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Turbulent Dynamo Amplification of Magnetic Fields in Laser-Produced Plasmas[1]

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Magnetic fields are ubiquitous in the Universe, as revealed by diffuse radio-synchrotron emission and Faraday rotation observations, with strengths from a few nG to tens of μG. The energy density of these fields is typically comparable to the energy density of the fluid motions of the plasma in which they are embedded, making magnetic fields essential players in the dynamics of the luminous matter in the Universe. The standard model for the origin of these intergalactic magnetic fields is through the amplification of seed fields via turbulent dynamo to the level consistent with current observations. We have conceived and conducted a series of experiments using high-power laser facilities to study the amplification of magnetic fields via turbulence. In these experiments, we characterize the properties of the fluid and the magnetic field turbulence using a comprehensive suite of plasma and magnetic field diagnostics. We describe the large-scale 3D simulations we performed with the radiation-MHD code FLASH on ANL's Mira to help design and interpret the experiments. We then discuss the results of the experiments, which indicate magnetic Reynolds numbers above the expected dynamo threshold are achieved and seed magnetic fields produced by the Biermann battery mechanism are amplified by turbulent dynamo. We relate our findings to processes occurring in galaxy clusters.

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