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Liquid DT Layer Approach to Inertial Confinement Fusion

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The baseline approach to high gain ICF involves the implosion of capsules containing a layer of DT ice [1]. DT ice layer designs require a high convergence ratio (CR > 30) implosion, with a hot spot that is dynamically created from DT mass originally residing in a thin layer at the inner DT ice surface. Although high CR is desirable in an idealized 1D sense, it amplifies the deleterious effects of realistic features and asymmetries [2]. An alternative ICF concept uses DT liquid layers [3]. DT liquid layers allow for much higher vapor densities than are possible with DT ice layers. The wide range of vapor densities that are possible with DT liquid layers provides flexibility in hot-spot CR (12 < CR < 25), which, in turn, will provide a reduced sensitivity to asymmetries and instability growth. Given enough vapor mass, the hot spot can be formed from the mass originally residing in the central vapor region. Recent experiments at the National Ignition Facility (NIF) have demonstrated cryogenic liquid DT layer ICF implosions, along with the associated flexibility in the hot spot CR [4,5].
There are tradeoffs involved in high CR ice layer and reduced CR liquid layer designs. With reduced CR, hot spot formation is expected to have improved robustness to instabilities and asymmetries [2-5]. In addition, the hot spot pressure (Pr) required for self-heating is reduced if the hot spot radius (Rhs) is increased (Pr α Rhs^-1). With a reduction in the hot spot Pr requirement, the implosion velocity and fuel adiabat requirements are relaxed. On the other hand, with larger hot spot size, the hot spot energy requirement for self-heating (Ehs) is increased (Ehs α Rhs^2), and the required capsule absorbed energy is increased. In this presentation, we will summarize the recent liquid layer experiments at the NIF and will discuss the hot spot energy, hot spot pressure, cold fuel adiabat, and capsule-absorbed energy requirements for achieving self-heating and propagating burn using liquid layer capsules with hot spot CR<20\.

References

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