Avalanches and its contribution for sheared granular flows

Michio Otsuki (Department of Materials Science, Shimane University) and
Hisao Hayakawa (Yukawa Institute for Theoretical Physics, Kyoto University)

Granular materials have the rigidity above a critical density ϕ_J, while it loses the rigidity below ϕ_J . This rigidity transition, known as the jamming transition, is characterized by the emergence of the storage modulus.

It is known that the storage modulus G behaves as $G \sim (\phi - \phi_J)^{1/2}$ for small amplitude of the strain, but we found the existence of a crossover from the known scaling to $G \sim (\phi - \phi_J)$ as the strain amplitude increases. This crossover can be represented by a single scaling function a shown Fig.1. We also found that the new scaling can be explained by a phenomenological model of stress avalanches in which the size distribution satisfies $\rho(s) \sim s^{-3/2}$ (Fig.2). The result for oscillatory sheared case for frictionless grains has already been reported in Ref.[1].

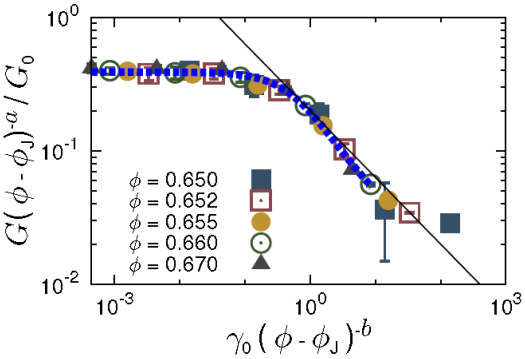

Fig.1: Scaling of the storage modulus.

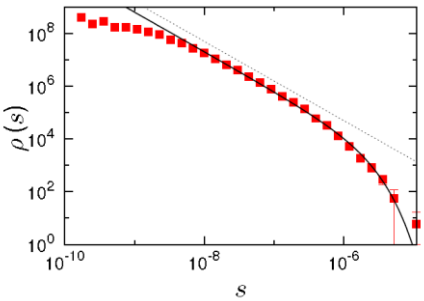

Fig.2: Size distribution of the avalanches.

In the presentation, we will show the rate dependence of the storage modulus for fast processes. We will also discuss the behavior of the loss modulus as well as the storage modulus for frictional grains under oscillatory shear.

[1] M. Otsuki and H. Hayakawa, Phys. Rev. E **90**, 042202 (2014).