Using multiple independent diagnostics to measure the hot-spot electron temperature of ICF implosions at the NIF

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Inertial confinement fusion (ICF) implosions at the National Ignition Facility (NIF) have recently achieved significant alpha-particle self-heating [1], however the ion temperatures inferred from deuterium-tritium (DT) reactions are significantly higher than predicted. A leading hypothesis for the anomalously high DT ion temperature is residual kinetic energy in the hot spot in the form of fluid velocity flows and turbulence. Due to the extremely high thermal velocity of electrons, the electron temperature (T_e) is not sensitive to residual kinetic energy effects that complicate ion temperature measurements. We are developing a technique to measure the hot-spot T_e and n_e by fitting data from several independent x-ray diagnostics to a single self-consistent model. Using both spectral and spatial measurements of hot-spot x-ray emission, we build and optimize a Cretin [2] model of the hot-spot to match the observables of all diagnostics simultaneously. The Continuum Spectrometer (ConSpec) [3] and differential titanium filters [4] measure x-ray continuum emission, while the dHIRES spectrometer [5] records time-resolved Kr line emission from Kr-doped capsules. Finally, x-ray penumbral imaging [6] provides high-resolution imaging of the hot-spot to define the size and shape of the hot-spot model, allowing absolute x-ray yields to be accurately modeled. Using this full set of diagnostics with different sensitivities to T_e and n_e, we present the initial analysis from ICF implosions at the NIF.

[1] O. A. Hurricane *et al.*, Nat. Phys. **12**, 800 (2016).
[2] H. A. Scott, JQSRT **71**, 689–701 (2001).
[3] D. B. Thorn *et al.*, Proc SPIE 1039009 (2017).
[4] L. C. Jarrott *et al.*, Phys. Rev. Lett. **121**, 085001 (2018).
[5] L. Gao *et al.*, Rev. Sci. Inst. **89**, 10F125 (2018).
[6] B. Bachmann *et al.*, Rev. Sci. Inst. **87**, 11E201 (2016).

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