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National Institute of Standards and Technology
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NIST, UC Davis Scientists Float New Approach to Creating Computer Memory

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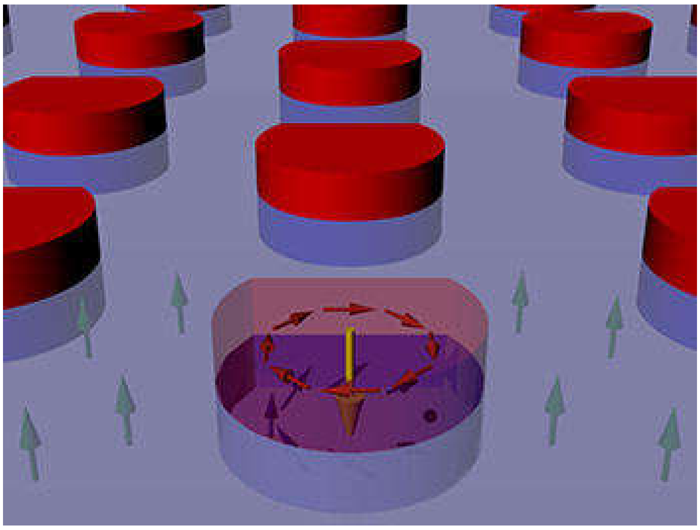

A magnetized cobalt disk (red) placed atop a thin cobalt-palladium film (light purple background) can be made to confer its own ringed configuration of magnetic moments (orange arrows) to the film below (purple arrows), creating a skyrmion in the film. The skyrmion, which is stable at room temperature, might be usable in computer memory systems.
Credit: Dustin Gilbert/NIST

What can skyrmions do for you? These ghostly quantum rings, heretofore glimpsed only under extreme laboratory conditions, just might be the basis for a new type of computer memory that never loses its grip on the data it stores.

Now, thanks to a research team including scientists from the National Institute of Standards and Technology (NIST),* the exotic ring-shaped magnetic effects have been coaxed out of the physicist's deepfreeze with a straightforward method that creates magnetic skyrmions under ambient room conditions. The achievement brings skyrmions a step closer for use in real-world data storage as well as other novel magnetic and electronic technologies.

If you have a passing familiarity with particle physics, you might expect skyrmions to be particles; after all, they sound a lot like fermions, a class of particles that includes protons and neutrons. But skyrmions are not fundamental pieces of matter (not even of yogurt (https://en.wikipedia.org/wiki/Skyr)); they are effects named after the physicist (https://en.wikipedia.org/wiki/Tony_Skyrme) who proposed them. Until just recently, magnetic skyrmions had only been seen at very low temperatures and under powerful magnetic fields.

The magnetic force in each individual atom in a magnet—what physicists call their "magnetic moments"—all line up the same way, like tiny compasses all pointing in the same direction. But under extreme conditions, certain magnetic materials (such as MnSi or FeCoSi) can, instead, develop spots where the moments curve and twist, forming a winding, ring-like configuration. These unusual objects possess an elasticity that protects them from outside influence, meaning the data they store would not be corrupted easily, even by stray magnetic fields or physical defects within the material. As a result, magnetic skyrmions present a promising basis for information memory systems and other nanoelectronic devices.

A hurdle in using traditional skyrmions was the extreme lab conditions needed to form them. Until recently, scientists glimpsed magnetic skyrmions only at low temperatures. While NIST's Dustin Gilbert was a graduate student in Kai Liu's lab at the University of California, Davis, he and Liu not only designed an approach to make the quantum objects, but also their creations remained stable at room temperature, with no magnetic field.

It took a trip to NIST to confirm the skyrmions' existence. Creating them involves placing arrays of tiny magnetized cobalt disks atop a thin film made of cobalt and palladium; the NIST Center for Neutron Research (NCNR) had just developed a state-of-art polarized neutron reflectometer that was well suited to study their lab results. Working with NCNR scientists, the team used neutrons to see through the disk to spot the skyrmions underneath. The team also captured images of the whirling configurations in the disk array at NIST's Center for Nanoscale Science and Technology (CNST) and Lawrence Berkeley Laboratory.

According to Gilbert, the findings should interest anyone following spintronics, a field that aims to use magnetic effects such as those skyrmions exhibit for information storage and processing.

"The idea that has been discussed is that, for example, you could just push these stable magnetic bundles in single file down a line and read their data. The advantage here is that you'd need way less power to push them around than any other method proposed for spintronics," says Gilbert, who recently began a postdoctoral fellowship at the NCNR. "What we need to do next is figure out how to make them move around. But for now, we can start exploring how we might use skyrmions in technology—the playground is open."

*D.A. Gilbert, B.B. Maranville, A.L. Balk, B.J. Kirby, P. Fischer, D.T. Pierce, J. Unguris, J.A. Borchers and K. Liu. Realization of Ground State Artificial Skyrmion Lattices at Room Temperature. *Nature Communications*, 6:8462, doi: 10.1038/ncomms9462 (2015).

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