Enhanced laser coupling, matter heating, and particle acceleration through Spatially-separated and Symmetrically-overlapped PW Lasers Irradiating Solid Target

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The next generation of PW lasers are, and will be, a combination of several beamlines, e.g., the iCAN project [1]. The overlapping of these spatially separated beamlines is inevitable and may heavily affect the laser energy coupling [2-4]. Here we demonstrate, with proof-of-principle experiments at the Vulcan Target Area West (TAW) laser facility at Rutherford Appleton Laboratory (RAL), that by overlapping the two intense laser beams symmetrically at the target front, the hot-electron beam (HEB) generation at the target front is well enhanced and the ion acceleration at the rear side of the target is also improved (both in their maximum energy and collimation). The underlying mechanism is pinpointed with three-dimensional Particle-in-Cell simulations, which show that magnetic reconnection is induced at the target front (by the self-generated magnetic fields) when the two beams are close enough to each other, and it plays a major role in the HEB generation enhancement. Moreover, our simulation also shows further enhancement of the laser energy coupling when overlapping more beamlines.

References

[1] Mourou, Gerard, et al. "The future is fibre accelerators." Nature Photonics 7.4 (2013): 258-261.
[2] Markey, K., et al. "Spectral enhancement in the double pulse regime of laser proton acceleration." Physical review letters 105.19 (2010): 195008.
[3] Morace, A., et al. "Enhancing laser beam performance by interfering intense laser beamlets." Nature communications 10.1 (2019): 1-9.
[4] Raymond, A. E., et al. "Relativistic-electron-driven magnetic reconnection in the laboratory." Physical Review E 98.4 (2018): 043207.