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Derivation of a two-phase flow model accounting for surface tension

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We are interested in the derivation of a two-phase flow model that incorporates surface tension effects using Hamilton's principle of stationary action. The Lagrangian functional, which defines the action, consists of kinetic energy—accounting for interface characteristics—and potential energy.
A key feature of the model is the assumption that the interface separating the two phases possesses its own internal energy, which satisfies a Gibbs form that includes both surface tension and interfacial area. Consequently, surface tension is considered in both the kinetic and potential energy terms that define the Lagrangian functional.
Applying the stationary action principle leads to a set of PDE governing the dynamics of the two-phase flow. This includes evolution equations for the volume fraction and interfacial area, incorporating mechanical relaxation and surface tension terms.

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