SEMINAR SERIES

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Exact solution of the random close packing problem in d=2 and entropy-stability competition

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Abstract: Predicting the densest random packing fraction of mono-disperse discs is relevant to a range of disciplines and technologies. Until recently, it was a decades-long unsolved problem. The difficulties were that it was ill-defined in the absence of a disorder criterion and that the packing fraction depends on the packing protocol. Since protocols depend on a large number of continuous parameters, it was difficult to find a general theoretical solution that applies to this infinite-parameter space.

I present here a recent new approach that has opened the door to an exact solution in two dimensions. I first formulate the problem in a well-posed form for planar packings of discs. Next, I show that all the infinitely possible packing protocols can be parametrised by the distribution of the cell order. I then describe a systematic criterion that ensures disorder. Then, I derive the exact value for the random close packing fraction:φ RCP = 0.852514….

The advantages of this method are that it:

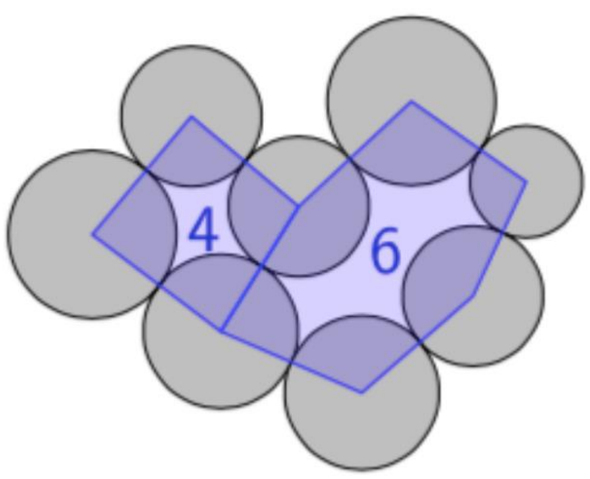
(i) yields directly the packing fraction;

(ii) parametrises all possible packing protocols;

(iii) makes it possible to define and limit all types of disorder;

(iv) it can be used to predict the highest packing fraction for families of protocols.

Finally, I will discuss the role of entropy and entropy-stability competition in this problem and in quasi-static dynamics of granular matter in general.



Biography of speaker: Raphael Blumenfeld received PhD in Theoretical Physics from Tel Aviv University and since then held positions at: the Cavendish Laboratory, University of Cambridge; Princeton University; Los Alamos National Laboratory, USA; then at Princeton University again. He returned to the Cavendish Laboratory Cambridge in 1998 and held a simultaneous position at Imperial College London. Since 2009 he is a Bye-Fellow and College Lecturer at Gonville & Caius College, University of Cambridge. Currently, he is the Director of Studies for the Physics Natural Science at the college. He is also a Distinguished Visiting Professor at a university in China, a High Level Foreign Talent , and a 1000-Talent plan award recipient from the Chinese government. He has over 130 publications, over a 100 of which in peer-reviewed journals. Raphael Blumenfeld ’s research interests have focused in recent years on the physics of a-thermal systems and, in particular, on the behaviour granular, cellular and porous materials. These type of systems are relevant in many contexts and a wide range of scales; from powders and suspensions of micron-size particles to the structure of the cosmic web on the scale of the universe. His research progresses in several directions. One is the construction of a statistical mechanics formalism for these non-ergodic and far-from-equilibrium systems. Another is the formulation of a fundamental stress theory for granular materials. A third direction is construction of a physics-based model for the dynamic behaviour of particulate systems.

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