P.17 Unusual order in squeezed spheres

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This contribution deals with the arisal of structures with an unusual symmetry from purely repulsive isotropic pair potentials. The most obvious of such potentials, such as power laws and gaussian core potentials, give energy minima that are triangular close packed structures in 2D and FCC or BCC in 3D.

It turns out that the soft spheres that the jamming community has been using for years to study disordered solids near the jamming transition, give rise to a range of surprising ordered structures at higher densities, as has already been reported for Hertzian disks [1], and for harmonic and Hertzian spheres in three dimensions [2, 3, 4],. Monodisperse repulsive harmonic disks in two dimensions form, apart from the triangular lattice everyone would expect, a square lattice and various non-bravais lattices that can be related to tiny periodic packings of hard spheres. These include the honeycomb, a stretched honeycomb, a chiral structure, and a previously unreported lattice that has a 5-particle basis. The essential physics behind the appearance of these structures amounts to a trade-off between “having one’s nearest neighbours further away” and “having fewer nearest neighbours”.

These findings allow us to make a few key observations about the ways systems of repulsive particles can respond to changes in density, including the possibilities to compress anisotropically, to deform non-affinely, and to transition to a different symmetry via a coexistence region. All of these options are realized by harmonic disks in 2D. A rough sketch of the resulting phases is shown in figure 1. Although it is unlikely that this particular potential, at these higher densities, represents a realizable physical system, there may well be other potentials with similarly rich behaviour. Preliminary studies of a recently introduced effective potential for adsorbed star polymers are promising in this respect [5].

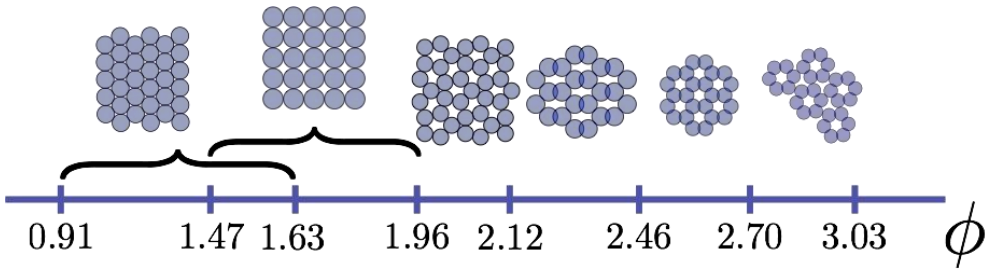

Figure 1: Sketch of $T = 0$ phases diagram of harmonic disks (drawn smaller for clarity) in 2D, as a function of “area fraction”. The nature of the transitions will be discussed in the talk.

[1] Miller WL, Cacciuto A. *Two-dimensional packing of soft particles and the soft generalized thomson problem*. Soft Matter 7, 7552 (2011)

[2] Pamies JC, Cacciuto A, Frenkel D. *Phase diagram of hertzian spheres*. J. Chem. Phys. 131, 044514 (2009)

[3] Prestipino S, Saija F, Malescio G. *The zero-temperature phase diagram of soft-repulsive particle fluids*. Soft Matter 5, 2795 (2009)

[4] Zhu YL, Lu ZY. *Phase diagram of spherical particles interacted with harmonic repulsions*. J. Chem. Phys. 134, 044903 (2011)

[5] Egorov SA, Paturej J, Likos CN, Milchev A. *Controlling the interactions between soft colloids via surface adsorption*. Macromolecules 46, 3648 (2013)