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Novel vorticity probe and its use for the study of strong cross-field sheared flow in the Large Plasma Device[1]

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We report evidence for the existence of coherent structures created by the Kelvin-Helmholtz instability in steady-state, shear-flow driven plasmas in the LArge Plasma Device (LAPD) facility at UCLA. The measurements are performed with the Vorticity Probe, a newly designed probe that can directly measure the plasma vorticity associated with the $\vec{E} \times \vec{B}$ shear flow by means of a method that is both simpler and more accurate than the methods used in neutral fluids. Because the rate of change of vorticity is a key quantity in nonlinear models, like in Hasegawa-Mima equation, for interchange modes in plasmas, its direct measurement is critical for verification purposes. The physical origin of the rate of change of plasma vorticity from $\vec{E} \times \vec{B}$ flow is the divergence of the ion polarization current. Vortex coherent structures occur when the vorticity is a nonlinear function of the stream function (which for magnetized plasmas is the electric potential divided by the magnetic field strength). A strong-shear-flow regime in the LAPD was used to create the Kelvin-Helmholtz instability. Comparisons of the measured vortex characteristics with the results from nonlinear simulations of the systems will be described. We also carry out nonlinear simulations of density and magnetic flux as passively advected scalars in the fluctuating potential and study the mixing of particles and magnetic flux across the shear layer, for which the Kelvin-Helmholtz instability is believed to be the underlying mechanism in both space and laboratory plasmas.

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