Spectroscopic Investigations of Implosions on the National Ignition Facility

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Hydrodynamic instabilities are a primary impediment to the success of inertial confinement fusion (ICF), as they can severely degrade capsule performance [1]. Even with perfectly smooth capsules, the fill tube and capsule support provide perturbations that seed instabilities. Consequently, understanding the evolution of perturbations and their effects on capsule performance is critical to the success of an ICF program. We discuss here the use of spectroscopic methods to diagnose the growth of hydrodynamic instabilities in imploding capsules. To understand capsule evolution and guide experimental design and interpretation, we use high-resolution HYDRA [2] simulations, postprocessed with Cretin [3], to simulate the spectra produced by capsules with specified initial perturbations. The spectral simulations cover a wide range of conditions, from the multi-keV hot spot to the cold dense pusher.

For capsules with mid-Z dopants, the resulting X-ray spectrum can be analyzed to obtain information about the plasma conditions. An analysis of the dopant K-shell line emission has been used to estimate the mass of ablator material mixed into the hot spot [4]. Other spectral features can be used to provide information about the shell and further constrain the mixed mass. Other recent work has focused on using spectroscopy to quantitatively characterize the growth of perturbations. Capsules containing a small amount of argon in the gas produce sufficient emission before peak compression to provide radiographic information. The analysis of simulated spectra from capsules with machined perturbations demonstrates the possibility of extracting quantitative measures of perturbation growth.

References

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