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

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Abstract

Compressible flow around twin particles 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

Due to aerodynamic interference between particles, the structure of the recirculation region and shock wave are changed significantly. In particular, in the case of a diagonal arrangement, one side of the downstream particles is strongly influenced by the upstream particles, and the asymmetry of the flow field is strong (Fig. 1). Figure 2 shows the apparent attractive and repulsive force coefficients. From the figure, the particles are attracted or separated due to aerodynamic interference,

depending on the relative angle of the particles. In addition, the effect of interference is small under low Mach number conditions, but the effect is strong under high Mach number conditions. In particular, in the case of an in-line arrangement, the apparent attractive force is tripled at the Mach number 0.95 compared to the case with the Mach number 0.3, and particles tend to strongly gather in the flow direction.

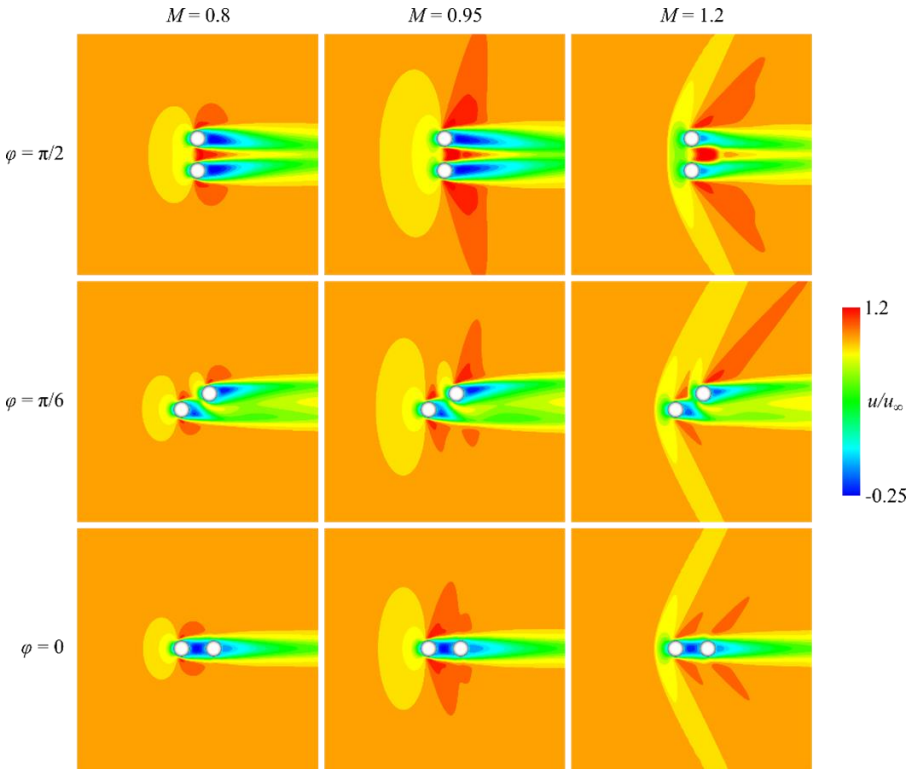

Fig. 1: Streamwise velocity distribution normalized by the streamwise velocity

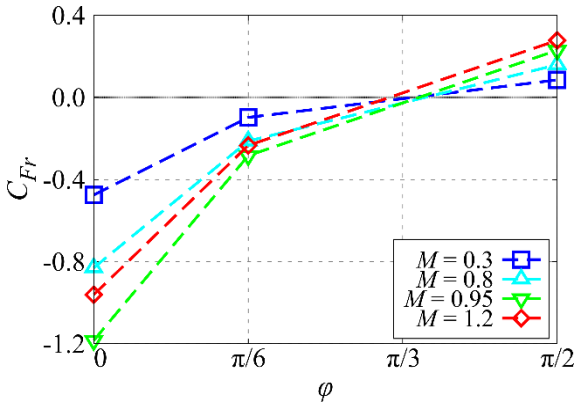

Fig. 2: Apparent attraction and repulsion forces acting between two particles

Publications

N/A

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	143 - 388
Elapsed Time per Case	200 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.30

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	7,167,970.09	0.35
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	52.50	0.05
/data and /data2	10,752.00	0.11
/ssd	35.00	0.01

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	22.95	0.16

*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.