In-Flight Shell Breakup in Direct-Drive DT Cryogenic Implosions

Framed, soft x-ray self-emission from DT cryogenic implosion at onset of hot-spot emission
The onset of hot-spot x-ray emission in directly driven DT cryogenic implosions is used to diagnose hot-spot assembly*

- The onset of hot-spot emission is observed at a larger radius than calculated by a 1-D models over a range of varying DT cryogenic implosions
- The discrepancy in the emission onset increases with an instability parameter** $S = \text{IFAR}/\alpha^{1.1}$, where $\alpha$ is adiabat and IFAR is in-flight aspect ratio
- For the least-stable implosion (highest S), modeling that includes laser imprint recovers the advance in emission; however, imprint does not explain the more-stable implosions

The results suggest a gap in our understanding specific to decompression at the start of deceleration.

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Collaborators


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An observed discrepancy in the onset of hot-spot x-ray self-emission motivated its use to diagnose early-stage hot-spot formation.

- An emission advance was shown in simulations of plastic implosions to accompany shell thickening due to imprint*.
- An analysis that extracts shell thickness is also being considered for the DT system (earlier talk, J. Baltazar et al., BO09.00006).

Three-dimensional modeling shows imprint *can* cause early hot-spot emission

- **ASTER**
  - resolves \( \ell < 200 \)
  - speckle-based model for laser imprint
- **S = 25**
  - \( \alpha = 1.7, \) IFAR = 39
  - 90% yield reduction due to imprint

Profile relaxation drives the early emission.

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Results: Data and Model

Two companion shots contrast the role of imprint in creating the emission discrepancy

- Imprint is modifying hot-spot formation (as compared to less specific signatures such as $Y_{DT}$, $\rho r$)
- There is a modeling gap regarding hot-spot formation for the more-stable implosion
The emission onset for implosions of differing stabilities is compared to 1-D modeling (LILAC)

Results

- $\Delta R_{\text{emis}}$ is the shift in onset determined from the emission versus limb-position curves of each analyzed shot
- The 3-D model suggests $S \leq 10$ are not explained by imprint

The discrepancy is reduced for more-stable implosions.
Additional experiments and data will test the leading candidate hypotheses for the discrepancy in the onset of the x-ray self-emission from the hot spot

- **Hydrodynamic origin**
  - Condensate, debris and damage maybe accumulated during cryogenic processing
  - a new cryo microscope will inspect for ~micron features after DT diffusion fill*

- **Shock-related processes such shock timing or shock release (studied in plastic ablator to date**: [**]** [†])
  - implosions are being planned in which shock parameters will be maintained while stability is increased with thicker cryogenic layers

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MD: molecular dynamics

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Backup
Enhanced emission due to mix is not considered a primary candidate for the observation

- Unless imprint is *OVER-predicted* and fortuitously in agreement, good agreement in the low-stability case is contrary to C mixing in higher-stability implosions
- Broad emission in the core is observed rather than localized features such as associated with fill tube at the NIF
- Mix is not indicated for implosions of stabilities in question based on previous analysis of x-ray emission* (see also D. Cao *et al.*, BO10.00006, this conference)

\[ f_{\text{CH}} \approx 2.4\% \]

\[ \text{Normalized emission, } y_{\text{H}}^{0.57} \]

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