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# Using X-ray Spectroscopy to Quantify Mix and Plasma Conditions in Ignition Experiments Using W-doped HDC Capsules at the NIF[1]

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Experiments at the National Ignition Facility (NIF) seek to produce fusion burn using thermal x-rays from a gold-lined uranium hohlraum to heat and compress a capsule filled with deuterium (D) and tritium (T). The DT fuel must be shielded from the Au M-band x-rays to prevent preheat, so tungsten (W) is doped into the high-density carbon (HDC) ablator. The W-doped HDC from the ablator can mix into the DT hot spot from fill tube-induced or other instabilities. X-ray emission of W L-band transitions (9-12 keV) is observed on most ICF implosions, indicating there is mix. This mix reduces the hotspot energy and temperature through ionization energy and radiative losses. Quantifying the total energy loss is important to understand the impact on the ignition boundary and our proximity to it. The spectra contain Mg- to F-like 3d-2p W emission features from the hot spot, Ti- and V-like 3d-2p emission features from the outgoing shock, and W L-shell fluorescents (L-alpha and -beta) and $3 \rightarrow 2$ absorption features from the cooler and denser surrounding fuel and remaining shell. The hot spot portion of the spectra are analyzed to infer temperature and mass distribution of the mix in the hotspot, and total radiative losses escaping the hotspot in both M-band, L-band, and continuum radiation. Results of radiative losses as a function of laser energy and W dopant-fraction in the Big Foot scaling series are presented. The measurements show a strong inverse correction between radiative losses from mix and neutron yield. A detailed analysis of the entire spectrum, including radiation transport and density effects, is in development. This uses the atomic kinetics/radiation transfer code CRETIN coupled to sufficiently detailed atomic physics models to reconstruct a complete and self-consistent picture of the temperature and density profiles and the absorption and emission processes. Planned improvements in data quality include high resolution and time-resolved measurements. This is a multi-year project to understand mix and its effects on hotspot physics through x-ray spectroscopy and atomic physics.

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