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Stochastic Acceleration of Heavy Ions in a Magnetized and Turbulent Plasma

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The exact mechanism that enables the acceleration of highly energetic charged particles in the Universe, cosmic rays [1], remains controversial. Although many processes may result in cosmic ray (CR) acceleration, turbulence is generally accepted to be essential to energizing the ions and electrons in the interstellar medium. Indeed, the original mechanism of CR acceleration proposed by Fermi [2] theorised that energetic charged particles gain energy in random scattering events with magnetized clouds. Given that the standard mechanism for the origin of these magnetic fields is via the turbulent dynamo mechanism [3], it is clear that a key process governing CR acceleration is related to how charged particles interact with stochastic magnetic fields embedded in a turbulent plasma.

We have performed an experiment at GSI [4] to investigate the interaction of fast heavy ions and turbulent magnetized plasma. Two opposing plastic targets, with textured surfaces, were driven by laser beams such that the ablated plasma collided and mixed in the central region, creating a turbulent, magnetized plasma. As this occurs, collimated pulses of ions (with period 9ns and velocity ~0.1c) from UNILAC, traverse the central region and the change in their energy profile is extracted from their time-of-flight (ToF). Our ToF data shows that the mean energy of the ion pulses crossing the turbulent magnetized plasma increases. Our experimental results are supported by 3D magneto-hydrodynamics simulations of the plasma conditions.

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