Advanced Eulerian Hydrodynamics

We are investigating new approaches for Eulerian hydrodynamics for shock-physics simulations to improve performance, robustness and accuracy above current production capabilities. The materials of primary interest are materials with strength but, fluids can also be simulated. The Eulerian algorithms under investigation are not the traditional Lagrangian-Remap schemes, but primarily operate in the Eulerian reference frame. Current efforts for performance enhancement include cache-optimizing and cache-oblivious algorithms, and data structures for efficient computation and parallel communication.

Lagrangian-Remap algorithms have a common problem of dealing with cells that contain multiple materials and how to handle the thermodynamic state ("mixed-cell" problem) within the cell. We are using Ghost Fluid Methods (GFMs) to explore ways to handle the material interfaces without requiring the mixing of different materials. Through the use of level-set methods, material interfaces can be tracked within the computational domain, and provide a "sharp" boundary between different materials.

Eulerian algorithms have the issue of diffusing the solution during advection, which can cause unrealistic behavior, such as numerical healing when damage is advected. To handle this issue, we are exploring advecting particles through the domain. These particles would transport solution variables which need to be advected without numerical diffusion.