Kolmogorov Flows in Strongly Coupled Plasmas: "A Molecular Dynamics Study"

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Kolmogorov flows have been widely used to study flow instability and transition to turbulence in Navier-Stokes fluids [1]. In the two dimensional case, Kolmogorov flow is generated by imposing a unidirectional force with magnitude varying sinusoidally along the other direction. For small enough forcing magnitude, this results into a series of parallel shear bands having sinusoidal velocity profile. At higher forcing magnitudes, the destabilizing inertial effects dominate over the stabilizing viscous effects and the velocity profile undergoes a transition to a vortex lattice [2, 3] and eventually turbulence [4]. We report for the first time, through large scale molecular dynamics simulations, the fate of such Kolmogorov flows in a strongly coupled Yukawa liquid. Such Yukawa liquids are ubiquitous in nature and typical examples include complex "dusty" plasma, colloids and certain dense astrophysical systems. They can exist in a state of strong coupling wherein the ratio of average potential to kinetic energy can significantly exceed unity. Starting from a thermally equilibrated Yukawa liquid, we superpose a sinusoidal velocity profile and observe a freely decaying Kolmogorov flow. The global transition of the flow pattern upon changing flow parameters is elucidated through various diagnostics. Our work highlights the possibility of observing such transitions in laboratory experiments in dusty plasma.

References

[1] Obukhov A. M., Russ. Math. Survey, 38 (1983) 113.

[2] Meshalkin L. and Sinai Ya. G., J. Appl. Math. Mech., 25 (1961) 1140.

[3] N. Platt, L. Sirovich, and N. Fitzmaurice, Physics of Fluids A 3, 681-696 (1991).

[4] She Z. S., Phys. Lett. A, 124 (1987) 161.