The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

A new segregated-explicit staggered scheme for lagrangian hydrodynamics

N. Therme[1]

[1] CEA-CESTA, Le Barp, France, nicolas.therme@cea.fr

Keywords: *Finite Volume, Lagrangian hydrodynamics, Mimetic methods*

In the field of gas dynamics, the design of positivity-preserving numerical methods is of main importance. Indeed, negative pressure and density can lead to nonlinear instabilities and a crash of the code. From this perspective, we propose a new staggered numerical scheme to solve Lagrangian hydrodynamics. It is part of the staggered grid hydrodynamics (SGH), a class of numerical discretization inspired from the initial work of von Neumann and Richtmyer [1]. In SGH, all the thermodynamic variables of the fluid, such as density, pressure and internal energy are cell-centered, whereas the velocity is defined at the nodes of the mesh. The internal energy equation is discretized instead of the total energy equation.

To ensure the local mass, momentum and total energy conservations, a particular structure of the discrete div and grad operators derived from the framework of mimetic methods [2] is used. The dissipation of kinetic energy into internal energy through shock waves is ensured by means of an artificial viscosity added in the discrete momentum equation. Following the method used in [4, 3], the viscosity residual derived from the discrete kinetic energy equation is compensated with a positive source term in the internal energy balance. This makes the scheme consistent with the conservative system of Euler equations. Furthermore the discretization preserves by construction the convex admissible states under a CFL condition. Finally, we illustrate this theory with some numerical results.

REFERENCES

[1] J. von Neumann and R.D. Richtmyer, “A method for the numerical calculations of hydrodynamical shocks”, *IJ. Appl. Phys.*, 21, pp. 232–238, 1950.

[2] K. Lipnikov, G. Manzini, M. Shashkov, “Mimetic finite difference method”, *J. Comput. Phys.*, 257, pp. 1163–1227, 2014.

[3] L. Gastaldo, R. Herbin, J. C. Latché and N. Therme “A MUSCL-type segregated – explicit staggered scheme for the Euler equations.”, *Comput. Methods Appl. Mech. Engrg.*, 187, pp. 365–383, 2000.

[4] R. Herbin, J. C. Latché and T. T. Nguyen, “Consistent segregated staggered schemes with explicit steps for the isentropic and full Euler equations”, *ESAIM, Math. Model. Numer. Anal.*, 52, pp. 893–944, 2018.