Title: Simulations of the Radiation-flow Within a Silica-aerogel Target

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Description of the Experiment and Associated Calculations

We propose to field a series of experiments to study the flow of radiation through silica-aerogel targets. The soft x-rays are generated by the Z-machine at Sandia National Laboratories. We have completed simulations of the experiments using 2-D Lagrangian and Eulerian codes. The results of the calculations for one of the targets are presented here.
A Well-characterized Source of Soft X-rays

- The Z-Machine at Sandia National Laboratories produces a very bright (230 TW) and energetic (1.8 MJ) radiation source for physics experiments.

- The soft x-rays can be used to study a variety of issues related to the generation and transport of radiation as well as radiation-matter interactions.

- Temperatures as high as 230 eV can be used to drive experiments that are placed along the axis of the pinch (dynamic hohlraum configuration). Outside the pinch, peak drive temperatures of about 150 eV are obtained.
At the Z Facility, Energy Stored in a Capacitor Bank is Used to Drive the Implosion of a Cylindrical Single or Double Wire Array. Peak Currents of 20 MA Vaporize the Wires. The Resulting Plasma is Driven Inwards by \((J \times B)\) Forces.
The Plasma Collapses Inwards onto the Central Axis, With Part of the Kinetic Energy Being Converted into X-rays

Radially Inward Force ($\mathbf{J} \times \mathbf{B}$)

Thermalization and X-Ray Pulse
In the Dynamic Hohlraum Configuration, a Double-nested Wire Array is used. Experimental Targets Can be Placed Either Within or at One End of the Pinch (Where the Temperatures Are Over 200 eV).

Imploded Tungsten Pinch
~1-2 mm diameter

Viewing slots in stainless steel current return cage

Cathode

Anode/Cathode Gap

4 cm
In the Vacuum Hohlraum Configuration, a Single Cylindrical Wire Array is used. The Outer Current Return Can is Solid. Peak Temperatures within the Can Are About 150 eV.

The Relatively Large Size of the Vacuum Hohlraum Allows Us to Perform Several Experiments Simultaneously. In the Configuration Described Here, the Target Will be Mounted on One of the Apertures of This Hohlraum.
The wire array slides into the current return can.
Description of the Proposed Experiment

- The target for the first experiment in the series is a disk of SiO₂ foam. It will be placed against one of the apertures of the vacuum hohlraum. The aperture, which has a diameter of 4 mm, is covered by a 12 micron thick plastic foil (density = 1.1 g/cc).

- The diameter of the disk is 11 mm and it is 5mm thick. The density of the material is 25 mg/cc

- The radiation drive from the vacuum hohlraum has a peak temperature of 144 eV. The transport of the x-rays through the vacuum and the SiO₂ will be calculated and the results compared to data.

- The diagnostics fielded on the experiment will include x-ray diodes and a framing camera.
Proposed Experiment for the Z-Machine

- Gold
- Vacuum
- Burn-thru foil (12microns)
- Si Aerogel (25mg/cc)

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Temperature Drive for the Vacuum Hohlraum Experiment
Setup for Lagrangian Simulations

- CH Foil (12 microns thick)
- Oxygen (1.0e-4 g/cc)
- SiO2 (25 mg/cc)
- Gold

Materials

Grid

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The size of the Lagrangian mesh was 35x20 in this calculation. A temperature profile was used to drive the problem. The source region is indicated in blue (line source). The radiation–flow was calculated using multi–group implicit Monte–Carlo photonics. The results shown are for a million–particle run.
Radiation Temperature Contours in the Problem at the Peak of the Driving Temperature Profile. The Radiation Front Has Advanced to the Half-way Point in the SiO2 Target.
Radiation, Electron and Ion Temperatures Versus K–Lines at Time $T=80$ NS (Peak of the Temperature Drive)
At time $t=80\ \text{ns}$ (peak of the driving temperature profile), the radiation front has advanced halfway into the SiO$_2$ target. The radiation reaches the front surface of the target at about 103 ns after the beginning of the problem. The jitter evident in the two curves is due to the statistical nature of the Monte Carlo calculation.
At t=80 ns, the pressure front has advanced to approximately the half-way point into the SiO2 target. The front reaches the exposed surface of the target 23 ns later.
Sound Speed Versus K-Lines at Different Times
The Opacity of the Silicon Dioxide was Changed by +/- 10% 

The plot of radiation temperature versus k-line at 80 ns shows that the variations in opacity do not have a large effect on radiation flow through the target.
The experiment was simulated using a 2-D Eulerian code.

The temperature drive was the same as in the Lagrangian calculations. The geometry and material EOS's were also identical.

A 3-T gray diffusion radiation-flow model was used in the Eulerian simulations. Gray tabular opacities were used for these calculations, whereas the Lagrangian IMC photonics simulations utilized multigroup opacities.
Material Temperatures (KeV) at 85 NS

Lagrangian Simulation
(IMC photonics)

Eulerian Simulation
(3-T gray diffusion)

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Conclusions

- In spite of the differences in the radiation-hydrodynamic models, the Lagrangian and Eulerian calculations for the radiation-flow through the silica-aerogel target are in substantial agreement.

- The effects of varying the material properties of the target (e.g. changes in opacities) have been studied.

- Different target geometries for subsequent experiments are being explored.

- The goal of the project is to have consistent and reasonable models for the transport of radiation from the source and the interaction of the radiation with target materials.