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James Badham

A new optical memory platform for super fast calculations

For decades there has been near constant progress in reducing the size, and increasing the performance, of the circuits that power computers and smartphones. But Moore's Law is ending as physical limitations — such as the number of transistors that can fit on a chip and the heat that results from packing them ever more densely — are slowing the rate of performance increases. Computing capacity is gradually plateauing, even as artificial intelligence, machine learning and other data-intensive applications demand ever greater computational power.

Novel technologies are needed to address this challenge. A potential solution comes from photonics, which offers lower energy consumption and reduced latency than electronics.

One of the most promising approaches is in-memory computing, which requires the use of photonic memories. Passing light signals through these memories makes it possible to perform operations nearly instantaneously. But solutions proposed for creating such memories have faced challenges such as low switching speeds and limited programmability.

Now, an international team of researchers has developed a groundbreaking photonic platform to overcome those limitations. Their findings were published in the journal Nature Photonics.

Working with UC Santa Barbara professor of electrical and computer engineering (ECE) John Bowers and ECE associate professor Galan Moody, ECE project scientist Paolo Pintus, also an assistant professor at the University of Cagliari, coordinated the project with University of Pittsburgh's Nathan Youngblood, Institute of Science Tokyo professor Yuya Shoji, and Mario Dumont, who received his Ph.D. in the Bowers lab.

The researchers used a magneto-optical material, cerium-substituted yttrium iron garnet (YIG), the optical properties of which dynamically change in response to external magnetic fields. By employing tiny magnets to store data and control the propagation of light within the material, they pioneered a new class of magneto-optical memories. The innovative platform leverages light to perform calculations at significantly higher speeds and with much greater efficiency than can be achieved using traditional electronics.

This new type of memory has switching speeds 100 times faster than those of state-of-the-art photonic integrated technology. They consume about one-tenth the power, and they can be reprogrammed multiple times to perform different tasks. While current state-of-the-art optical memories have a limited lifespan and can be written up to 1,000 times, the team demonstrated that magneto-optical memories can be rewritten more than 2.3 billion times, equating to a potentially unlimited lifespan.

"These unique magneto-optical materials make it possible to use an external magnetic field to control the propagation of light through them," Pintus said. "In this project, we use an electrical current to program micro-magnets and store data. The magnets control the propagation of light within the Ce:YIG material, allowing us to perform complex operations, such as matrix-vector multiplication, which lies at the core of any neural network."

The authors believe that the findings could mark the beginning of a revolution in optical computing, paving the way for practical applications in the near future.

Media Contact
Shelly Leachman
Editorial Director
(805) 893-2191

sleachman@ucsb.edu

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