Abstract

We will present the results of several radiation-hydrodynamics simulations which model the aftermath of an exploding high yield (~300 MJ) indirect drive target in a xenon filled reactor chamber. The goal is to determine the radial extent to which debris from the target and hohlraum expands into the target chamber. The 3D radiation-hydrodynamics code Cooper has been used in two modes. First, 1D integrated simulations beginning from ignition until a time of 100 µs have been performed. Second, two-dimensional simulations model the growth of fluid instabilities as the target material expands into the xenon gas. These simulations are also used to investigate the early-time interaction between the burning target and hohlraum shortly after ignition.

The radiation hydrodynamics code Cooper was used for these simulations.

- Cooper is a 3D Lagrangian radiation-hydrodynamics code which operates on a structured tetrahedral mesh.
- Cooper uses compatible hydrodynamics to improve energy conservation.
- The edge-centered artificial viscosity is used to capture shocks and subsonic restoring forces are used to suppress anomalous grid distortion.
- Radiative transfer is modeled using multigroup diffusion theory.
- The results presented here used tabulated opacity generated by the IONMIX code.
- DT and Xenon are used in these simulations.
- The DT is modeled using a fully ionized ideal gas.
- The Xenon is modeled using an equation of state generated by the IONMIX code.

One dimensional simulation setup

- The 1D spherical mesh is divided into four regions as shown in the figure below.
  - The fuel region contains highly compressed DT and represents the implosion target.
  - The ablator region fills the rest of the hohlraum and contains DT at a much lower density and temperature.
  - The hohlraum is modeled as a 1 gram spherical shell at the solid density of gold. Because EOS and opacity data for gold are not available, the hohlraum is modeled using data for xenon.
  - The large chamber region surrounds the hohlraum and contains very low density xenon.
- Ignition is simulated by uniformly introducing 55 MJ of energy within the fuel region over 10 ps. The energy is evenly split between the ion and electron internal energy.

The hohlraum expands to a maximum radius of ~80 cm

- The hohlraum absorbs radiation, heats and expands.
- The inward moving hohlraum interacts with a strong shock launched from the fuel.

Early time two dimensional simulation setup

- Simulations are performed either with or without an LEH.
- The LEH is modeled using the same state-EOS as the hohlraum to prevent severe grid distortions. Moreover, the opacity of DT is used to make the LEH more transparent than the hohlraum.
- The hohlraum is given rounded corners to avoid zone tangling which occurs immediately shortly after the simulation begins.

Simulations without an LEH show the hohlraum expanding inward

- Early time simulations without an LEH model the first four nanoseconds.
- 2D simulations show that a strong shock wave launched from the fuel interacts with the inner hohlraum surface leading to severe grid distortions and mixing between the DT and the hohlraum.
- One-dimensional simulations show shocks to unphysically reflect off of the center.
- The 1D simulations show that the hohlraum expands to a radius where the hohlraum, fuel and ablator are mixed together.

Simulations are beginning using more accurate equations of state

- Cooper uses a tabulated EOS of state for xenon. The tables are generated using the IONMIX code.
- This EOS is not accurate especially in the high density hohlraum region since it uses an ideal gas model for the electrons.
- Future simulations will rely on equations of state generated by the newly developed BADGER code written by Todd Helverson (see NPS00101). This code uses a QEOS model that can accurately describe the high density conditions found in the hohlraum.
- An R-T plot of a 1D simulation using BADGER is shown to the right. Preliminary simulation results show not only a significant difference in the density profiles but also a substantial increase in energy loss.
- Additional simulations are needed to understand the behavior of the hohlraum/ablator interface.
- Future simulations will use an actual gold hohlraum since BADGER is capable of generating gold EOS data.

Future Work

- Cooper simulations of the LFE reactor are ongoing. Many of the future simulations will focus on modifying parameters to understand the effects described here.
  - The size of the LEH and material used to model it will be varied to see if there is an effect on the overall energy lost from the system.
  - Additional late time perturbation simulations will be performed with varying perturbation shapes.
- More advanced EOS tables will be used – including tables generated by the BADGER code.
- Additional modifications to Cooper will be made to improve simulation results.
  - A rezoner is currently being implemented. This will be necessary in the future to avoid grid tangling in 2D simulations.
  - Planned modifications to the code will lead to improved parallel performance.
  - Specialized 1D versions of hydrodynamic and diffusion solvers will be implemented to substantially speed-up 1D simulations.