Planar Modeling of Target-Mount Perturbation Experiments on OMEGA using 3-D Ray Trace

Grayscale indicates laser intensity

Silk

Spider silk

$x(y(nm))$

$t = 30\,\text{ps}$

$t = 1400\,\text{ps}$

Mass density (g/cc)

3.0

2.6

2.2

1.8

1.4

1.0

0.6

0.2

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Summary

Shadowing and refraction of laser illumination by the ablating silk causes perturbations with length scales of up to 60 μm

- OMEGA cryo targets are suspended using up to four spider silks.
- Experiments placed silks on or above laser-driven planar targets to determine their effect on illumination uniformity.
- These experiments were simulated in planar geometry, modeling the finite-beam effects of the twelve laser port locations.
- Both simulation and experiment demonstrate that silks imprint large-scale perturbations.
Collaborators

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OMEGA cryogenic targets are suspended in the target chamber using four spider silks attached to a C-shaped mount.

- Silk-mounted targets have an ~140-\(\mu\)m region where the silk is adjacent to the target surface, with composition CH\(_9\)N\(_2\)O\(_{41}\) and \(\langle Z \rangle = 6.7\).

- Spider silks are typically composed of two entwined protein strands ~1 \(\mu\)m in diameter.
Target silks have been found to affect target performance in some experiments*

- Saturn**-target neutron yields are reduced when silks are added to the existing spoke target mounts.

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Spider silk shadowing and refraction reduce illumination uniformity

- As the silk ablates it generates a plasma that refracts laser light, casting shadows that imprint on the target

- Silk suspended 27 μm over the target surface
Planar experiments have been performed to measure the silks’ effect on target illumination

- The target was driven with a 2-ns square \(~400\text{-TW/cm}^2\) pulse
- Silks were suspended at 27 and 42 \(\mu\text{m}\) above the foil
- For comparison, one silk was placed on the target surface
Experiments show that shadowing induces mass modulations that grow in time

- An optical-depth variation of 1 corresponds to a $\sim 10\text{-}\mu\text{m}$ mass modulation
- Detector resolution is $\sim 20\ \mu\text{m}$

![Graphs showing relative optical-depth variation over distance for different times and conditions.](image-url)
Placing a silk on the foil produces a 50-μm perturbation

- The silk ablates within 100 ps, creating a high-Z plume, causing an illumination perturbation
- This seeds Rayleigh–Taylor growth, which eventually punctures the foil
A silk suspended 27 \( \mu m \) above the foil produces a 60-\( \mu m \) perturbation

- Shadows cast by the ablating silk cause the foil to puncture in two lines parallel to the silk
Future work

The effects of stalk target mounts will also be investigated

- These experiments also included stalks mounted on planar targets
- X-ray radiographs show hexagonal shadowing matching the beam geometry
- These will be modeled in 3-D planar geometry
Summary/Conclusions

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- Experiments placed silks on or above laser-driven planar targets to determine their effect on illumination uniformity.
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- Both simulation and experiment demonstrate that silks imprint large-scale perturbations.
The target-silk experiments have been simulated in full 3-D planar geometry

- Hydrodynamic symmetry is enforced parallel to the silk
- Simulations are performed in 3-D ray trace independently modeling each of the 12 OMEGA beams
- The 3-D ray trace uses a version of Kaiser’s\(^1\) method, with improved accuracy
  - a high-resolution orthogonal fine-scale mesh is overlaid on simulation
  - sub-zone integration is used to trace rays through the fine-scale mesh