Study on fluid dynamic interference between particles in high-speed flows

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Abstract

Compressible flow around multiple 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 obtain 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, direct numerical simulations are conducted and a large-scale parallel calculation is required.

Achievements of the Year

This year, we prepared the CFD code based on the immersed boundary method to analyze the flow around multiple particles using level set function and ghost cell method. We generated an inequally spaced Cartesian grid and calculated that a normal shock wave passes through a field in which 100 stationary particles are arranged in an equally spaced grid region. The grid resolution was 10 points per particle, and the movement of particles due to fluid force was also taken into account. The density ratio of particles and fluid was set to unity, and the analysis was performed under conditions where particle motion is easy to occur. The figures show the density distribution at different times. The semitransparent isosurface corresponds to the shock wave front. The movement of particles and the flow around the particles interacting with the normal shock wave could be calculated.

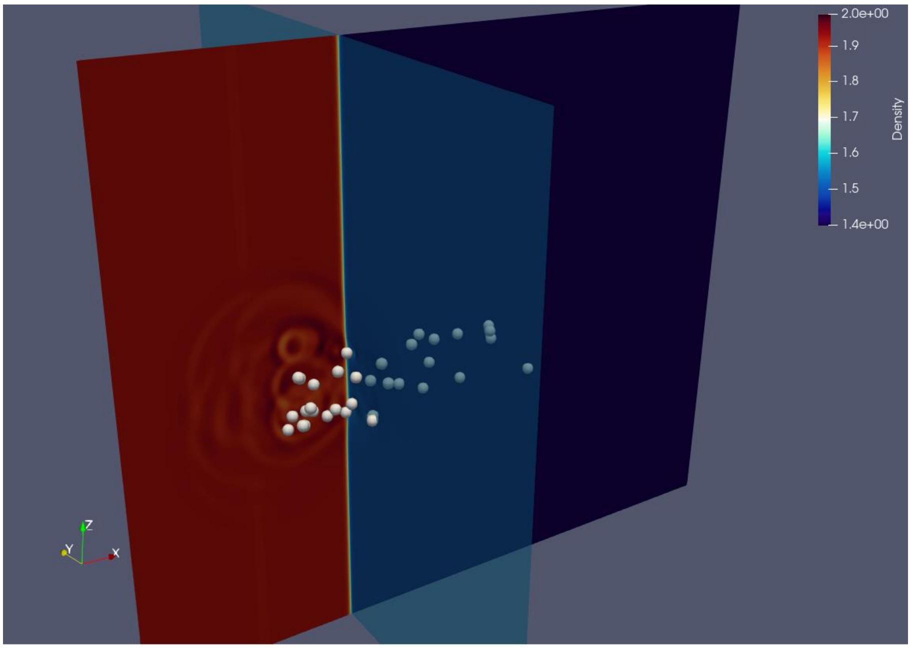

Fig. 1: Density distribution around particles interacting with a normal shock wave

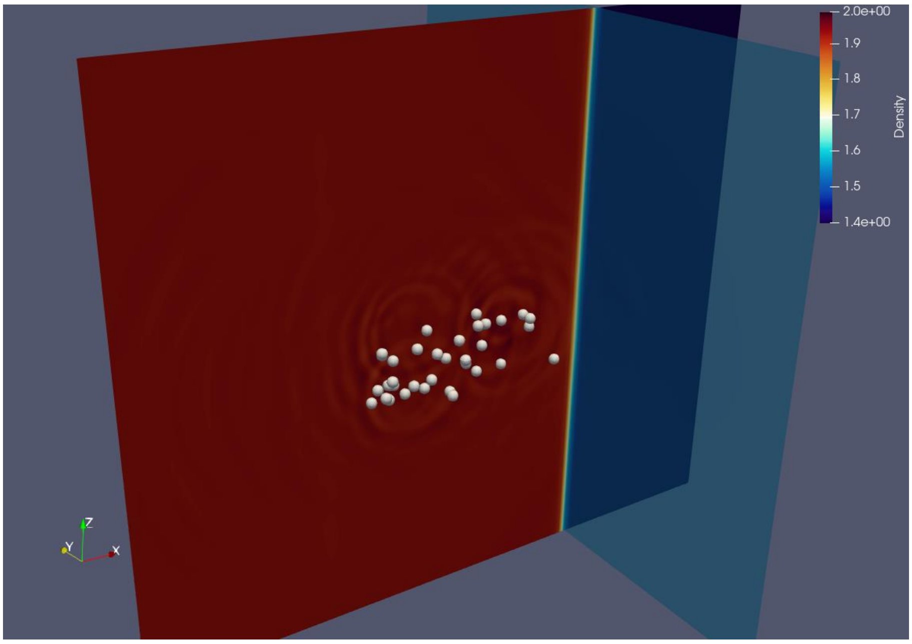

Fig. 2: Density distribution around particles interacting with a normal shock wave

Publications

N/A

Usage of JSS

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	8 - 143
Elapsed Time per Case	10 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources*1(%): 0.26

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage*2(%)
TOKI-SORA	7,007,238.75	0.32
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	0.05
/data and /data2	11,057.22	0.07
/ssd	0.00	0.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	20.55	0.07

[*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.