BOSTON UNIVERSITY

Boston University College of Arts & Sciences
Center for Space Physics

2023—2024 SPACE PHYSICS SEMINAR SERIES

Generation and amplification of cosmic magnetic fields in a collisionless plasma

Astronomical observations suggest pervasive micro-gauss magnetic fields in our Galaxy and in the intracluster medium (ICM) of galaxy clusters. It is widely believed that such dynamically important magnetic fields are produced by plasma dynamos acting upon some ``seed'' magnetic fields. However, a complete understanding of this process in a weakly collisional plasma is still lacking. We report a first-principles numerical and theoretical study of plasma dynamo in a fully kinetic framework. By applying an external mechanical force to an initially unmagnetized plasma, we develop a self-consistent treatment of the generation of ``seed'' magnetic fields, the formation of turbulence, and the inductive amplification of fields by fluctuation turbulent dynamo. The driven large-scale motions in an unmagnetized, weakly collisional plasma are subject to strong phase mixing, which in turn leads to the development of thermal pressure anisotropy. The Weibel instability is then triggered and produces filamentary, micro-scale ``seed'' magnetic fields. The plasma is thereby magnetized, enabling the stretching and folding of the fields by the plasma motions and the development of pressure-anisotropy instabilities. The scattering of particles off these microscale magnetic fluctuations provides an effective viscosity, impacting the field morphology and turbulence. During this process, the seed fields are further amplified by the fluctuation dynamo until they attain equipartition with the turbulent flow. This work has important implications for magnetogenesis in dilute astrophysical systems by demonstrating that equipartition magnetic fields can be generated from an initially unmagnetized plasma through large-scale turbulent flows.

Thursday, January 25th

4:00-5:00 p.m.

725 Commonwealth Ave | Room 502

Muni Zhou

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