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Strongly correlated classical plasmas under external forcing and dissipation - examples using molecular dynamics approach

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Systems with excess of average potential energy per particle than its kinetic energy develop strong correlations. It is well known that such systems are not amenable to standard procedures of BBGKY hierarchy. This results in failure of both kinetic and fluid models. Phenomenology is the normal way out. If such a strongly correlated system is further subject to strong drive and/or dissipation, ``near first principles" computational methods such as Molecular Dynamics become necessary. Examples of such strongly correlated systems under external drive are found in Laboratories, Space station plasma experiments, astro-plasmas, to mention a few.

Many component plasmas interact via a screened Coulomb or Yukawa interaction wherein the screening is effected by the lighter components. Larger, heavy particles immersed in such a plasma can acquire huge amount of Coulomb charge and tend to be in a state of strong correlation. This heavy component also responds at much slower time scales compared to the lighter components. Modeling the dynamics of this slow, heavy and strongly correlated component using Molecular dynamics is a challenging problem with compounded difficulties in the presence of drive and dissipation. An MPI based molecular dynamics code in two and three dimensions has been developed to address the above said issues. The code is modular and is capable of handling a variety of model classical interaction potentials, external forcing, dissipation and a range of boundary conditions.

Using this simulation tool, in the first part, taking Kolmogorov flow as a prototype, we present transition from laminar to turbulent flow, shear heating and dynamic reduction of correlation strength for a model Yukawa liquid. In the second part, a strongly correlated Yukawa liquid subject to external gravity and external temperature gradient is shown to exhibit Rayleigh-Benard convection with a new scaling law for onset of convection. Correlated fluid flow past an obstacle is shown to yield Von-Karman vortices with a novel Strouhal – Rayleigh relationship for Yukawa liquids.

References:

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