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Cooperative excitations in nonlinear dust acoustic waves: from order to turbulence

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The dusty plasma is composed of micro-meter sized dust particles suspended in the low pressure gaseous plasma background. The higher mobility of electrons than that of ions causes strong negative charging up to 10^4 electrons per dust particle. It makes the suspended dust particles a coupled Yukawa system, which can be tuned from the gas to the solid state by increasing coupling [1-6]. Through the interplay of dust inertia, screened Coulomb field, ion streaming, thermal agitation, etc., dust acoustic waves (DAWs) with longitudinal dust particle oscillation can be self-excited [7]. This fundamental nonlinear acoustic-type density wave is governed by modulation-type nonlinear dynamical equations, similar to many nonlinear waves exhibiting ubiquitous nonlinear cooperative phenomena from order to turbulence with increasing driving [8-13]. The proper dust size and spatiotemporal scales of the DAW make it a good platform to visualize and understand those ubiquitous nonlinear wave phenomena from the micro- to the macroscopic level, through optical tracking individual particle motion and monitoring dust density evolution illuminated by a laser sheet over a large area.

In this talk, our past works on the following subjects from ordered to turbulent DAWs will be briefly reviewed: a) cooperative dust micro-motion in plane waves and wave breaking through wave particle interaction, b) high and low amplitude singular cooperative excitations such as rogue wave events, and acoustic vortices (AVs) with helical wave fronts winding around defect filaments in weakly disordered DAWs, c) Decomposing DAW turbulence into multi-scale modes and viewing it as a zoo of multiscale interacting AVs, and d) multi-scale coherent excitations of acoustic wave turbulence in cold dusty plasma liquids [8-13].

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