High order moment methods and robust and accurate numerical schemes for the description of dispersed flows

This post-doctoral project relies on the extension of a hyperbolic two-fluid model to take into account the polydispersity of the dispersed phase using moment methods and the development of high order realizable schemes for its resolution.

Indeed, disperse multiphase flows, consisting of particles, droplets or bubbles into a fluid are encountered in many applications such as sprays arising from the fuel injection process in the combustion chambers of aeronautical and automobile combustion engines or bubble columns. Difficulties for modeling and simulating this flows comes from the development of hyperbolic two-fluid models for them [1], also taking into account their size distribution, and thus their polydispersion, which can have a strong influence on their behavior [2, 3].

With Prof. Rodney O. Fox of Iowa State University, we recently published [4] a hyperbolic two-fluid model for monodisperse multiphase flows. In principle, this model can be used to simulate multiphase flows involving gas bubbles in a liquid and heavy droplets in a gas, which covers the full range of density ratios needed for real-world applications. However, several additional modeling components and numerical developments will be required before our approach can reach its full potential. This will be pursue in collaboration with Rodney O. Fox.

In term of modeling, it will be necessary to extend the model in [4] to polydisperse multiphase flows. This step will utilize the conditional quadrature method of moments (CQMOM) [5]. In term of numerical developments, high order numerical schemes have to be developed, since for now, only first order numerical schemes were used for the model of [4]. A particular attention will be paid on the preservation of the realizability of the moments in the extended model, meaning that a set of non-linear constraints on moments have to be preserved to ensure that they are moments of a positive measure, i.e. the moment vector is in the moment space, as it was already done for the advection term in [6], even for moment vectors close to the boundary of the moment space.

The extension of the model will be implemented on the structured TITAN solver of EM2C to simulate a bubble column. Data from the DEBORA project [7] conducted by CEA-Grenoble will be used for validation.

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References


