Experimental assessment of hot electron effects on shock-wave propagation in plane plastic targets irradiated at 10^{15} Wcm^{-2}

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According to widely used scaling laws, irradiation of solid matter with blue or vuv laser at intensity about 10^{15} W/cm^2 should drive shock-waves with about 50 Mbar pressure, which are of interest to material science, planetary science and inertial confinement fusion. A few recent experiments in plane geometry [1,2], however, showed significant departure from expectations and simulations. In particular, the shock break-out time from the target rear surface was considerably longer than the value obtained from simulations. It was suggested that the discrepancy could be partly explained by target rarefaction caused by hot electron preheating.

To test this hypothesis, in March 2017 we performed an experiment at Prague Asterix Laser System. Plane targets with plastic layers of different thickness (in the range 10 – 180 µm) and a 5 µm layer of Titanium were irradiated by a 300 ps FWHM pulse focussed to a spot of 100 µm FWHM, and a time- and space-averaged intensity of about 10^{15} W/cm^2 (λ=438 nm). We used streaked optical pyrometry (SOP) to detect shock break-out from the target rear surface, and inferred hot electron properties by Ti K_α spectroscopy and bremsstrahlung cannon measurements. SOP revealed radiation emission nearly simultaneous to laser irradiation, compatible with hot electron generation. The signal was clearly more intense for thinner targets, and consistent with spectroscopic results. Experimental shock break-out times vs target thickness fall in a band whose lower limit is approximately reproduced by DUED hydrodynamic simulations. Shock pressures of about 50 Mbar are inferred from simulations. In a small set of shots with laser intensity decreased by a factor 3, we found no evidence for presence of hot electrons, and shock break-out times were in good agreement with simulations using nominal parameters.

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References

[1] D. Batani *et al.*, Phys. Plasmas **21**, 032710 (2014)