Dynamics of Vibrated Grains

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Abstract

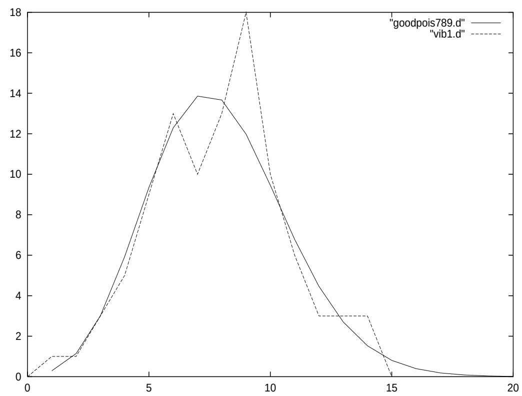
We study number density distribution and the behavior of time correlation functions in the density of grains for a quasi-two dimensional system of vibrated grains. We study the system at various packing fractions, from low to high. At low densities we recover usual gas like behavior, reflected in a Poissonian statistics for the number density distribution. At higher densities we notice effects like formation of cages of the kind that are seen in glass transition. We study these effects with a perspective of understanding the similarities and differences between an atomic fluid and a "scaled up fluid" like a vibrated granular system.

Typeset using REVTEX

In recent years, granular systems have emerged as an active area of research. Interest in this field has grown as a result of observations coming from interesting and relatively low-tech experiments being done around the world [1]. A vibrated granular system consisting of a large number of macroscopic grains in rapid motion, provides us with a large-scale statistical mechanical system which is of interest both for its relevance to fundamental theoretical issues such as fluctuation-dissipation connection, notion of temperature and so on and its importance in industrial applications.

Here we have experimentally studied a quasi two dimensional granular system consisting of a layer of a large number of spherical particles (mustard seeds) covering a vertically driven horizontal ground glass plate. The driving was provided by a speaker attached to a signal generator. The chosen frequency setting was $300Hz$. We carried out the experiment at various densities ; typical values being 400, 600 and 800 particles in an area of 9.5×12 *sq mm*. In order to analyze the number density distributions and the time dependent number density correlation functions we had the following set up. We captured each visual frame of the vibrated grains using a CCD camera attached to a video system. We could see the movie on a monitor [2]. Each frame was tagged using a timer which kept track of the time of recording. Subsequently we converted the film frames recorded in the videotape into *bmp* files in the computer and analyzed and plotted our data.

Our low packing fraction data fitted well to a Poissonian statistical distribution for the number distribution for the grains (See Fig. 1). This indicates that at low densities a vibrated granular system has a dilute gas like behavior. We expect a better agreement with Poissonian statistics in the dilute limit for a larger number of data points. As we probed higher densities we noticed the formation of cages. We intend to study this caging with a view to undestanding the formation of glassy states in such systems [3]. One important difference between probing a liquid consisting of smaller sized particles, say, a colloidal glass forming liquid and probing glass-like states in such vibrated granular system is that we can study these effects in great detail by directly looking at the system without the use of a microscope. In colloids only recently due to advances in technology researchers can probe cage formations by looking through a confocal microscope [4]. In order to probe such effects in detail we need to study the behavior of velocity autocorrelation functions which we expect to reflect back-scattering effects due to cage formation. Such back scattering effects would lead to negative velocity autocorrelations. It would be interesting to look at tagged particle diffusion and study the slowing down of diffusional relaxation with the increase in the packing fraction in such a system. Such a study is expected to shed light on the similarities and differences between an atomic fluid and a "scaled up fluid" like a vibrated granular system.



FIGURES

FIG. 1. The number distribution of vibrated grains (dashed line) for 400 grains contained in an area of 8×8 *sq cm* compared against a Poissonian distribution (solid line) with the same mean value as the experimentally determined one. This experimental run involved 100 data points.

Acknowledgements: We thank R. Pratibha for providing us with a CCD camera and a video equipment and P. Vishwanath for helping us with digital conversion of data. The work based on this technical report was done at the Theorists' Laboratory at RRI with help from the RRI workshop.

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