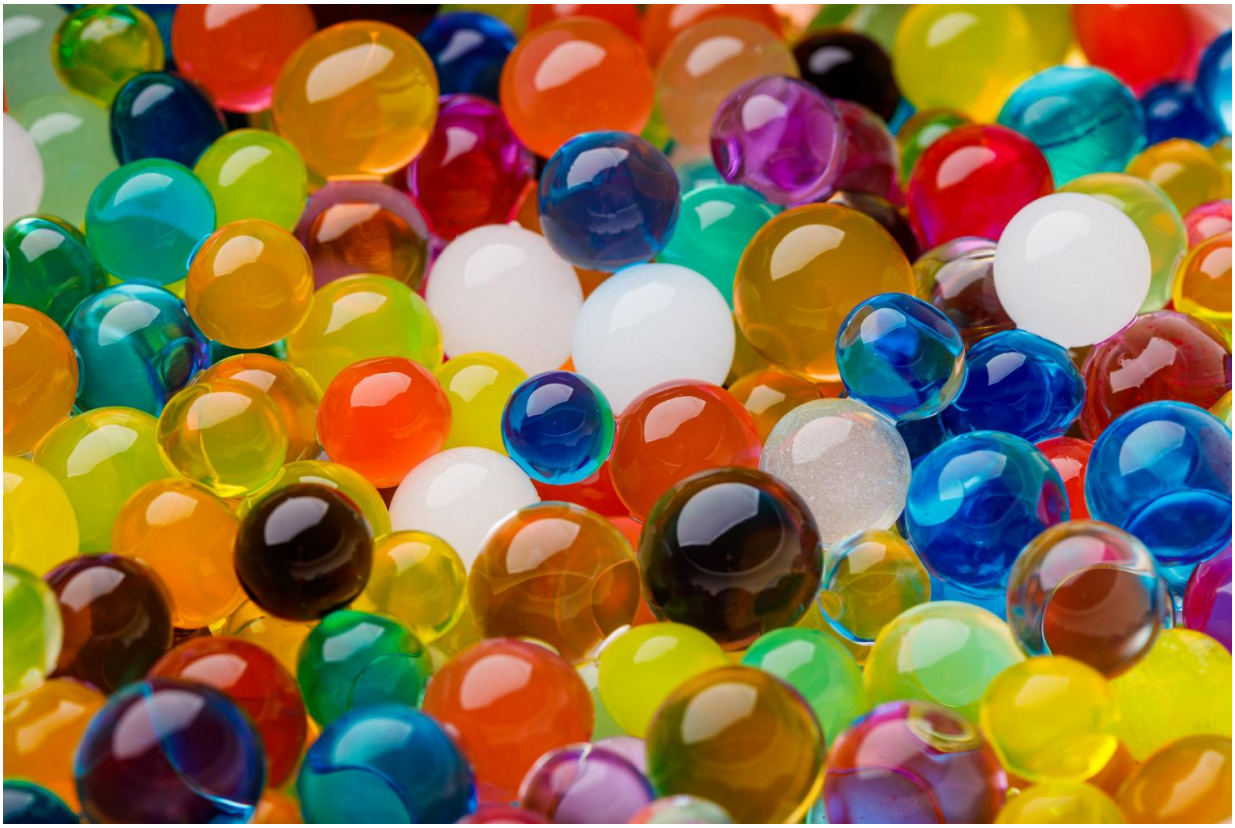
Elastic Leidenfrost effect enables soft engines

July 24 2017



Credit: Dr. Scott Waitukaitis

Water droplets float in a hot pan because of the so-called Leidenfrost effect. Now, physicists have discovered a variation: the elastic Leidenfrost effect. It explains why hydrogel balls jump around on a hot

plate making high-pitched sounds. They have published the results of their study in *Nature Physics*.

Most of the time, research arises through the gradual advancement of science. But sometimes, research projects emerge from a sudden strike of curiosity. Physicist Scott Waitukaitis (Leiden University / AMOLF) stumbled across a YouTube video of bouncing hydrogel balls on a hot plate and was so inspired that he decided to write an NWO Veni grant proposal to explore the phenomenon.

Leidenfrost effect

The dance of water droplets in a frying pan is a well-known phenomenon called the Leidenfrost effect. The warm undersides of the droplets vaporize so quickly that they float around on a cushion of vapor. In striking contrast, hydrogel balls exhibit sustained bouncing motion. What's more, they scream while they bounce. Why and how do they do this? Waitukaitis and group leader Martin van Hecke (Leiden University / AMOLF) discovered that an unknown effect underlies the bouncing and screaming: the elastic Leidenfrost effect, which they describe in a publication in *Nature Physics*.

Elastic Leidenfrost

Hydrogel balls are elastic spheres that are mostly (98 percent) water —there is no shell. When they touch the hot plate, a small amount of water vaporizes, as happens with regular water droplets. Using high-speed videography to scrutinize the vaporization process at the interface between the sphere and the hot surface, Waitukaitis discovered that the released vapor interacts with the squishy sphere to create rapid oscillations in pressure and deformation. The movement that follows injects energy into the sphere, leading to a sustained bouncing. "These

oscillations happen rapidly, at a frequency of a few thousand cycles per second, causing the high-pitched sounds," says Waitukaitis.

Soft Engine

This phenomenon may seem trivial, but Waitukaitis and colleagues contend that it brings to light a useful concept. "Effectively, the sphere acts like an engine in the way that it harnesses energy from the surface," he says. "What's incredible, however, is that all of the components of an engine, such as the fuel, the piston mechanism, and the mechanical output, are embedded in a single hydrogel ball."

Given that the mechanism explicitly requires the object to be squishy, the researchers call this a "soft engine." The idea could be useful in other fields, as well. "One could take advantage of this idea in soft robotics. You could, for example, run a set of wires through the arms of a hydrogel robot and heat them where you want movement."

More information: Scott R. Waitukaitus, Antal Zuiderwijk, Anton Souslov, Corentin Coulais, Martin van Hecke, Coupling the Leidenfrost Effect and Elastic Deformations to Power Sustained Bouncing, *Nature Physics*, DOI: 10.1038/nphys4194

Coupling the Leidenfrost Effect and Elastic Deformations to Power Sustained Bouncing. *arXiv*, arxiv.org/abs/1705.03530

Provided by Leiden Institute of Physics