Finite Atwood-Number Effects on Deceleration-Phase Instability in Direct-Drive Implosions of Gas-Filled Capsules: Performance degradation in direct-drive inertial confinement fusion implosions can be caused by several effects, one of which is Rayleigh–Taylor (RT) instability growth during the deceleration phase. Room-temperature implosions have a finite Atwood (A_T) number $\left(A_T = \rho_{\text{shell}} - \rho_{\text{gas}} / \rho_{\text{shell}} + \rho_{\text{gas}}\right)$ at the gas–shell interface, which creates short-scale RT growth during the deceleration phase. The effect of the Atwood number on target performance was studied in recent OMEGA gas–filled capsule implosions. The Atwood number was changed by varying the tritium concentration (n_T) in the DT gas mixture used to fill these targets. Pre-shot single-mode *DRACO* simulations demonstrated higher perturbation growth factors at the gas-shell interface during deceleration as n_T decreased from 90% to 50%, which changed the A_T from –0.03 (stable) to 0.05 (unstable). Cryogenic implosions on OMEGA do not have this fuel–shell interface ($A_T = 0$). The OMEGA implosions revealed that reduced n_T led to higher measured neutron-averaged ion temperatures and, as a result, higher neutron yield compared to simple yield scaling laws. Ion-temperature variation (ΔT_i) as measured by different detectors along different lines of sight during implosions decreased with a reduction in n_T. Ion-temperature variation is an indication of bulk nonuniformity flow inside the fuel and a measure of implosion asymmetries. The current hypothesis explaining these counter-intuitive observations is that short-scale RT growth in these room-temperature implosions reduced ΔT_i by preventing large-scale bulk motion of warm fuel into the colder RT bubbles within the shell as shown in Fig. 1.

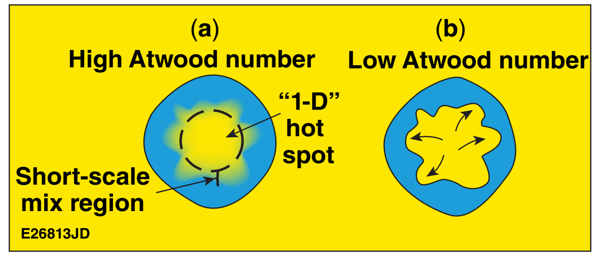

Figure 1. (a) Schematic illustrating the hypothesis that short-scale RT growth in high-Atwood-number implosions prevents fuel from flowing into cold bubbles as happens in (b).

In Fig. 2, the recorded ΔT_i from these experiments is shown with respective measured D:T ratios and calculated A_T at the start of the deceleration phase. The stable implosions ($A_T < 0$) show the largest ΔT_i, similar to the values seen in OMEGA cryogenic implosions. Alternatively, the high A_T targets had increased short-scale RT growth and reduced ΔT_i. Figure 3 shows that target performance relative to 1-D *LILAC* predictions improved with increasing A_T, contrary to intuition, since increased RT growth rates are thought to decrease overall performance. Increased yield correlates with higher T_i, which is hypothesized to be a result of short-scale RT growth preventing the DT hot spot from penetrating into the cold bubbles. Future multimode simulations are required to test this hypothesis and study if short-scale growth reduces bulk-fluid motion and ΔT_i within the core.

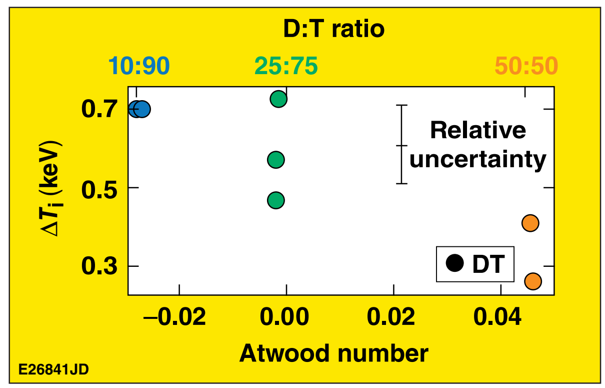

Figure 2. Experimental ion-temperature variation versus fuel D:T ratio and Atwood number.

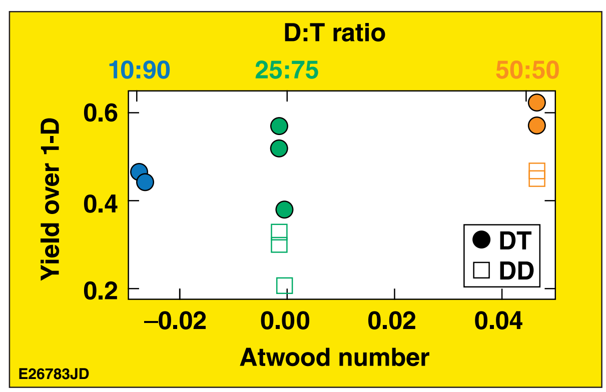

Figure 3. Experimental yield over predicted yield (DD, DT) versus fuel D:T ratio and Atwood number.

Omega Facility Operations Summary: During October, 2017, the Omega Laser Facility conducted 190 target shots with an average experimental effectiveness (EE) of 96.6% (OMEGA had 117 target shots and an EE of 96.2%, while OMEGA EP conducted 73 target shots with an EE of 97.3%). The ICF program had 92 shots for experiments led by LLE, while the HED program accounted for 67 target shots for experiments led by LLNL, SNL, and LLE. The NLUF program accounted for 31 target shots for three experiments led by the University of California, Berkeley, General Atomics, and Princeton University, respectively.

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