MATERIAL WITNESS

A JAMMY GUESS?

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Take a jar of sand, give it a shake and let it settle. The static configuration that results is a jammed state, in mechanical equilibrium thanks to contact between grains. It is disorderly, yet, unlike a fluid, it has a finite yield stress. It is of tremendous practical importance — jamming in powders can cause problems in industry and technology, and abrupt unjamming of granular piles may lead to avalanches — but it is still poorly understood.

A jammed state is a random close packing; for a large collection of grains, the number of distinct states of this sort is innumerable. How do these states compare? A framework for understanding jammed states was provided in the late 1980s by Sam Edwards, a pioneer of 'soft-matter' physics who died last year. With his student R. B. S. Oakeshott, he proposed the ansatz that all jammed packings are equally likely[1]. Edwards went on to formulate a picture of granular media, long before the subject became topical, based on the formation of 'force chains' of particles in contact, susceptible to large stress fluctuations.

Edwards's conjecture allows for the definition of a kind of entropy related to the logarithm of the number of these equiprobable packings. It is the launching point for several theoretical treatments of grains and jamming that draw on statistical mechanics. The equivalence of jammed states amounts to treating the problem within a microcanonical ensemble. In traditional statistical mechanics this corresponds to an ensemble of states with the same energy, but in Edwards's granular model volume plays the role of energy.

All very good; but is the conjecture actually correct? Are all jammed packings equally likely? There have been efforts to test that hypothesis, both in simulations and experimentally[2–4], but the results have been able to suggest only that it is a good, if not universal, approximation (for one thing, the jammed states obtained from shaking grains are not generally the densest possible).

Now Martiniani *et al.* have put Edwards's conjecture to a direct test[5]. They have calculated the configurational landscape for a system of 64 soft discs: two-dimensional, circular particles with a hard core, a soft shell, and a distribution of radii, held at a constant packing fraction. This system is large enough to represent a genuine granular medium, but small enough for the configurational space to be rather exhaustively sampled and mapped — although even then it pushes the available computational resources to their limit. The researchers calculate the volumes of the basins of attraction for distinct minima in the high-dimensional configuration space, these being measures of the state probabilities.

They find that Edwards's conjecture holds only for a rather specific case, namely at the threshold between jammed and unjammed states. This is precisely the state of practical significance for many granular systems: where the collection of grains just freezes into immobility, or, conversely, where it is just about to regain the ability to rearrange. It seems hard to imagine that this is sheer coincidence: the configurational equiprobability at this special point must surely be indicating a profound feature of the problem. But what? And did Edwards's inspired guess stem from some deeper intuition? ❒

References

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CELL MECHANOTRANSDUCTION

Stretch to express

Forces applied to the cell surface induce stretching of the chromatin in the nucleus and a rapid increase in gene expression.

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Cells in living organisms are constantly subjected to varying levels of mechanical forces, such as fluid shear stress on the surface of endothelial cells and contractile forces in muscle cells. It is now well recognized that these mechanical cues elicit important biological responses, including the activation and modulation of gene expression that enables cells to adapt to their physical environment. However, many of the molecular details of how cells translate mechanical stimuli into biochemical outputs remain incompletely understood. Reporting in *Nature Materials*, Belmont, Wang and colleagues now provide compelling evidence that forces originating on the cell surface are transmitted to the nucleus, and result in chromatin stretching and rapid increase in gene transcription[1].

Whether or not the nucleus itself can act as a mechanosensor is one particularly intriguing question in the field of cellular mechanobiology[2]. Mechanical forces are physically transmitted from the cell surface