Debris produced by PW-class lasers incident on solid targets

P. W. Bradford [1], I. Aukett [1], H. Ahmed [1], S. Astbury [1], N. Booth [1], D. Carroll [1], M. Ehret [2], D. Haddock [1], C. Spindloe [1], I.-M. Vladisavlevici [2], J. Green [1]

[1] *Central Laser Facility, Rutherford Appleton Laboratory, Didcot (United Kingdom)*

[2] *Extreme Light Infrastructure, ELI Beamlines Facility, Dolní Břežany (Czech Republic)*

Debris produced by intense (10^{14} - 10^{15} Wcm^{-2}) lasers irradiating solid targets has long been known to threaten optics and diagnostic equipment inside the experimental chamber and modelling tools [1,2] have been developed to help predict the extent of the damage incurred. At higher intensities (>10^{19} Wcm^{-2}), however, the mechanism of debris production is less well known. As plans are drawn up for high repetition rate MJ-class lasers for fusion energy production and PW-class beamlines are integrated into these systems as part of fast ignition schemes, the problems posed by debris may become more acute. Debris is also thought to be a significant risk to lower energy PW-class lasers operating at high repetition rates [4]. Disruption to these laser systems will impact studies of fusion-relevant physics as well as, potentially, research into the effects of space debris on satellites.

When assessing the impact of debris on objects close to a laser target, it is important to characterise the quantity of material ejected, as well as its velocity, phase and angular distribution. We present results of debris monitoring in recent [3] and historic [4] campaigns on the PW-class Gemini laser. Videos taken with a fast framing camera and backlighter allow us to record the size, velocity and phase of debris produced by solid targets of varying thickness (ranging from 10 nm to 1 μm). Passing a green backlighter beam transversely across the target and using a lens to magnify the image onto a camera, we observed debris ejected from the front and rear surface at shot rates of ~1 shot-per-minute. A simple model of debris formation is discussed in relation to our experimental data, using 1D equations of heat and shock wave propagation in uniform media.

References

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