Characterizing the evolution of dynamo-generated magnetic fields in a turbulent laser plasma

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It has recently been demonstrated experimentally on the OMEGA laser facility that turbulent plasma (created by the collision of two destabilized plasma jets) is capable of generating strong magnetic fields via the small-scale turbulent dynamo mechanism, provided the magnetic Reynolds number of the plasma is sufficiently high. Such magnetic fields, whose energy at saturation is comparable to the turbulent fluid motions, have a complex stochastic structure. A proton imaging diagnostic can be used to provide a detailed statistical characterization of these fields, including measurements of typical and maximal field strengths, structure sizes, the magnetic-energy spectrum, and intermittency. We apply these analysis techniques to a series of proton images captured at different times during the evolution of the plasma, to chart in detail the development of magnetic fields. The validity of the analysis technique is tested via post-processing of FLASH simulations of the experiment, in which the exact magnetic field is known. The turbulence itself is also diagnosed in parallel via an X-ray diagnostic. The results presented here seem to support the theoretical expectation that magnetic field growth occurs in two phases: a rapid period of initial growth, followed by a second period in which magnetic energy grows approximately linearly. More generally, the methodology described provides a useful paradigm for the measurement of stochastic magnetic fields in laboratory experiments.