Statics and Dynamics of Systems of Rigid Particles
Isaac Newton Institute, 10 December 2003

Concluding Discussion: My personal list of issues in need of addressing - RB

Statics

1. Isostatic vs non-isostatic packings:
   a) Are the stress equations of the isostatic state hyperbolic, parabolic or elliptic?
   b) The relations between the two states and the nature of the equations in between?
2. Infinitely rigid vs compliant particles:
   a) Are isostatic granular systems confined to infinitely rigid grains?
   b) If yes, is modelling these systems of much use?
   c) If not: (i) how marginally rigid are isostatic systems of compliant grains? (ii) what are the stress equations in such systems? (hyperbolic, parabollic, elliptic, a combination)
3. Rough vs smooth, Spherical monodisperse vs arbitrary-shape and polydisperse particles:
   a) How different are the behviours of these systems - can one theory describe them? (universality?)
   b) Can simulations of one type of system be used for insight into another?
5. Coarse-graining microscopic equations to continuous macroscopic scales:
   a) The stress field in isostatic systems appears to couple to geometric fluctuations - how to upscale such constitutive information?
6. Experiments:
   a) Looking inside systems - confocal microscopy. x-ray tomography, MRI, big particles, computer simulations
   b) Measurements of forces, stresses, strains, contacts, densities
7. How to test and discriminate different models numerically and experimentally?

Dynamics

1. Slow vs. fast flows - what are the controlling / characterising parameter(s)
2. Yield and plastic flow:
   a) Assumptions in current models and the sensitivity to these.
   b) The phase space of variables - Internal vs fully determinate
   c) Aging
   d) Simulations: (i) sensitivity to kinematic rules; (ii) do we need more simulations of non-spherical particles?
3. Fast flow:
   a) Avalanches
   b) Fluidity vs gasity
   c) What happens upon slowing down and eventual consolidation - Is there hope for seamless modelling?
4. Buildup of granular systems - piling, deposition, sedimentation:
   a) Effects of history / memory
   b) Marginal rigidity as a critical state
   c) Relations to models of rigidity percolation, traffic jamming

5) Sensitivity of rigid particle dynamics to compliance of grains and ranges of validity

6. Microscopic discrete vs macroscopic continuous flow equations:
   a) Coarse-graining - theoretical methods, new coarse-grained fields for experimentalists to measure
   b) Insight from simulations into upscaling
7. Experiments:
   a) Looking inside systems - confocal microscopy. x-ray tomography, MRI, big particles, computer simulations
   b) Measurements of the relevant fields: displacement (strains), rotations, evolution of contact networks

Essential to all the above

1. Sensitivity of models of rigid particles to compliance and ranges of validity
2. The need for criteria for acceptance or discardability of models both for static and dynamic systems
3. Bridges: Statics → yield → plastic flow → slow fluid-like flow → fast flow. Are we making a dent here?