Proton deflectometry to study magnetic field generation, dynamics and reconnection

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Laser-driven proton beams have attractive properties for measuring transient electromagnetic fields within plasmas. The small virtual source size (~10 μm) provides excellent spatial resolution for imaging, while the proton beam acceleration time is of the order of the pulse duration (~1 ps), providing good temporal resolution. In this talk, I will discuss how we have used proton beams to study the magnetic fields generated during laser-solid interactions from a variety of experimental conditions and geometries. The proton deflections can enable quantitative measurements of the fields, using approaches such as a 1D polar-coordinates field reconstruction technique or using a numerical field reconstruction method. We used the proton deflectometry technique to study a number of scenarios including nanosecond duration laser interactions to observe Biermann-battery fields, the suppression field generation and the formation of radiation-driven double ablation fronts [1]. Using short-pulse higher intensities heats electrons to relativistic temperatures, and consequently generates stronger and highly dynamic magnetic fields. The interaction of the magnetic fields from two neighboring interactions was been studied, either using two picosecond laser pulses to form a relativistic electron-driven magnetic reconnection geometry [2], or to observe the picosecond generated fields colliding with a nanosecond generated plasma and field structure.

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References

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[2] C. A. J. Palmer, et al., Field reconstruction from proton radiography of intense laser driven magnetic reconnection, Physics of Plasmas, **26**, 083109 (2019).