Visualizing micro and macroscopic coherent excitations in nonlinear acoustic waves: from order to turbulence

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Dusty plasma is composed of micro-meter sized dust particles suspended in the low pressure gaseous plasma background. In the dusty plasma with eV electron temperature, each micro-meter sized particle can be negatively charged up to 104 electrons due to the much larger mobility of electrons than that of ions. The system can be changed from the solid, liquid, to the gas states by proper tuning system control parameters under room temperature. In those states, nonlinear dust acoustic waves (DAWs), associated with longitudinal dust particle oscillations can be self-excited, through the interplay of dust inertia, Coulomb interaction, ion streaming, or thermal agitation. The proper particle size and spatiotemporal dynamical scales make the DAW a good platform to directly visualize and understand generic micro- to macroscopic dynamical behaviors of nonlinear acoustic waves, through optical tracking individual particle motion. In this talk, our past studies on the micro and macroscopic coherent and singular excitations in DAWs from order to wave turbulence will be briefly reviewed. Their spatiotemporal dynamical behaviors and micro-origins, such as chaotic particle motion in the nonlinear periodic DAW, wave-crest particle trapping and heating, wave breaking through wave-particle interaction, pairwise generation and annihilation of acoustic vortices (AVs) with helical waveforms winding around defect filaments, uncertain rogue wave events with extreme amplitude through particle focusing by distorted waveforms, viewing DAW turbulence as a zoo of interacting multi-scale AVs, viewing multi-scale thermally excited phonons in the cold liquid state as the microscopic acoustic wave turbulence, etc., will be presented and discussed.