Study of inertial waves in two-dimensional strongly coupled dusty plasma

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Plasmas with a micrometer and sub-micrometer sized dust grains immersed in them have become an important test bed for addressing fundamental questions related to strongly correlated medium or complex plasma [1, 2]. We consider complex (dusty) plasma as a prototype where instantaneous particle positions are routinely measured in both laboratory experiments as well as computer simulations and are often modeled as Yukawa systems [3].

Rotating fluids support internal wave motions known as inertial waves, which travel perpendicular to the axis of rotation [4]. There are many bodies in our solar system, which have solid rotating inner core and a fluid outer core. Wave related phenomena have been studied in strongly correlated grain medium, for example, compressional and shear modes, Mach cone , transverse waves and driven transverse wave [5-7].

In the present study, we consider a 2D grain bed in a strongly coupled liquid state and perform molecular dynamics simulations. We use a Yukawa medium as a prototype medium. To study the vortex flow dynamics of rotational shear flow in strongly correlated liquids, a Rankine vortex is chosen as an initial condition [8, 9]. Using molecular dynamics simulation, we study the emergence of finite ampliude or non-linear inertial waves due to the azimuthal motion of ideal rotational flow and the effect of the strong correlation of the medium over such waves, wherein restoring force is provided by the finite compressibility and elasticity of the medium.

The evolution of isotropic inertial waves emerging from an unsteady initial coherent vortex source (Rankine vortex) has been studied for strongly correlated dusty plasma medium [10]. We find that spontaneously generated inertial wave speed in dusty plasma is suppressed by the compressibility of the system and is less sensitive to coupling strength. We also report a transition from “incompressible to compressible” flow. This transition is found to depend on the screening parameter and azimuthal speed of the vortex source.

In this study, the effects of azimuthal speed of a vortex source, strong correlation, large screening, and the compressibility of the medium on the propagation of generated inertial waves will be presented.

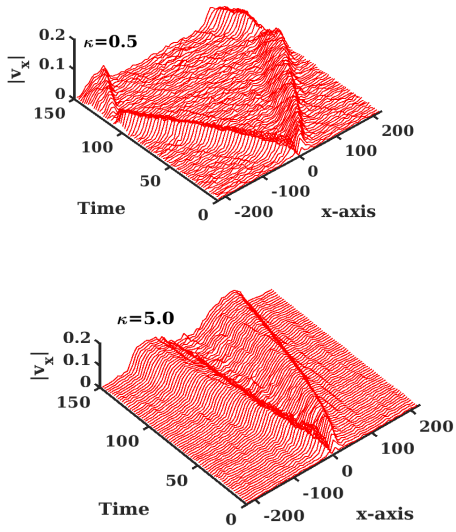

Figure : 3D plot of space, time and absolute value of fluidized y averaged velocity along x direction. Propagation of inertial wave with various value of screening parameter κ for $U_0 = 2.5$ and coupling parameter (Γ_0)= 50.

References

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