Scientists announce first room-temperature magnetic skyrmion bubbles

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From left to right: Argonne researchers Wanjun Jiang, Suzanne G.E. te Velthuis, and Axel Hoffman, published a new way to make magnetic skyrmion bubbles at room temperature. Credit: Mark Lopez/Argonne National Laboratory

New ideas are bubbling up for more efficient computer memory.

Researchers at UCLA and the U.S. Department of Energy's Argonne National Laboratory announced today a new method for creating magnetic skyrmion bubbles at room temperature. The bubbles, a physics phenomenon thought to be an option for more energy-efficient and compact electronics, can be created with simple equipment and common materials.

Skyrmions, discovered just a few years ago, are tiny islands of magnetism that form in certain materials. If you wrapped one up into a sphere, its magnetic fields would point away in all different directions—so they stay in neat little packages and don't unravel easily.

Scientists found they could prod these skyrmions to move using electric currents, and an idea was born: could we use them to represent 1s and 0s in computer memory?

Transistors, which form the basis of today's computing, are tiny devices that stop the flow of electric current (off and on, 1 and 0). But there's a limit to how small we can make them, and we're running up against it. Scientists want to find a way to create 1 and 0 by using physics phenomena that don't actually change the atomic structure of the material—for example, making a line of skyrmions that could be read as 1s (skyrmion) and 0s (no skyrmion).

But the only way we knew how to make new individual skyrmion bubbles on demand was at very, very low temperatures (below 450 degrees Fahrenheit) with expensive equipment like spin-polarized scanning tunneling microscopes—not practical for making consumer devices like laptops, and not even easy for most scientists to make so they could study them.

"Our new method is the simplest way to generate skyrmion bubbles thus far," said Argonne postdoctoral researcher Wanjun Jiang, the first author

on the study.

The team used a geometric structure to 'blow' the bubbles into shape in a very thin film. Using the Center for Nanoscale Materials, a DOE Office of Science user facility at Argonne, they built a constricted wire out of a three-layered structure in which a tiny layer of magnetic material is sandwiched between tantalum and tantalum-oxide layers.

Long stripes of magnetic domains appear in the magnetic material on one side of a tiny channel. When the scientists applied an electric current to the metal layers, the stripes stretched through the channel and broke into tiny spherical skyrmion bubbles on the other side—much like how children blow soap bubbles.

By running a smaller electric current through the system, they could make the skyrmions move.

"These aren't exotic materials—they're widely used already in the magnetics industry," said Argonne materials scientist Axel Hoffmann, the corresponding author on the paper. The electric current needed to move the skyrmions is much lower than what's used in other experimental memory alternatives, like racetrack memory, he said.

"With this system we can explore many of the theoretical ideas on skyrmion physics that have been proposed over the past few years," said Argonne physicist Suzanne G.E. te Velthuis, who co-authored the study.

"We think this method could apply to many more materials," Jiang said. "This opens many new opportunities for the future."

More information: The study, "Blowing Magnetic Skyrmion Bubbles," was published on June 12 in *Science Express*: DOI: 10.1126/science.aaa1442

Provided by Argonne National Laboratory