About dynamics of shocks induced by complex spot laser irradiation of layered targets

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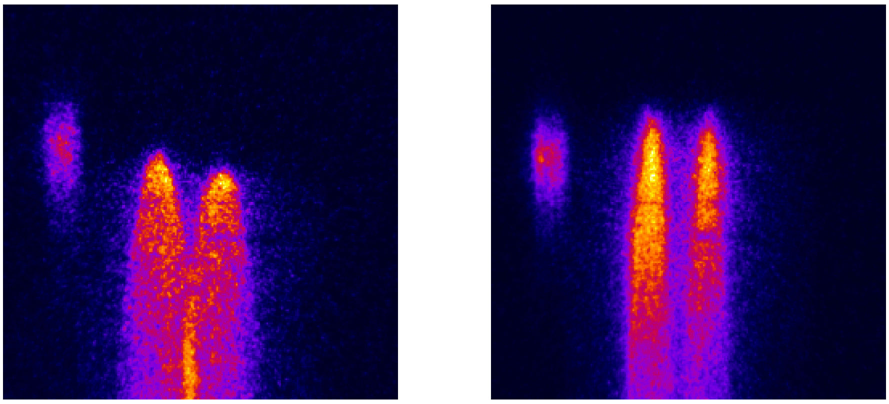
The aim of the present work is the analysis of laser inducted shock behavior in experiments with double (or complex) focal spot, in particular, the cumulative effect in double layer foam-metal targets.

Experiments were realized using the PALS (Prague Asterix Laser System) iodine laser. By splitting the laser beam in two equal parts with a prism we could obtain two focal spots, which gives very large non-uniformity. A photographic objective has been employed to image the target rear face onto a streak. [1] One of the main experimental results is the difference in time-resolved rear-side self-emission images obtained with the streak camera for aluminium and aluminium-foam targets. Namely, we obtained the bright area between two spots for the double-layer targets (look at fig. 1a), which is not have place in the experiments with monolayer Al target (look at fig. 1b).

In order to provide qualitative simulations with a 2D code [2,3], we assumed an axial-symmetric approximation, i.e. we have used a coaxial striped spatial profile for the laser spot. Some experimental data and preliminary analysis (including simulations with "mono-ring" and "central-spot+ring" 2D simulations) was recently published in [4]. In a case of double-layer targets the shock generated at the interface spreads back into the foam, continues to compress the foam-base, and finally produce a central region with a much higher pressure, as compared to the case of the simple Al foils.



a **b**

Fig. 1(colour on-line). Rear side optical streak camera experimental images (in arbitrary units): a) target with 10 μm Al+50 μm foam (ρ_{foam} = 50 mg/cm^3); b) 10 μm simple Al target. The total time window is 1600 ps (vertical) and the imaged region is 1330 μm wide (horizontal). The laser energy is the same for both shots: E = 52 J. Time flows from top to bottom. The signal on the upper right part of the image is the time fiducial indicating the arrival of the laser pulse on the front side of the target.

The 2D simulations with an axial symmetry are not completely adapted to reproduce our experiment. Indeed, the convergence of the shocks towards the axis can cause an artificial increase in pressure. Also the region around the centre of the cylinder is critical for possible artefacts in discretization. Hence, in order to acquire more confidence in our results, we realized simulations with another spatial profile, i.e. we used a double-ring spatial profile to see a shock collision dynamics and additional central spot with the same size for additional comparison with simulations of one-spot dynamics. The diameter of the central spot and the thickness of rings as well as the distance between rings were chosen close to experimental spot diameters. The diameters of bands and the distance between central spot to the first ring were chosen much larger than the ring thickness.

We have analyzed the dependence of shock behaviour from laser intensity and foam density. Some results will be presented in the poster and will be published soon. Fig. 2 demonstrates the temperature of the rear side (the last cell of the target) as a function of time for the Al-foam (ρ_{foam} = 50 mg/cm^3, left) and the Al (right) targets for a set of laser intensities.

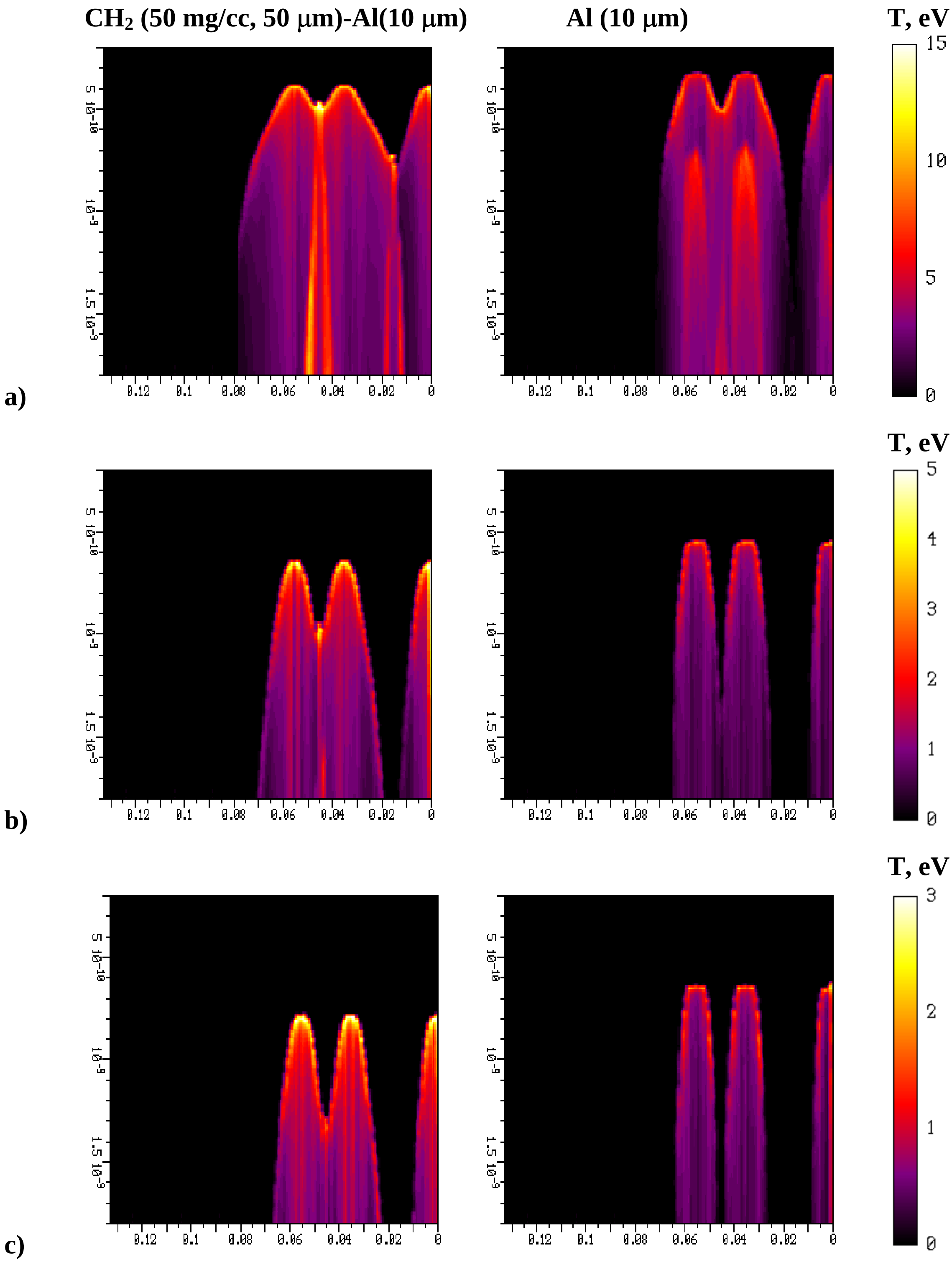


Fig. 2 (colour on-line). The temperature of the rear side (the last cell of the target) as a function of time for the Al-foam (ρ_{foam} = 50 mg/cm^3, left) and the simple Al (right) targets for different laser intensities: (a) 10^{15} W/cm^2; (b) 10^{14} W/cm^2; (c) 5 10^{13} W/cm^2. The total time window is 1600 ps (vertical) and the imaged region is 1330 μm wide (horizontal) as in fig. 1.

Finally, we have experimentally observed and numerically analyzed the behaviour of shocks generated by a “double laser spot” on foam-Al layered targets. We have observed the shock breakout on the target rear side and we saw that the region between the two spots becomes brighter that the spots themselves. This is explained as a result of the collision between the two individual shocks, generating larger pressure in the collision region. We performed hydrodynamic simulations in 2D (in “double-ring” format), which despite the assumption of axial symmetry seem to reproduce the qualitative feature of our results.

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