BOSTON UNIVERSITY

Boston University College of Arts & Sciences
Center for Space Physics

2025 SPACE PHYSICS SEMINAR SERIES

Current sheets and the plasmoid instability: mediators of fast magnetic reconnection and turbulence

Current sheets are localized regions of the plasma in which the current density can become singular in the zero-dissipation limit. While the critical role of such structures in mediating fast reconnection and turbulence has been recognized for some time, the universal nature of the plasmoid instability of these structures in high-Lundquist-number plasmas and its role has become a subject of significant interest relatively recently. Enabled by sophisticated computer simulations and analytical theory and tested by experiments, the plasmoid instability has transformed our understanding of magnetic reconnection and inspired new research in space, astrophysical, and laboratory (including fusion and high-energy-density) plasmas. In this talk, I will review the evolution of our understanding in systems where closed field lines exist (such as in a torus) and those where they may not (such as in stellar coronae and compact astrophysical objects where field lines may be line-tied). Even the definition of magnetic reconnection in the latter class of systems remains a contested issue. In turbulent systems characterized by the formation of thin current sheets, the onset of the plasmoid instability is shown to interrupt the inertial range and introduce new power laws for the dissipation range and produce coherent structures that play an essential role in particle acceleration and heating in non-relativistic as well as relativistic regimes. Exascale computers, exploited by state-of-the-art codes, hold the promise of breaking new ground in making predictions in plasma regimes that have been hitherto inaccessible. Despite the progress made in theory and experiment, many open questions remain. Some of them will be discussed.

Thursday, March 27th

3:30 - 4:30 p.m.

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