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Staying out of jams

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What do sand, coal, cereal, ice cubes, marbles, gravel, sugar, pills, and powders have in common" They are all granular materials, members of an unruly family of substances that refuse to completely conform to the laws of behavior for either solids or liquids—much to the consternation of theoretical physicists and manufacturers alike.

Whether it's a huge grain silo, a coal hopper or a pharmaceutical manufacturing plant, being able to predict the behavior of dense granular packings subjected to different external stresses is key to keeping things from jamming up or collapsing.

A Brandeis study in the current on-line issue of *Physical Review Letters* advances a novel theoretical framework to statistically predict the properties of static, mechanically stable grain packings, analogous to the theory known as equilibrium statistical mechanics that governs molecular matter. The study makes inroads into the fundamental understanding of the properties of granular materials.

Until now, such a predictive theoretical framework has been elusive because of the lack of energy conservation. Physicists employ the principle of conservation of energy to describe the behavior of a collection of atoms or molecules. But, in fact, while grains of sand may be tiny, a collection of them in a dune or pile dissipates energy through heat when shaken, stirred or otherwise perturbed. Atoms and molecules, on the other hand, do not lose energy when they collide.

"We asked a simple question," said Brandeis physicist Bulbul

Chakraborty. “Could we construct a statistical framework to predict the probability of a certain arrangement of grains that have settled after having been disturbed" What’s the probability of finding grains arranged in a hexagonal packing, say, compared to a square packing" How do these probabilities change when the grains are shaken more vigorously"”

Chakraborty said her group’s research concerned itself with granular packings that have settled after being disturbed because these are the configurations of granular materials close to jamming—and that is typically where the trouble begins. When you walk along a beach, you do not sink into the sand because it is in a jammed state and can support your weight. On the other hand, you sink in quicksand because it is fragile and unjams when you walk on it. Jamming can also cause a lot of grief as when massive grain silos collapse.

“Jamming is a phenomenon that occurs in countless engineering and industrial applications; this framework is the first step to understanding and preventing unwanted and costly jams,” said Chakraborty.

Source: Brandeis University