Comput. Phys. Commun. **88** (1995) 128; Dorland, W. et al.: Phys. Rev. Lett. **85** (2000). 5579.