NUCLEAR ENERGY UNIVERSITY PROGRAMS

Sharp Interface Tracking in Rotating Microflows of Solvent Extraction

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Abstract

The objective of this project is to develop a specialized sharp interface tracking simulation capability for predicting interaction of micron-sized drops and bubbles in rotating flows relevant to optimized design of contactor devices used in solvent extraction processes of spent nuclear fuel reprocessing. The primary outcomes of this project include the capability to resolve drops and bubbles micro-hydrodynamics in solvent extraction contactors, determining from first principles continuum fluid mechanics how micro-drops and bubbles interact with each other and the surrounding shearing fluid for realistic flows. In the near term, this effort will play a central role in providing parameters and insight into the flow dynamics of models that average over coarser scales, say at the millimeter unit length. In the longer term, it will prove to be the platform to conduct full-device, detailed simulations as parallel computing power reaches the exaflop level.

The team will develop an accurate simulation tool for flows containing interacting droplets and bubbles with sharp interfaces under conditions that mimic those found in realistic contactor operations. The main objective is to create an off-line simulation capability to model drop and bubble interactions in a domain representative of the averaged length scale. The technical approach is to combine robust interface tracking software, subgrid modeling, validation quality experiments, powerful computational hardware, and a team with simulation modeling, physical modeling and technology integration experience. Simulations will then fully resolve the microflow of drops and bubbles at the microsecond time scale. This approach is computationally intensive but very accurate in treating important coupled physical phenomena in the vicinity of interfaces. The method makes it possible to resolve spatial scales smaller than the typical distance between bubbles and to model some non-equilibrium thermodynamic features such as finite critical tension in cavitating liquids.