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Turbulent amplification of magnetic fields in the laboratory[1]

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Magnetic fields exist ubiquitously in the Universe, as revealed by either diffuse radio-synchrotron emission, or 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. At present, the origin and the distribution of the magnetic fields are far from being understood. The standard model for the origin of these intergalactic magnetic fields is through the amplification of seed fields via turbulent processes to the level consistent with current observations. We have conducted a series of laboratory experiments using high power laser facilities [1,2] to exploit the scale invariance of the magneto-hydrodynamics equations. While the scaling is not perfect (e.g., in what concerns dissipation coefficients such as resistivity or viscosity), the similarity is sufficiently close to make such experiments interesting – and the results have been showing up the fundamental physical process at play. Our results indicate the magnetic field is indeed amplified by turbulent mechanisms. We relate our findings with processes occurring in supernova remnants and in cluster of galaxies. These experiments provide an example of magnetic field amplification by turbulence in plasmas, a physical process thought to occur in many astrophysical phenomena.

[1] G. Gregori et al., Nature 481, 480 (2012);
[2] J. Meinecke et al., Nature Phys. 10, 520 (2014).

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