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TWO-PHASE FLOW REDUCED-ORDER MODEL WITH POLYDISPERSE OSCILLATING DROPLETS

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In the context of two-phase compressible flows involving both separated and dispersed phases i.e. spray of droplets, Direct Numerical Simulations (DNS) using an interface-tracking method are not tractable for industrial applications because of the multi-scale nature of the flow. Two-scale multi-fluid models with diffuse interface, amenable to realistic computational time, can be predictive for atomization, as long as they rely on the proper modeling of the small-scale interfacial dynamics below a given threshold.

From given large- and small-scale potential and kinetic energies, the Stationary Action Principle (SAP) and the second principle of thermodynamics [1, 2] provide a framework to derive well-posed models with coherent momentum and energy equations. Several works (see e.g. [3, 2]) also indicate that geometrical quantities such as interfacial area density or surface average of mean and Gauss curvatures are relevant to describe small-scale phenomena. Among them, the well-studied oscillation dynamics of droplets is strongly linked to these geometrical variables, and it is then a natural starting point for our model.

In this work we pursue the design of a small-scale flow model, extending [4, 2]. We first assess the relevance of a new set of geometrical variables through differential geometry and DNS with geometrical post-processing. Interpreting geometrical variables as moments of a statistical distribution of the droplets, we then propose monodisperse and polydisperse closures that provide small-scale energies. Finally, we derive a small-scale model with the SAP and second principle of thermodynamics.

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