

Area: Statistical Mechanics of Granular Media

Miniprojects with Mario Nicodemi

Project description

- **TITLE: Statistical Mechanics of granular media and non-thermal systems**

One of the most active and important research areas in Statistical Mechanics concerns the equilibrium and off-equilibrium properties of “*complex systems*”. *Granular media*, such as powders and sands, are a very important example in this category. They have substantial industrial applications and raise, as well, important issues of fundamental physics. One of the main open conceptual problems concerning granular materials is the lack of a theoretical framework where they could be described. Because of the absence of a “thermal bath” we cannot treat them with usual theories of Physics. One very important research topic in this perspective is the development of a generalised Statistical Mechanics to describe statics and dynamics of such systems. In particular, granular materials can either be jammed and rigid, or yield and flow. A crucial issue is to understand the nature of a critical line separating crystallised and melted states and the origin of “jamming”. In this perspective, we are investigating the rheology of granular suspensions and its connections with colloids. Finally, while dynamical instabilities are very important and well known in Fluid Mechanics, their counterpart in athermal fluids, such as granular mixtures, has just begun to be discovered. We are, thus, also investigating instability and pattern formation mechanisms in granular media and their analogies to those found in thermal fluids.

The aim of this project is to use computer simulations to describe the above properties of granular media. Inserted in the framework of a new fascinating chapter of Physics, Fluid and Statistical Mechanics of non-thermal media, a successful project will help to shed light on the precise mechanisms underlying those phenomena and to understand their, still elusive, physical basis. This mini-project is perfectly suited to become a full PhD research project, but the student will need a solid background in math/phys and computation.

Further readings: P. Richard, M. Nicodemi, R. Delannay, P. Ribiere, D. Bideau. Slow relaxation and compaction of granular systems. **Nature Materials** *4*, 121 (2005). M. Pica Ciamarra, A. Coniglio, and M. Nicodemi, Thermodynamics and Statistical Mechanics of Dense Granular Media. **Phys. Rev. Lett.** *97*, 158001 (2006). D.S. Grebenkov, M. Pica Ciamarra, M. Nicodemi, and A. Coniglio, Flow, ordering, and jamming of sheared granular suspensions, **Phys. Rev. Lett.** *100*, 078001 (2008). M. Pica Ciamarra, A. Coniglio, and M. Nicodemi. Shear instabilities in granular mixtures. **Phys. Rev. Lett.** *94*, 188001 (2005).