Discovery Science experiments at NIF:  
3D Bubbles Dynamics for the ablative Rayleigh-Taylor Instability

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The advent of high-power lasers facilities such as the National Ignition Facility (NIF) and the Laser Megajoule (LMJ) provide unique conditions to study the physics of turbulent mixing flows in High Energy Density Plasmas [1,2]. We report here on highly nonlinear ablative Rayleigh-Taylor Instability (RTI) experiments performed on the NIF as part of the Discovery Science program. Planar plastic samples were directly irradiated by 300 to 500 kJ of UV laser light (351 nm) and the growth of 3D laser imprinted modulations is quantified through time-resolved x-ray radiography (see figure below).

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure1.png}
\caption{X-ray radiograph of 3D broadband modulations initially produced by the imprinting of a laser beam without any optical smoothing.}
\end{figure}

For the first time, four generations of RTI bubbles are created as larger bubbles overtake and merge with smaller bubbles as a result of the unprecedented long laser drive (30 ns duration). The experimental data, analysed both in real and Fourier space, are compared with classical bubble-merger models [3], as well as recent theory predicting 3D bubbles reacceleration due to vorticity accumulation caused by mass ablation [4]. These experiments are of crucial importance for hydrodynamics and for benchmarking 2D and 3D radiation hydrodynamics codes used in Inertial Confinement Fusion.