Research Report（April, 2020- March, 2021）

Enrollment from April 2019 | Department of Applied Mechanics and Aerospace Engineering | Masahito WATANABE

I. List of Papers

[1] M. Watanabe, Y. Kitamura, N. Hatta, H. Yoshimura, ”Experimental Analysis of Lagrangian Coherent Structures and Chaotic Mixing in Rayleigh-Benard Convection”, Proc. ASME 2020 Fluids Engineering Division Summer Meeting, No. 20116, Orlando, USA (Online), July, 2020. (Selected as an ASME FED Graduate Student Scholar.)

II. List of Talks

[2] M. Watanabe, H. Yoshimura, ” Lagrangian Coherent Structures in Rayleigh-Benard Convection with Perturbations”, International Workshop on Multiphase Flows: Analysis, Modelling and Numerics, Waseda University, Tokyo, Japan (Online), December, 2020.

[3] M. Watanabe, Y. Kitamura, N. Hatta, R. Kamakura, H. Yoshimura, ”Lagrangian Coherent Structures and Lobe Dynamics in Perturbed Rayleigh-Benard Convection", JSIAM 2020 Annual Meeting, 359-360, Ehime University (Online), September, 2020 (in Japanese).

[4] M. Watanabe, Y. Kitamura, N. Hatta, R. Kamakura, H. Yoshimura, ”Experimental Analysis of Chaotic Transport and Lagrangian Coherent Structures in Rayleigh-Benard Convection”, JSME 2020 Annual Meeting, S05307, Nagoya University (Online), September, 2020 (in Japanese).

III. Research Results in AY2020

Rayleigh-Benard convection is typical natural convection that appears in a fluid layer with heated bottom and cooled top planes. When the Rayleigh number is set at a number above a critical one, the velocity field oscillates slightly. Even when the velocity field seems to be stable in such flow, some fluid particles may be transported chaotically. Solomon and Gollub (1988), and Camassa and Wiggins (1991) have modeled the convection as a two-dimensional Hamiltonian model with perturbations and investigated the chaotic mixing. However, the invariant structures in perturbed Rayleigh-Benard convection have not been experimentally clarified enough. Therefore, in AY2020, we have detected the invariant manifolds called the Lagrangian coherent structures (LCSs) from the two-dimensional velocity field obtained by Particle Image Velocimetry (PIV) and clarified the global structures of fluid transports.

IV. Research Plan for AY2021

Since the LCSs detected in experiments are partly different from those in the model proposed by Solomon and Gollub (1988), we will plan in AY2021 to propose a novel two-dimensional perturbed Hamiltonian model that elucidate the experimental results better. In addition, we will plan to investigate numerically and experimentally the variation of LCSs and periodic orbits in order to clarify the mechanism of how stable transports bifurcates to chaotic ones when the Rayleigh number is varied.