Antiferromagnetic materials allow for processing at terahertz speeds

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In high-speed fiber optics, it is often the case that either the bandwidth of the transmission media cannot keep up with the data flow or the data simply cannot be processed fast enough. Then the picture judders or the resolution is temporarily scaled down, and television viewers have to make do with lower resolution images. Soon, such low bandwidth could be a thing of the past. Researchers at the Czech Academy of Sciences, together with their colleagues at Mainz University, have discovered a way to dramatically increase data processing rates by around 100 times up to terahertz speeds.

In general, data memory and storage rely on the use of ferromagnetic materials. However, these are associated with two drawbacks. First, the areal density and, thus, the storage capacity of these materials is restricted as they reach natural limits. This is because each bit of information is stored in a kind of tiny bar magnet, each of which represents a zero or a one depending on its alignment. But if these bar magnets are placed too close together, they begin to influence each other. The second problem is that there are also restrictions on the speeds with which data can be written to this type of storage medium. It is not possible to go faster than gigahertz rates without immense energy expenditure.

But this is not the case with antiferromagnetic memory, which can be written at a much higher density because the bar magnets are always aligned alternately, and so have no effect on each other. This means they can store considerably more data and allow much faster writing speeds.

Antiferromagnetic memory allows for terahertz processing rates

"If you want to send information, such as moving images of a soccer match, you send this in the form of light that can be transmitted by fiber-optic cables," explained Professor Jairo Sinova, Head of the Interdisciplinary Spintronics Research group (INSPIRE) at Johannes Gutenberg University Mainz. "As this is possible at frequencies in the terahertz range, it happens extremely rapidly. At present, the reception speed has to be slowed down to be processed by the computer or television because these devices process and store data using electricity-based techniques, and the speed these operate at is just a few hundred gigahertz. Our antiferromagnetic memory concept is now capable of working directly with data sent at rates in the terahertz range." This means the signal no longer has to be slowed down by the device. Instead, it can also be processed at terahertz speeds by the computer or TV.

The scientists carried out the initial research back in 2014. They passed an electric current through the antiferromagnets and were thus able to align the tiny storage units appropriately. They originally used a cable for this, a rather slow connection method. "Instead of the cable, we use now a short laser pulse to induce an electric current. This current aligns the bar magnets, in other words, their spin moments," said Sinova. Instead of using cables, the new memory works wirelessly, and instead of requiring direct electric current, the effects are now generated using light. Thanks to this, the researchers were able to dramatically increase speeds, thus meeting the requirements necessary to enable future users to view judder-free, ultra-high-definition images.

More information: Kamil Olejník et al, Terahertz electrical writing speed in an antiferromagnetic memory, *Science Advances* (2018). DOI: 10.1126/sciadv.aar3566

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