SCIENCE FLASH NEWS

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Graphene can hold multiple states of superconductivity, a new study finds

The ordinary graphite in pencil lead is proving to be surprisingly multifaceted at the microscale. In a study published in the journal *Nature*, MIT researchers report that a certain microscopic structure found in natural graphite can host multiple superconducting states. Superconductivity is an electronic state of matter in which electrons pair up and glide through a material with zero resistance.

While there are thousands of materials known to be superconductors, it is rare for one material to host multiple forms of superconductivity.

The researchers discovered the multiple superconducting states in atomically thin exfoliations of graphite, known as graphene. Specifically, graphene is a single-atom-thin sheet of carbon atoms arranged precisely in a microscopic lattice. The team made its discoveries in samples of rhombohedral graphene, which is a natural structure within graphite consisting of a stack of four or five graphene layers.

Interestingly, the researchers found that several of the new superconducting states in rhombohedral graphene are able to persist in the presence of a magnetic field, which normally kills superconductivity.

In a further surprise, these superconducting states even get stronger when exposed to a magnetic field.

Overall, the findings reveal a new family of unconventional superconducting states in one seemingly simple material.

https://phys.org/news/2026-06-graphene-multiple-states-superconductivity.html

Clean crystal surface lets single molecules hit ultimate quantum limit

Scientists at the Max Planck Institute for the Science of Light (MPL) have developed a technique for interrogating molecules on surfaces with spectroscopic precision, thereby reaching the ultimate quantum limit for the first time. With their findings, published in *Science*, the researchers open new opportunities for the study of molecule-surface interactions and molecular quantum technologies.

Many optical quantum technologies rely on nanoscale objects, such as atoms or molecules, that interact strongly with light. These quantum emitters are used for generating single photons, storing quantum information and entanglement distribution, processes that find application in quantum communication and computation.

To investigate these emitters individually, researchers need to keep them in one place for a long time. This is usually achieved by either trapping them in a vacuum or placing them inside a bulk material. Quantum emitters located on a surface would create new opportunities to manipulate their functionalities by "touching them," for example, with an atomically sharp tip, as is used in scanning tunneling microscopy (STM) and atomic force microscopy (AFM).

However, scientists have not previously been able to gain control over surface-bound atoms and molecules while preserving their quantum-optical properties. The reason is that surfaces can easily absorb contaminants from the environment, creating highly unstable and "noisy" surroundings that compromise the properties of the quantum emitters. Researchers in the Nano-Optics Division of MPL have now devised a way to overcome this barrier.

https://phys.org/news/2026-06-crystal-surface-molecules-ultimate-quantum.html

Novel crystal strategy delivers near-perfect zero thermal expansion from 11 K to 893 K

Almost every material expands when heated. Well-known examples include railroad tracks and concrete roadways, which feature visible expansion gaps to accommodate this effect. However, thermal expansion poses a far more acute challenge for extremely precise technologies, such as lasers and semiconductor manufacturing equipment, where even minute dimensional changes can compromise precision.

Scientists have long sought to develop materials that maintain dimensional stability across a wide temperature range.

Now, a team led by Prof. Lin Zheshuai from the Technical Institute of Physics and Chemistry (TIPC) of the Chinese Academy of Sciences (CAS) has designed a material with an exceptionally broad zero-thermal-expansion temperature window.

The study is published in *Nature Chemistry*.

Why most zero-expansion materials fail

The core challenge in creating an ideal zero-thermal-expansion material (ZTM)—one that is isotropic, stable over a broad temperature range and physicochemically robust—lies in balancing the forces driving positive thermal expansion against those driving negative thermal expansion (contraction) to achieve a net zero effect.

Unfortunately, at elevated temperatures, atomic vibrations responsible for positive thermal expansion intensify and readily overpower the mechanisms behind negative thermal expansion. Consequently, most isotropic ZTMs function only within a narrow window, typically below 400 K (~127 °C).

https://phys.org/news/2026-06-crystal-strategy-thermal-expansion.html

Horizon edge states gain finite description in string theory calculation

Modern physics theories highlight the key role of horizons—boundaries beyond which information cannot reach an observer—in a variety of cosmological and gravitational phenomena. Two renowned examples of these boundaries are event horizons in black holes and the cosmological horizon of the de Sitter spacetime, a model of an expanding universe with a positive vacuum energy.

Many quantum theories predict the existence of quantum states or excitations in the proximity of horizons, which are known as edge modes. Edge modes are additional degrees of freedom that can emerge when space is divided into two distinct regions. Rather than being distributed throughout space, they are typically localized near or on the boundary that divides the two regions.

Researchers at the Abdus Salam International Center for Theoretical Physics and the University of Amsterdam recently set out to calculate the contribution of edge modes to the Euclidean partition function, a quantity that encodes information about all possible quantum states of a system and their statistical properties.

Their paper, published in *Physical Review Letters*, extends the characterization of these states to string theory, a physical framework that portrays fundamental particles as tiny vibrating strings.

https://phys.org/news/2026-06-horizon-edge-states-gain-finite.html

Solid-state material turns visible light into high-energy UV at sunlight intensity, expanding solar energy potential

Two cups of warm water don't make one cup of boiling water. But in the quantum world, multiple low-energy photons can combine to produce a single, higher-energy photon.

A research team at Kyushu University has developed a solid-state molecular material that "upgrades" visible light into ultraviolet (UV) light under ordinary outdoor sunlight, achieving a conversion efficiency of 1.9%. The study is published in *Nature Communications*.

Harsh UV light is something most people try to avoid in summer, yet it is indispensable in fields ranging from air purification and resin curing in 3D printing to gel hardening in dental fillings and nail art. Despite its importance, UV accounts for only about 6% of the sunlight reaching Earth's surface, with only a fraction of that being practically usable.

"What we do here is 'add together' the energy from two visible light photons to make one ultraviolet photon. It's a fascinating process called photo upconversion," explains Yoichi Sasaki, associate professor at Kyushu University's Faculty of Engineering and the study's corresponding author.

https://phys.org/news/2026-06-solid-state-material-visible-high.html

Poo emoji, earthworm castings and pasta all obey the same coiling theory, physicists find

Ask a child to draw some poo, and the shape will invariably be the same: a coil, broad at the base and pointy at the top, similar to a spiral swirl of soft-serve ice cream. In fact, the often-used poo emoji has this exact shape, as do most actual mounds of feces found in nature. Exceptions occur, though, particularly in the feces of some worms that extrude their excrement "upside down" from the ground. As it turns out, there is remarkable physics behind these differences in poo shapes.

As early as 1881, Charles Darwin marveled at the neat, spiral-shaped fecal castings of earthworms. However, he never understood why these feces take their fascinating, tower-like shapes. Now, physics has provided the answer—and it explains both Darwin's original observations and the shape of the modern poo emoji.

Most animals defecate downward. As their feces coil, the pile grows higher and the fall height decreases, making each successive coil smaller. This creates the characteristic pointy mound—precisely the shape of the poo emoji. Lugworms, however, defy gravity by extruding their feces upward.

A new study by physicists Mehdi Habibi (Wageningen University and Research), Neil M. Ribe (CNRS/Université Paris-Saclay) and Daniel Bonn (University of Amsterdam), published in *Nature Communications*, reveals something remarkable: The lugworms operate in a previously unknown physics regime where coil size is independent of height—exactly as Darwin observed. The coil radius stays constant, creating uniform spirals rather than tapered mounds.

https://phys.org/news/2026-06-poo-emoji-earthworm-pasta-obey.html

How do flocking birds and schools of fish move? New research offers crystal-clear answer

Flocking birds and schools of fish are a familiar sight. While previous research has uncovered the broad dynamics driving these movements, their underlying intricacies remain a mystery. Now a study by a team of New York University mathematicians offers new insights into these phenomena. It reveals that flocks and schools behave in ways similar to a soft crystalline material, with individual birds and fish serving as "atoms" that are evenly spaced in a lattice-like formation.

The findings, reported in the journal *Physical Review Fluids*, offer detailed insights into the hydrodynamic and aerodynamic interactions crucial in aerospace and automotive engineering, robotics and energy harvesting.

"Our findings offer a new way to understand how animal collectives coordinate movement and respond to their environment," says Christiana Mavroyiakoumou, a researcher at NYU's Courant Institute School of Mathematics, Computing, and Data Science at the time of the study and now a fellow at Oxford University's Mathematical Institute. "More specifically, lines of birds or fish behave like an elastic material with regularly spaced individuals held together by flexible, or spring-like, bonds—akin to soft crystalline substances in which atoms are arranged in an orderly, repeating pattern."

https://phys.org/news/2026-06-flocking-birds-schools-fish-crystal.html

Thank you!

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