# Granular material - a not so simple matter

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We propose to highlight complexity of granular matter by means of two different studies. In the first one, a series of equilibrium states reached by disordered packings of rigid, frictionless disk in two dimensions, under gradually varying stress, are studied by numerical simulations. Statistical properties of trajectories in configuration space are found to be independent of specific assumptions ruling granular dynamics, and determined by geometry only. A monotonous increase in some macroscopic loading parameter causes a discrete sequence of rearrangements. For a biaxial compression, we show that, due to the statistical importance of such events of large magnitude, the dependence of the resulting strain on stress direction is a Lévy flight in the thermodynamic limit.
For the second study, we address the relationship between the statistical fluctuations of grain displacements for a full quasistatic plane shear experiment, and the corresponding anomalous diffusion exponent α. We experimentally validate a particular case of the Tsallis-Bukman scaling law, $\alpha = 2 / (3-q)$, where q is obtained by fitting the probability density function (PDF) of the displacement fluctuations with a q-Gaussian distribution, and the diffusion exponent is measured independently during the experiment. Applying an original technique, we are able to evince a transition from an anomalous diffusion regime to a Brownian behavior as a function of the length of the strain window used to calculate the displacements of the grains. The outstanding conformity of fitting curves to a massive amount of experimental data shows a clear broadening of the fluctuation PDFs as the length of the strain window decreases, and an increment in the value of the diffusion exponent—anomalous diffusion. Regardless of the size of the strain window considered in the measurements, we show that the Tsallis-Bukman scaling law remains valid, which is the first experimental verification of this relationship for a classical system at different diffusion regimes. We also note that the spatial correlations show marked similarities to the turbulence in fluids, a promising indication that this type of analysis can be used to explore the origins of the macroscopic friction in confined granular materials.