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Direct numerical simulation of two-phase compressible flows with phase change

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The development of numerical solvers able to simulate compressible two-phase flows is still a great challenge in computational fluid dynamics. Numerical solvers for compressible flows, with an interface capturing approach, are mainly based on fully explicit shock-capturing methods. However, the drawback of these explicit approaches is the stringent time step constraint associated with the propagation of acoustic waves. As a consequence, these solvers are only efficient at high Mach numbers. A compressible numerical solver able to simulate two phase flows with phase change is presented. The solver is based on a complete entropic formulation of the Navier-Stokes equations, which are solved with an implicit projection method. The Van der Waals equation of state (EoS) is used to describe both phases. Moreover, an innovative splitting of the equations is proposed to correctly handle capillary effects.An original implicit formulation of the EoS allows to handle the heat term which appears in the energy equation which is implicitly discretized. Saturation conditions at the interface are imposed in terms of saturation temperature varying with the local thermodynamic pressure. The solver is suitable to treat low Mach number compressible flows since it is asymptotically preserving. The compressible solver proposed has many interesting features. It is able to describe acoustic waves, but it does not require to impose the stability constraint due to acoustic waves propagation. It is able to take into account the real gas effects and any EoS can be used, provided the sound speed can be computed. It is effective at low Mach number. Finally, this solver is suitable for liquid vapor phase changes (vaporization and condensation), induced either by temperature or pressure variations. In the present paper the solver is introduced. Specific attention is given to the implemented methodology to simulate phase change induced by pressure and temperature variations. Simple test cases are described in order to demonstrate the validity of the numerical simulations. These include flat liquid gas interface evolution and single bubbles growth and condensation under temperature and pressure gradients. The developed approach open the path to the simulation of a large number of multi-physical problems concerning two phase compressible flows, among witch bubble cavitation and liquid drop acoustic interactions.