Numerical Simulations of Fully Developed Turbulence

Report Number：R17EACA05
Subject Category：JSS2 Inter-University Research
URL：https://www.jss.jaxa.jp/ar/e2017/4404/

Responsible Representative

Susumu Goto, Graduate School of Engineering Science, Osaka University

Contact Information

Susumu Goto　goto@me.es.osaka-u.ac.jp

Members

Keita Hanajima, Susumu Goto, Ken Komoda, Jun Kanki, Yutaro Motoori

Abstract

In this project, we are revealing the universality in the statistics and dynamics of fully developed turbulence at sufficiently high Reynolds numbers. For this purpose, we conduct direct numerical simulations of turbulence under different boundary conditions so that we can investigate the small-scale university of the simulated turbulence. We conducted, in this year, the simulations of a turbulent boundary layer, turbulence in a rotating container, and turbulence in a periodic cube.

Reasons for using of JSS2

The main aim of the current study is to reveal the statistics and dynamics of fully developed turbulence. This is one of the most important subjects in aerospace engineering, and it is deeply related to projects in JAXA. In addition, the numerical simulations of turbulence at high Reynolds numbers require a supercomputer with sufficient memory and cores, we have considered the use of the JSS2.

Achievements of the Year

We have conducted direct numerical simulations of the turbulence in a periodic box, turbulence in a precessing container, a turbulent boundary layer; and we have investigated, in detail, the statistics and dynamics of the simulated turbulence. This year, in particular, we have obtained interesting results on the turbulent boundary layer. It is known that the hairpin-like vortices, which are observed (Fig. 1) in the low-Reynolds-number turbulent boundary layer, disappear in regions at higher-Reynolds numbers. Our numerical simulations reveal that the essential difference in the sustaining mechanics of small-scale vortices at low and high Reynolds numbers. This explains the disappearance of the hairpin-like vortices in high-Reynolds-number turbulent boundary layers.

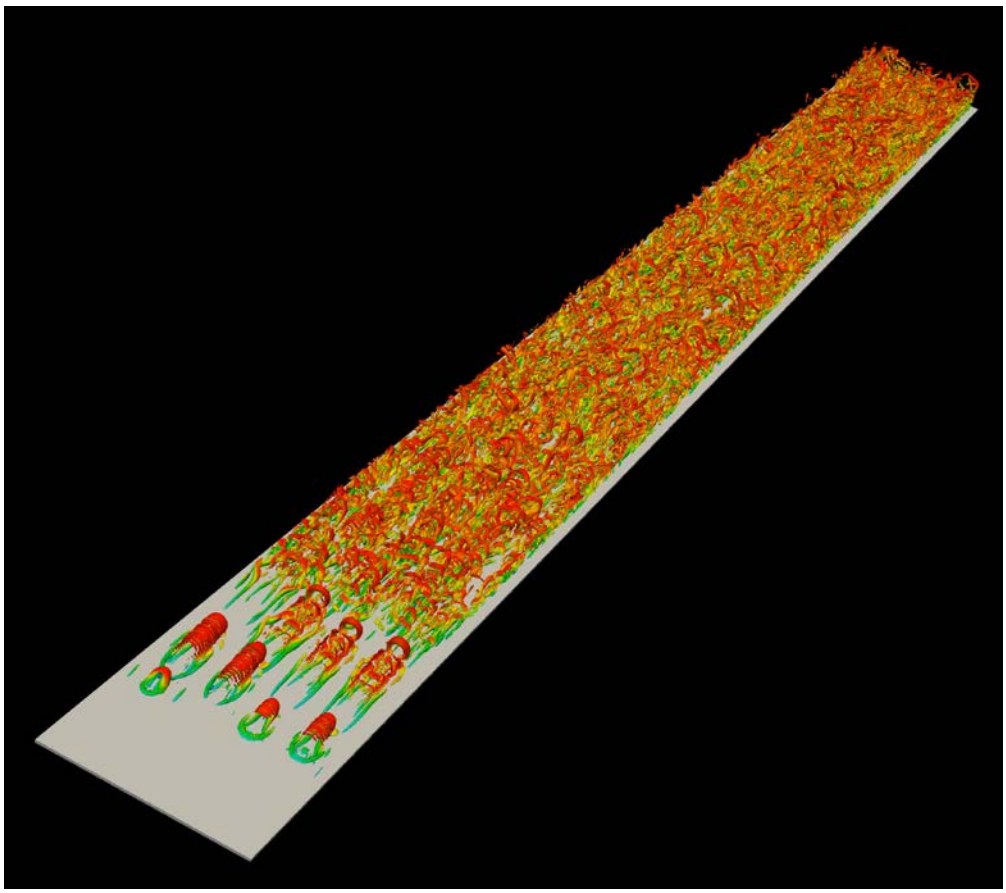

Fig.1 Hairpin-like vortices in a turbulent boundary layer at low Reynolds numbers.

Publications

- Peer-reviewed papers

1) Susumu Goto, Yuta Saito, Genta Kawahara, Hierarchy of antiparallel vortex tubes in spatially periodic turbulence at high Reynolds numbers, Phys. Rev. Fluids 2 (2017) 064603.
2) Yasufumi Horimoto, Susumu Goto, Sustaining mechanism of small-scale turbulent eddies in a precessing sphere, Phys. Rev. Fluids 2 (2017) 114603.
3) Yasufumi Horimoto, Gabriel Simonet-Davin, Atsushi Katayama, Susumu Goto, Impact of a small ellipticity on the sustainment condition of developed turbulence in a precessing spheroid, Phys. Rev. Fluids 3 (2018) in press.

- Oral Presentations

1) Susumu Goto, Lennaert van Veen, Statistics of Spatially-Periodic Turbulence Driven by Steady Forces (22nd May 2017, SIAM Conference on Applications of Dynamical Systems)
2) Susumu Goto, Hierarchy of vortices in turbulence at high Reynolds numbers (31st October 2017, OIST seminar)

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	16
Elapsed Time per Case	100.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.29

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	2,336,396.14	0.31
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	580.61	0.40
/data	10,337.83	0.19
/ltmp	13,671.88	1.03

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