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The Potential Role of Electric Fields and Plasma Barotropic Diffusion on the Inertial Confinement Fusion Database[1]

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The generation of strong, self-generated electric fields ($\approx$ 1-10 GV/m) in direct-drive, inertial-confinement-fusion capsules has been reported [1], prompting the question whether such fields can have observable consequences on target performance. Two anomalies in the inertial confinement fusion database are well known: (1) an observed $\approx$ 2x greater-than-expected deficit of neutrons in an equimolar D^3He fuel mixture compared with hydrodynamically equivalent DD [2] mixtures, and (2) a similar shortfall of neutrons when trace amounts of argon are mixed with DD fuel in indirect-drive implosions [3]. A new mechanism based on barodiffusion (or pressure gradient-driven diffusion) in a plasma is proposed that incorporates the presence of shock-generated electric fields to explain the reported anomalies. For Omega-scale implosions the (low Mach number) return shock has an appreciable scale length over which the lighter DD ions can diffuse away from fuel center. The depletion of DD fuel is estimated and found to yield a corresponding reduction in neutrons, consistent with the anomalies observed in experiments for both argon-doped DD fuels and D^3He equimolar mixtures. The reverse diffusion of the heavier ions towards fuel center also increases the pressure, potentially resulting in lower stagnation pressures and larger imploded cores in agreement with gated self-emission x-ray imaging data. The theory is applied to studying the degree of potential fractionation of THD fuel mixtures for an upcoming ignition tuning campaign on the National Ignition Facility.

[1] Rygg et al., Science 319, 1223 (2008), Li et al., PRL 100, 225001 (2008)
[2] Rygg et al., PoP 13, 052702 (2006)
[3] Lindl et al., PoP 11, 339 (2004).

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