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On the conservation of primary and secondary properties in the simulation of multiphase flows

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The simulation of multiphase flows is prone to numerical instabilities when high density ratios and/or surface tension are present. These complicate, and eventually impede, the simulation of industrially relevant flows.

However, since the physical system is stable, so should the discrete one. To accomplish stability of the discrete system, we mimic the key feature describing it in the physical one i.e.: we preserve mechanical energy at the discrete level. Building on top of our existing experience on the Direct Numerical Simulation of single-phase turbulent flows [1], we extend these ideas into multiphase flows. To do so, we adopt the Conservative Level Set [2] for representing the interface, and introduce new energy-preserving discretizations to both the convective [3] and the surface tension [4] terms.

As a result, the discretized system of equations is not only inherently stable, but is also equipped with the conservation of a secondary property (energy), which advances the physical reliability of the system. Interestingly enough, the conservation of linear momentum (a primary property) is achieved but for the surface tension term. Its impact on spurious currents is discussed as well.

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