Godunov-type schemes for Lagrangian hydrodynamics. Application to steam explosion.

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Steam explosion is a fast vaporization of a liquid leading to a pressure shock. This phenomenon is of interest in the nuclear safety field. During a core-meltdown crisis, molten fuel rods interacting with water could lead to a steam explosion. Consequently, we want to evaluate the risks created by this phenomenon. To do it we use Euler equations in a Lagrangian framework.

Our target is to develop a numerical scheme for the two dimensional Lagrangian hydrodynamics. We choose to use Godunov-type schemes which naturally captures shocks. Since we need to define node velocities in order to move the mesh, we use nodal fluxes. Therefore a nodal solver, which permits to compute node velocities and pressures, is needed. The development of such schemes has been initiated by Després and Mazeran with GLACE [1] and pursued by Maire and his collaborators with EUCCLHYD [2]. The nodal solvers of these schemes are multidimensional generalization of the one dimensional acoustic solver. However, both of them can give an incorrect direction of the velocity in the simple case of a one dimensional Riemann problem.

Consequently we develop a new nodal solver, using Després-Mazeran's ideas with a continuous point of view around the node. The nodal solver obtained is also a multidimensional generalization of the acoustic solver and only depends on the angular repartition of the physical data around the node. Hence it always recovers the right direction of the nodal velocity in the case of one dimensional Riemann problems. Then we compare the behavior of our scheme with GLACE and EUCCLHYD on several tests.

References

[1] Bruno Després and Constant Mazeran. Lagrangian gas dynamics in two dimensions and lagrangian systems. *Archive for Rational Mechanics and Analysis*, 178(3):327–372, 2005.

[2] Pierre-Henri Maire, Rémi Abgrall, Jérôme Breil, and Jean Ovadia. A cell-centered lagrangian scheme for two-dimensional compressible flow problems. *SIAM Journal on Scientific Computing*, 29(4):1781–1824, 2007.