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Spatiotemporally-Resolved Multi-Field Measurements in Multiphase Flows with Phase Change

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Multiphase flows are encountered in diverse applications and across a wide range of scales. Despite the numerous and well-performed experimental investigations encountered in literature, only a limited number of studies have been performed specifically with a focus on the simultaneous spatiotemporal characteristics of the underlying physical processes in such flows; a limitation linked inherently to the many challenges that arise when performing these measurements. Two-phase flows, in particular, present the experimentalist with a unique set of characteristics, including restricted (often sub-mm) fluid domains, moving and complex interfaces, and phases with large density or refractive index changes that render the extraction of reliable information challenging.

Experimental techniques based on optical measurement principles have experienced significant growth recently. They can provide detailed information with high spatiotemporal resolution on important scalar (e.g., temperature, concentration, phase) and vector (e.g., velocity) fields in different flows, as well as interfacial characteristics. This has been instrumental to step-changes in our fundamental understanding of these flows, and to the development and validation of advanced models with ever-improving predictive accuracy and reliability. Relevant techniques rely upon optical methods such as direct photography, laser-induced fluorescence, laser Doppler velocimetry/phase Doppler anemometry, particle image/tracking velocimetry, and variants thereof.

In this talk, we will discuss recent progress in the development and application of a range of infrared, laser-based and other optical diagnostic techniques to multiphase flows in the presence of phase change, in particular flow boiling and freezing. We will cover the deployment of simultaneous techniques for the generation of multi-physics, multi-field and multi-scale information, discuss specific challenges faced when attempting to perform such measurements, and present a future outlook for these methods that will enable an increasingly complete fundamental understanding of relevant underlying phenomena, and the design of improved devices, technologies and systems.