

Semi-implicit numerical method for hyperbolic problems

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Numerical methods for fluid-structure interaction are used in many fields of application. In explicit methods, stability is ensured by the CFL criterion, which depends on the local sound velocity. This criterion severely penalizes the time step due to the large differences in wave velocities between fluids and solids. Similarly, implicit methods that do not use the CFL condition are very costly in terms of computation time due to the cost of inversion of the system matrix.

In this presentation, we focus on the implementation of a semi-implicit numerical method for this problem. The idea is to transform a system of nonlinear conservation laws into a linear system in which the nonlinearity is reflected in the source term using a relaxation method (kinetic scheme). Time integration is performed using the Deferred Correction method [3]. Abgrall and Torlo propose such a semi-implicit, matrix-free method of any order in [2, 1] in 1D on a uniform mesh. It enables a CFL condition of a few units to be achieved without having to invert any matrix. We will present two versions of the scheme (Finite Difference and Finite Volume) of arbitrarily high order on non-uniform 1D meshes. These schemes are stable and convergent, and we will present their properties on uniform and non-uniform meshes. We will apply this method to the hyperelasticity model and build its Lagrangian version in order to extend it to fluid-structure applications. The aim is to extend it to multi-D unstructured meshes.

- [1] R. Abgrall, D. Torlo. *High order asymptotic preserving deferred correction implicit-explicit schemes for kinetic models*. SIAM Journal on Scientific Computing, **42**, B816–B845, 2020. doi : 10.1137/19M128973X.
- [2] R. Abgrall, D. Torlo. *Some preliminary results on a high order asymptotic preserving computationally explicit kinetic scheme*. Communications in Mathematical Sciences, **20(2)**, 297–326, 2022. doi :10.4310/cms.2022.v20.n2.a1.
- [3] M. L. Minion. *Semi-implicit spectral deferred correction methods for ordinary differential equations*. Commun. Math. Sci., **1(3)**, 471–500, 2003.