LA-UR- 02-3017

Approved for public release;
distribution is unlimited.

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

Author(s): Joysree Aubrey, Blake Wood, Darrell Peterson and George Kyrala

Submitted to: ICOPS 2002

Los Alamos

NATIONAL LABORATORY

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

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

**Joysree Aubrey, Blake Wood,
Darrell Peterson and George Kyrala**

Los Alamos National Laboratory

**ICOPS 2002
May, 2002**

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 ($\mathbf{J} \times \mathbf{B}$) Forces.

The Plasma Collapses Inwards onto the Central Axis, With Part of the Kinetic Energy Being Converted into X-rays

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).

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 SiO_2 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 SiO_2 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

Temperature Drive for the Vacuum Hohlraum Experiment

Setup for Lagrangian Simulations

Radiation-flow Simulations Using a 2-D Lagrangian Code

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

```

* FOR PROBLEM 1
* FILE PCHP700R
* TIME 0.000374
* CYCLE 9963
* CODE VERSION
* PROBLEM NAME PCHP70
* PROBLEM NUMBER 1
* CONTOURS OF VARIABLE TR
* DATA RANGES FROM 1.0000E-06 TO 0.1301
* INTERVAL = 1.0000E-02
* A - 0.0000E+00
* B - 1.0000E-02
* C - 2.0000E-02
* D - 3.0000E-02
* E - 4.0000E-02
* F - 5.0000E-02
* G - 6.0000E-02
* H - 7.0000E-02
* I - 8.0000E-02
* J - 9.0000E-02
* K - 0.1000
* L - 0.1100
* M - 0.1200
* N - 0.1300
* O - 0.1400

```

Radiation, Electron and Ion Temperatures Versus K-Lines at Time T=80 NS (Peak of the Temperature Drive)

Radiation Temperature Versus K-Lines at Different Times

At time $t=80$ ns (peak of the driving temperature profile), the radiation front has advanced halfway into the SiO₂ 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.

Pressure Versus K-Lines at Different Times

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 $\pm 10\%$

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.

2-D Eulerian Calculations

- 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

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.