On the potential role of ion species separation in inertial confinement fusion implosion performance

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The measurement of strong, self-generated electric fields (~1-10 GVolts/m) in imploding capsules [1], their attribution to polarized (plasma) shock fronts [2], and the identification of plasma-enhanced binary species diffusion from barodiffusion and electrodiffusion [3] have led to a growing interest in the potential role of species separation in inertial-confinement-fusion (ICF) thermonuclear fuels. In particular, the arranged sequence of (4) shocks in a central-hot-spot ICF target may lead to transient species separation of the deuterium (D) and tritium (T) across each shock front as the main DT fuel is traversed. The process of species separation involves interpenetration of each fuel species, resulting in a drift velocity that can lead to resistive-like heating. Estimates of the degree of associated entropy increase or dissipation energy following four-shock traversal of the main fuel gives nearly 100 Joules, which may significantly affect ignition performance margins. A number of anomalies on the National Ignition Facility (NIF) database may be consistent with frictional heating of the DT fuel following shock passage. In particular, nuclear and x-ray data consistently point to 2-3x anomalously low hot-spot stagnation pressures. Additional shock heating over what is expected in a classical fluid may be consistent with the modified Rankine-Hugoniot jump conditions for a multi-species plasma with self-generated fields [4]. LSP hybrid PIC simulations of the coalesced shock in the DT gas of a NIF ignition capsule suggest a bifurcation of the shock into D- and T-rich components [5], thereby altering the conventional (fluid-based) notion of plasma shock morphology. This talk will inform the plasma community of the potential importance of species separation effects in ICF and their implications for ongoing efforts to demonstrate ignition at the NIF.