Simulation of Enhanced Neutron Production in OMEGA EP Cryogenic Implosions

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Summary

Interaction of the OMEGA EP beams with an imploding cryogenic capsule produces enhanced yield

- The OMEGA EP laser will add two short-pulse (2.5 kJ at 20 ps), high-intensity beams (>10^{19} \text{ W/cm}^2) to OMEGA to study the physics of fast ignition.

- A relativistic electron model had been added to the multidimensional hydrocode \textit{DRACO}.

- Stagnation is modified by shocks driven by the electron-heated, high-density shell, depending on the timing of the beam:
  - an extra “spherical” kick at time of low shell $\rho R (<0.3 \text{ g/cm}^2)$
  - one-sided displacement at peak shell $\rho R (>0.4 \text{ g/cm}^2)$

- The total DT yield reaches $3 \times 10^{15}$, permitting the development of near-ignition neutron diagnostics for the NIF.
A direct-drive target was designed at OMEGA energy (25 kJ) to give > 300 g/cm³ densities.
Fast-ignitor mass densities are reached in 1-D simulation

A 1-MeV electron has a range of about 0.4 g/cm².
Simulations were carried out with a 20-ps, 1-MeV electron beam with total energies of 400 J and 1 kJ.

- Electrons are instantaneously transported in a straight line through the target.
- They give their energy to the background electrons using a penetration depth formulation applied in each zone.

![Diagram of electron beam interaction](image-url)
At the low density (250 g/cm$^3$) the ignitor beam heats equally both sides of the core.
At the peak of the density (500 g/cm$^3$) the ignitor beam heats mostly one side of the target.
Timing the electron beam at the time of peak shell density produces a higher yield. The increased neutron rate can be easily diagnosed.

- For 1 kJ, $Y = 3.2 \times 10^{15}$
- For 1 kJ, $Y = 1.8 \times 10^{15}$
- For 400 J, $Y = 1.1 \times 10^{15}$
- For 400 J, $Y = 1.0 \times 10^{15}$
- No fast electrons, $Y = 5 \times 10^{14}$

The increased neutron rate can be easily diagnosed.
At peak neutron rate, the beam-heated region produces the enhanced neutron yield.

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**No ignitor beam**

- Mass density (g/cm³)
  - 0.0
  - 7.0

**400 J at low density**

- Ion temperature (keV)
  - 0.0
  - 7.0

- Neutron rate (1/zone/s)
  - $10^{20}$
  - $10^{22}$

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The ignitor beam causes neutrons to be produced over a large volume.
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