Relativistic interaction with critical laser-machining gas target

Omri Seemann[1], Yang Wan[1], Sheroy Tata[1], Eyal Kroupp[1], Victor Malka[1]

[1] *Weizmann Institution of Science, Rehovot, Israel*

omri.seemann@weizmann.ac.il

Interaction of intense laser at near critical density is a fertile domain of science that thanks to the increase of laser plasma energy coupling, opens new perspectives for particle accelerators and bright radiation sources. Development of targets that can easily be modified and optimized have been pursued to investigate this regime. Based on gas targets, those developments have considerable benefits such as high repetition rate viability and competitive cost. Due to the inherent limit of the laser depletion and filamentation in such gas targets that are too long or with too smooth density gradients, the use of gas target alone is not enough. Here, we show a technique using a second laser pulse to locally heat the gas and control the longitudinal and transverse density profile through the generation of shock and rarefaction waves in flexible geometries which are dictated by the laser intensity distribution. This approach allows to create the near critical density target with micron scale gradients and to control the density in the long density upramp of the target, allowing to deliver stable proton sources with monoenergetic spectrum. Beyond permitting proton acceleration, this approach can also be used to control the transverse density in a way that allows manipulation of laser spatial phase at the relativistic intensities near the target. This was observed to generate an astigmatic phase in the laser beam, and might be used in the future as a new type of high intensity optic.

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