Multi-scale cooperative micro-motion and structural rearrangements in cold dusty plasma liquids

Lin I, Hau-Wei Hu, and Yun-Xuan Zhang
Department of Physics and Center for Complex Systems, National Central University
e-mail: lini@phy.ncu.edu.tw

Counterintuitively, the micro-structure and motion in the cold liquid around freezing are not completely disordered. The interplay of the coherence generated by the strong mutual interaction under the solid-like packing, and the disorder generated by the stochastic thermal agitation slightly stronger than that in the solid, makes the cold liquid exhibit rich heterogeneous multiscale structural and dynamical behaviors. For example, multi-scale crystalline ordered domains (CODs) with different lattice orientations could emerge, which facilitate or frustrate thermal phonon excitation and propagation. It in turn induces avalanche-like cooperative particle hopping, structural rearrangement, and defect motion. Nevertheless, they are difficult to be directly visualized due to the small atomic scale for liquids in nature.

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 about 10^4 electrons per dust particle. Through tuning the strong Coulomb coupling, the suspended dust particles can be tuned from the gas to the solid state with proper spatial and temporal scales (order of second relaxation time and sub-mm inter-particle spacing), which facilitate the direct microscopic visualization of structure and motion through digital video microscopy [1-5]. It makes the dusty plasma liquid a good platform to mimic and understand the generic micro-behaviors of the liquid at the kinetic level.

In this talk, our past works on the micro-behaviors of the cold dusty plasma liquid around freezing will be briefly reviewed [6-13], especially for: a) the emerging of CODs with various lattice orientations and separated by multiscale defect clusters, b) the stick-slip type particle with alternative rattling in the cage formed by surrounding particles and the avalanche-like cooperative hopping in the form of multiscale clusters for inducing multi-scale structural rearrangement and defect motion governed by the conservation of Burgers vector, c) the thermally induced micro-acoustic wave (phonon) turbulence, and identifying the alarm for avalanche structural rearrangement through decomposing the multi-scale phonons, and d) the effect of supercooling and confinement induced layering.

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