Shock-Ignition Experiments on OMEGA at NIF-Relevant Intensities

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A new setup enables studies of shock-ignition at intensities of up to $1 \times 10^{16}$ W/cm$^2$ on OMEGA

- Shock ignition uses a highly shaped laser pulse with a trailing high intensity ($\sim 5 \times 10^{15}$ W/cm$^2$) spike
- Good coupling of the shock-beam energy was observed, leading to an $\sim 20\times$ increase in neutron yield.
- A significant Raman backscattering signal was observed with no indication of the two-plasmon-decay instability
- Up to 16% of the energy of the high intensity beams was converted into hot electrons of $\sim 45$ keV temperature
Collaborators


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Shock ignition requires $\sim 3.5 \times$ less energy to achieve marginal ignition than a conventional hot-spot isobaric target.

Marginal shock ignition (350 kJ)

Marginal conventional ignition (1.2 MJ)

Conventional hydro-equivalent marginal ignition

Laser–plasma interaction during the spike pulse and hot-electron generation are important issues for shock ignition.

Hot $e^-$ with Maxwellian $T_{\text{hot}} = 150$ keV, $E_{\text{hot}} = 17\%$ of spike energy, treated using a multigroup diffusion model.

*LILAC simulations by C. D. Zhou and R. Betti*
60 OMEGA beams are split into 40 low-intensity drive beams and 20 tightly focused, delayed beams.

Hydrodynamic performance, energy coupling, laser backscattering, and hot-electron generation are studied.

- The delay and intensity of the tightly focused beams are varied.
A significant amount of energy is coupled into the capsule by the high-intensity beams.

60 beam, 20.8 kJ uniform illum. N yield: $1.3 \times 10^{10}$

40 beam, 13.7 kJ nonuniform illum. N yield: $\sim 2 \times 10^8$

40 + 20 beam, 13.6 + 4.8 kJ = 18.4 kJ nonuniform illum. N yield: $3.7 \times 10^9$

- ~11% power imbalance
Up to 16% of the shock-beam energy is converted into hot electrons of 45-keV temperature.

- The neutron yield enhancement is most sensitive to shock-beam timing.
Up to 35% of the shock-beam laser energy is lost due to backscatter.

- No measurable signal of the 3/2 harmonic
- SRS dominates back reflection at highest intensity
- SBS reflection is relatively stable at ~10%
Experiments with repointed beams show reduced illumination nonuniformities and improved performance.

- ~2.6% power imbalance with repointed beams

**Calculated 40-beam drive power**

<table>
<thead>
<tr>
<th>Direct laser power deposited (TW/cm²)</th>
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- 40 beam, 13.5 kJ improved illum. N yield: $1.6 \times 10^9$
- 40 + 20 beam, $13.9 + 5.6 \text{ kJ} = 19.5 \text{ kJ}$ improved illum. N yield: $3.3 \times 10^9$

**X-ray pinhole images**

View 1

View 2
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