DPP15-2015-000508

Abstract for an Invited Paper
for the DPP15 Meeting of
the American Physical Society

The Physics of the Laboratory Magnetosphere[1]

MICHAEL MAUEL, Columbia University

During the past decade, experiments and simulations have characterized a new regime of high-beta toroidal plasma confinement using unique facilities, called laboratory magnetospheres. In a laboratory magnetosphere, a large plasma is confined by a relatively small, magnetically levitated, superconducting current ring. Nonlinear processes, including the inverse cascade of turbulent fluctuations and turbulent self-organization, are studied and controlled in near steady-state conditions. Because a dipole's magnetic field lines resemble the inner regions of planetary magnetospheres, these studies link laboratory and space plasma physics. However, unlike planetary magnetospheres, the magnetic field lines from a levitated dipole are axisymmetric and closed, imparting unique properties to the laboratory magnetosphere. A levitated dipole confines plasma without field-aligned currents, even when plasma pressure exceeds the local magnetic pressure ($\beta > 1$). Particle drifts are omnigeneous, and the dynamics of passing and trapped particles are similar. Because parallel currents can be a source for instability, many well-known low-frequency instabilities found in other toroidal configurations, like kink, tearing, ballooning, and drift modes, are not found in a dipole plasma torus. Instead, interchange and entropy modes, which resonate with bounce-averaged magnetic drifts, dominate plasma dynamics. This review emphasizes observations from the levitated dipole experiments at MIT and at the University of Tokyo, shows the application of gyrokinetic simulations and bounce-averaged fluid models with drift-kinetic closures to model the physics of the up-gradient turbulent pinch, describes the structure and chaotic dynamics of interchange and entropy mode instability, and introduces opportunities to apply the new physics of the laboratory magnetosphere to explore turbulent transport processes within a large quasi-steady magnetized plasma torus.

[1]Acknowledging contributions from Drs. D. Garnier, J. Kesner, M. Nishiura, B. Rogers, Z. Yoshida, and the CTX, LDX, and RT-1 Teams and support from the DOE-NSF Partnership for Plasma Science.