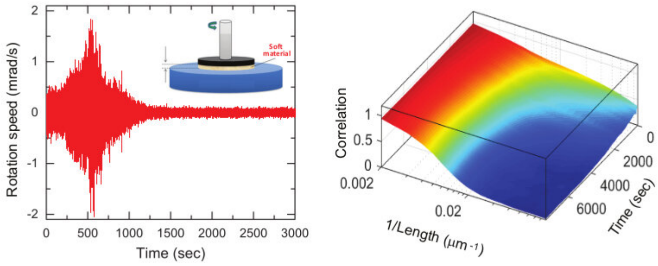
Soft materials allow scientists to study earthquakes in the lab

8 January 2020



Left: Measured angular speed of the top plate versus time. Inset shows the schematic of the experiment. Right: Time evolution of spatial correlation of domains, connecting burst-like event and internal reorganizations of the material Credit: Pradip Bera et al.

Under constant stress, certain soft materials reorganize themselves in a manner very similar to how the Earth's crust is restructured during earthquakes, a new study by researchers at the Indian Institute of Science (IISc), Raman Research Institute (RRI) and ETH Zurich has found.

The team studied thin sheets of two types of soft materials—a tightly packed gel of soap-like molecules, and a glass made from clay nanoparticles—sheared between two steel plates. When force was continuously applied by the plate on the material, the internal reorganization of the material generated burst-like patterns over time that resembled seismograph data generated by earthquakes.

"When you apply a certain stress, the material is trying to adjust. Its shear rate is fluctuating. This fluctuation is similar to what is seen during earthquakes," says Ajay Sood, DST Year of Science Chair Professor at the Department of Physics, IISc, and senior author of the paper published in *Nature Communications*.

Earthquakes typically occur due to friction between pieces of the Earth's surface called tectonic plates, releasing a sudden burst of energy that causes severe damage to the environment and human lives. Scientists still don't know how to predict when an earthquake will strike next, or how strong it will be.

To simulate earthquakes in the lab, researchers usually apply force to rocks or ceramic materials and study how they deform and crack under stress. But because these are solids, it can be difficult to study changes that happen inside the materials before they split open.

"The main disadvantage with these previous experiments is that no one can probe the domain structure directly," says Sayantan Majumdar, Associate Professor at RRI and one of the authors. "We cannot see what is going on inside the material."

In the current study, the researchers used soft materials instead, and observed how they reacted under stress. Using an optical microscope and camera, they were able to look closely at how the inside of the material changed over time.

They found that the rate at which the material reorganized itself showed burst-like patterns persisting over thousands of seconds, resembling seismic foreshocks and aftershocks. These events usually happen over hundreds of kilometers during earthquakes. "We were able to observe this phenomenon at about 10 micron scale length. That is a huge advantage," says Pradip Bera, first author and a Ph.D. student at the Department of Physics, IISc.

The researchers also found that these patterns obeyed laws that govern earthquake dynamics. One of these, called the Gutenberg-Richter law, describes the strength of earthquakes. Another, called the Omori law, describes how the frequency of aftershocks reduces over time. Values for mathematical parameters defined by these laws, when calculated for the soft materials, were found to be very close to those that have been reported for real earthquakes. The time gaps between spikes were also found to closely match real-life patterns.

The researchers hope that further studies on such materials will eventually help identify microscopic precursors of earthquakes.

More information: P. K. Bera et al. Quantitative earthquake-like statistical properties of the flow of soft materials below yield stress, *Nature Communications* (2020). DOI: 10.1038/s41467-019-13790-2

Provided by Indian Institute of Science

APA citation: Soft materials allow scientists to study earthquakes in the lab (2020, January 8) retrieved 21 January 2021 from https://phys.org/news/2020-01-soft-materials-scientists-earthquakes-lab.html

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