



THE UNIVERSITY of EDINBURGH
School of Engineering

Institute for Multiscale Thermofluids Seminar Series

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Title: High-Speed Visualization and Modelling of Heat Transfer Dynamics in Complex Droplet Impact on Heated Surfaces

Abstract: Particle-laden droplet impact on heated surfaces is a complex thermo-fluid phenomenon involving strong coupling among droplet deformation, particle motion, phase change, and interfacial heat transfer. Understanding and quantifying these coupled dynamics is important for engineering applications such as additive manufacturing, spray coating, and spray cooling. In comparison with single-phase droplet impact, particle-laden droplets introduce additional governing factors, including particle size and particle volume fraction, together with conventional impact parameters such as the Weber and Reynolds numbers.

In this seminar, I will focus on ice-particle-laden droplets impacting heated surfaces. Such droplets can potentially enhance heat transfer through both the latent heat of melting and particle-induced disturbance of thermal boundary layers. However, direct quantification of the transient interfacial heat transfer during impact remains highly challenging. To address this issue, we developed a high-speed measurement technique that enables simultaneous measurement of interfacial temperature, interfacial heat flux, and droplet impact dynamics. The method employs an infrared (IR)-transparent substrate coated with an IR-opaque and emissive ITO layer, combined with a high-speed IR camera operating at 1,000 fps. Owing to the visible transparency of the substrate, high-speed visible imaging can also be performed simultaneously to capture droplet deformation and particle motion. I will present experimental results for ice-particle-laden droplet impact obtained under different Weber numbers, Reynolds numbers, and mixture compositions. In addition, I will discuss a modelling approach, based on the classical close-contact melting (CCM) theory, to interpret the local heat transfer beneath moving ice particles in the thin spreading liquid film after impact.

Speaker Bio: Dr. Takahiro Okabe is an Associate Professor at Hirosaki University, Japan, where he leads the Bioheat Laboratory as principal investigator. He received his Ph.D. from Tohoku University, Japan, in 2015. From 2015 to 2016, He was a JSPS postdoctoral research fellow in Japan. He then served as an Assistant Professor at Hirosaki University until 2021, and he has been an Associate Professor there since 2021. He has received various awards, including the JSME Young Engineers Award, the HTSJ Award for Young Researchers, the JSTP Young Scientist Award, and the JSME Award for Best Paper. His research focuses on fundamental issues in complex thermo-fluid phenomena, such as droplet impact on heated surfaces and heat transfer in biological tissues, through the development of advanced measurement methods, with applications in both medical and industrial technologies.