A cell-centered implicit-explicit Lagrangian scheme for a unified model of nonlinear continuum mechanics on unstructured meshes

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34$^{\text{th}}$ Seminar on Computational Fluid Dynamics (Paris, January 2022)

A cell-centered implicit-explicit updated Lagrangian finite volume scheme on unstructured grids is proposed for a unified first-order hyperbolic formulation of continuum fluid and solid mechanics, namely the Godunov-Peshkov-Romenski (GPR) model. The scheme provably respects the stiff relaxation limits of the continuous model at the fully discrete level, thus it is asymptotic preserving. Furthermore, the GCL is satisfied by a compatible discretization that makes use of a nodal solver to compute vertex-based fluxes that are used both for the motion of the computational mesh as well as for the time evolution of the governing PDEs. Second order of accuracy in space is achieved using a TVD piecewise linear reconstruction, while an implicit-explicit (IMEX) Runge-Kutta time discretization allows the scheme to obtain higher accuracy also in time. Particular care is devoted to the design of a stiff ODE solver, based on approximate analytical solutions of the governing equations, that plays a crucial role when the visco-plastic limit of the model is approached. We demonstrate the accuracy and robustness of the scheme on a wide spectrum of material responses covered by the unified continuum model that includes inviscid hydrodynamics, viscous heat conducting fluids, elastic and elasto-plastic solids in multidimensional settings.

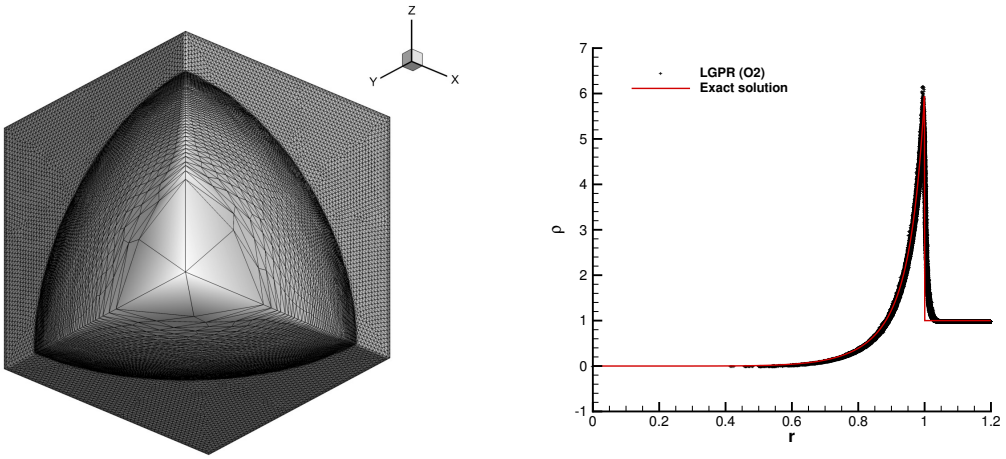

Figure 1: Blast problem. Mesh configuration (left) and scatter plot of cell density (right) at the final time $t = 1$ obtained with mesh size $h = 1/60$ in 3D.

References

[1] W. Boscheri, S. Chiocchetti, I. Peshkov. A cell-centered implicit-explicit Lagrangian scheme for a unified model of nonlinear continuum mechanics on unstructured meshes. *J. Comput. Physics*, accepted (2022).