Numerical Study of Breakdown and Shock Wave Structures for Improvement of Flight Performance in a Beamed-Energy Vehicle

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Abstract

Propulsion performance of a beamed-energy vehicle is improved by reproducing breakdown physics and shock wave propagation induced inside a rocket nozzle.

Reasons for using of JSS2

We used JSS2 because computational costs for reproducing a multi-dimensional physics of the breakdown process and shock wave propagation inside the rocket nozzle of the beamed-energy vehicle were increased.

Achievements of the Year

A multi-dimensional breakdown structure was numerically reproduced when an external magnetic field was applied to the inside of the rocket nozzle, which indicated that the asymmetric plasma structure was induced because of the polarization drift. In addition, the open-front approach was proposed by equipping a butterfly valve on the nozzle front, which improved the propulsion and air-breathing performances of the beamed-energy vehicle by removing the expansion wave propagating inside the rocket nozzle.

Publications

- Peer-reviewed papers

1) M. Takahashi and N. Ohnishi, "Joule-Heating-Supported Plasma Filamentation and Branching During Subcritical Microwave Irradiation," AIP Advances, Vol. 7, 055206, 2017.
2) M. Takahashi, "Physics of Millimeter-Wave Discharge and Its Application to Microwave Rocket," Journal of Plasma Fusion Research, Vol. 93, No. 10, pp. 478-483, 2017.
3) M. Takahashi and K. Komurasaki, "Discharge from a High-Intensity Millimeter Wave Beam and Its Application to Propulsion," Advances in Physics: X, Vol. 3, Issue 1, 1417744, 2018.
4) M. Takahashi and N. Ohnishi, "Open-Front Approach a Microwave Rocket Sustained by a Resonant Magnetic Field," Journal of Propulsion and Power (accepted).
5) M. Takahashi and N. Ohnishi, "Postural Control for Beam-Riding Flight of a Microwave Rocket Using an External Magnetic Field," Transactions of the Japan Society for Aeronautical and Space Sciences, Aerospace Technology Japan (accepted).
6) M. Takahashi and N. Ohnishi, "Thrust-Performance Maximization of Microwave Rocket Sustained by Resonant Magnetic Field," Transactions of the Japan Society for Aeronautical and Space Sciences, Aerospace Technology Japan (accepted).
7) M. Takahashi and N. Ohnishi, "Gas-Species-Dependence of Microwave Plasma Propagating under External Magnetic Field," Journal of Applied Physics (under review).

- Non peer-reviewed papers

1) M. Takahashi and N. Ohnishi, "Numerical Modeling for Microwave Breakdown on a Beaming Rocket Supported by an External Magnetic Field," Proceedings of 10th International Workshop of Strong Microwaves and Terahertz Waves: Sources and Applications, A3.3, 2017.
2) M. Takahashi and N. Ohnishi, "Numerical Study for Interactions between Separation on Supersonic Flow and Laser-Induced Blast Wave," Proceedings of the 31st International Symposium on Shock Waves, SBM000130, 2017.
3) M. Takahashi and N. Ohnishi, "Two-Fluid Model Development for Magnetized Plasma Driven by an Intense Microwave Irradiation," Proceedings of Plasma Conference 2017, 21P-98, 2017.
4) M. Takahashi, T. Kogushi and N. Ohnishi, "Fluid-Orbit Coupling Calculation for Maintaining Stable Flight of a Laser Propulsion Vehicle," Proceedings of 3rd Symposium on SSPS, 2017.
5) M. Takahashi and N. Ohnishi, "Separation Control on an Airfoil Using Repetitive Laser Pulses,"AIAA Paper 2018-1430, 2018.
6) M. Takahashi, M. Myokan, Francesca Gnani, Henny Bottini, A. Iwakawa, N. Ohnishi and A. Sasoh, "Separation Control Using Repetitive Laser Pulses," Proceedings of Aerodynamics Symposium, 2L4, 2018.
7) M. Takahashi, M. Myokan, Francesca Gnani, Henny Bottini, A. Iwakawa, N. Ohnishi and A. Sasoh, "Separation Flow Control Using Blast Wave Propagation Induced by Repetitive Pulse Irradiation," Proceedings of Symposium on Shock Waves, 080, 2018.

- Presentations

1) M. Takahashi and N. Ohnishi, "Numerical Modeling for Microwave Breakdown on a Beaming Rocket Supported by an External Magnetic Field," 10th International Workshop of Strong Microwaves and Terahertz Waves: Sources and Applications, Nizhnij Novgorod, Russia, 2017.
2) M. Takahashi, "Examination of Microwave-Driven In-Tube Accelerator (MITA)," Seminar on Discharge Induced by High-Energy Electromagnetic Beam and Its Application, Rokkasyo Village, 2017.
3) M. Takahashi, T. Kogushi and N. Ohnishi, "Fluid-Orbit Coupling Calculation for Maintaining Stable Flight of a Laser Propulsion Vehicle," 3rd Symposium on SSPS, Tohoku University, 2017.
4) M. Takahashi and N. Ohnishi, "Separation Control on an Airfoil Using Repetitive Laser Pulses," 2018 AIAA Aerospace Sciences Meeting, Kissimmee, Florida, 2018.
5) M. Takahashi, M. Myokan, Francesca Gnani, Henny Bottini, A. Iwakawa, N. Ohnishi and A. Sasoh, "Separation Control Using Repetitive Laser Pulses," Aerodynamics Symposium, Tendo, 2018.
6) M. Takahashi, M. Myokan, Francesca Gnani, Henny Bottini, A. Iwakawa, N. Ohnishi and A. Sasoh, "Separation Flow Control Using Blast Wave Propagation Induced by Repetitive Pulse Irradiation," Symposium on Shock Waves, Tohoku University, 2018.

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	2 - 100
Elapsed Time per Case	50.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.11

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	869,058.46	0.12
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	476.84	0.33
/data	9,765.63	0.18
/ltmp	1,953.13	0.15

Archiver Resources		
Archiver System 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