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Perturbation Growth at the Internal Interface of a Plane Target Under Indirect Laser Drive*

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Abstract. Perturbation growth at an internal interface of a multi-layer plane target under direct laser drive has been studied previously. The same type of experiments have been done using Al/Au targets under indirect laser drive in order to get better uniformity. In these experiments, the Richtmyer-Meshkov instability generated by the first shock is coupled with a Rayleigh-Taylor instability during the acceleration phase that follows. This paper reports our current progress.

1 Introduction

Perturbation growth at an internal interface of a multi-layer plane target under direct laser drive has been studied previously [1, 2, 3, 4]. The same type of experiments have been done under indirect laser drive in order to get better uniformity. In fact, two types of experiments have been done on Phebus by H. Croso, B.Meyer and F.Mucchielli [5]. First, the acceleration of a 20 μm Al foil has been used to test the numerical simulations of the foil gross hydrodynamics by the Lagrangian 2D code FCI2. Then, bilayered Al/Au plane targets of different thicknesses and different surface roughnesses have been investigated under the same experimental conditions. The laser probe beam (face radiography) on the payload side gives the temporal delay between the emission of the two constituents of the target, which yields to the depth of the inter-penetration zone. For the time being, the numerical interpretation of these temporal delays is done by modeling the perturbation growth.

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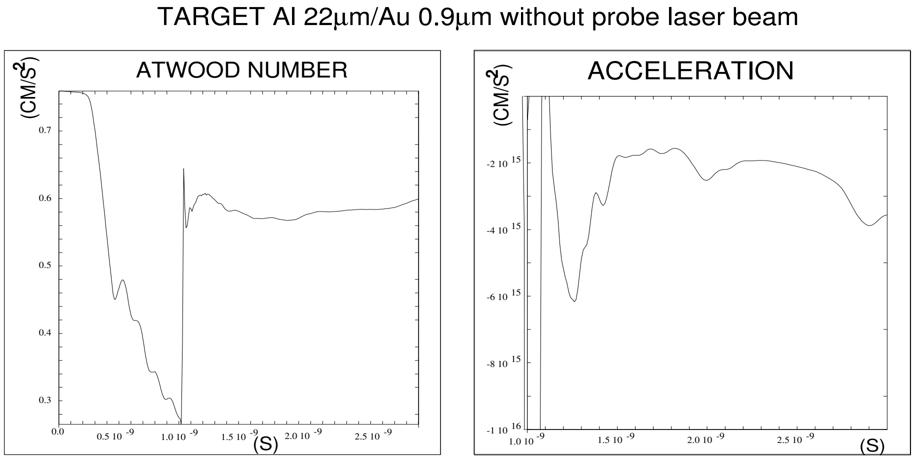

Figure 1: Hydrodynamical data at the interface.

2 Numerical simulations

A calculation of the entire experimental configuration has been done with the 2D code FCI2 for the Al foil case. The fit between the x-ray shadowgraphy measurement and the numerical simulation is quite good. It is then possible to extract boundary conditions (pression, fluxes, spectrum) to initiate numerical simulations of different targets with plain interfaces. Different Al/Au plane targets were investigated. We choose to present a Au 0.9μm/Al 22μm target with two different surface finish. This class of targets gave good experimental results, with a nice Rayleigh-Taylor phase; this Al thickness permits also to separate the study of the interface from the ablative phenomenon.

3 Mix width estimate

The initial perturbations are characterized by contact profilometry and interferometry. Fourier analysis are conducted on 200μm length experimental records. We will refer to a "good" surface finish (rms=$7.4\dot{A}$) and a "bad" surface finish (rms=$240\dot{A}$). To model the perturbation growth, we distinguish a linear Richtmyer-Meshkov stage

$$a(k,t) = a(k,0)(1 + kA_t \Delta vt) \tag{1}$$

followed by a Rayleigh-Taylor stage.For the linear growth

$$\ddot{a}(k,t) = \gamma^2(k) a(k,t), \tag{2}$$

we take in account the finite thickness h of the Au payload by correcting the linear growth rate

$$\gamma(k) = \left[\frac{1-r}{1+r\coth(kh)}kg\right]^{1/2}, \quad r = \frac{1-A_t}{1+A_t} \tag{3}$$

where the time-dependent acceleration g and density ratio r are given by the numerical simulation (Figure 1).

The interface perturbation is then reconstructed at each time

$$Z(x,t) = a(k_n,t)\sum_{n=1}^{N}[\cos\phi_n\cos(k_n x) + \sin\phi_n\sin(k_n x)] \tag{4}$$

From *Z(x,t)*, a mix length is determined by

$$h(t) = Z_{max}(t) - Z_{min}(t). \tag{5}$$

Aluminum penetration length in gold is then equated to 0.5*h(t)*.

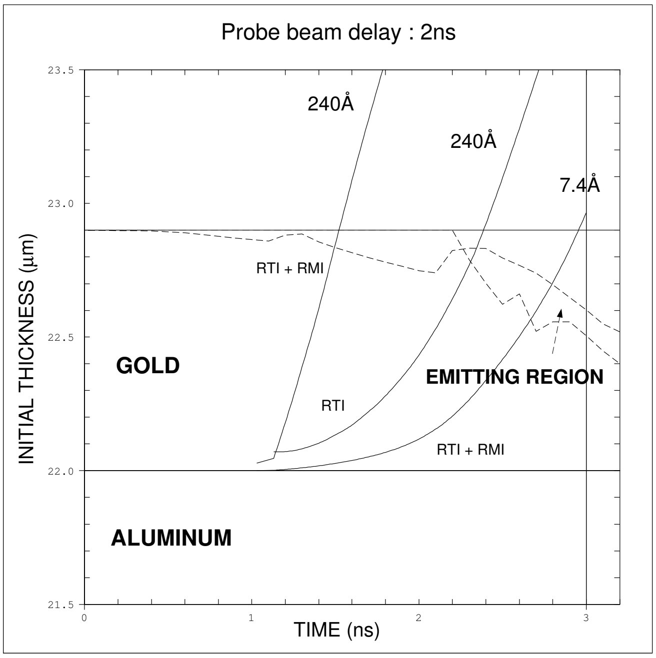

Figure 2: Mix development versus the RMS amplitude of the initial perturbation. For the "bad" surface finish case, two calculations have been made: the first one modeling both the RMI and RTI stage, the second one modeling only the RTI stage.

For a $2ns$ probe beam delay, the approximate period of time we are interested in is $3ns$. For the "good" surface finish, the defaults stay in the linear stage; on the other hand, dominant modes are saturating in the "bad" surface finish case. For the time being, this is modeled with the saturation model of S. Haan [6], but mode coupling effects should be taken into account. Calculations using the Shvarts *et al* modal model [7] are in progress. Figure 2 presents the mix development versus the RMS amplitude of the initial perturbation. Emitting regions are determined via the rough requirements:

$$T_e > 200eV; n_e > n_c \tag{6}$$

For the good surface finish, a $0.41ns$ delay of $He\alpha$ line emission is found, in good agreement with the experiment ($0.45ns$).

4 Conclusion

A first numerical interpretation of instability experiments done under indirect drive with the Phebus laser has been shown. Some achievements, like a better determination of emitting regions, and the use of weakly nonlinear theory instead of saturation model for the evaluation of the perturbation growth, are in progress.The next step will be using targets with controlled defaults (mono-mode or multimode), which would open the way to Eulerian simulations, well adapted to a weakly non linear behavior.

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