SCIENCE FLASH NEWS

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Physicists magnetize a material with light: Terahertz technique could improve memory chip design

MIT physicists have created a new and long-lasting magnetic state in a material, using only light.

In a study that appears in *Nature*, the researchers report using a terahertz laser—a light source that oscillates more than a trillion times per second—to directly stimulate atoms in an antiferromagnetic material. The laser's oscillations are tuned to the natural vibrations among the material's atoms, in a way that shifts the balance of atomic spins toward a new magnetic state.

The results provide a new way to control and switch antiferromagnetic materials, which are of interest for their potential to advance information processing and memory chip technology.

If a memory chip could be made from antiferromagnetic material, data could be "written" into microscopic regions of the material, called domains. A certain configuration of spin orientations (for example, up-down) in a given domain would represent the classical bit "0," and a different configuration (down-up) would mean "1." Data written on such a chip would be robust against outside magnetic influence.

https://phys.org/news/2024-12-physicists-magnetize-material-terahertz-technique.html

Study claims all observables in nature can be measured with a single constant: The second

A group of Brazilian researchers has presented an innovative proposal to resolve a decades-old debate among theoretical physicists: How many fundamental constants are needed to describe the observable universe? Here, the term "fundamental constants" refers to the basic standards needed to measure everything.

The study is published in the journal *Scientific Reports*.

The group argues that the number of fundamental constants depends on the type of space-time in which the theories are formulated; and that in a relativistic space-time, this number can be reduced to a single constant, which is used to define the standard of time. The study is an original contribution to the controversy sparked in 2002 by a famous article by Michael Duff, Lev Okun and Gabriele Veneziano published in the *Journal of High Energy Physics*.

The whole story had begun ten years earlier, in the summer of 1992, when the three scientists met on the terrace of the cafeteria at CERN, the European Organization for Nuclear Research. During an informal conversation, they discovered that they disagreed on the number of fundamental constants.

https://phys.org/news/2024-12-nature-constant.html

Particle that only has mass when moving in one direction observed for first time

For the first time, scientists have observed a collection of particles, also known as a quasiparticle, that's massless when moving one direction but has mass in the other direction. The quasiparticle, called a semi-Dirac fermion, was first theorized 16 years ago, but was only recently spotted inside a crystal of semi-metal material called ZrSiS. The observation of the quasiparticle opens the door to future advances in a range of emerging technologies from batteries to sensors, according to the researchers.

The team, led by scientists at Penn State and Columbia University, recently published their discovery in the journal *Physical Review X*.

"This was totally unexpected," said Yinming Shao, assistant professor of physics at Penn State and lead author on the paper. "We weren't even looking for a semi-Dirac fermion when we started working with this material, but we were seeing signatures we didn't understand—and it turns out we had made the first observation of these wild quasiparticles that sometimes move like they have mass and sometimes move like they have none."

https://phys.org/news/2024-12-particle-mass.html

Theory-based approach gives access to quarks' tiny transverse motion within protons

Nuclear theorists at Brookhaven National Laboratory and Argonne National Laboratory have successfully employed a new theoretical approach to calculate the Collins-Soper kernel, a quantity that describes how the distribution of quarks' transverse momentum inside a proton changes with the collision energy.

The research is published in the journal *Physical Review D*.

The new calculation precisely matches model-based reconstructions from particle collision data. It is particularly effective for quarks with low transverse momenta, where earlier methods fell short.

This theory-based approach provides the first accurate calculations of how the distribution of quarks' transverse momentum within protons changes with collision energy. The approach will provide significantly more accurate theoretical predictions for the small transverse motions of quarks inside protons. This will eliminate the need to model the most complex strong-force governed quark-gluon interactions.

https://phys.org/news/2024-12-theory-based-approach-access-quarks.html

X-ray data-enhanced computational method can determine crystal structures of multiphase materials

A joint research team led by Yuuki Kubo and Shiji Tsuneyuki of the University of Tokyo has developed a new computational method that can efficiently determine the crystal structures of multiphase materials, powders that contain more than one type of crystal structures. The method can predict the structure directly from powder X-ray diffraction patterns, the patterns of X-rays passing through crystals roughly the same size as instant coffee particles.

Unlike conventional methods, this approach does not require the use of "lattice constants" and can be applied to existing experimental data that could not be analyzed until now. Thus, the new method is a crucial asset for discovering new material phases and developing new materials. The findings are published in *The Journal of Chemical Physics*.

Many materials can have several crystal structures, "phases," even in the same solid state. Determining the underlying crystal structures of materials is essential for understanding their properties and formulating strategies to develop new materials. However, conventional methods make calculations using the "lattice constant," a property of the crystal being investigated.

https://phys.org/news/2024-12-ray-method-crystal-multiphase-materials.html

X-ray vision: Seeing through the mystery of an X-ray emissions mechanism

Since the 1960s, scientists who study X-rays, lightning and similar phenomena have observed something curious: In lab experiments replicating these occurrences, electrons accelerated between two electrodes can be of a higher energy than the voltage applied.

According to Penn State researchers, this defies an assumption in physics that the energy of the electrons should correspond with the voltage applied. Despite the decades-long awareness of this apparent contradiction, researchers couldn't figure out why this was happening.

Recently, a team of Penn State researchers used mathematical modeling to explain the underlying mechanism at play. They published their results in *Physical Review Letters*.

"In these lab experiments, voltage is applied between two electrodes, which are electrical conductors. Then, electrons, which are negatively charged particles, are accelerated through a gap, which could be gas or a vacuum," said Victor Pasko, professor of electrical engineering at Penn State and corresponding author of the study.

"The energy that the electrons can gain should correspond with the voltage applied, but in all these experiments, energies were exceeding that voltage by a factor of two or three, which was a puzzle."

https://phys.org/news/2024-12-ray-vision-mystery-emissions-mechanism.html

New laser technique achieves atomic-scale precision on diamond surfaces

Imagine placing an object under a microscope and pressing a button to rearrange the surface atoms with atomic-scale precision. This once sci-fi scenario is now a reality thanks to pioneering research published in *Applied Surface Science*.

"Our laser method provides atomic-level control over diamond surfaces in a standard air environment," says lead researcher Dr. Mojtaba Moshkani.

"This level of precision is typically only possible with large, complex vacuum equipment. The ability to achieve it with a simple laser process is truly remarkable."

Harnessing the power of deep ultraviolet (UV) laser light, researchers have developed a technique for precise surface processing of diamonds. The method allows for the controlled removal of as little as 1 percent of a single atomic layer, offering unprecedented control over the structure and properties of the diamond surface.

Using a deep ultraviolet laser, the team demonstrated how precisely delivered pulses of light can trigger localized chemical reactions on a diamond surface. The reaction, driven by a two-photon process, removes carbon atoms selectively from the top atomic layer.

https://phys.org/news/2024-12-laser-technique-atomic-scale-precision.html

Thank you!

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