Numerical Plasma Simulation on Advanced Space Propulsion Systems

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Abstract

Due to the limitation of the existing spacecraft technology level, it is very difficult to enable solar system explorations in a quick and cost-effective mannger. Objective of this study is to obtain a breakthrough spacecraft propulsion technology that enables solar system exploration of the next generations.

Reasons and benefits of using JAXA Supercomputer System

Design optimization of spacecraft propulsion requires a huge computer resource, hence supercomputer usage is very important.

Achievements of the Year

Magnetoplasma Sail, MPS, is a space propulsion system using the interactions between the solar wind and the artificial magnetic field generated by the onboard coil. MPS performs magnetospheric inflation by the plasma injection. There are two mechanisms on the magnetospheric inflation: the effect of extending the magnetic field line due to the dynamic pressure and the effect of augmenting the magnetic moment due to the thermal pressure. We clarified the optimal injection plasma conditions considering the thermal and dynamic pressure. The thrust improved as the thermal pressure and the dynamic pressures increased, but the thrust gain was limited of 2.3. The reason why the thrust gain was limited was that when either the thermal or the dynamic pressure is superabundance, the magnetic sound wave increases and shock waves are formed in the magnetosphere, blocking the thrust transfer. The temperature and density of the injected plasma tend to increase the magnetic sound waves. As optimal conditions for plasma injection that could achieve high thrust, we proposed the low power conditions with low dynamic pressure, high density and low

temperature, or high specific impulse conditions with relatively high dynamic pressure, low temperature and low density.

Publications

- Non peer-reviewed papers

Yuki Murayama, Ryota Hara, Yoshiki Yamagiwa, Yuya Oshio, Hiroyuki Nishida, Ikkoh Funaki, Magnetohydrodynamic Analysis of Magnetoplasma Sail for Plasma Injection Angle considering Thermal Pressure and Dynamic Pressure, 33rd International Symposium on Space Technology and Science, ISTS-2022-b-42, Oita, Feb.-Mar. 2022.

Usage of JSS

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	1
Elapsed Time per Case	10 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.02

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	148,837.27	0.01
TOKI-ST	91,733.80	0.11
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	130.00	0.13
/data and /data2	800.00	0.01
/ssd	800.00	0.21

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.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage*2(%)
ISV Software Licenses (Total)	0.00	0.00

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