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Asymptotic–preserving Deferred–Correction Residual–Distribution schemes

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In many models, such as kinetic models, multiphase flows, viscoelasticity or relaxing gas flows, hyperbolic systems with relaxation can occur. Stiff relaxation terms in these situations may produce spurious unphysical results. To deal with such small-scale parameter we should classically refine our discretization depending on relaxation parameter, and this is not always feasible. We present a high order scheme that can be used over the complete range of the relaxation parameter and, moreover, that can preserve the asymptotic limit of the physical model.

To deal with stiff terms, it is natural to use an implicit or semiimplicit formulation. To get a high order scheme, we recast a (DeC) Deferred Correction approach. This scheme is able to combine an explicit stable low-order scheme with a high order (even implicit or unstable) one, such as the pure formulation of Residual Distribution. The resulting method keeps the good properties from both schemes: stable and high order. The cost is just of a few intermediate steps. Thanks to this, we can produce a scheme which is fast and reliable.

The low order and the high order schemes, that we have used, come from the Residual Distribution (RD) framework. This class of schemes are finite element based, and all finite element, finite volume and discontinuous Galerkin schemes can be reinterpreted through it. The main idea is to compute residuals for each cell of the discretized domain, then to distribute each residual to degree of freedom of the cell. For the first order scheme we used an onlyflux residual distribution scheme with an implicit-explicit (IMEX) approach, which is stable but first order and too diffusive. In particular, we have used the kinetic relaxation model by Aregba-Driollet and Natalini. For the higher order scheme, we used a full spacetime residual distribution scheme.

We have tested some example with different schemes, reaching the asymptotic preserving properties and the correct order of convergence for 1D and 2D.

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