Seminar

Institute for Plasma Research

Title : Shear flows in 2D strongly coupled fluids: A theoretical and computational study

Speaker : Ms. Akanksha Gupta
Institute for Plasma Research, Gandhinagar

Date : 27th January 2017 (Friday)

Time : 02.00 PM

Venue : Committee Room 4, (New Building), IPR

Abstract :

Micron-sized conducting or dielectric spherical grains immersed in a classical ideal plasma tend to attain large mean negative charge shielded by the background plasma. These mutually repellent particles of the grain-medium, interacting through a Yukawa-type potential, trapped in the sheath generated by the background plasma and external gravity, typically can attain inter-particle distances of the order of a millimeter, thus forming very low density, soft Yukawa matter. By controlling the temperature of the grain-medium using neutral atom collisions, gas like, liquid-like and solid-like phases of this grain medium have been discovered wherein, the individual particle dynamics is captured and analyzed in experiments.

Of particular interest is the liquid-state of this system, called a Yukawa liquid, which emerges due to strong spatial correlations. Yukawa liquid provides a fertile ground to understand several far-from-equilibrium phenomena such as onset of instability from macroscale shear flows, nonlinear dynamics of vortices, vortex-vortex interaction and coherent structures in a correlated medium. In this thesis, using non-equilibrium molecular dynamics simulations of Yukawa liquid, with no assumptions about local transport coefficients, the linear and nonlinear dynamics of a macro scale shear flow, namely 2D Kolmogorov flow (K-flows) of the soft grain medium is addressed. K-flows are known to exhibit sharp transition to turbulence, multiple coherent vortices and several other interesting cyclic properties in continuum models. Also, due to their smooth flow profiles, it is expected that K-flows may be relatively easily realizable in experiments. Using a newly developed 2D pseudo spectral code for compressible Navier-Stokes-like continuum model with visco-elastic effects arising from spatial correlation incorporated via a relaxation time, 2D Kolmogorov flow is studied in both linear and nonlinear limits. Qualitative comparision between particle and continuum model is made wherever possible. For example, in the particle study, molecular shear heating is found to play an important role in destroying the coherent vortices, while Navier-Stokes-like continuum model is seen to sustain these features relatively longer periods. Reasonable consistency is seen between particle and continuum models, in predicting the onset of turbulence as a function of strong correlation in particle model and elastic relaxation time in continuum model respectively. Similar comparisons between particle and fluid models for circular shear flows and forced Kolmogorov flows have also been attempted. The details of the above said studies will be presented in this talk.