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Laser-driven magnetic filaments as a platform for high-field science

A. Arefiev [1], T. Wang [1], Y. He [1], H. Rinderknecht [2], T. Blackburn [3], and T. Toncian [4]

1) UC San Diego, La Jolla, USA

2) Laboratory for Laser Energetics, Rochester, USA

3) University of Gothenburg, Gothenburg, Sweden

4) Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

High-power high-intensity multi-beam laser systems that are becoming operational around the world can now be used to create a platform for high-field science that is based on relativistically transparent magnetic filaments driven by irradiating lasers within a dense plasma [1]. The strength of the quasistatic field can be comparable to that of the laser (fig. 1b), reaching the megatesla level. This talk will review several phenomena that can be studied with experimentally achievable laser intensities at multi-PW laser facilities. These include emission of dense gamma-ray beams in the quantum regime [1,2] and electron-positron pair creation from light alone [2,3]. Astrophysical environments are known for exotic physics regimes that involve generation of extreme magnetic fields and creation of matter and antimatter from light alone. The discussed platform provides a potential path towards recreating relevant regimes in laboratory conditions.

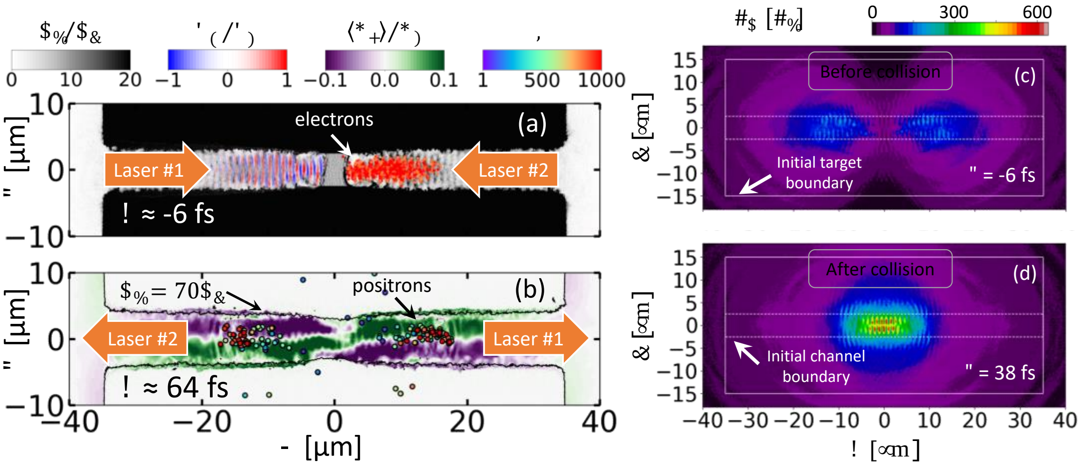

Figure 1: Structured target during irradiation by two laser ($a_0 = 190$) in a PIC simulation. (a) Electron density n_e (gray scale), electric field E_y of laser #1, and electrons with $\gamma \geq 800$ accelerated by laser #2 (dots, colored by γ). (b) Laser-accelerated positrons (points), confined by the quasistatic plasma magnetic field $\langle B_z \rangle$ (color scale). (c) and (d) Photon density ($\varepsilon_\gamma \geq$ 1 keV) before and after the collision of the two lasers. E_0 and B_0 are the peak laser fields in vacuum; n_c is the classical critical density.

References

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