Shock-Augmented Ignition

- Proposed by R. Scott et al. [1]
- Drop in drive power reduces coronal pressure
- Allows for the launch of a late-stage strong shock with moderate power
- Lower peak intensities can mitigate laser-plasma instabilities

Figure 1. Comparison between a shock augmenting pulse and a standard central hot spot (CHS) ignition pulse

Ignition Comparison

- Hohlraum model converts laser pulse to X-rays
- One-dimensional implosion simulated using 1-D radiation-hydrodynamics code HYADES
- Shock-augmented pulse created from modified NIF-like pulse

Figure 2. Plot of the pressure and density profiles in the shell before and after the shock collision

- Augmenting shock collides with rebound shock near inner surface of shell
- Raises shell density and hot spot pressure, triggering ignition

Figure 3. Schematic of hohlraum dimensions

Bayesian Optimization

- Bayesian optimization [3] is used to find the best pulse shape
- Choice of optimization parameter helps focus on low-velocity implosions
- Six parameters optimized over 1800 simulations

Figure 4. Schematic of capsule dimensions

Conclusions

- A strong, late-stage shock can be launched in an implosion when coronal pressure is reduced via a drop in driver power
- Only a moderate rise (≈50 eV in 1 ns) in x-ray drive is required to launch the shock
- One-dimensional radiation-hydrodynamics simulations have shown that a shock-augmented pulse can increase yield compared to a CHS pulse while lowering implosion velocity

Figure 5. CHS laser pulse and x-ray drive

Figure 6. SAI laser pulse and x-ray drive

References

Shock-Augmented Ignition

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Laser to x-ray conversion was handled with a time-dependent physics model [2].

\[ S_r = 14.1 \times S_a^{0.748} \times E_a^{0.511} \]

- \( S_r \): flux reflected from wall
- \( S_a \): laser flux absorbed in wall
- \( P_{\text{las}} \): laser power
- \( A \): absorbing surface area

Figure 3. Schematic of hohlraum dimensions
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Figure 4. Schematic of capsule dimensions

Central Hot Spot Ignition

$E_{laser} = 1.66 \text{ MJ}$
$E_{yield} = 9.61 \text{ MJ}$
$v_{imp} = 372 \text{ km/s}$

Shock-Augmented Ignition

$E_{laser} = 1.57 \text{ MJ}$
$E_{yield} = 14.31 \text{ MJ}$
$v_{imp} = 342 \text{ km/s}$

Figure 5. CHS laser pulse and x-ray drive

Figure 6. SAI laser pulse and x-ray drive
Bayesian optimization [3] is used to find the best pulse shape.

Choice of optimization parameter helps focus on low-velocity implosions.

Six parameters optimized over 1800 simulations.

$E_{\text{laser}} = 1.46 \text{ MJ}$
$E_{\text{yield}} = 17.20 \text{ MJ}$
$v_{\text{imp}} = 337 \text{ km/s}$

Figure 6. Plot showing the six pulse parameters that were used in the Bayesian optimization algorithm.
Conclusions

• A strong, late-stage shock can be launched in an implosion when coronal pressure is reduced via a drop in driver power

• Only a moderate rise (≈50 eV in 1 ns) in x-ray drive is required to launch the shock

• One-dimensional radiation-hydrodynamics simulations have shown that a shock-augmented pulse can increase yield compared to a CHS pulse while lowering implosion velocity