Research on particle simulation methods

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Abstract

This research aims to acquire simulation technology using particle methods, known to be useful for simulating multi-physics phenomena, to accelerate aircraft development.

Reasons and benefits of using JAXA Supercomputer System

Using JSS3 was necessary because simulations that involve tens of millions of particles in a large computation domain consume a large amount of memory, which is not available on usual workstations.

Achievements of the Year

To understand and model the underlying physics of aircraft icing, we simulated the phenomenon of a single liquid droplet impinging to a solid object using the Moving Particle Simulation method. Particularly, we used JSS3 to conduct high resolution calculations in order to check the dependency of results on particle resolution. As a result, we found that droplet bounce in a room temperature condition and droplet adhesion to the solid in a supercooled condition were predictable at a relatively low resolution condition (approx. 30 thousand particles). Setting a higher resolution (approx. 2 million particles) enabled capturing local features such as wrinkles that appear on the droplet surface. In addition, we simulated icing on the leading edge of an aircraft main wing using tens of millions of particles and listed future research tasks necessary to improve physical fidelity and to lower computational cost.

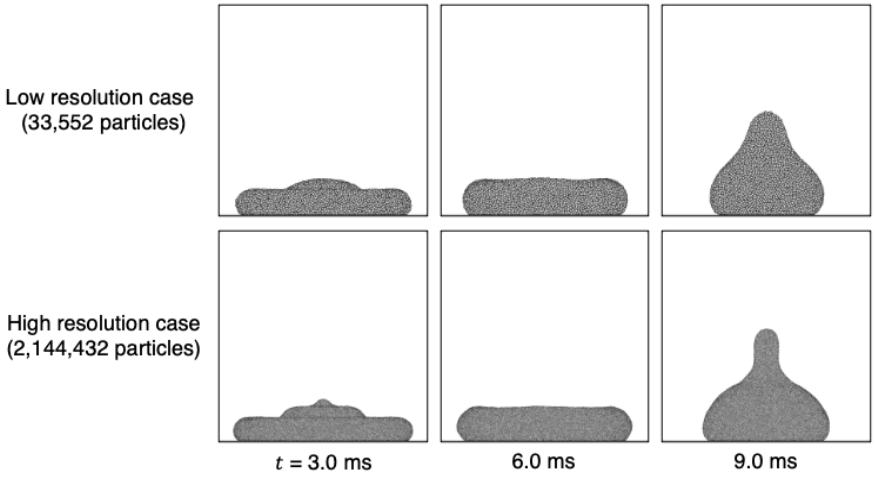

Fig. 1: Result of a droplet impingement simulation. JSS3 was used for the high resolution case.

Publications

- Oral Presentations

[1] Tsujimura, H., Kubota, K., Development of particle method tool for aircraft icing prediction and its validation through droplet freezing analysis, 42nd Aerospace Numerical Simulation Symposium, 3C07, 2024.

[2] Tsujimura, H., Kubota, K., Numerical analysis of droplet freezing on cold surfaces using the moving particle simulation method, 16th World Congress on Computational Mechanics, 2024.

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 2
Elapsed Time per Case	300 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	4.62	0.00
TOKI-ST	36,055.96	0.04
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	2,955.66	0.21
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	224.21	0.15
/data and /data2	6,860.43	0.03
/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)	187.68	0.13

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