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Deflection of laser accelerated protons due to multi-megagauss magnetic fields in high-intensity laser-plasma interactions

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Self-generated magnetic fields are produced in high-intensity laser-plasma experiments from several mechanisms, including relativistic electron currents and misaligned density and temperature gradients (the Biermann Battery effect). Understanding the formation and timescales of these magnetic fields is important in several high energy density regimes ranging from astrophysical jets to the fast ignition approach to laser fusion energy. Here we will present a study of the magnetic fields produced in cylindrical geometry using wire targets (10-25µm in diameter) with the Titan laser (700fs, 50 J) at the Jupiter Laser Facility. The spatial and energy distributions of the laser accelerated protons produced in the interaction are recorded using radiochromatic film (RCF) and Thomson Parabola ion spectrometers, respectively. A cylindrical RCF stack was installed around the wire target which provided a large-angle sampling of the spatial distribution. Two well-defined bands, offset ±8-15° vertically from the laser plane and surrounding the wire azimuthally, are observed for proton energies up to 7.5 MeV. We will show that the two bands observed on the RCF can be attributed to the formation of caustics in linear proton radiography theory whereby the energetic protons are deflected due to the self-generated magnetic fields. Finally, these results will be compared with 2D and 3D Particle-in-cell (PIC) simulations which qualitatively reproduce the observed bands with magnetic fields on the order of 10 MG due to the Biermann Battery effect.

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Author: CURRY, Chandra (SLAC National Accelerator Laboratory/University of Alberta)

Co-authors: PROPP, Adrienne (SLAC National Accelerator Laboratory); PAK, Arthur (Lawrence Livermore National Laboratory); AURAND, Bastian (Heinrich-Heine-University Düsseldorf); RAMAKRISHNA, Bhuvanesh (Indian Institute of Science Education and Research, Bhopal); RUYER, Charles (SLAC National Accelerator Laboratory); ROEDEL, Christian (SLAC National Accelerator Laboratory); GOYON, Clement (Lawrence Livermore National Laboratory); FIUZA, Frederico (SLAC National Accelerator Laboratory); WILLIAMS, Jackson (Lawrence Livermore National Laboratory); RUBY, John (Lawrence Livermore National Laboratory); KIM, Jongjin (SLAC National Accelerator Laboratory); GAUTHIER, Maxence (SLAC National Accelerator Laboratory); WILLI, Oswald (Heinrich-Heine-University Düsseldorf); MISHRA, Rohini (SLAC National Accelerator Laboratory); GOEDE, Sebastian (SLAC National Accelerator Laboratory); KERR, Shaun (Lawrence Livermore National Laboratory/University of Alberta); GLENZER, Siegfreid (SLAC National Accelerator Laboratory); TSUI, Ying (University of Alberta)

Presenter: CURRY, Chandra (SLAC National Accelerator Laboratory/University of Alberta)

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