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Admissibility preserving Flux Reconstruction / Discontinuous Galerkin methods for compressible flows

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Discontinuous Galerkin (DG) / Flux Reconstruction (FR) methods are high order explicit finite element methods for solving advection dominated equations. They are very successful in obtaining reliable, small scale capturing methods that are arithmetically intense and thus suitable for modern memory bound HPC hardware. These methods have been used in various applications, including those involving numerical modelling of the atmosphere.

We will discuss a Lax-Wendroff Flux Reconstruction (LWFR) variant of the method which is arbitrary high order and advances time in a single stage, unlike the multi-stage Runge-Kutta (RK) methods. The single stage nature of the LWFR scheme minimizes inter-element communication, making the method more efficient than the standard RK methods. However, it loses out on admissibility preservation properties that are present in the standard Strong Stability Preserving (SSP) RK methods. Admissibility properties like positivity of density and pressure, entropy stability are crucial for the robustness and reliability of a numerical method. To that end, we present a novel subcell based shock capturing method that suppresses spurious oscillations for discontinuous solutions while also giving admissibility preservation. The idea of enforcing admissibility is to use a flux limiter which is interlaced within the face loops. The framework is also extended to handle source terms while maintaining high order accuracy and admissibility.

Several applications of the method like astrophysical jet flow and Kelvin-Helmholtz instability will be shown to demonstrate the accuracy and robustness of the method.

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