Material deformation at atomic scale resembles avalanches

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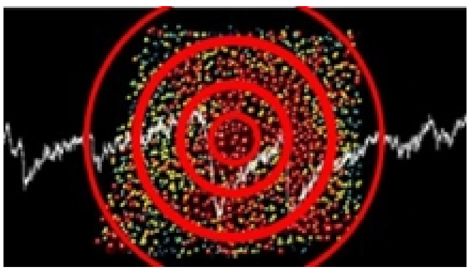

Credit: Marthe Sohpie

The rearrangement of particles in materials during deformation, such as when a spoon is bent, doesn't occur independently, but rather resembles highly collective avalanches that span the entire material. This is the conclusion of experimental research conducted by researchers from the University of Amsterdam (UvA) and the University of Illinois at Urbana-Champaign. The team's findings, which are published in the latest edition of *Nature Communications*, offers a new universal theory of deformation.

Within the field of physics, the every-day deformation of materials has traditionally been described in very different contexts. For example, when a spoon is bent or a mobile phone cover shaped during production, small sporadic atomic rearrangements occur that ultimately give rise to the changing shape of the material. In soft materials such as cream or tooth paste, similar rearrangements occur with much larger constituent particles giving rise to the overall shape change. However, until now attempts to describe what exactly happens during the deformation process have been impeded by the large length-scale gap between microscopic rearrangements and macroscopic deformation. This has precluded a complete understanding of deformation processes.

Particle rearrangement

To gain a better insight into this process, the researchers made use of a new method by which they directly imaged the three-dimensional motion of grains inside a model system with a three-dimensional laser-scanning technique on fluorescently labelled suspensions. This allowed them to accurately track the motion of the individual particles in space and time and connected this motion to the applied deforming force, thereby bridging the gap between micro and macro scale. What they found was that the motion strongly resembles an 'avalanche' in that the particles do not rearrange themselves individually, but rather collectively move into a new position. Moreover, by analysing the variations in the applied force, the particles also revealed statistics very similar to the seismic activity of earthquakes.

Avalanches

'Avalanches are important phenomena that occur not only in the surge of snow down an incline, but also in a wider context such as through the spread of forest fires, diseases or in the dynamics of stock markets', says Peter Schall, professor of Soft Condensed Matter Physics at the UvA and one of the researchers who took part in the project. 'They typically develop in highly collective systems that are distinct by their critical state and in which a small event can trigger a large effect.'

The beauty of this finding is that deformation – like many other avalanche phenomena – are described by identical statistical distributions, thereby allowing unification of widely different phenomena, says Schall. 'For the process of deformation, this offers a new universal theory in which the gap between microscopic rearrangements and macroscopic flow is bridged by simple, self-similar scaling relations. These are independent of the material and can include anything from nanorods to rocks to everyday materials. This greatly reduces the complexity of the phenomenon into a unifying framework and should ultimately lead to the better prediction and design of material properties.

More information: D. V. Denisov et al. Universality of slip avalanches in flowing granular matter, *Nature Communications* (2016). DOI: 10.1038/ncomms10641

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