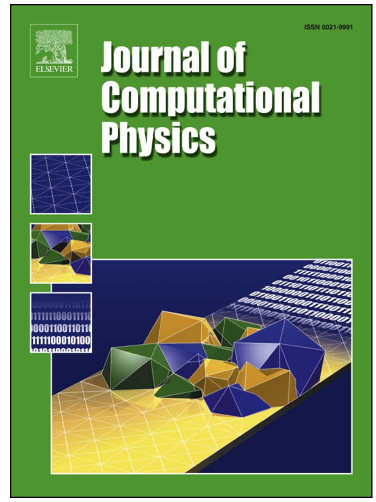

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A new nodal solver for the two dimensional Lagrangian hydrodynamics

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Abstract

We describe a cell-centered Godunov type scheme for the Lagrangian hydrodynamic equations on general unstructured meshes with nodal fluxes. The nodal solver only depends on the angular repartition of the physical variables around the node and not on the length of the edges. The scheme verifies a weak consistency property. Numerical results are compared to EUCCLHYD and GLACE schemes which are also cell-centered schemes with node based fluxes for Lagrangian hydrodynamics.

Keywords: Lagrangian scheme, Godunov scheme, Compressible gas dynamics

1. Introduction

Steam explosion is a fast vaporization of water leading to pressure shocks. This phenomenon is of interest in, for example, nuclear safety. Indeed, during a core-meltdown crisis, molten fuel rods interacting with water could lead to steam explosion. Consequently, we want to be able to evaluate the risks created by this phenomenon. A convenient way to do it is to simulate this phenomenon. In order to do it, one needs a multi-fluid model, and a numerical scheme. In this article, the model used is the Euler equations. These equations are used in a Lagrangian framework [3], which is convenient to compute multi-material flow. Indeed, it has the advantage of naturally capturing material interfaces contrary to the Eulerian framework. The considered model, can be written in an integral form on a domain moving with the fluid Ω_j

$$\begin{cases} \frac{d}{dt}\int_{\Omega_j(t)} \rho dV = 0, \\ \frac{d}{dt}\int_{\Omega_j(t)} \rho \mathbf{u} dV + \int_{S_j(t)} p\mathbf{n} dS = \mathbf{0}, \\ \frac{d}{dt}\int_{\Omega_j(t)} \rho E dV + \int_{S_j(t)} p\left(\mathbf{u},\mathbf{n}\right) dS = 0, \\ \frac{d}{dt}\int_{\Omega_j(t)} dV - \int_{S_j(t)} \left(\mathbf{u},\mathbf{n}\right) dS = 0, \end{cases} \tag{1}$$

where S_j is the boundary of Ω_j. The physical variables are the density ρ, the velocity $\mathbf{u}$, the total energy E and the pressure p. Note that the pressure is usually given by an equation of state depending on the internal energy $e = E - \frac{|\mathbf{u}|^2}{2}$ and the density.

Classically, staggered schemes with the idea of Von Neumann [27] are used to solve Lagrangian hydrodynamics. However these methods need the use of an artificial viscosity in order to capture shocks. We refer the reader interested by such methods to [3, 6, 28, 16] and their references.

Another possible approach is the use of finite element formulations. These methods won't be discussed here, and we refer the interested reader to [23] and the work done on high-order Lagrangian finite element methods for the BLAST code [12, 26].

We choose to study cell-centered Godunov type schemes for their natural good properties. Indeed such schemes are conservative, do not need the use of artificial viscosity to capture shocks and are naturally

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