An asymptotic preserving multidimensional ALE method for a system of two compressible flows coupled with friction

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ABSTRACT

In this paper, we present a multidimensional scheme to approximate solutions of two compressible inviscid fluids coupled with friction. This model is a simplified version of the Scannapieco-Cheng [1] model where only friction is considered. It can also be viewed as a simplification of the model proposed in [2] for which the electron effect is neglected or of the Baer-Nunziato model [3], neglecting the interfacial terms and in the case where there is no phase transition.

Our goal in this paper is to address two difficulties. First one is inherent to this kind of model and rely to the asymptotic preserving (AP) property [4] in the high friction regime or infinite friction regime. In the former regime, the fluids interpenetration follows a diffusion law. In the latter one, the mixture evolves as a single fluid. If no attention is paid to these regimes, the scheme will fail to capture it at a reasonable calculation cost. The second difficulty comes from the numerical framework we consider. We want our scheme to be able to deal with Arbitrary-Lagrange-Euler (ALE) frame and unstructured meshes in order to properly handle highly deformed calculation domains.

While authors propose an asymptotic discretization for this system in 1D in the Eulerian frame, no asymptotic preserving scheme has been yet published for 2D unstructured meshes for this model. The scheme presented in this work is split into two steps. In the first step we solve two Euler system of equations coupled by friction. Since each fluid has its own velocity, the Lagrangian mesh of each fluid will evolve separately during this step. Then, in the second step, the conservative variables vector of each of the fluid will be projected onto a common mesh (not necessarily identical to the initial mesh).

It is demonstrated, that the scheme we propose, preserves the properties of conservation, stability and consistency with respect to the continuous model for all regimes (independently of the value of the friction parameter). We describe our ALE strategy and propose several numerical problems (Sod shock tube, triple point and Rayleigh-Taylor) to asses the method. Some comparisons with a non-AP scheme are provided.

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