ON THE CONSERVATION OF ENERGY FOR INTERFACE-CAPTURING TECHNIQUES FOR MULTIPHASE FLOWS. APPLICATION TO FALLING FILMS.

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The simulation of falling films is a relevant problem of industrial and scientific interest. Their chaotic behavior presents a challenge to which the community has devoted many efforts. Among several possible approaches to multiphase flows, the use of interface capturing schemes is popular and amenable in modern computational architectures. In particular, the use of level-set techniques allows for a flawless treatment of topological changes [1], most notably in atomization processes.

The use of interface-capturing schemes involves an Eulerian frame which irretrievably clips the spectra of resolvable interfacial features. Such a limited resolution may break the imbalance between kinetic and surface energies. The aforementioned present a dynamic equilibrium which manifests itself trough the capillary force. While capillary force affects the velocity field trough the pressure jump, the induced transport of the marker may modify the surface morphology, ultimately modifying the curvature. The mathematical responsible of a such a subtle equilibrium is the first variation of area formula. This states that:

$$\frac{dS}{dt} = -\int_{\Gamma} \kappa \vec{u} \cdot \vec{n}_{\Gamma} dS, \tag{1}$$

where S corresponds with the interfacial surface, Γ states for the interface and κ is the curvature of such an interface. In the spirit of previous works [2], the inherent geometric structure of the underlying equations should be satisfied in order to attain a high level of fidelity of the numerical model. In this regard, the present work includes a novel method for the calculation of curvature that satisfies equation 1 at the discrete level, providing with high quality simulations.

The present work details the numerical simulation of a falling film with the novel energy preserving scheme. The results points to the diminishing of numerical oscillations. Examples are shown in Figure 1.

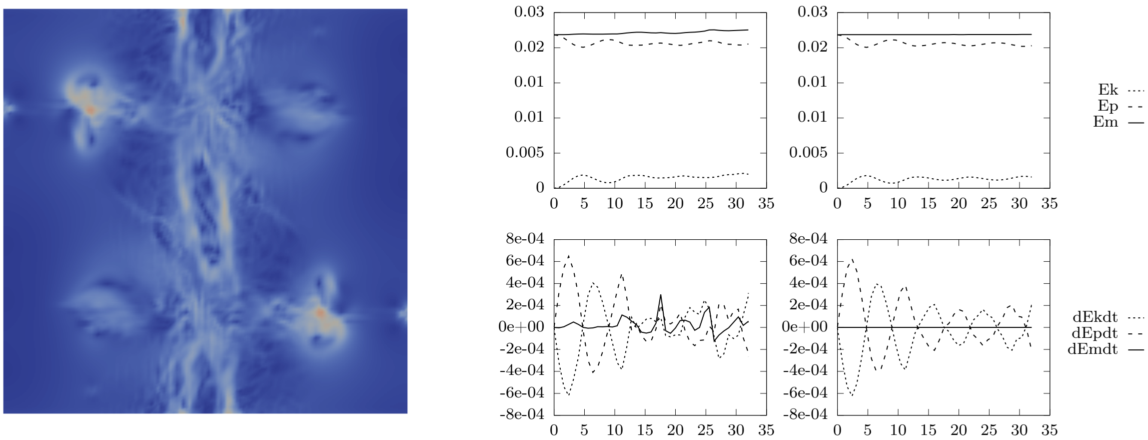

Figure 1. Left: Velocity magnitude for an oscillating film at $We = 100$ and $\rho_r = 1$ resolved with an energy-preserving scheme in a 128×128 mesh. Right: Evolution of kinetic, potential and total energy for the original curvature (left) and the proposed improved discretization (right).

References

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