Distributed Implicit Discontinuous Galerkin MHD Solver

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Abstract

The discontinuous Galerkin method is a favorable alternative to the finite volume method, which is often used in astrophysical codes dealing with MHD. DG methods offer higher order accuracy and reduced diffusion compared to the finite volume method while keeping the scheme highly parallelizable. The MHD equations are nonlinear, therefore, we need to solve a nonlinear problem in each time step, which involves non-differentiable numerical fluxes (such as HLLD), so care must be taken when applying a nonlinear solver. We propose in this work using a damped nonlinear solver on each time step. Another complexity of solving MHD equations using DG is satisfying the Gauss's law of zero divergence of magnetic flux density, often achieved by techniques such as divergence cleaning, or Constrained-Transport. In this work, we chose another approach - using exactly divergence-free space for representation of the magnetic field. Another problem that requires handling is the presence of undershoots and overshoots in the DG solution - this is handled in this work by using the Vertex-based limiter. This work is being implemented using the FE libraries deal.II and Trilinos in 3D and fully parallel/distributed manner.

References

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