

## Research Report (April, 2020 – March, 2024)

In the **SGU** course of **Mathematical Physical Science: April 2020-March 2024**

Conferring university Waseda University	Degree name Doctor of Engineering (by completing a course)	Date of conferment March 15, 2024
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Enrollment from April 2020

Department of Applied Mechanics  
and Aerospace Engineering

Takahiro USHIOKU

### **I. List of Papers**

- [1] T. Ushioku and H. Yoshimura, Particle image velocimetry measurement of velocity fields surrounding cloud cavitation induced by submerged water-jet. (Accepted, peer-reviewed)
- [2] T. Ushioku and H. Yoshimura, Numerical investigation of cloud cavitation and its induced shock wave, Proc. ASME 2021 Fluid Engineering Division Summer Meeting, No. 65731, 9 pages, 2021. (Peer-reviewed)
- [3] T. Ushioku and H. Yoshimura, Numerical study of unsteady behavior of cloud cavitation by smoothed particle hydrodynamics, Proc. ASME 2020 Fluids Engineering Division Summer Meeting, No. 20117, 7 pages, 2020. (Peer-reviewed)
- [4] T. Ushioku and H. Yoshimura, Numerical analysis of cloud cavitation and induced shock waves by two-dimensional SPH method. (Under review)

### **II. Record of Awards**

- [5] ASME 2021 Fluids Engineering Division Summer Meeting, Best Presentation Award, November 2021.

### **III. List of Talks**

[International conference]

- [6] T. Ushioku, Unsteady behavior of cloud cavitation and its induced shock waves, International Workshop on Multiphase Flows: Analysis, Modeling and Numerics, Tokyo, Japan, December 2023.
- [7] T. Ushioku, Z. Liu and Y. Yoshimura, PIV measurement of velocity field of laser-induced cloud cavitation, AJKFED 2023, 2-04-1-03, Osaka, Japan, July 2023.
- [8] T. Ushioku and H. Yoshimura, Multiphase flow analysis of unsteady behavior of cloud cavitation by the smoothed particle hydrodynamics method, International Workshop on Multiphase Flows: Analysis, Modeling and Numerics, December 2020.
- [9] T. Ushioku, M. Kunishima, T. Imamura and H. Yoshimura, Experimental observations of single bubble dynamics and induced shock waves, Fourth International Conference on Recent Advances in Nonlinear Mechanics, 256–259, Lodz, Poland, May 2019. (Peer-reviewed)

[Domestic conference]

- [10] R. Kangyu, M. Yu, H. Kashiwabara, Y. Ryuzaki, T. Ushioku and H. Yoshimura, Variational formulation and numerical simulation of stochastic Rayleigh-Plesset equation, JSME Kanto branch 30th Meeting, 14F17, Waseda University, March 2024. (in Japanese)
- [11] T. Ushioku, H. Kashiwabara, M. Yu and H. Yoshimura, Observation and measurement of two-dimensional velocity fields induced by laser-induced cloud cavitation via particle image velocimetry, JSIAM 2023 Annual Meeting, J022-1, Tokyo Metropolitan University, September 2023. (in Japanese)

- [12]T. Ushioku and H. Yoshimura, Experiments and numerical analysis of rebounding behaviors of a laser-induced cloud cavitation, JSME Annual Meeting 2022, J023-01, Toyama University, September 2022. (in Japanese)
- [13]T. Ushioku and H. Yoshimura, Numerical investigation of shock wave phenomena associated with collapse of cloud cavitation by two-dimensional SPH method, JSIAM Annual Meeting 2021, G-2-1-4, Hokkaido University (Online), September 2022. (in Japanese)
- [14]T. Ushioku and H. Yoshimura, Numerical Analysis of Unsteady Behavior of Cloud Cavitation and Its Induced Shock Waves by Two-Dimensional Smoothed Particle Hydrodynamics Method, JSME Annual Meeting 2021, J022-09, Chiba University (Online), September 2021. (in Japanese)
- [15]T. Ushioku and H. Yoshimura, Numerical analysis of unsteady behavior of cloud cavitation based on two-phase mixture theory, JSIAM Annual Meeting 2021, G-2-1-4, Shibaura Institute of Technology (Online), September 2021. (in Japanese)
- [16]T. Ushioku and H. Yoshimura, Modeling and numerical simulation of single bubble dynamics and shock wave propagation, JSME Dynamics and Design Conference 2021, No. 142, Tokyo University (Online), September 2021. (in Japanese)
- [17]T. Ushioku and H. Yoshimura, Unsteady Behavior of Cloud Cavitation and Vortex Flow Structure Based on Mixture Model of Liquid and Gas, JSIAM Annual Meeting 2020, G-2-1-3, Ehime University (Online), September 2020. (in Japanese)
- [18]T. Ushioku and H. Yoshimura, Numerical analysis of unsteady phenomena of cloud cavitation by the two-dimensional smoothed particle hydrodynamics method, JSME Annual Meeting 2020, Nagoya University (Online), J024-09, September 2020. (in Japanese)
- [19]T. Ushioku and H. Yoshimura, Numerical analysis of two-dimensional flow in cloud cavitation by SPH method, JSME Kanto branch 26th Meeting, 17G14, Waseda University, March 2020. (in Japanese)
- [20]T. Ushioku and H. Yoshimura, Variational formulation of stochastic Rayleigh-Plesset equation and bifurcation analysis, JSIAM Annual Meeting 2018, 175–176, Nagoya University, September 2018. (in Japanese)

#### **IV. Research Results in AY 2023**

In AY2023, we have made an experimental measurement of velocity fields surrounding a cloud cavitation via Particle image velocimetry (PIV) method and an ultra-high-speed observation of shock waves in association with the cloud collapse. Then, we have found that flows of twin vortices are formed and move along the boundary of the cloud associated with its unsteady behavior. Furthermore, we have observed that weak pressure waves are emitted prior to the cloud collapse and multiple shock waves are generated when the cloud collapses. These experimental results show qualitatively good agreement with our previous multiphase flow analysis by using the SPH method.

#### **V. Summary (From April 2020 to May 2024)**

We have studied the unsteady behavior of cloud cavitation and its induced shock waves with great supports from this project. Unfortunately, I lost an opportunity to study abroad due to the COVID-19, while I gained valuable experiences through my presentations and discussion with other young researchers in international workshops and meetings held by this project. We greatly appreciate to professors, staffs and students involved in this project.