Local Structure Metric Based on Voronoi Diagram and Minkowski Tensors Reveals Non-Universality in Random Ellipsoid Packings

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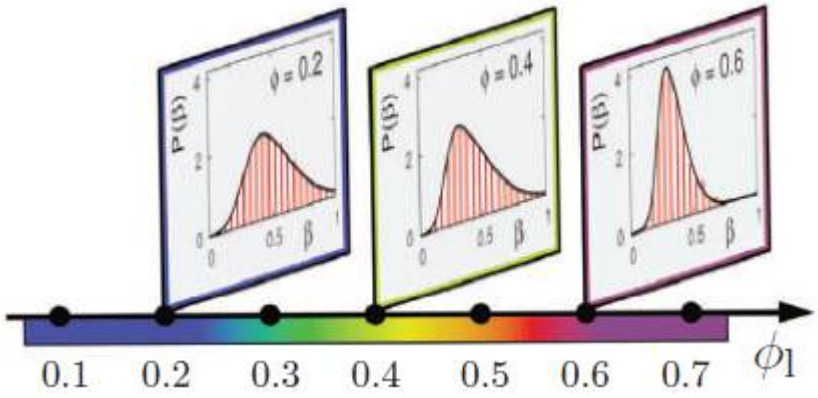
In particulate systems with short-range interactions, such as granular matter or simple fluids, local structure determines the macroscopic physical properties. We analyse local structure metrics derived from the Voronoi diagram of oblate ellipsoids, for various aspect ratios α and global packing fractions ϕ_g. We focus on jammed



static configurations of frictional ellipsoids, obtained by tomographic imaging and by discrete element method simulations. The rescaled distribution of *local packing fractions* ϕ_l, defined as the ratio of particle volume and its Voronoi cell volume, is found to be independent of the particle aspect ratio, and coincide with results for sphere packs. By contrast, the typical *Voronoi cell shape*, quantified by the Minkowski tensor anisotropy index $\beta = \beta_0^{2,0}$, points towards a difference between random packings of spheres and those of oblate ellipsoids. While the average cell shape β of all cells with a given value of ϕ_l is similar in dense and loose jammed sphere packings, the structure of dense and loose ellipsoid packings differs substantially such that this does not hold true.

Key words：structure metrics, jamming, random close packing, aspherical and frictional particles, non-universal properties, statistical physics

References

1. F.M. Schaller et. al., Philosophical Magazine 93, 3993 (2013)

2. G.E. Schröder-Turk et. al., EPL 90, 34001 (2010)

3. G.E. Schröder-Turk et. al., NJP 15, 083028 (2013)

4. F.M. Schaller et. al., EPL 111(2), 24002 (2015)

5. F.M. Schaller et. al., PRL 114, 158001 (2015)