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TOWARDS AN EFFICIENT SIMULATION OF CAVITATING FLOWS WITH REAL GAS EFFECTS AND UNCERTAINTY QUANTIFICATION

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Modeling two-phase flows is of primary importance for engineering applications. Two aspects are fundamental: (i) how to model the interface between two fluids with different thermodynamic properties and (ii) to characterize the mechanisms occurring at the interface as well as in zones where the volume fractions are not uniform.

Instead of the traditional approaches to multiphase modeling, where an averaged system of (ill-posed) partial differential equations (PDEs) discretized to form a numerical scheme are considered, the discrete equation method (DEM) results in well-posed hyperbolic systems. This allows a clear treatment of non-conservative terms (terms involving interfacial variables and volume fraction gradients) permitting the solution of interface problems without conservation errors. This method displays several advantages, such as an accurate computation of transient flows as the model is unconditionally hyperbolic, boundary conditions solved with a simple and accurate treatment, an accurate computation of non-equilibrium flows as well as flows evolving in partial or total equilibrium. With the DEM, each phase is compressible and behaves according to a convex equation of state (EOS). In many works of interface problem, the *Stiffened Gas* (SG) EOS was usually used [1, 2, 3]. As explained in Saurel *et al.* [2], this EOS allows an explicit mathematical calculations of important flow relation thanks to its simple analytical form. Moreover, in mass transfer problem it assures the positivity of speed of sound in the two-phase region, under the saturation curve.

When complex fluids are considered, such as cryogenic, molecularly complex and so on, the use of simplex EOS can produce imprecise estimation of the thermodynamic properties, thus deteriorating the accuracy of the prediction. Increasing the complexity of the model and calibrating the adding parameters with respect to the available experimental data constitutes a valid option for saving the good prediction of the model. Nevertheless, it could be very challenging because of the numerical difficulties for the implementation of more complex mathematical model and because of the large uncertainties that generally affected the experimental data. This amount of uncertainty should be taken into account for assessing the variability of the quantity of interest.

An effort for developing a more predictive tool for multiphase compressible flows is underway in Bacchus Team (INRIA-Bordeaux). Within this project, several advancements have been performed, *i.e.* considering a more complete systems of equations including viscosity [4], working on the thermodynamic modeling of complex fluids [6], and developing stochastic methods for uncertainty quantification in compressible flows [5].

The aim of this paper is to show how the numerical solver based on a DEM formulation has been modified for including a complex equation of state for the vapor region, and how the cavitation term can be treated when non-convex equations of state are used for describing the vapor region. Moreover, main uncertainties of the system will be identified and propagated through the numerical solver (by means of a non-intrusive stochastic method) for computing both some statistics of the numerical solution and the ranking of most important uncertainties.

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