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Mesoscopic modeling of transport properties in strongly coupled dusty complex plasmas.

Strongly coupled plasmas are systems where the average potential interaction energy per particle dominates the average kinetic energy. These varieties of systems occur in diverse physical scenarios: condensed matter systems such as molten salts and liquid metals, charged particles in cryogenic traps, diverse astrophysical systems, two-dimensional semiconductor nanostructures, and dusty plasmas, which are completely or partially ionized complex gases containing particles of solid material electrically charged of the order of microns and can be dielectric or conductive. Strongly Coupled Complex Dusty Plasmas (SCCDPs) have significant technological and theoretical implications, as they can exist in both “liquid” and “crystalline” phases. In particular, the transport properties of SCCDP in the liquid state are of practical meaning in various areas of science and technology, for example, polymer physics, medical, semiconductor and chemical industries, environmental safety, space plasmas, and in particular, in the understanding of physical properties induced by temperature of dense plasmas, that are of fundamental interest for inertial confinement fusion and astrophysics. Specifically, the shear viscosity η is essential to predict the collective properties of non-ideal complex systems. When η decreases as shear increases, the fluid exhibits “shear thinning”; this behavior occurs in different systems with the same universality class. Examples of such systems include complex mixtures such as polymer solutions, foams, slurries, pastes, micelles, gels and granular flows. Most SCCDP systems can be studied using the One Component Plasma (OCP) model that considers a single type of charged species and uses a potential that takes into account the existence and effects of the other sorts of species acting as a charge neutralizing background (polarizable or nonpolarizable). However, for strongly coupled liquids, kinetic theories and their conventional hydrodynamic derivatives suffer from convergence and closure problems, which is why molecular dynamics (MD) and dissipative particle dynamics (DPD), combined with the increase in computational power, have played an central role in the investigation of transport properties in complex fluids by predicting exact quasi-experimental observations and comparing them with data from mathematically based theories, making it possible to study the dynamic properties of a wide variety of dusty plasma liquids, ranging from the gaseous state to the strongly coupled liquid state, such as Coulomb gas and Yukawa liquids at the atomic and molecular level. The use of DPD-electrostatic methods has recently been reported to predict the structural, thermodynamic and dynamic properties of neutral systems of confined charged spheres (Coulomb gas) in a quasi-2D geometry at various temperatures and different charge values, finding a topological phase transition in a low-density Coulomb gas. On the other hand, with this same technique, an exhaustive study of the influence on the shear viscosity of the polyelectrolyte concentration, the persistence length, the salt concentration and the quality of the solvent has been reported, using numerical simulations of solutions confined under steady Poiseuille flow, reproducing various scaling regimes for viscosity, both under good solvent and theta solvent conditions. The key role that electrostatic interactions play in viscosity is confirmed when the ionic strength is varied. In this presentation, I will present the bases of this methodology, its extension and results applied to the modeling of the transport properties (viscosity and diffusion) of strongly coupled dusty complex plasmas.

Presenting Author

Estela Mayoral Villa

Presenting Author Affiliation

Instituto Nacional de Investigaciones Nucleares

Presenting Author Gender

Female

Country

México

Presenting Author Email Address

estela.mayoral@inin.gob.mx

Primary author: MAYORAL VILLA, Estela (Instituto Nacional de Investigaciones Nucleares)

Presenter: MAYORAL VILLA, Estela (Instituto Nacional de Investigaciones Nucleares)

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