High-order finite elements for multigroup multimaterial ALE radiation-hydrodynamics, electron-ion coupling, and TN burn in the BLAST code

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ABSTRACT

BLAST is an arbitrary Lagrangian-Eulerian (ALE) code based on high-order finite elements [1]. It performs multi-material simulations of compressible shock hydrodynamics and multigroup radiation diffusion. We present the overall discretization framework of the coupled multi-physics system, along with a detailed description of the latest BLAST functionality, namely, its electron-ion coupling and thermonuclear burn capabilities.

In space, the radiation hydrodynamics system is discretized by a mixture of high-order H^1 (mesh position, velocity), discontinuous L^2 (electron and ion energies, radiation energy) and H^{div} (radiation flux) finite element spaces. To discretize time, we derive an IMEX time integration scheme that blends explicit hydrodynamics and implicit radiation diffusion sub-steps. The TN burn terms are treated explicitly, while the electron-ion coupling term is treated implicitly.

Every implicit radiation diffusion step requires solving a nonlinear system. We perform a two-block overlapping Gauss-Seidel iteration. The first block couples the electron and ion energies to the radiation energy, and is solved locally on each element. The second block leads to a global H^{div} system which is solved independently for the radiation flux of every group, thus avoiding the global coupling between all radiation energy groups.

We present results on standard radiation diffusion benchmarks, followed by a more challenging ICF capsule simulation (originally proposed by R. Tipton, LLNL), where a four-pulse radiation temperature drive is used to compress a deuterium capsule.

REFERENCES

[1] R. Anderson, V. Dobrev, Tz. Kolev, R. Rieben and V. Tomov, *High-Order Multi-Material ALE Hydrodynamics*, SIAM J. Sci. Comp., Vol. 40(1), pp. B32-B58, (2018).

Performed under the auspices of the U.S. Department of Energy under Contract DE-AC52-07NA27344 (LLNL-ABS-765044)