HiFi – implicit semi-structured spectral element code for multi-fluid applications.

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ABSTRACT

HiFi is a two- and three-dimensional implicit semi-structured high order finite (spectral) element code framework [1]. It is an open source project that is continuously improved and further developed, as well as extensively utilized, for magnetized fusion, solar physics and basic plasma physics applications in a collaboration between the U.S. Naval Research Laboratory and the University of Washington. The distinguishing capabilities of the code include fully 3D adaptive spectral element spatial representation with flexible multi-block geometry, highly parallelizable implicit time advance, and general flux-source form of the partial differential equations (PDEs) and boundary conditions that can be implemented in its framework. The multi-block spectral element spatial discretization used in HiFi allows for geometrically and topologically complex adaptive computational domains, while also providing simultaneous exponential spatial convergence and localization of the discretized differential operators. Non-linear 2^{nd}-order implicit time advance is implemented in HiFi using the PETSc [2] libraries for efficient parallelization and access to multiple iterative and direct linear solvers, including those in independently developed and linked libraries. This flexibility is expanded with further access to multiple generic and *in house* developed Schur-complement-based preconditioners.

In HiFi, these state-of-the-practice numerical techniques are combined with a user-friendly interface, which allows for simple specification of a diverse set of fluid-based PDEs to be solved within the framework. This is accomplished through the general flux-source form of the PDEs, as well as both explicit and flux-based boundary condition options, which are provided in a free-standing *physics* module that is separate from the main *solver* algorithm library. The HiFi framework has been extensively verified and used for simulations of various multi-fluid magnetohydrodynamic phenomena, including magnetic reconnection and relaxation and cylindrical tokamak sawtooth oscillations. Some of the recent HiFi applications and the latest status of the ongoing code development effort are to be discussed.

REFERENCES

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