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.

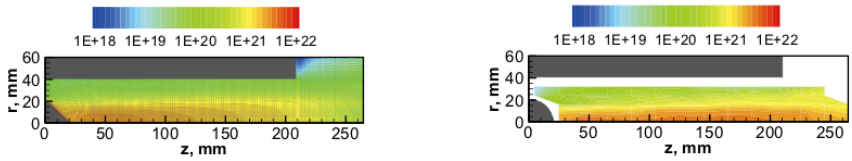
Reasons and benefits of using JAXA Supercomputer System

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

Achievements of the Year

For a self-field magnetoplasmadynamic (MPD) thruster, the numerical simulation was conducted to verify and validate the experimental result. The numerical simulation was performed at a discharge current of 9 kA for a hydrogen propellant (0.4 g/s). As a result, the numerical result was in good agreement qualitatively with the experimental result as shown in Fig. 1. Although this numerical simulation code has not been validated yet, it can be improved by incorporating with adequate electrode model.

In addition, magnetohydrodynamic analysis was performed on the magneto plasma sail to investigate the influence of plasma injection conditions on thrust characteristics. This year, we dealt with the magneto plasma sail in the case of performing the plasma injection which combined the dynamic pressure and the static pressure. As a result of numerical analysis, it was confirmed that the pressure condition (ratio between dynamic pressure and static pressure) of the injection plasma affected the thrust characteristics of the magneto plasma sail, and the thrust gain peaked. From this result, it was found that there was an optimal condition for the pressure condition of the injection plasma.



(a) numerical result (b) experimental result

Fig. 1: Electron number density inside MPD Arcjet, m3. (H2, 0.4 g/s, 9 kA)

Publications

- Non peer-reviewed papers

Shitan Tauchi, Yuya Oshio, Akira Kawasaki, and Ikkoh Funaki, Characterization of a Quasi-Steady Self-Field MPD Thruster with Various Electrode Configurations, AIAA-2020-0191, AIAA SciTech Forum, Jan. 2020, Orlando.

Usage of JSS2

Computational Information

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

Resources Used

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

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	172,259.24	0.02
SORA-PP	2,886.29	0.02
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	42.92	0.04
/data	429.15	0.01
/ltmp	8,789.07	0.75

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.