Study of particle Mach number and temperature effects on shock-particle interaction

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Abstract

Compressible flow around particles placed in a flowfield is investigated by the direct numerical simulation of the Navier-Stokes equations at Reynolds number of O(10^2). The objective of the present study is to obtained fundamental insight into the effects of aerodynamic interference between particles in subsonic to supersonic flows. Influences of the aerodynamic interference on the lift, drag, and moment coefficients of the particles are determined, and the flow physics is investigated based on detailed information such as velocity and pressure distributions. The calculation condition is designed for conditions in which particles in a high-speed flow pass through shock waves, turbulence, and shear layer. In addition to the knowledge of high-speed flow around single particles obtained in our previous research, the aerodynamic interference between particles will be clarified to obtain fundamental knowledge for the high-fidelity modeling of compressible gas-particle flows.

Reasons and benefits of using JAXA Supercomputer System

In the present study, a parametric study by direct numerical simuation of the Navier-Stokes equations is conducted, and thus, a large-scale parallel calculation is required.

Achievements of the Year

The particle temperature and Mach number effects on drag coefficient in the shock-particle interaction process were investigated by direct numerical simulations and axisymmetric simulations of compressible Navier–Stokes equations. The particle Reynolds number was set to 300, and the particle Mach number and the particle temperature were varied. The isothermal condition or adiabatic condition was imposed on the particle surface. The results of three-dimensional simulations showed that the axial symmetry of flow field is preserved at least until t=7t_s. The drag coefficient obtained by the axisymmetric and three-dimensional simulations was approximately equal at least until t=7t_s. Influences of the particle temperature and the particle Mach number on the drag coefficient were elucidated by axisymmetric simulations under various conditions.

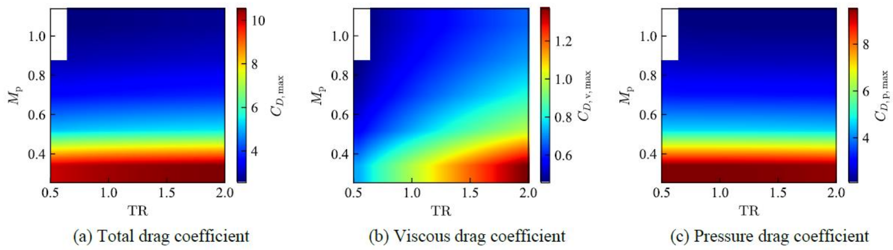

Fig. 1: Peak value of drag coefficient.

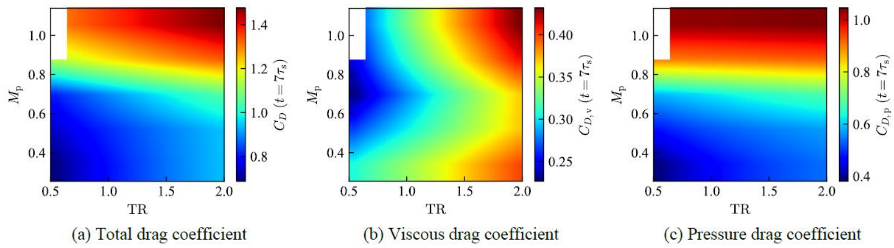

Fig. 2: Drag coefficient at t=7t_s.

- **Publications**

  N/A

- **Usage of JSS**

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	1 - 324
Elapsed Time per Case	20 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.04

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	1,018,753.07	0.05
TOKI-ST	0.00	0.00
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	54.45	0.04
/data and /data2	9,526.22	0.05
/ssd	0.00	0.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	17.95	0.06

[*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.