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Shear jamming: where does it come from and how is it affected by particle properties?[1]

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Granular systems have been shown to be able to behave like solids, under shear, even when their densities are below the critical packing fraction for frictionless isotropic jamming. To understand such a phenomena, called shear jamming, the questions we address here is: how does shear bring a system from a unjammed state to a jammed state and how do particle properties, such as inter-particle friction and particle shape, affect shear jamming? Since Z can be used to distinguish jammed states from unjammed ones ($Z = 3$ is the isotropic jamming point for $2D$ frictional disks), it is vital to understand how shear increases Z. In the first part of this talk, we propose a set of three particles in contact, denoted as a trimer, as the basic unit to microscopically characterize the deformation of the system. Trimers, stabilized by inter-grain friction, are then expected to bend in response to shear to make extra contacts to regain stability. By defining a projection operator of the opening angle of the trimer to the compression direction in the shear, O, we see a systematically linear decrease of this quantity with respect to shear strain, demonstrating the bending of trimers as expected. In the second part of this talk, we look into the effect of particle properties on shear jamming. Photoelastic disks either wrapped with Teflon to reduce friction or with fine teeth on the edge to increase friction are used to study the effect of friction. In addition, disks are replaced with ellipses to introduce anisotropy into the particle shape. Shear jamming is observed for all the cases. For the disk system, the lowest packing fraction that can reach a shear jammed state increases with friction. For the ellipse system, shear brings the system to a more ordered state and particles tend to align to a certain angle relative to the principal directions of shear, regardless of packing fraction.

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