New Classes of Magnetoelectric Materials Promise Advances in Computing Technology

Argonne National Laboratory

Argonne, IL – Although scientists have been aware that magnetism and electricity are two sides of the same proverbial coin for almost 150 years, researchers are still trying to find new ways to use a material's electric behavior to influence its magnetic behavior, or vice versa.

Thanks to new research by an international team of researchers led by the U.S. Department of Energy's Argonne National Laboratory [1], physicists have developed new methods for controlling magnetic order in a particular class of materials known as "magnetoelectrics."

Magnetoelectrics get their name from the fact that their magnetic and electric properties are coupled to each other. Because this physical link potentially allows control of their magnetic behavior with an electrical signal or vice versa, scientists have taken a special interest in magnetoelectric materials.

"Electricity and magnetism are intrinsically coupled – they're the same entity," said Philip Ryan, a physicist at Argonne's Advanced Photon Source [2]. "Our research is designed to accentuate the coupling between the electric and magnetic parameters by subtly altering the structure of the material."

The Argonne-led team focused on the compound EuTiO3 (europium-titanium oxide), which has a simple atomic structure that suited it especially well to the experiment. The titanium atom sits in the middle of a cage constructed of the europium and oxygen atoms. By first compressing the cage through growing a thin film of EuTiO3 on a similar crystal with a smaller lattice and then applying a voltage, the titanium shifts slightly, electrically polarizing the system, and more importantly, changing the magnetic order of the material.

"The europium and the titanium combine to control the two properties," Ryan said. "The position of the titanium influences the electric behavior, while the europium generates the magnetic nature. There's a shared responsibility for the system's coupling behavior."

This new approach to cross-coupling magnetoelectricity could prove a key step toward the development of next-generation memory storage, improved magnetic field sensors, and many other applications long dreamed about. Unfortunately, scientists still have a ways to go to translating these findings into commercial devices.

Potential magnetic and electric memories each have a distinct appeal to researchers. Electric memories – like the kind used into today's electronics – allow

computers to write data fast and very efficiently. Magnetic memories are less energy efficient, but are extraordinarily robust.

"The more we learn about magnetoelectrics, the more we open up this space that gives us the best of both worlds," Ryan said.

Because the electric and magnetic parameters in these particular materials are so strongly linked, engineers might also be able to use them in the future to create non-binary memories.

"Instead of having just a ‘0’ or a ‘1,’ you could have a broader range of different values," Ryan said. "A lot of people are looking into what that kind of logic would look like."

A paper based on the research, "Reversible control of magnetic interactions by electric field in a single-phase material," was published in Nature Communications.

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For more information visit http://www.anl.gov [1].

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