Seminar

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Institute for Plasma Research

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Title:	Molecular Dynamics Study of Subcritical Transition to Turbulence in a 3D Yukawa Liquid
Speaker:	Mr. Suruj Jyoti Kalita Institute for Plasma Research, Gandhinagar
Date:	18th November 2024 (Monday)
Time:	03:30 PM
Venue:	Seminar Hall, IPR Online Link: https://meet.google.com/bdu-dmpn-syc

Abstract

Turbulent flows are everywhere, starting from water pouring from a tap to blood flow through our arteries to stirred coffee cups to atmospheric flows to river flows to oceanic flows to the solar surface, supernovae explosions, accretion disks, etc. When a small or infinitesimal amplitude perturbation is applied to an unstable equilibrium, the perturbation grows and leads to non-linear saturation. For example, when two fluid layers move at different velocities and cross a threshold shear gradient, the interface becomes unstable to Kelvin-Helmholtz instability. Examples of such turbulent systems are Rayleigh-Benard convection, Ion-Temperature Gradient turbulence in Tokamaks, wherein turbulence occurs beyond a certain critical temperature gradient. These systems, where transition to turbulence is based on linearly unstable modes, triggered beyond a certain threshold, are known as supercritical. On the other hand, subcritical turbulence occurs in systems that are linearly stable. For example, plane Couette flow (PCF), plane Poiseuille flow (PPF), Taylor-Couette flow, etc. These flows are observed in rivers, oceans, geophysical flows, and in astrophysical scenarios, such as accretion disks.

A Yukawa liquid, often realizable in Complex plasmas, provides a perfect test bed to study fluid instabilities and turbulence related studies. Due to the stretched length-scales and slow time-scales, macroscale fluid phenomena can be studied accurately at the kinetic level, with the possibility of experimental verification. A screened Coulomb potential, also called a Yukawa potential, is often used in theory and simulations to model Complex plasmas.

In the present Thesis, using classical “first principles” 3D MD simulations, the possibility of subcritical transition to turbulence in PCF is investigated in a 3D Yukawa liquid, using a few millions of particles. By perturbing a PCF with finite-amplitude disturbance, subcritical transition to turbulence is demonstrated [1]. The characteristics of turbulence and its sustenance is shown to depend on the nature of the perturbation and its amplitude. Unlike supercritical turbulence, here the turbulence is shown to be spatially localized and interspersed with laminar regions, which are typical characteristics of subcritical turbulence. The effect of system size or aspect ratio [2] and the effect of stable stratification [3] on subcritical turbulence in PCF is investigated. The interaction of PCF in a Yukawa liquid with coherent vortex structure [4] is studied. In this presentation, several of the above said points will be discussed along with pointers to several open problems.

References

[1] S Kalita, R Ganesh, “Spot formation in three-dimensional Yukawa liquid,” Physics of Fluids, 33, 095118, 2021.

[2] S Kalita, R Ganesh, “Turbulent spot formation in three-dimensional Yukawa liquids using large-scale molecular dynamics simulation - effect of system size,” Physica Scripta, 99, 055246, 2024.
[3] S Kalita, R Ganesh, “Turbulent spot formation in stably stratified three-dimensional Yukawa liquids,” Physical Review Research, 6, 01319, 2024.
[4] S Kalita, R Ganesh, Manuscript Under Preparation, 2024.