The effects of hydrodynamic gradients on measurements of ion temperature and areal density

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The hotspot formed in an ICF implosion contains deuterium-tritium plasma with large temperature and density gradients. These gradients are enhanced by the growth of hydrodynamic instabilities during the implosion. In this work we evaluate the effect of these gradients on measurements of ion temperature and fuel areal density. This is achieved by simulating the capsule implosion, hotspot formation and evolution in 3D using the CHIMERA radiation-hydrodynamics code. A suite of computational tools are then used to produce synthetic diagnostics for neutron yields, energy spectra and images from the simulation output [1].

The hotspot ion temperature can be inferred from the width of the DD and DT primary neutron spectral peaks. Previous work has quantified the effect of bulk fluid motion of the hotspot on this measurement [2,3]. In this work, we use the Braginskii ion fluid description [4] to quantify the effects of ion temperature, pressure and density gradients on the width of the spectral peaks. It is shown that sufficiently large gradients can broaden the spectra even without changing the burn-averaged ion temperature.

The fuel areal density can be inferred from the amount of neutron scattering occurring in the plasma. This is usually measured using the down-scattered ratio (DSR); the ratio of neutrons in the 10-12 MeV energy range to those in the 13-15 MeV range. However, the spatial distribution of the hotspot and the range of angles through which neutrons scatter means that the DSR can be a poor measure of the fuel areal density in a given line-of-sight. In this work we identify other quantities which can be used to infer the fuel areal density and evaluate their sensitivity to inhomogeneities and gradients in the hydrodynamic quantities. For example, it is shown that ratio of DT to DD neutron yields is particularly sensitive to the mean fuel areal density through which the neutrons escape.

References

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