To improve forecasting earthquakes, NJIT mathematician studies grains

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A new and better way to predict earthquakes and avalanches may soon be available to forecasters thanks to mathematical research underway at NJIT. Using mathematical modeling, researchers are investigating how forces and pressures propagate through granular materials.

"Computational Homology, Jamming and Force Chains in Dense Granular Flows," a four-year, $378,603 National Science Foundation grant has been awarded to Louis Kondic, associate professor of mathematical sciences at NJIT. Kondic will study how the physical properties of granular materials, like sand or salt, can lead to jamming, large force fluctuations and ultimately how they can pressure a building to topple. Both earthquakes and avalanches involve similar materials and reactions.

"The mystery is to learn how forces and pressure propagate or move through grains," said Kondic. "We know the answer for liquids, but for granular materials, we do not. As a result, it is difficult to build efficient devices for dealing with them. Silos can collapse due to non-uniform pressures on their walls. Salt, sand or coal often jams when flowing out of hoppers. But why they behave like this remains unknown."

2006, Kondic was the co-author of "On Velocity Profiles and Stresses in Sheared and Vibrated Granular Systems Under Variable Gravity" which appeared in Physics of Fluids. Other articles by him investigating similar research have appeared in *Applied Mathematics and Mechanics* (2008), *SIAM News* (2007) and *Physics Review E* (2005).

The current project centers on so-called force chains, which are crucial for understanding granular systems. The attached figure shows computer simulations of heterogeneous, ramified structures (colored yellow). "Similar forces do not propagate uniformly, but instead form chain-like structures," said Kondic. "We will propose new mathematical methods for quantifying these structures. The algorithms will account for the geometrical properties of the forces. Such a generalized model that describes the properties of these features does not exist."

According to Kondic, the research applies to earthquakes and avalanches because when tectonic plates move, they can cause an earthquake. Where the points of these plates meet, the material will typically be in a granular form. Researchers now believe that a better understanding of the forces that exist in this granular state can lead to new methods for predicting when and where earthquakes and/or avalanches will occur.

This project will employ a highly interdisciplinary approach that integrates new geometrical techniques, modeling, and experiments. It will address fundamental questions concerning the physical properties of granular media and other jammed materials such as glasses, foams, and colloids.

Although the existence of force chains has been known for decades, a quantitative understanding of their role in physical processes has proved to be elusive because previous studies have been unable to devise an unbiased and general definition for them. Precise identification and characterization of force chains and the response of jammed materials to applied forces will likely have a transformative impact in many arenas.

The NJIT study is part of a larger NSF project involving Robert P. Behringer, professor of physics, Duke University; Konstantin Mischaikow, professor, department of mathematics, Rutgers University-New Brunswick; Corey O'Hern, associate professor, departments of

mechanical engineering and physics, Yale University.

To view Louis Kondic's bio, please visit this link http://www.njit.edu/publicinfo/newsroom/kondic_bio.php.

Source: New Jersey Institute of Technology