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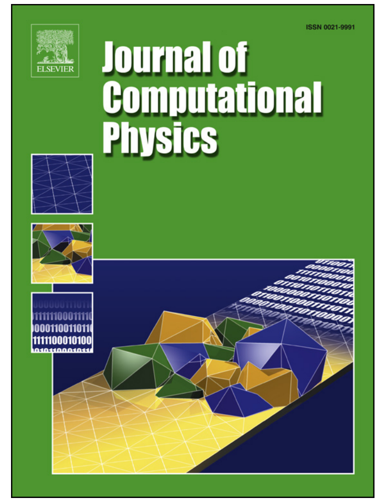

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Modeling hyperelasticity in non equilibrium multiphase flows

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Abstract

The aim of this article is the construction of a multiphase hyperelastic model. The Eulerian formulation of the hyperelasticity represents a system of 14 conservative partial differential equations submitted to stationary differential constraints. This model is constructed with an elegant approach where the specific energy is given in separable form. The system admits 14 eigenvalues with 7 characteristic eigenfields. The associated Riemann problem is not easy to solve because of the presence of 7 waves. The shear waves are very diffusive when dealing with the full system. In this paper, we use a splitting approach to solve the whole system using 3 sub-systems. This method reduces the diffusion of the shear waves while allowing to use a classical approximate Riemann solver. The multiphase model is obtained by adapting the discrete equations method. This approach involves an additional equation governing the evolution of a phase function relative to the presence of a phase in a cell. The system is integrated over a multiphase volume control. Finally, each phase admits its own equations system composed of three sub-systems. One and three dimensional test cases are presented.

Keywords: Hyperelasticity, Discrete Equation Method, Godunov type method

1 Introduction

Solid-fluid interaction in cases of extreme deformation occurs in many fundamental and industrial applications: hypervelocity impact on satellites, blast effects on structure... In such problems, high pressure and high density ratio are present at the level of interfaces. Works by [20], [1] and others, showed the attractiveness of the diffuse interface approach to model interface between ideal compressible fluids having different thermodynamic features. This kind of model is reminiscent of the multiphase flow model developed initially by [3] for the multi-velocity models or [18] and [19] for the one velocity models. Diffuse interfaces method presents several advantages compared to a direct coupling of models of homogeneous fluids through a sharp interface. Using this kind of multiphase flow models, the same equations are solved everywhere by using the same numerical scheme. This is achieved by considering a negligible quantity of other phases even in pure phase. With such an approach, there is no need of interface tracking or mesh distortion. This kind of model can describe the dynamic generation of new interfaces without having to re-mesh the domain, destroy or create cells. The main drawback of the Eulerian diffuse interface approach, compared to the Lagrangian formulation, is that the interfaces are not stiff. Indeed, the 'mixture cells' are always present at the vicinity of moving interfaces. The thickness of the 'mixture region' increases in time thus, depending on the treated problem, the method can only be used for short physical times.

This approach has been extended in [32] for the phase transition and in [9], [8], [27] for the interaction between elastoplastic solids and fluids dimension for a one-velocity model. Such one-velocity approach is

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