TUAT Fluid Dynamics Seminar

Interactions of cavitation bubbles with surface-attached bubbles, particles, and droplets

Lecturer:

Dr. Zibo Ren

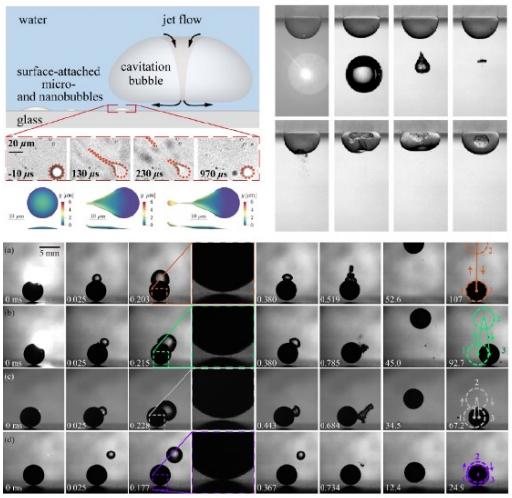
Date: Tuesday, 25th July, 2023

Time: 15:30 - 16:30

Place: Building 6 - Room201

Abstract

Cavitation near boundaries can cause severe damage to surfaces due to the existence of cavitation nuclei and contaminations like particles. It can also be harnessed in surface cleaning, emulsification, and medical treatment. This talk focuses on cavitation bubbles near rigid boundaries, investigating cavitation inception from surface-attached micro- and nanobubbles, and interactions between cavitation bubbles and surface-attached rigid particles or oil droplets. (i) First, we design experiments on cavitation inception from surface micro- and nanobubbles due to strong shear flows and strong ultrasonic fields, respectively. In response to strong shear flows, surface micro- and nanobubbles deform, pinch off, and release free gaseous nuclei. At a driving frequency of about 100 kHz, surface micro- and nanobubbles are observed to merge with ultrasonic cavitation bubbles and then detach from the substrate, thus becoming free gaseous nuclei. In summary, we prove that surface micro- and nanobubbles can evolve into free gaseous nuclei, which provides new ways to remove the attached gaseous bubbles from surfaces. (ii) Second, we find by experiments that laser-induced cavitation bubbles can accelerate spherical metal particles from surfaces. By theoretical analysis, we reveal that the lift forces on the particles are originated from the decelerating expansion of the cavitation bubbles. Our findings provide an invasive way to manipulate particles immersed in water. (iii) Finally, we find by experiments that laser-induced cavitation bubbles can interact with surface-attached hemispherical oil droplets in four typical ways: oil droplet rupture, water droplet entrapment in oil droplet, oil droplet large deformation, and oil droplet mild deformation. We successfully predict in theory the direction of the migration of the collapsing cavitation bubbles, and establish the phase diagram for oil droplet responses.



Biography

Zibo Ren received his bachelor degree (2018) and Ph.D. degree (2023) from the Department of Energy and Power Engineering, Tsinghua University. His Ph.D. thesis focuses mainly on experimental and theoretical investigations on cavitation inception from surface micro/nanobubbles, and cavitation bubble interactions with particles/droplets near solid boundaries. During his Ph.D., he has also participated in studies of bubble dynamics near complex geometries, and cavitation thermodynamics in Venturi flows. He has published his research works in Physical Review Letters (Editors' Suggestion), Physical Review Fluids, and Physics of Fluids (Editor's pick). His Ph.D. dissertation has been selected as one of the outstanding Ph.D. dissertations in Tsinghua University. He has also received awards such as NSK Sino-Japan Friendship Outstanding Paper Prize in 2022, and the Best Poster Award in JFM/FLOW Symposium China 2022. During his spare time, he likes reading and travelling.

Organized by: Prof.Y.Tagawa (tagawayo@cc.tuat.ac.jp)