Jamming and Unjamming Transitions of Granular Materials

(Invited Talk #2)

Ling Zhang[1], Ziwei Wang[2], Jie Zheng[1], Jie Zhang [1,3,]*

[1]Department of Physics & Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China

[2]Zhiyuan College, Shanghai Jiao Tong University, Shanghai 200240, China

[3]Institute of Natural Sciences, Shanghai Jiao Tong University, Shanghai 200240, China

***Email of Presenting Author: jiezhang2012@sjtu.edu.cn**

Study of the jamming transitions of granular materials has become an active field of research in recent years. In this talk, we are going to present results from two experiments, focusing on different perspectives of jamming transition.

Shear jammed states have been discovered recently (Zhang et al Granular Matter 2010, Zhang et al Soft Matter 2010, and Bi et al Nature 2011). Due to friction between the system and the third dimension, it is unclear whether a fragile state would still exist along the route of shear jamming if the friction were completely eliminated. In a novel apparatus developed recently at SJTU, the friction is completely eliminated by letting the particles float on the surface of a shallow water layer, revealing more details of the route of shear-jamming. Using high-precision force-gauge and simple-beam apparatus, we are able to measure small forces of three orders of magnitude below the limit of the photo-elastic resolution between particles and boundaries. In the first part of this talk, we are going to discuss the recent progress towards the understanding of the nature of the fragile states.

An inverse process of the jamming transition is the unjamming transition, where granular systems may suddenly lose rigidity and start to flow freely. Understanding such a process is of crucial importance towards the understanding of natural disasters such as snow avalanches, landslides and earthquakes. Recent work by Banigan and colleagues (Nature Physics 2013) has provided some new insight in the study of unjamming and jamming transitions by applying nonlinear dynamical methods. To test their proposition experimentally, we have designed a rotating drum filled with bi-disperse photo-elastic disks to create particle avalanches. In the second part of this talk, we will discuss several main findings from this novel experiment. In unjamming transition, Lyapunov vector and velocity fields are found strongly correlated in spatial domain, whereas in jamming transition no such a strong correlation is observed. The Lyapunov exponents are positive in unjamming transition and negative in jamming transition. In addition, the total stress variation, kinetic energy, and non-affine motion of particles all show strong correlations in the time domain during avalanches. Their spatial correlations have also been analyzed.