Physicists discover temperature key to avalanche movement

February 1 2005

100 years after Einstein's landmark work on Brownian motion, physicists have discovered a new concept of temperature that could be the key to explaining how ice and snow particles flow during an avalanche, and could lead to a better way of handling tablets in the pharmaceutical industry. This research is reported today in a special Einstein Year issue of the New Journal of Physics published jointly by the Institute of Physics and the German Physical Society (Deutsche Physikalische Gesellschaft).

Everything from powdery snow to desert sands, from salt to corn flakes are granular materials. Physicists have known for many years that granular materials have many perplexing properties that make them behave at times liquid solids, liquids, and even gases. This new research reveals for the first time how to measure a concept called "granular temperature" – that could be the key to explaining how they behave.

"Take the solid snow covering a ski slope, for instance", suggests lead author of the paper Patrick Mayor of the EPFL in Lausanne, Switzerland. "While it stays still it is a solid, but as soon as it starts flowing downhill as happens during an avalanche the flowing material is behaving more like a liquid. Similarly, during a desert storm, sand grains are whipped up and behave like molecules in a gas, rather than as a solid".

"Whereas most materials are usually described as solid, liquid or gases, granular systems do not seem to fall into any of these categories and are often considered a separate state of matter of their own," says Mayor, "The diverse behaviour of granular materials makes it extremely difficult to establish a general theory that accounts for the observed phenomena."

Mayor and his colleagues, Gianfranco D'Anna, Alain Barrat, Vittorio Loreto, have shown that shaken granular matter behaves in a way related to Einstein's theory of Brownian motion, first published in 1905.

The temperature of an object reflects the random motion of its constituent parts. For instance, the faster the molecules in a gas or liquid are moving around the higher the temperature of the material.

Temperature also measures the degree of agitation of molecules in a liquid or a gas. Mayor and his colleagues have now devised a thermometer that can measure the temperature of a granular material based on the degree of agitation of its component particles. The researchers also discovered that, unlike usual liquids, temperature varies depending on which way and how far they insert the "thermometer" into the granular material.

Being able to measure "temperature" might allow researchers to better understand the peculiar properties of a granular material, which is of crucial importance to industries that handle powders and particulate materials from pharmaceutical pills and food powders to sand and cement in the construction industry.

The paper will be published on Monday 31st January 2005 in New Journal of Physics (www.njp.org) as part of a celebratory focus issue on "Brownian Motion and Diffusion in the 21st Century" (stacks.iop.org/1367-2630/7/i=1/a=E01). The paper can be downloaded free of charge from 31st January at stacks.iop.org/1367-2630/7/28. Reference: P Mayor et al. New J. Phys. 7 (2005) 28.

Source: Institute of Physics