

# Rethinking equilibrium: In nature, large energy fluctuations may rile even 'relaxed' systems

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An international research team led by the University at Buffalo has shown that large energy fluctuations can rile even a "relaxed" system, raising questions about how energy might travel through structures ranging from the ocean to DNA.

The research appeared online Oct. 21 in *Physical Review E*.

In their study, the scientists used [computer simulations](#) to model the behavior of a closed, granular system comprising a chain of equal-sized [spheres](#) that touch one another and are sandwiched between two walls. [Energy](#) travels through this system as [solitary waves](#), also known as non-dispersive energy bundles.

When the system was disturbed by multiple energy perturbations -- imagine someone tapping on each of the walls -- the energy spread unevenly through the system.

Distinct hot and cold spots with an energy much higher and lower than the average energy per sphere persisted over short periods of time, and some regions remained cold over extended times. This held true even in simulations that lasted for several days, demonstrating that the system's eventual state was something very different from what is traditionally thought of as equilibrium.

Like many systems in nature, the system the scientists simulated is subject to strong, nonlinear forces, which vary sharply as a system evolves.

"This work shows that the concept of equilibrium should be broadened," said Surajit Sen, PhD, the UB physics professor who led the study.

"When you have strongly nonlinear forces in finite systems, as you do in the granular system, the energy may not be equitably distributed.

"Nature may be capable of showing far greater energy fluctuations even in the equilibrium/tranquil state than we might ordinarily expect," Sen continued. "We know that in the [open ocean](#), there are large, rogue waves that can cause ships to go down. Where do these enormous, [rogue waves](#) come from? Another question is whether external stimulations that lead to these kinds of large fluctuations can arise in confined, biological systems, such as [DNA](#), and subsequently affect their properties."

Sen's collaborators on the project included Edgar Avalos of Chung Yuan Christian University in Taiwan; Diankang Sun, a postdoctoral fellow at New Mexico Resonance; and Robert L. Doney, a physical scientist at the U.S. Army Research Labs at Aberdeen Proving Grounds. Avalos is a former UB Fulbright Fellow. Sun and Doney studied at UB as PhD candidates working with Sen.

In their simulations, the researchers modeled a granular system that was lossless, meaning that the system continuously retained all of the energy added to it through [perturbations](#). While all real-world mechanical systems inevitably lose energy over time, an effectively lossless system may be realized as a nonlinear circuit.

In addition to identifying persistent hot and cold spots in the granular system, Sen and his colleagues confirmed the findings of a group of

researchers who described how solitary waves can grow their energy content when passing through each other in such a system.

Provided by University at Buffalo

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