DPP17-2017-000682

Abstract for an Invited Paper
for the DPP17 Meeting of
the American Physical Society

In search of late time evolution self-similar scaling laws of Rayleigh-Taylor and Richtmyer-Meshkov hydrodynamic instabilities - recent theorical advance and NIF Discovery-Science experiments.

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Hydrodynamic instabilities, and the mixing that they cause, are of crucial importance in describing many phenomena, from very large scales such as stellar explosions (supernovae) to very small scales, such as inertial confinement fusion (ICF) implosions. Such mixing causes the ejection of stellar core material in supernovae, and impedes attempts at ICF ignition. The Rayleigh-Taylor instability (RTI) occurs at an accelerated interface between two fluids with the lower density accelerating the higher density fluid. The Richtmyer-Meshkov (RM) instability occurs when a shock wave passes an interface between the two fluids of different density. In the RTI, buoyancy causes "bubbles" of the light fluid to rise through (penetrate) the denser fluid, while "spikes" of the heavy fluid sink through (penetrate) the lighter fluid. With realistic multi-mode initial conditions, in the deep nonlinear regime, the mixing zone width, H, and its internal structure, progress through an inverse cascade of spatial scales, reaching an asymptotic self-similar evolution: $h_{RT} = \alpha_{RT} A g t^2$ for RT and $h_{RM} = \alpha_{RM} t^{\theta}$ for RM. While this characteristic behavior has been known for years, the self-similar parameters α_{RT} and θ_{RM} and their dependence on dimensionality and density ratio have continued to be intensively studied and a relatively wide distribution of those values have emerged. This talk will describe recent theoretical advances in the description of this turbulent mixing evolution that sheds light on the spread in α_{RT} and θ_{RM} . Results of new and specially designed experiments, done by scientists from several laboratories, were performed recently using NIF, the only facility that is powerful enough to reach the self-similar regime, for quantitative testing of this theoretical advance, will be presented.