Magnetohydrodynamic modeling of space plasma processes

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Abstract

This project investigates basic processes in space plasmas, by using supercomputer simulations. In particular, we study “magnetic reconnection” in space, an abrupt change in magnetic topology. In order to support research activities by ourselves and by other groups, we develop massively-parallel simulation codes. They are publicly available on the Internet.

Ref. URL: http://th.nao.ac.jp/MEMBER/zenitani/openmhd-e.html

Reasons for using JSS2

Space plasma processes are basically described by magnetohydrodynamics (MHD) equations, which are notoriously complex. Supercomputer simulation is necessary to predict the nonlinear evolution of the system.

Achievements of the Year

We have studied basic properties of plasmoid-dominated turbulent reconnection in solar coronal conditions. By carrying out a series of large-scale magnetohydrodynamic (MHD) simulations, we have found that the energy consumption rate is faster than expected in high (magnetic) Reynolds number regimes for solar corona. We have also investigated influence of the flow shear in plasmoid-dominated reconnection [1].

We have renewed our simulation code. The latest code employs MPI nonblocking procedures in the halo communication and better domain decomposition methods. As a consequence, its strong-scaling efficiency is 94% for 5000 cores. We implemented an MPI-MPI hybrid parallelization code, but it has a problem in some situations. We are currently investigating this issue. The latest version of the MHD code is publicly available as a 2019 edition of “OpenMHD” code.

Publications

- Peer-reviewed papers

1) M. Hosseinpour, Y. Chen, and S. Zenitani, On the effect of parallel shear flow on the plasmoid instability, Physics of Plasmas, 25, 102117 (2018)

2) S. Zenitani and T. Umeda, On the Boris solver in particle-in-cell simulation, Physics of Plasmas, 25, 112110 (2018)

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	40 - 2000
Elapsed Time per Case	36 Hour (s)

Resources Used

Fraction of Usage in Total Resources[*1] (%): 0.06

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2] (%)
SORA-MA	555,906.29	0.07
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	67.29	0.07
/data	1,228.12	0.02
/ltmp	3,146.70	0.27

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage: Percentage of usage relative to each resource used in one year.