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Extreme events in avalanche structural rearrangements in microscopic acoustic wave turbulence of cold dusty plasma liquids

Author list here Hao-Wei Hu [1], Lin I[1], --- (times 12pt)
[1] Department of physics, National Central University, Taiwan
e-mail (speaker): yosino0311@gmail.com

Microscopically, the two-dimensional liquid around freezing can be viewed as a patchwork of crystalline ordered domains surrounded by defect clusters around their interfaces. The interplay between stochastic thermal agitation and particle mutual interaction excites multiscale collective motions (waves or phonons) and avalanche-type structural rearrangements (SRs) in the form of clusters with various sizes in the space-time space, akin to seismic activities [1,2]. In this work, using the quasi-two-dimensional cold dusty plasma liquid as a platform for direct visualization, we experimentally investigate the statistical correlations of thermally induced multiscale acoustic wave turbulence, micro-structures, and avalanche structural rearrangements. Particle motions are decomposed into multiscale modes, in which the local phase and amplitude can be extracted [3,4].

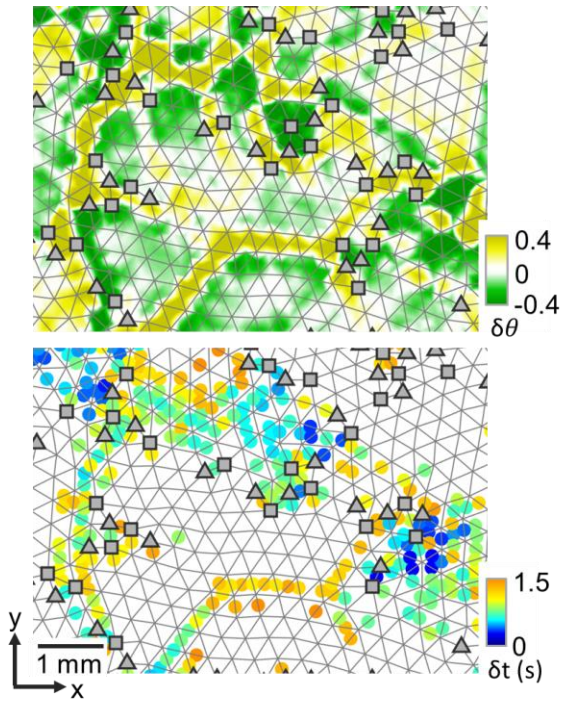

Figure 1 Upper panel: bond angle variation $\delta\theta$ over 1.5 s. Lower panel: SR sites identified by thresholding the variations of bond lengths and angles in a 1.5 s time interval, respectively. Particles sit at the vertices of the background grid. Squares and triangles represent sevenfold and fivefold disclination defects, respectively. SR sites are color coded by their occurring time δt from the starting time of each plot.

It is found that dislocation defects facilitate the excitation and propagation of large amplitude low frequency acoustic waves along strips with the same directions as the Burgers vectors of defects. The synchronization of the above low frequency waves with high-frequency waves enhances the local particle shear motion, and initiates the stick-slip propagation of SRs along the above strips which can intersect with one another. The number of dislocation defects in the quiescent period can serve as a warning alarm for the SR excitations with large cluster sizes.

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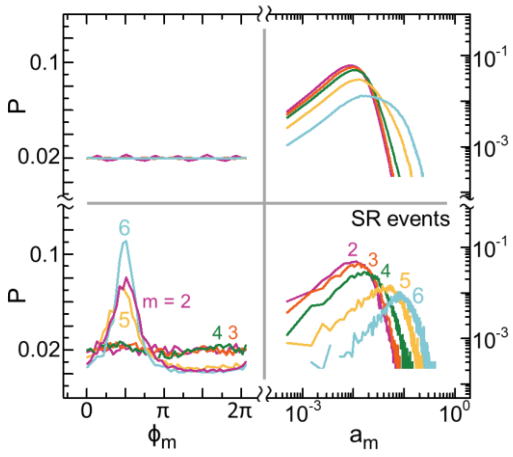

Figure 2 Histogram of instantaneous phase ϕ_m and amplitude a_m of modes m = 2 to 5, where m is the decomposed mode number from the sifting process of Hilbert-Huang transform. The histogram events of upper (lower) two panels are at time when SR not occurs (SR occurs). It shows that SR event occurrence is correlated with the phase synchronization of the large-amplitude decomposed modes.

References

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