The Physics and Geometry of Sphere Packings

Shomeek Mukhopadhyay

(Physics Department, Duke University and Chemistry Department, Columbia University)

Jorge Peixinho , Jeff Morris (Levich Institute, City College of New York)

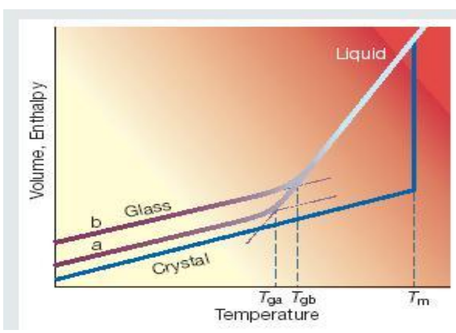
Why are sphere packings important ?

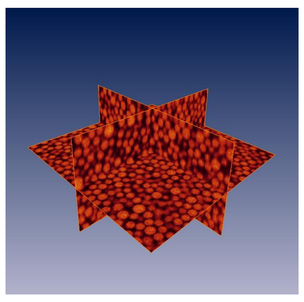
Kepler , 1611
Hales Proof, 1998

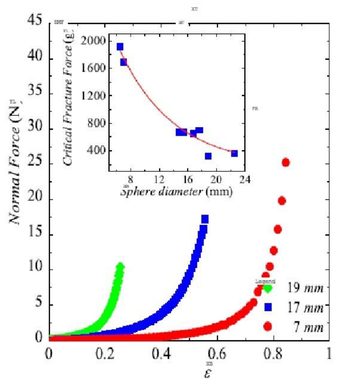
Random Loose = 56 %

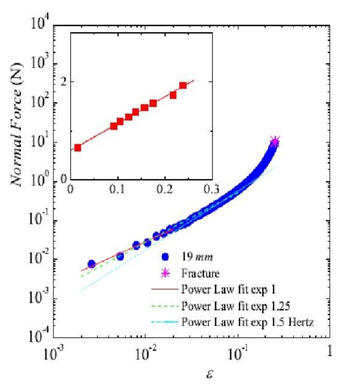
Random Close = 64%

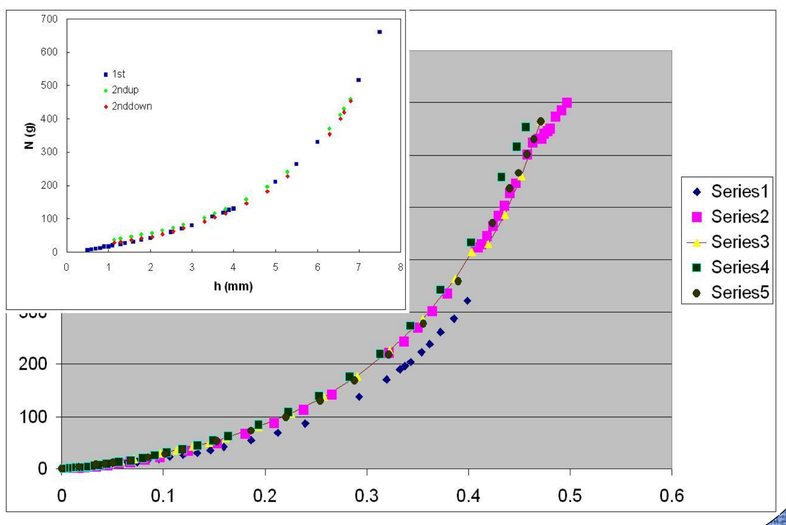
Crystalline = 74 %

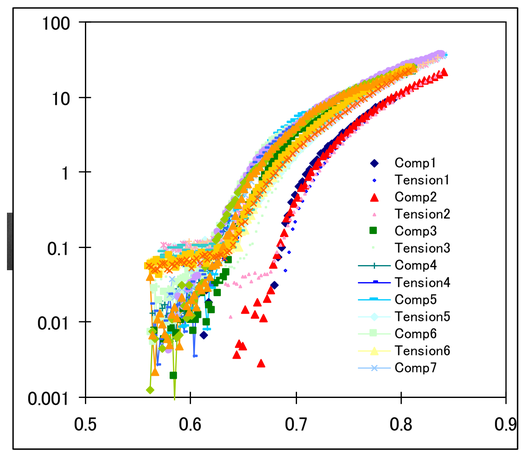




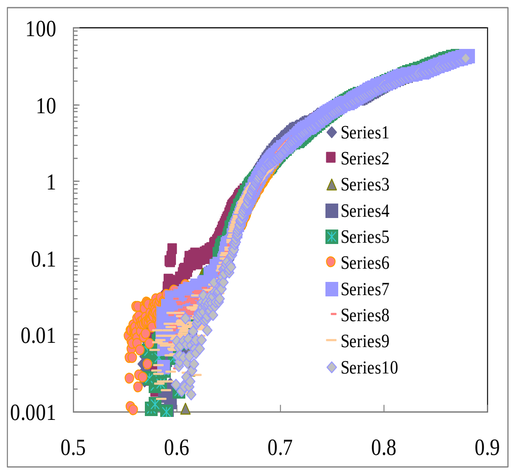








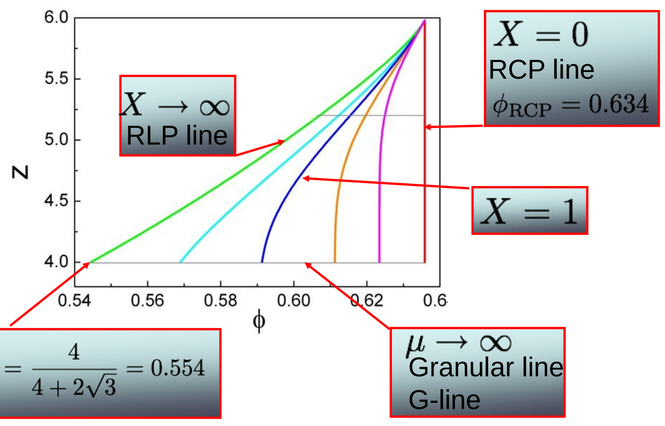
500 microns/sec



50 microns/sec

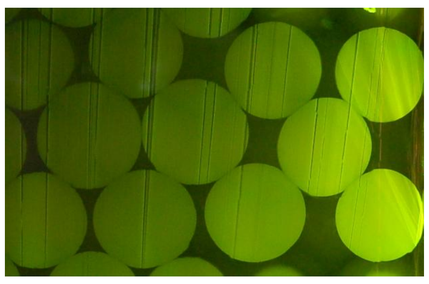
Average Exponent for power law : 1.31
However the exponent is rate dependent

The phase space (Z,ϕ)

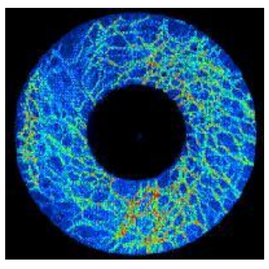


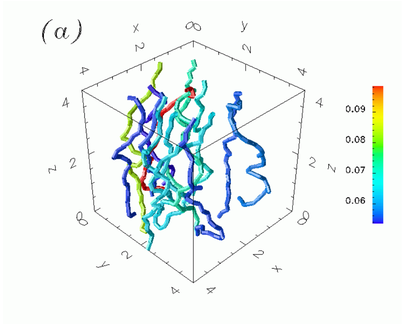
Model system : Polyacrylamide Hydrogel

1. Loaded with R6G : index almost matched.
2. Size tunable with salt/alcohol.
3. Highly Deformable.(Hertzian)

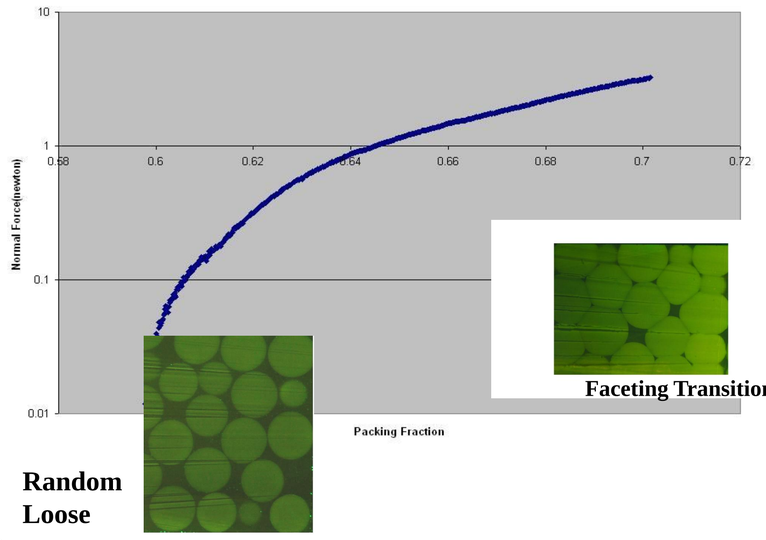


2 D or 3 D under uniaxial stress

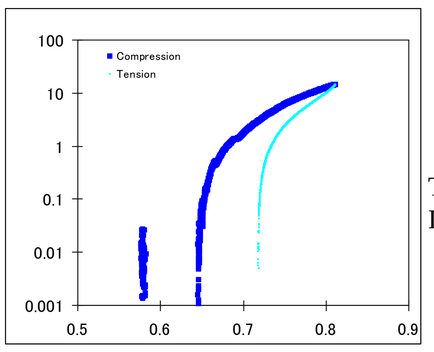




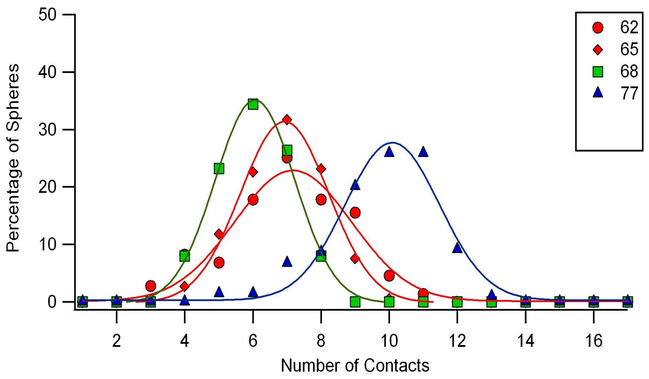
1700 Spheres



History Dependence



The slowest Speed
Is 0.5 microns/second



References

1. Chakraborty and Behringer : Jamming of Granular Matter : *Encyclopedia of Complexity and System Science (2009).*
2. Majmudar and Behringer , *Phys. Rev. Lett*. (2007).
3. Henkes and Chakraborty , Phys. Rev. Lett. (2005).
4. Song, Wang and Makse , *Nature* (2008).

Conclusions

1. Dynamics under normal stress and shear.
2. Relationship between packing fraction and contact number distribution.
3. How unique is the random close packing?