Research on plasma analysis method in electric propulsion

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Abstract

The objective of this study is to understand plasma physics phenomena in electric propulsion such as hollow cathode and MPD thruster. In order to investigate the distribution of plasma inside and outside the electric propulsion, which is difficult to measure with an electrostatic probe, the plasma flow inside and outside the electric propulsion device is analyzed by numerical simulation.

Reasons and benefits of using JAXA Supercomputer System

When analyzing the flow field in an electric propulsion thruster using the particle method, JSS3 enables us to perform the analysis under various conditions because of its very high computational power.

Achievements of the Year

Hollow cathodes have two operating states: spot mode, which is a stable operating state, and plume mode, which is an unstable operating state. In the plume mode, ionization instability causes discharge oscillations that adversely affect the operation of electric propulsion systems. In order to investigate the difference in plasma physics between the spot mode and the plume mode, the plasma flow inside and outside the hollow cathode was calculated using the hybrid-PIC method. The obtained plasma potential distribution is shown in (Fig.1). The plasma potential under the plume-mode-like operating condition were generally higher than those under the spot-mode-like operating condition, which was qualitatively consistent with the experimental trend.

In the numerical analysis of MPD thrusters, the plasma and neutral particles are conventionally treated as continuum. However, this method cannot capture the rapid increase in the Larmor radius of the ions due to the sudden decrease in the magnetic flux density. Therefore, we adopt the Hybrid-PIC method for numerical analysis. For the future particle method analysis of MPD thrusters, the DSMC method is applied to the arcjet thruster, which has many structural similarities with MPD thrusters and for which there are many known data. The validity of the

obtained results is verified by comparing them with experimental data.

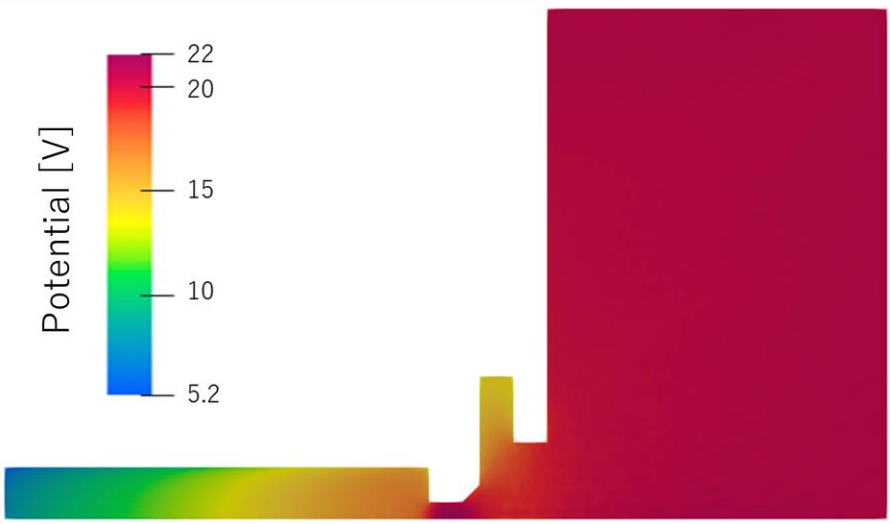

Fig. 1: Plasma potential distribution inside and outside the hollow cathode

Publications

- Oral Presentations

Ryohei Takagi, Kiyoshi Kinefuchi, Sinatora Cho, Hiroki Watanabe, Hybrid-PIC simulation of plasma plume in hollow cathode, The 67th Space Science and Technology Union Conference, Oct. 2023.

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	12
Elapsed Time per Case	24 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.01

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	0.00	0.00
TOKI-ST	70,285.23	0.08
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	1,020.00	0.85
/data and /data2	0.00	0.00
/ssd	0.00	0.00

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)	188.57	0.09

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