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Turbulent Hydrodynamics Experiments in High Energy Density settings

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The advent of MJ class lasers offers novel opportunities to study turbulent mixing flows in High Energy Density (HED) plasmas [1], for fundamental hydrodynamics or laboratory astrophysics experiments [2]. We report on 2 series of experiments performed on the NIF and LULI2000 laser facility. These experiments are devoted to the study of the highly nonlinear stage of the Rayleigh-Taylor Instability (RTI), at the ablation front or at a decelerated interface (see Fig.1).

On NIF, we have developed a long duration planar Direct Drive Platform with an unprecedented long laser drive (30 ns [3]. Planar plastic samples are irradiated by 450 kJ of 3w laser irradiation distributed over a 2-mm wide flat laser spot. Starting from deliberately enhanced imprinted modulations, at least two generations of bubbles are created for the RTI at the ablation front, as larger bubbles overtake and merge with smaller bubbles. The sensitivity to initial conditions is studied by changing the imprint seeds of the perturbations. These experiments are of crucial importance for benchmarking 2D and 3D radiation hydrodynamics code for Inertial Confinement Fusion. A future evolution of the platform may allow us to evidence for the first time the Landau-Darrieus instability [4] in High Energy Density (HED) conditions.

On LULI2000, we have developed a novel HED experimental platform to study the highly nonlinear phase of single-mode, and multimode RTI in scaled laboratory conditions relevant for the physics of young Supernova Remnants [5]. One of the main advantages of HED settings is to allow an easy scan of initial conditions, by changing some characteristics of the initially solid target, such as the pre-imposed modulated pattern (single-mode or multimode) or density contrast at the unstable interface (hence Atwood number). We concentrate thereafter on the behavior of the 2D single mode RTI in the highly nonlinear stage for Atwood numbers ranging from ~0.44 to 0.97. The RTI evolution is diagnosed by PW transverse radiography (Fig. 1b) with ~25 μm spatial resolution. The highly nonlinear stage of the classical RTI is evidenced..

A scale-up of the platform at MJ laser energy [6], associated to x-rays diagnostics with enhanced spatial resolution [7] is under development and will enable quantitative progresses in the field of Turbulent Hydrodynamics Experiments in HED settings.

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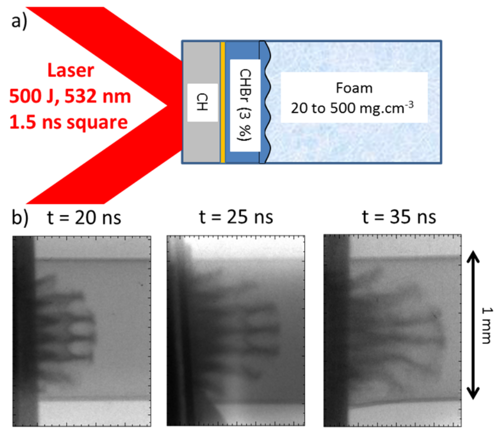

Figure 1: a) Schematics of the LULI2000 experiments. b)Time-resolved radiographs showing the evolution of (λ = 120 μm, 20 μm peak to valley amplitude) 2D sinusoidal (perturbations for Atwood ~0.97