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Marshall N. Rosenbluth Outstanding Doctoral Thesis Award Talk: Dynamics of two-dimensional electron vortices subject to applied $E \times B$ strain flows[1]

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Presented here is a novel experimental technique to study the two-dimensional (2D) fluid dynamics of magnetized, non-neutral pure electron plasmas subject to applied boundary conditions [1,2]. Details of the experimental procedure are given, and data regarding elliptical distortions of the plasmas are discussed. The $E \times B$ drift dynamics of the plasmas studied here are directly analogous to that of the vorticity in a 2D inviscid, incompressible fluid [3]. The experimental apparatus is designed so that the electric potential on the boundary can be specified in the plane perpendicular to the magnetic field while preserving translational symmetry along the field. This allows one to study vortex dynamics in the presence of external flows. Initially axisymmetric electron vortices are prepared with radial vorticity profiles ranging from smooth (e.g., Gaussian) to quasi-flat. When quasi-flat profiles are subjected to constant external strain flows, the vortices are either destabilized or distorted elliptically in a periodic fashion, depending on the strain-to-vorticity ratio. The data are in quantitative agreement with a theoretical fluid model where the vorticity is treated as piecewise constant in an elliptical region [4]. However, when the profile is sufficiently smooth, the amplitude of the oscillation can decay due to spatial Landau damping [5]. Finally, adiabatic behavior of the system is studied by gradually increasing the strain rate over time using both smooth and piecewise ramp functions. [1] N. C. Hurst, et. al., Phys. Rev. Lett. 117, 235001 (2016) [2] N. C. Hurst, et. al., J. Fluid Mech. 848, 256 (2018) [3] C. F. Driscoll and K. S. Fine, Phys. Fluids B 2, 1359 (1990) [4] S. Kida, J. Phys. Soc. Japan 50, 3517 (1981) [5] D. Schecter, et. al., Phys. Fluids 12, 2397 (2000) This work is done in collaboration with J. R. Danielson, D. H. E. Dubin, and C. M. Surko.

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