Thermal fluctuations of Strongly Coupled Dusty Plasmas: A Theoretical and Experimental Study

Ankit Dhaka, P.V. Subhash, P. Bandyopadhyay and A. Sen

Institute for Plasma Research, A CI Homi Bhabha National Institute, Bhat, Gandhinagar, Gujarat, 382428, India

A study of the thermal fluctuations of a dynamic system at the microscopic scale can provide valuable clues for understanding transport processes [1]. In this work, we report theoretical and experimental investigations of density fluctuations of a strongly coupled dusty plasma towards that end. The dynamics of dusty plasma are described in the framework of the Generalized Hydrodynamic (GH) model that incorporates strong coupling and viscoelastic memory effects [2]. An analytical form of the Density Autocorrelation Function (DAF) is obtained in terms of the transport parameters of the system from the hydrodynamic matrix [3]. The analytical results are validated against a DAF with a classical molecular dynamics simulation of the dusty plasma. The theoretical findings of this study are then applied to laboratory experiments. The experiments are carried out in capacitively coupled radio frequency Argon plasmas.

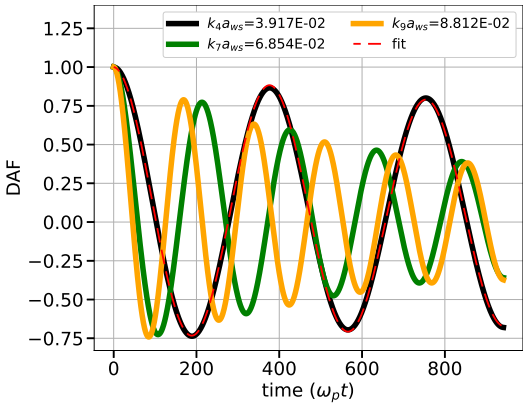

Figure 1: *Modes of DAF obtained from MD Simulation. The dashed line marks the fitting of analytically derived expression of DAF.*

The dusty plasmas are produced by introducing the mono-dispersive micron-sized Melamine Formaldehyde particles in the background plasma. The kinetic information, obtained by capturing dust particles' space and time dynamics with the help of a high-speed imaging system, is used to calculate the DAF in the inverse space. The experimental results are compared with the model equations over a range of coupling parameters.

References

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

[2] P. K. Kaw and A. Sen, Physics of Plasma, **5**, 3552 (1998)

[3] Dhaka, A., Subhash, P.V., Bandyopadhyay, P and A. Sen., Scientific Reports **12**, 21883 (2022).