An extended multiphase model for conservative interface computation in hydrocodes, phases transitions, detonations waves, and fluid mixtures with internal degree of freedom.

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Abstract

We have developped in (Saurel & Abgrall (1999); Saurel & Metayer (2001); Abgrall & Saurel (2002)) a new approach for multiphase mixtures able to deal with non equilibrium effects. In particular it is able to deal with mixtures involving several velocities as well as with interface problems such as those considered in hydrocodes, where the interface conditions correspond to a unique velocity and pressure. The transition from multiple velocities to a single velocity at interface is an intrinsic feature of the model (Abgrall & Saurel (2002)). This model is unconditionnaly hyperbolic and is able to solve interface problems in a full conservative manner. No interface tracking or reconstruction is used. The same equations with the same numerical algorithm are solved everywhere.

Within this approach, the pure fluid equations are solved at the microscale so that local interface conditions are fulfilled. The discrete formulas are then averaged and provide the discrete model. In this paper we present the continuous limit of these discrete equations. It provides the averaged interfacial pressure and velocity as well as explicit formulas for the relaxation coefficients: "drag" force and pressure relaxation coefficient. For a given microstructure (or topology), the model is free of parameter and fulfills automatically the second law of thermodynamics.

In this context, detonation waves or phase transition waves can be solved in two ways. The first way is conventional and assumes that the decomposition rate is known (Chinnayya *et al.* (2002)). The second way consider that a kinetic relation is known for the front propagation. For detonation wave, the CJ (or extended CJ condition) is suitable. For evaporation waves similar conditions may be used. When the kinetic relation is known, the reactive Riemann problem is solved and embedded in the discrete multiphase model. Validations of this approach will be presented (LeMetayer *et al.* (2002)).

The multiphase model can also be extended to account for internal degree of freedom in each fluid: bubble pulsations (Gavrilyuk & Saurel (2002)) and rotation (turbulence). Doing so, the model involves three translational velocities (fluid 1, fluid 2 and interface), two rotational energies, and one vibrational velocity. The creation of rotation (turbulence) is determined by examining the entropy production. It is able to solve turbulence problem such as shock interaction with a gas bubble without using any adjustable

parameter (Saurel *et al.* (2002)).

References

Abgrall, R. & Saurel, R. 2002 Discrete equations for physical and numerical compressible multiphase mixtures. *Journal of Computational Physics* In revision.

Chinnayya, A., Daniel, E. & Saurel, R. 2002 Computation od detonation waves in heterogeneous energetic materials. *Journal of Computational Physics* In revision.

Gavrilyuk, S. & Saurel, R. 2002 A compressible multiphase flow model with microinertia. *Journal of Computational Physics* **175**, 326.

LeMetayer, O., Massoni, J. & Saurel, R. 2002 Modeling non equilibrium evaporation waves. *Journal of Computational Physics* In preparation.

Saurel, R. & Abgrall, R. 1999 A multiphase godunov method for compressible multifluid and multiphase flows. *Journal of Computational Physics* **150**, 425–467.

Saurel, R., Gavrilyuk, S. & Renaud, F. 2002 A multiphase model with internal degree of freedom: Application to shock bubble interaction. *Journal of Fluid Mechanics* Submitted.

Saurel, R. & Metayer, O. L. 2001 A multiphase model for compressible flows with interfaces, shocks, detonation waves and cavitation. *Journal of Fluid Mechanics* **431**, 239–271.