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Astrophysical Turbulent Dynamos in High Energy-Density Laboratory Plasmas[1]

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Turbulent dynamos exponentially amplify weak, primordial magnetic fields to produce the present-day magnetic universe on scales from the interplanetary to the intergalactic. Advances in HED experimental techniques make possible for astrophysical turbulent dynamos to be recreated in the laboratory. Taking advantage of this, we devised, using the FLASH MHD code, a new scheme to observe the astrophysical turbulent dynamo in action. The key to our scheme on the OMEGA-EP laser was to involve its long pulse beams in dual roles: First, the laser beams initiated a quasi-steady, turbulent, magnetized plasma by irradiating a simple target cone of machined plastic. Then, the laser beams continuously heated the ablated plasma, thereby sustaining the highly irresistive conditions necessary for turbulent dynamo activity through their 10 ns-long pulse. As the turbulent dynamo evolved, we sketched its trajectory by timing a TNSA proton beam to project deflection images revealing the plasmas electric currents that underlay its magnetic field. We found that in its 5 ns lifetime the turbulent dynamo exponentially amplified the plasmas magnetic energy on all resolved scales unto saturation at 10s of times its initial amount. Hence, we matched our experiment to predictions with greatest fidelity.

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