SISMA

Séminaire Informatique Scientifique & Mathématiques Appliquées

A two-phase flow model with scale separation for the separated-to-disperse phase transition

Ward Haegeman (CMAP, ONERA)

Two-phase flows play an important role in a variety of industrial applications, such as the injection and atomization of liquid fuel in combustion chambers. The multi-scale nature of such flows makes the use of Direct Numerical Simulations prohibitive, as mesh convergence is out of reach. A large number of models for either separate or disperse regimes have been developed. As the atomization process is characterized by the transition and co-existence of different regimes, many efforts have been conducted to couple solvers originally tailored for a particular regime. However, the coupling terms often depend explicitly on mesh parameters and such approaches do not allow for a complete thermodynamic description which includes both scales.

In this presentation, a two-scale, compressible two-phase flow model with surface tension is presented. The model allows for a unified description of the separate interface and disperse phase regimes. The inter-scale mass transfer terms, activated when the local curvatures exceed a grid-independent length threshold, allow for a dissipative transition from one regime regime to the other through atomization. This mass transfer process accompanies a pressure relaxation towards a modified Laplace law such that local curvatures do not exceed the prescribed threshold. It leads to a local regularization of the large-scale interface.

The backbone of the model is derived through the use of Hamilton's Stationary Action Principle. The source terms are derived such that the inter-scale mass transfer is dissipative for the extended thermodynamics, which includes the surface energies at both scales. The potentialities of the proposed approach are demonstrated through a numerical proof of concept developed in the isothermal setting.