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Flow characteristics of bounded self-organized dust vortex in a complex plasma

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(Dated: March 24, 2017)

Dust clouds are often formed in many of the dusty plasma experiments when micron size dust particles are introduced in a plasma, by spatial non-uniformities of the potential and shows a self-organized patterns like vortex or circulation flows[1]. Steady equilibrium dynamics of such a dust clouds is analyzed for varying Reynolds number, which is confined in an azimuthally symmetric cylindrical setup by an effective potential and is in equilibrium with an unbounded sheared plasma flow. The impact of nonconservative force due to sheared ions field generates finite vorticity of the confined dust clouds. In the linear limit ($Rn \ll 1$), the collective flow is characterized by symmetric and elongated vortex with scales correlate with the driving field and frictions with boundaries[2,3]. However in limit ($Rn \geq 1$), the nonlinear inertial transport ($\mathbf{u} \cdot \nabla \mathbf{u}$) is effective and the vortex structure is characterized by a new unsymmetric equilibrium and emergence of a circular core region with uniform vorticity over which the viscous stress are negligible. The core domain is surrounded by a virtual boundary of highly convective flow followed by thin shear layers, that filled with low-velocity co-rotating and counter-rotating vortices enabling the smooth matching with external boundaries. The effective boundary layer thickness is recovered to scale with the dust kinematic viscosity as $\Delta r^3 \approx \mu$ in linear regime, and is turn into $\Delta r^2(u_\parallel/L_\parallel) \approx \mu$ in the nonlinear regime through a critical kinematic viscosity μ^* that signifies a structural bifurcation of the flow streamlines[4]. The proposed flow characteristics are relevant with many microscopic biological activity at lower Rn, and gigantic vortex flows such as Jovian great red spot, white ovals at higher Rn.

Reference:-

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