SCIENCE FLASH NEWS

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New photonic crystal approach can enable sensitive and affordable detection of biomarkers

Biomarkers are small molecules of interest to researchers, because they can indicate underlying diseases, often even before symptoms even appear. However, detecting these markers can be challenging as they are often present in very low quantities, especially in the early stages of a disease. Traditional detection methods, while effective, usually require expensive components like prisms, metal films, or optical objectives.

In a recent paper published in Applied Physics Letters, researchers at the University of Illinois Urbana-Champaign have unveiled a novel approach to detecting low concentrations of biomarkers that paves the way for biodetection technology that is simple to use, highly sensitive, and surprisingly affordable.

https://phys.org/news/2024-05-photonic-crystal-approach-enable-sensitive.html

Researchers develop framework for databasing properties of crystal defects

Point defects (e.g. missing, extra or swapped atoms) in crystalline materials often determine the actual electronic and optical response of a given material. For example, controlled substitutions in semiconductors like silicon are the backbone of modern technology. Despite their importance, point defects are notoriously difficult to simulate and characterize, particularly across wide regions of the periodic table.

Researchers at Lawrence Livermore National Laboratory (LLNL) have now created software as part of its open-source software distribution that can efficiently and effectively automate and analyze these types of calculations.

The authors demonstrated the fully automated approach on several technologically important materials. including gallium nitride (the basis of all modern solid-state lighting), gallium oxide (an emerging ultrawideband gap semiconductor) and strontium titanate (a widely studied common mineral), with the work recently published in the *Journal of Applied Physics* and selected as an Editor's Pick as part of a special issue on "Defects in Semiconductors."

https://phys.org/news/2024-05-framework-databasing-properties-crystal-defects.html

Researchers develop perovskite X-ray detector for medical imaging

Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences, in collaboration with researchers at Central China Normal University, have developed a high-performance perovskite X-ray complementary metal-oxide-semiconductor (CMOS) detector for medical imaging.

The study was published in *Nature Communications* .

X-ray imaging is vital for the diagnosis and treatment of cardiovascular and cancer diseases. Direct-conversion X-ray detectors made of semiconductor materials exhibit superior spatial and temporal resolution at lower radiation doses compared to indirect-conversion detectors made of scintillator materials. However, the currently available semiconductor materials, such as Si, a-Se, and CdZnTe/CdTe, are not ideal for general X-ray imaging due to their low X-ray absorption efficiency or high costs.

https://phys.org/news/2024-05-perovskite-ray-detector-medical-imaging.html

Scientists Discover New Property of Light

A team of physicists and chemists has discovered a previously unknown way in which light interacts with matter, a finding that could lead to improved solar power systems, light-emitting diodes, semiconductor lasers and other technological advancements. “Silicon is Earth’s second-most abundant element, and it forms the backbone of modern electronics,” said Dr. Dmitry Fishman, a chemist at the University of California, Irvine.

“However, being an indirect semiconductor, its utilization in optoelectronics has been hindered by poor optical properties.”

“While silicon does not naturally emit light in its bulk form, porous and nanostructured silicon can produce detectable light after being exposed to visible radiation.”

Scientists have been aware of this phenomenon for decades, but the precise origins of the illumination have been the subject of debate. For their experiments, the researchers produced in their laboratory silicon glass samples that ranged in clarity from amorphous to crystal.

This research is described in a paper in the journal *ACS Nano*.

https://www.sci.news/physics/photon-momentum-silicon-12912.html

Scientists use generative AI to answer complex questions in physics

When water freezes, it transitions from a liquid phase to a solid phase, resulting in a drastic change in properties like density and volume. Phase transitions in water are so common most of us probably don't even think about them, but phase transitions in novel materials or complex physical systems are an important area of study.

To fully understand these systems, scientists must be able to recognize phases and detect the transitions between. But how to quantify phase changes in an unknown system is often unclear, especially when data are scarce.

Researchers from MIT and the University of Basel in Switzerland applied generative artificial intelligence models to this problem, developing a new machine-learning framework that can automatically map out phase diagrams for novel physical systems.

The research is published in *Physical Review Letters*.

https://phys.org/news/2024-05-scientists-generative-ai-complex-physics.html

Scientists demonstrate the potential of electron spin to transmit quantum information

The spin of the electron is nature's perfect quantum bit, capable of extending the range of information storage beyond "one" or "zero." Exploiting the electron's spin degree of freedom (possible spin states) is a central goal of quantum information science.

Recent progress by Lawrence Berkeley National Laboratory (Berkeley Lab) researchers Joseph Orenstein, Yue Sun, Jie Yao, and Fanghao Meng has shown the potential of magnon wave packets—collective excitations of electron spin—to transport quantum information over substantial distances in a class of materials known as antiferromagnets.

Their work upends conventional understanding about how such excitations propagate in antiferromagnets.

The coming age of quantum technologies—computers, sensors, and other devices—depends on transmitting quantum information with fidelity over distance.

With their discovery, reported in a paper published in *Nature Physics*, Orenstein and coworkers hope to have moved a step closer to these goals.

https://phys.org/news/2024-05-scientists-potential-electron-transmit-quantum.html

The quantum theory of gravitation, effective field theories and strings: Past and present

Gravity is one of four fundamental interactions. The most precise description of this force is still provided by Einstein's General Theory of Relativity, published in 1915, an entirely classical theory. This description sets gravity apart from the other three forces—strong, weak, and electromagnetism—all described by quantum fields. Therefore, any attempt to unify the four forces must depend on a description of gravity that uses the principles of quantum mechanics. This has been an active area of theoretical physics since the 1930s. A historian and a physicist, Alessio Rocci from VUB in Brussels and Thomas Van Riet from KU Leuven in Belgium have set out a historical overview of the development of quantum theories of gravity to explain our current view on a future unified theory of the four forces. This work has been published in *The European Physical Journal H*.

https://phys.org/news/2024-05-quantum-theory-gravitation-effective-field.html

Thank you!

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