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 : 18th September 2017 (Monday)

Time : 11.00 AM

Venue : Seminar Hall, IPR

Abstract :

Micron-sized conducting or dielectric spherical grains immersed in a classical near-ideal plasma tend to typically attain large mean negative charge which is shielded by the background plasma. These mutually repulsive particles of the grain-medium, interacting through a Yukawa-type potential, get trapped in the sheath generated by the background plasma and external gravity. Particles in this medium 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.

Yukawa liquid, which is a liquid state of the grain medium, provides a realizable experimental 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 work, using non-equilibrium molecular dynamics (MD) simulations of Yukawa liquid with Kolmogorov flow (K-flows) as the initial condition and with no assumptions about local transport coefficients, the linear and nonlinear dynamics of a macro scale shear flow are addressed. K-flows are known to exhibit sharp transition to turbulence, multiple coherent vortices and several other interesting cyclic properties in continuum models are easier to achieve in laboratory grain plasma experiments, due to their smooth flow profiles. To complement the MD studies we address the continuum fluid dynamics of strongly coupled grain plasma using a fully compressible, generalized fluid model by means of computational fluid dynamics (CFD) simulations with K-flows as initial shear flow profile. A new, parallelized nonlinear pseudo spectral code has been developed and is benchmarked against eigen values for Kolmogorov flow obtained from linear analysis. A comparison between particle (MD) and continuum model (CFD) is attempted. 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 strength in particle model and elastic relaxation time in continuum model respectively. The details of the above said studies will be presented in this talk.