Contribution ID: **41** Type: **Oral**

Cosmological magnetic fields and particle acceleration in the laboratory

Wednesday 9 August 2017 11:00 (30 minutes)

Magnetic fields are ubiquitous in the Universe. 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. Magnetic fields are also essential for the production of high energy cosmic rays. The standard theoretical model for the origin of these strong magnetic fields is through the amplification of tiny seed fields via turbulent dynamo to the level consistent with current observations. Here we demonstrate, using laser-produced colliding plasma flows, that turbulence is indeed capable of rapidly amplifying seed fields to equipartition with the turbulent fluid motions. These results support the notion that turbulent dynamo is responsible for the observed present-day magnetization of the Universe. We also show that such turbulent and magnetized plasmas can drive plasma instabilities that energize electrons above the thermal background, thus providing a possible injection mechanism for cosmic ray acceleration. We conclude by discussing future experiments at the National Ignition Facility laser to study second order Fermi acceleration.

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Session Classification: Plenary session