7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Spontaneous Fluctuations of Densities in Strongly Coupled Complex Plasma

Ankit Dhaka, P.V. Subhash, P. Bandyopadhyay, A. Sen
Institute for Plasma Research, A CI of Homi Bhabha National Institute, Gandhinagar, Gujarat INDIA
e-mail (speaker): ankit.dhaka@ipr.res.in

Thermal motions of particles in a dynamic system cause fluctuations of various physical quantities at microscopic scales [1]. The studies of these fluctuations have proven essential for understanding transport processes from microscopic level. One way to study fluctuations is to obtain an auto correlation function, which is marker of time dynamics of fluctuating quantities such as densities, velocity or stresses etc. We report theoretical and experimental findings of density fluctuations for strongly coupled system using dusty plasmas as models. An analytical form of Density Autocorrelation Function (DAF) is derived in terms of the transport parameters of the system in the framework of the generalized hydrodynamic (GH) model [2]. The analytical results are validated against classical molecular dynamics simulation of Dusty plasma, where the Density Autocorrelation Function (DAF) characterizes the temporal evolution of density fluctuations [3]. The theoretical findings of this study are applied to laboratory experiments carried out in capacitively coupled radio frequency Argon plasmas. The dusty plasmas are produced by introducing the mono-dispersive micron-sized Melamine Formaldehyde particles in plasma environment. The DAF is experimentally estimated from the particles trajectories obtained using high-speed imaging system and compared with theoretical findings.

In the fundamental sense, the present derivations extend the famous observation of Landau-Placzek that the variation of density fluctuations in time can be described by the equations of irreversible thermodynamics to strongly coupled systems. While in the applied domain, the present approach is expected to provide a simple and accurate framework to obtain the transport properties of complex plasmas both theoretically and experimentally.

References

[1] J. P. Hansen and I. R. MacDonald, ‘Theory of Simple Liquids, Elsevier’, 2013.

[2] P. K. Kaw and A. Sen, ‘Low Frequency modes in strongly coupled dusty plasmas’, Physics of Plasma, pp. 3552-3559, 1998.

[3] Dhaka, A., Subhash, P.V., Bandyopadhyay, P and A. Sen. “Auto-correlations of microscopic density fluctuations for Yukawa fluids in the generalized hydrodynamics framework with viscoelastic effects”, Sci Rep 12, 21883 (2022)