Physicists catch a magnetic wave that offers promise for more energy-efficient computing

September 9 2015, by James Devitt

A team of physicists has taken pictures of a theorized but previously undetected magnetic wave, the discovery of which offers the potential to be an energy-efficient means to transfer data in consumer electronics. Credit: Purestock

A team of physicists has taken pictures of a theorized but previously undetected magnetic wave, the discovery of which offers the potential to be an energy-efficient means to transfer data in consumer electronics.

The research, which appears in the journal *Physical Review Letters*, was conducted by scientists at New York University, Stanford University, and the SLAC National Accelerator Laboratory.

"This is an exciting discovery because it shows that small magnetic waves—known as spin-waves—can add up to a large one in a magnet, a wave that can maintain its shape as it moves," explains Andrew Kent, a professor of physics at NYU and the study's senior author. "A specialized x-ray method that can focus on particular magnetic elements with very high spatial resolution enabled this discovery and should enable many more insights into this behavior."

"Magnetism has been used for navigation for thousands of years and more recently to build generators, motors, and data storage devices," adds co-author Hendrik Ohldag, a scientist at the Stanford Synchrotron Radiation Laboratory (SSRL), where the soliton was discovered. "However, magnetic elements were mostly viewed as static and uniform. To push the limits of energy efficiency in the future we need to understand better how magnetic devices behave on fast timescales at the nanoscale, which is why we are using this dedicated ultrafast x-ray microscope."

These magnetic waves are known as solitons—for solitary waves—and were theorized to occur in magnets in the 1970s. They form because of a delicate balance of magnetic forces—much like water waves can form a tsunami. However, these magnetic waves are not destructive; they could potentially be harnessed to transmit data in magnetic circuits in a way that is far more energy efficient than current methods that involve moving electrical charge.

This is because solitons are stable objects that overcome resistance, or friction, as they move. By contrast, electrons, used to move data today, do generate heat as they travel, due to resistance and thus requiring additional energy, such as from a battery, as they transport data to its destination.

In their search, the scientists deployed x-ray microscopy at the Stanford

Synchrotron Radiation Lightsource —using a method akin to the way x-rays are used to image the human body—in order to image the behavior of specific magnetic atoms in materials. The technique offers extraordinarily high spatial resolution and temporal resolution. The scientists created a condition in magnetic materials where the sought-after solitons should exist by injecting an electrical current into a magnetic material to excite spin-waves.

They observed an abrupt onset of magnetic waves with a well-defined spatial profile that matched the predicted form of a solitary magnetic wave—i.e., a magnetic soliton.

The study's other authors included: Dirk Backes, an NYU postdoctoral fellow at the time of the study and now at the University of Cambridge; Ferran Macià, an NYU postdoctoral fellow at the time of the study and now at the University of Barcelona; Stefano Bonetti, a postdoctoral fellow at Stanford University and now at Stockholm University; and Roopali Kukreja, a postdoctoral fellow at Stanford's Department of Materials Science and Engineering at the time of the study and now at the University of California, San Diego.

Provided by New York University

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