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Observation of Self-Similarity in the Magnetic Fields Generated by the Ablative Nonlinear Rayleigh-Taylor Instability[1]

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The Rayleigh-Taylor (RT) instability has been extensively studied because of its relevance to ignition target designs in inertial confinement fusion, material strength studies in high energy density physics, and astrophysical systems. This talk presents the first measurements of magnetic field generation by the nonlinear RT instability in laser-accelerated planar foils using ultrafast proton radiography at the OMEGA EP Laser System. Thin plastic foils were irradiated with 4-kJ, 2.5-ns laser pulses at focused laser intensities of $\sim 10^{14}$ W/cm^2. Target modulations were seeded by laser nonuniformities and amplified during the target-acceleration phase by the RT instability growth. A high-energy proton beam tracked the hydrodynamic evolution of the target and mapped the magnetic field spatial distribution with high spatial and temporal resolution. The experimental data show self-similar behavior [1] in the growing cellular magnetic field structures [2-3]. The calculated magnetic cell-merging rate is consistent with the value determined by earlier x-ray measurements [4], linking the cellular magnetic field structures with the RT bubble and spike growth. The results are consistent with two-dimensional magnetohydrodynamic simulations, showing MG-level magnetic field generation in the laser-driven foil [3]. The work could benefit the understanding of magnetic-seed-field generation in high energy density plasmas and the flow-driven processes that induce global magnetic structures prior to their turbulent amplification by the dynamo process.

[1] U. Alon et al., Phys. Rev. Lett. 72, 2867 (1994).
[2] L. Gao et al., Phys. Rev. Lett. 110, 185003 (2013).
[3] L. Gao et al., Phys. Rev. Lett. 109, 115001 (2012).
[4] O. Sadot et al., Phys. Rev. Lett. 95, 265001 (2005); V. A. Smalyuk et al., Phys. Rev. Lett. 81, 5342 (1998)

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