Researchers discover theoretical model to predict jamming

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Researchers at the UCLA Henry Samueli School of Engineering and Applied Science have come up with a theoretical model to predict when granular materials become jammed. This advancement not only broadens fundamental knowledge, it also provides new avenues to a number of practical areas that ranges from materials innovation to medicine. The study, currently available on the *Nature Physics* Web site, will be published in the journal's print edition on May 1.

“We started this research by looking at the behavior of dry powders as solid lubricants as well as the behavior of a powdered rock in fault zones called gouge during an earthquake. What we found led us to a model that can accurately predict the behavior of dense granular flows. What we realized soon after was that the granular particles interact similarly to that of molecules in materials that jam, such as colloids and foam” said study’s author Pirouz Kavehpour, an assistant professor of mechanical and aerospace engineering and director of the Complex Fluids & Interfacial Physics Laboratory at UCLA. “From there, we were able to find a universal law that can predict the jamming behavior for the first time.”

According to Emily Brodsky, associate professor of earth and planetary sciences at UC Santa Cruz and also an author of the study, “We understand how water flows. We understand how honey flows. We even understand how elastic bands deform. But granular flows are complicated and hard to understand. If you’re pouring sand down a hill or in an hour glass, there was never a good formula for the strain or the strain rate as a function of stress. This formula is definitely new and unique."

Kevin Lu, UCLA graduate student and lead author of the study, showed that the formula also quantified glass-transition. "Glass is a solid that flows. But structurally, it's a liquid. The molecules in a glass are jammed and unable to flow past each other so the material actually flows sluggishly. One evidence of this can be found in the window panes of old churches in Europe. Studies have shown that the bottom of the windows are consistently thicker than the top. Glassy liquids flow very much in the same manner as granular media." said Lu.

This new theoretical framework, the authors believe, can be applied to many different areas. Pharmaceutical companies can use the new equation to decide the size and quantities of pills that may or may not fit through a shoot that fills containers. Also, from knowing the fundamentals of jamming, scientists can now engineer materials that are both durable and strong. Instead of working with composites or alloys, the jamming theory provides a roadmap to tune material properties from pure substances.

"It can also help us to better understand certain diseases in medicine. In sickle cell anemia, for example, the abnormal blood cells are long and skinny, resulting in the obstruction of blood flow to various organs. Now we can do more to reduce the likeliness of death-threatening implications to benefit the medical community," said Lu.

As a geologist who studies fault zones and earthquakes, Brodsky is particularly interested in the granular flow of gouge found in fault zones and having a formula to figure out when the rock is jammed and when it's free flowing can be significant.

"Knowing how things flow and the granular behavior in a fault zone is one of the very important steps in trying to figure out how exactly faults slip," said Brodsky.

Source: University of California - Los Angeles