NRL LASER FUSION PROGRAM

Bimonthly Highlights

July-August 2000

Density oscillations in a rippled rarefaction wave determine the feedout-generated seed for the Rayleigh-Taylor instability at short-to-moderate perturbation wavelengths

Fig. 1

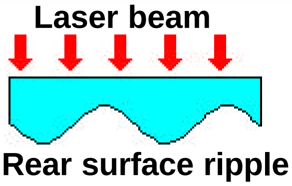
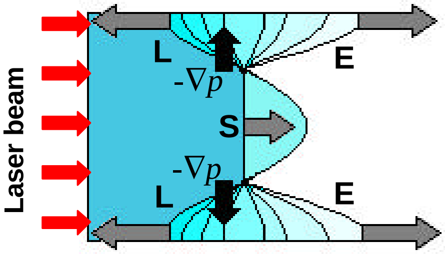


Fig. 2



The feedout process transfers mass perturbations from the rear to the front surface of a driven target, producing the seed for the RT instability (Fig. 1). We have investigated this process analytically and numerically for the case of perturbation wavelength comparable to or less than the shock-compressed target thickness. It was shown that the lateral mass flow in the target (Fig. 2) leads to oscillations of the mass non-uniformity before the rippled rarefaction wave breaks out at the front surface of the target. This may result in RT bubbles produced at locations where the areal mass was initially higher.

The lateral mass flow in the case of a planar, single-mode geometry is driven as shown in Fig. 2. A planar shock wave **S** approaches the rippled rear surface. A rippled rarefaction wave is reflected , first at the valleys, then at the peaks. The expansion **E** starts from the valleys, decreasing the pressure there, whereas near the peak locations the pressure is maintained at the constant post-shock value. The resulting lateral pressure gradient drives mass from the peaks to the valleys, thus decreasing the pressure at the peaks and increasing it in the valleys. The mass flow continues when the pressure gradient vanishes, thus overshooting the equilibrium situation and building up a reversed pressure gradient. These sonic oscillations of areal mass in a rippled rarefaction wave were first studied theoretically at NRL in 1996.

Fig. 3

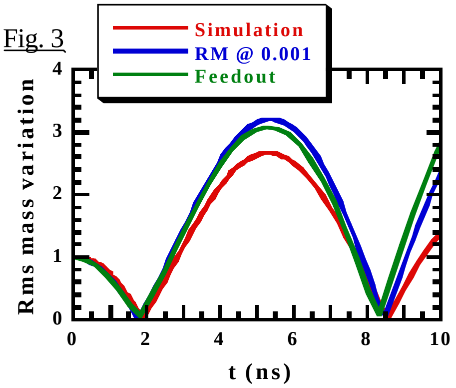


Fig. 4

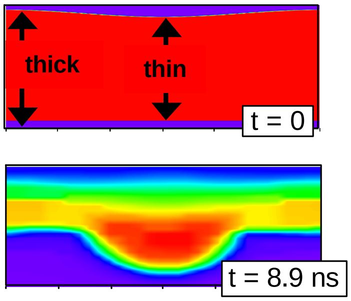
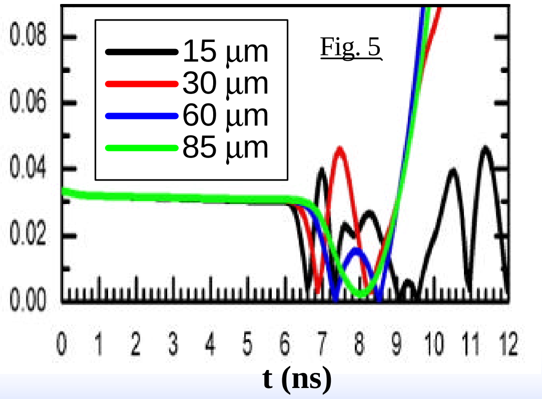


Figure 3 compares results of the analytical linear theory for cases of feedout and Richtmyer-Meshkov instability at large density difference (gas density behind the rear surface of the target taken 1/1000 of the target density) to our 2D simulation. Ideal gas EOS and constant pressure drive is used (origin of time corresponds to the shock breakout). Figure 4 illustrates formation of the bubble where the target, a 60-µm thick plastic slab rippled at the rear, is initially thicker. This is due to lateral mass flow in the rippled rarefaction wave. The laser light is incident from below; the upper part is the density map before the start of the laser pulse, the lower is 8.9 ns after.

The complicated oscillatory mass behavior due to feedout has yet to be observed in experiment. To observe the oscillations, it is desirable to have a long driving laser pulse (at least 4 ns), highly uniform irradiation, and sensitive diagnostics for face-on radiography. The oscillatory behavior predicted by this theory is observed in hydrodynamic code calculations for typical parameters available with the Nike facility: 4-8 ns pulses onto 60 to 90 µm thick polystyrene targets (Fig. 5 shows mass perturbation vs. time for a 60 µm target and four perturbation wavelengths). Current Nike experiments are studying this phenomenon via streaked x-ray backlighting of mass perturbations.



For comments about content of the ***BIMONTHLY HIGHLIGHTS***, contact Steve Obenschain (202) 767 0689
To get on the mailing list contact Yefim Aglitskiy (202) 404 1158
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