High-order Finite Element Lagrangian Hydrodynamics with Radiation Diffusion

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ABSTRACT

Radiation hydrodynamics plays an important role in many physical systems, including for inertial confinement fusion experiments. In these systems, the amount of energy transported by thermal photons can become significant to the internal or kinetic energy of the material. This talk gives and overview of our recent research in Arbitrary Lagrangian-Eulerian (ALE) simulation methods for radiation hydrodynamics problems based on the combination of two high-order finite element discretization approaches: one for the hydrodynamics and another for the radiation part.

Our high-order hydrodynamics algorithm consists of alternating Lagrange and advection phases discretized with continuous and discontinuous Galerkin methods respectively on general curvilinear meshes. This approach [1,2], has shown significant improvements compared to low-order schemes, e.g in terms of symmetry preservation and sub-zonal shock resolution, and has been recently been extended to multi-material settings. Some of its features include: high-order continuous kinematic and discontinuous thermodynamic fields coupled with high-order explicit time integration, energy conservation on semi-discrete level, general curvilinear mesh optimization, several non-linear approaches for ensuring monotonicity during remap, and well-defined computational kernels suitable for modern computer architectures.

Parallel to the above ALE hydrodynamics algorithm, we consider two approaches for discretizing multigroup high-order radiation diffusion. The first one is a generalization of classical nodal methods, while the second one uses H(div)-conforming finite elements to match the centerings of the radiation energy density and hydrodynamics thermodynamic field unknowns. These approaches are also posed on general curvilinear grids, which is critical for symmetry preservation in axisymmetric computations [3].

In this presentation we will review the high-order hydrodynamic and radiation diffusion approaches and report some initial results in the coupling between the two. We will illustrate this with preliminary numerical results on model radiation hydrodynamics problems in our research code BLAST.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344, LLNL-ABS-662714.

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