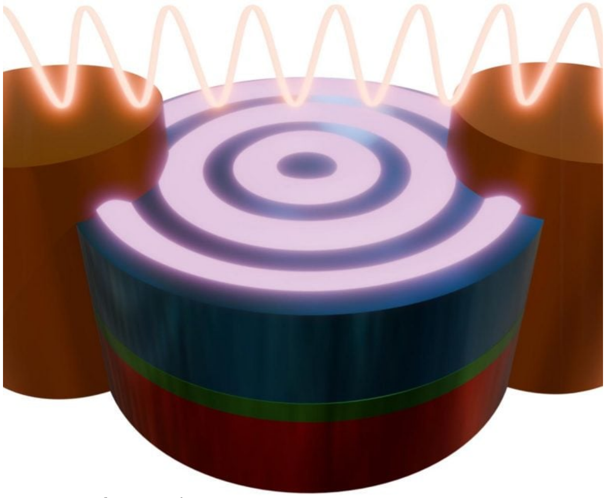
Computing to Be Revolutionized by Swirling Magnons

Posted by Okachinepa 09/30/2024



Courtesy of SynEvol
Credit: Sabri Koraltan

This novel approach promises considerable improvements over conventional CMOS technology and might pave the way for the next generation of computer devices by using alternating currents to create and steer spin waves in synthetic ferrimagnetic vortex pairs.

Our phones, laptops, and desktop computers' central processing units (CPUs) are dependent on billions of transistors constructed using complementary metal oxide semiconductor (CMOS) technology. Physical limitations and questions over these devices' long-term sustainability have surfaced as the need for them to get smaller develops. Furthermore, the hunt for alternative computing architectures is being fueled by their notable losses and energy consumption.

Magnons, the quanta of spin waves, are among the promising candidates. "Consider a serene lake. The waves that are created when a stone falls into the water go away from the source. We now swap out the stone for an antenna and the lake for a magnetic substance. According to Sabri Koraltan of the University of Vienna, "the propagating waves are called spin waves and can be used to transfer energy and information from one point to another with minimal losses."

Spin waves can be generated and then utilized by magnonic devices to carry out both standard and non-traditional computer activities.

The research project coordinator, Sebastian Wintz of Helmholtz-Zentrum Berlin, continues, "We need to use spin waves with short wavelengths to reduce the footprint of magnonic devices, which are difficult to generate using state-of-the-art nano antennas due to limited efficiency." Only in highly specialized nanofabrication facilities with clean rooms and cutting-edge lithography processes can nano antennas be created.

The researchers from Germany and Austria made a significant advancement when they discovered a much easier solution: electric current passes straight through a magnetic stack that has swirling magnetic patterns.

According to Sabri Koraltan, "our research demonstrates that we can achieve spin-wave emission with an efficiency that surpasses conventional methods by several orders of magnitude by using a lateral alternating current geometry in synthetic ferrimagnetic vortex pairs." The magnetization patterns of synthetic ferrimagnetic systems are opposing.

The lower layer has an anticlockwise feeling of rotation if the top layer contains a clockwise revolving vortex. This makes it possible to use the magnetic fields produced by the alternating currents to efficiently excite the magnetization pattern.

"We were even able to observe the predicted spin waves at nanoscale wavelengths and Gigahertz frequencies using our high-resolution 'Maxymus' x-ray microscope, based at the BESSY II electron synchrotron in Berlin," says Sebastian Wintz.

Furthermore, we have shown that the direction of these spin waves may be dynamically controlled by merely altering the applied current's magnitude by utilizing unique materials that alter their magnetization in response to strain. Sabri Koraltan concludes, "This can be viewed as a significant step towards active magnonic devices.

Dieter Süss, head of the University of Vienna's Physics of Functional Materials Department, continues, "Our new generation of micromagnetic simulation software, magnum.np, allowed us to perform large-scale simulations, which were crucial to understand the main mechanisms behind this efficient and controllable spin-wave excitation."

Creating reprogrammable magnonic circuits is made possible by the capacity to reroute spin waves on demand. This could result in computing systems that are more flexible and energy-efficient. The results, which were reported in Science Advances, mark a significant breakthrough in the search for novel methods of producing magnons for potential use in next-generation technologies based on magnons.