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Diocotron Mode Damping from a Flux through the Critical Layer[1]

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Experiments and theory characterize a novel type of spatial Landau damping of diocotron modes which is *algebraic* rather than *exponential* in time; this damping is caused by a flux of particles through the wave/rotation critical layer.[3] These $k_z = 0$ diocotron (drift) modes with azimuthal mode numbers $m_\theta = 1, 2...$ are dominant features in the dynamics of non-neutral plasmas in cylindrical and toroidal traps; and they are directly analogous to Kelvin waves on 2D fluid vortices. Spatial Landau damping is the resonant interaction between a mode at frequency f_m and the plasma rotation $f_E(r)$, at the critical radius R_c where $f_m = m_\theta f_E(R_c)$. This is mathematically analogous to velocity-space Landau damping with $f_k = kv/2\pi$. •Experimentally, diocotron modes on pure electron plasmas exhibit exponential Landau damping when the *initial* plasma density is non-zero at R_c. Here, we demonstrate that a steady outward *flux* of particles through R_c causes diocotron modes to damp algebraically to zero amplitude, as $D(t) = D_0 - \gamma_m t$. The outward flux is controlled and measured experimentally, and the damping rates γ_m are proportional to the flux. In general, any weak non-ideal process which causes outward flux may cause this damping. •Analytics and simulations have developed a simple model of this damping, treating the transfer of canonical angular momentum from the mode to particles transiting the nonlinear trapping region at R_c. The model qualitatively agrees with experiments for $m_\theta = 1$, but nominally predicts a discrepant algebraic exponent for $m_\theta = 2$, perhaps due to the amplitude dependence of the trapping structure. Overall, this novel flux-driven damping is determined by the *present* magnitudes of the wave and outward flux, in contrast to the Landau analysis of phase mixing of the *initial* density.

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[3]A.A. Kabantsev, et al., Phys. Rev. Lett. 112, 115003 (2014).