Giant magnetic fields in intense laser-solid interactions as astrophysical analogues

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The aim of this paper is to study giant magnetic fields created by high intensity laser fields in a solid target and study the turbulent evolution. Currently there is a great deal of interest in finding astrophysical analogues of stellar phenomena in the lab. This study addresses the parallels between turbulence in lab generated magnetic fields and those in the solar atmosphere.

Ultra-intense laser pulses can launch mega-ampere pulsed currents of relativistic electrons inside the target, producing mega-gauss magnetic fields. The transport of these giant currents through solid media is not fully well known till date. To study the transport process, we measure the spatio-temporal evolution of the magnetic fields at the rear side of the thin dielectric (fused silica), plastic (mylar), and metal (aluminium) foil, targets of various thickness and materials.

The *p*-polarized interaction laser pulse (≥10^{19} W/cm^2, 800 nm, 25 fs) was focused to a spot of 12 μm (FWHM). A linearly polarized, time-delayed and frequency-doubled (400 nm) probe pulse, extracted from the main interaction pulse, was suitably attenuated to low intensities (~10^{10} W/cm2) and focused to a 75 μm diameter spot on the target rear at near-normal incidence. The magnetic fields induce a birefringence in the plasma at the target rear, resulting in a change in the polarization state of the incident probe, which was inferred from standard polarimetric measurements of the Stokes' parameters of the reflected probe.

We observed the magnetic field rises to 100s of mega-gauss during first few picoseconds and decreases thereafter. Also, we observed larger, less filamented magnetic field for plastic (mylar) targets than that for fused silica or metal (aluminium) foil targets. We will analyze the power spectra of the magnetic fields to see the evolution of turbulence in the plasmas at the target front and at the rear and then draw parallels between lab plasmas and astrophysical objects.

References:

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