DPP15-2015-001009

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

Vortex dynamics of electron plasmas in externally imposed $E \times B$ flows

NOAH HURST[1], University of California - San Diego

Electron plasmas confined in cylindrical Penning-Malmberg traps may be used to study two-dimensional vorticity dynamics through an isomorphism between the Drift-Poisson equations for $E \times B$ flow and the Euler equations describing an ideal fluid.[2] In the work to be described here, the boundary conditions are varied by biasing segments of a confining electrode. This results in the imposition of ExB flows that advect the electron density (which is the analog of fluid vorticity). In this manner, the response of a stable, coherent 2D vortex to irrotational shear and strain flows can be studied with the precision and control not possible in traditional fluids such as water.[3] Behavior to be described includes partial or complete vortex destruction through the stripping of peripheral vorticity, vortex fission, and breaking of adiabatic invariance for a vortex in time-dependent external flow fields. It is shown that vortex stripping is the dominant response to external strain, and the conditions necessary for partial stripping, fission, and total decoherence are elucidated. One advantage of electron plasma experiments over those with traditional fluids is the ability to control the relevant timescales, and this enables novel studies of non-adiabatic effects and the fission process. Beyond basic vortex dynamics and 2D turbulence,[4] these studies are potentially relevant to geophysical fluid flows[5] and shear suppression of turbulence in plasmas.[6]

[1]Work done in collaboration with J. R. Danielson and C. M. Surko.

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