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Electron spin resonance sheds light on tin-based perovskite solar cell efficiency

Perovskite solar cells are attracting attention as next-generation solar cells. These cells have high efficiency, are flexible, and can be printed, among other features. However, lead was initially used in their manufacture, and its toxicity has become an environmental issue.

Therefore, a method for replacing lead with tin, which has a low environmental impact, has been proposed. Nevertheless, tin is easily oxidized; consequently, the efficiency and durability of tin perovskite solar cells are lower than those of lead perovskite solar cells.

To improve the durability of tin perovskite by suppressing tin oxidation, a method that introduces large organic cations into tin perovskite crystals to form a two-dimensional layered structure called Ruddlesden-Popper (RP) tin-based perovskites has been proposed. However, the internal state of this structure and the mechanism by which it improves performance have not been fully elucidated.

In this study, researchers at University of Tsukuba used electron spin resonance to investigate an RP perovskite solar cell's internal state during operation from a microscopic perspective. The research is published in the journal *npj Flexible Electronics*.

https://phys.org/news/2025-01-electron-resonance-tin-based-perovskite.html

Theoretical model explains the anomalous properties of water in extreme conditions

Water, a molecule essential for life, has unusual properties—known as anomalies—that define its behavior. However, there are still many enigmas about the molecular mechanisms that would explain the anomalies that make the water molecule unique. Deciphering and reproducing this particular behavior of water in different temperature ranges is still a major challenge for the scientific community.

Now, a study presents a new theoretical model capable of overcoming the limitations of previous methodologies to understand how water behaves in extreme conditions. The paper, featured on the cover of *The Journal of Chemical Physics*, is led by Giancarlo Franzese and Luis Enrique Coronas, from the Faculty of Physics and the Institute of Nanoscience and Nanotechnology of the University of Barcelona (IN2UB).

The study not only broadens our understanding of the physics of water, but also has implications for technology, biology and biomedicine, in particular for addressing the treatment of neurodegenerative diseases and the development of advanced biotechnologies.

https://phys.org/news/2024-11-theoretical-anomalous-properties-extreme-conditions.html

Novel time-of-flight-resolved stimulated Raman scattering microscopy enables high-resolution bioimaging

Stimulated Raman scattering (SRS) microscopy is an optical vibrational spectroscopic imaging technique and has emerged as an appealing label-free imaging tool for tissue and cell imaging and characterization with high biochemical specificity.

In a new paper published in *Light: Science & Applications*, a team of scientists, led by Professor Zhiwei Huang from Optical Bioimaging Laboratory in the Department of Biomedical Engineering, College of Design and Engineering, National University of Singapore, Singapore, have developed a novel time-of-flight resolved Bessel light bullet-enabled stimulated Raman scattering (B^2-SRS) microscopy for deeper tissue SRS 3D chemical imaging with high spatial resolution.

The reported technique will have broad applications for label-free deep tissue 3D chemical imaging in biological and biomedical systems and beyond.

https://phys.org/news/2024-07-flight-raman-microscopy-enables-high.html

A shade closer to more efficient organic photovoltaics

Over the last five years, non-fullerene acceptors have produced heterojunction-based devices with record-breaking efficiencies, nearing the 20% mark. However, researchers recently suggested that single-component films of the non-fullerene acceptor Y6 could generate charges without the need for a heterojunction when exposed to sunlight.

Inspired by this finding, the team led by Derya Baran and postdoc Anirudh Sharma investigated charge generation in other non-fullerene acceptors. Similar to Y6, the acceptors, which strongly absorb near-infrared light, produced charges without a donor–acceptor interface. They did so because the exciton split spontaneously, which surprised the researchers. The findings are published in the journal *Advanced Materials*. Solar modules based on semitransparent devices resulted in 5.3% efficiency and 82% visible transmittance, indicating their high degree of transparency.

"We are now investigating next-generation non-fullerene acceptors at a fundamental level to understand their photophysics and how charge transport layers impact the overall performance of homo-junction devices," Sharma says.

https://phys.org/news/2024-04-closer-efficient-photovoltaics.html

Physicists find unexpected crystals of electrons in new ultrathin material

MIT physicists report the unexpected discovery of electrons forming crystalline structures in a material only billionths of a meter thick. The work adds to a gold mine of discoveries originating from the material, which the same team discovered only about three years ago.

In a paper published Jan. 22 in *Nature*, the team describes how electrons in devices made, in part, of the new material can become solid, or form crystals, by changing the voltage applied to the devices when they are kept at a temperature similar to that of outer space. Under the same conditions, they also showed the emergence of two new electronic states that add to work they reported last year showing that electrons can split into fractions of themselves.

The physicists were able to make the discoveries thanks to new custom-made filters for better insulation of the equipment involved in the work. These allowed them to cool their devices to a temperature an order of magnitude colder than they achieved for the earlier results.

The team also observed all of these phenomena using two slightly different "versions" of the new material, one composed of five layers of atomically thin carbon; the other composed of four layers.

https://phys.org/news/2025-02-physicists-unexpected-crystals-electrons-ultrathin.html

New paradigm in photothermal therapy: Researchers develop ultrasound-assisted photothermal therapy technology

Professor Jin-ho Chang's research team from the Department of Electrical Engineering and Computer Science at DGIST has developed "Ultrasound-assisted photothermal therapy (ULTRA-PTT)" technology that significantly enhances the performance of conventional photothermal therapy. The findings of the study were published in *Advanced Optical Materials*.

This technology was developed in collaboration with Senior Researcher Hye-min Kim from the Advanced Photonics Research Institute at GIST using the team's proprietary "ultrasound-induced optical clearing" technology.

Phototherapy, using light, is widely used in clinical settings for skin tightening, laser tattoo removal, and laser cancer therapy, since it can selectively improve or destroy targeted lesions. However, as light travels through biological tissues, optical scattering occurs, causing distortion of the light path and limiting the depth of light penetration.

https://phys.org/news/2024-06-paradigm-photothermal-therapy-ultrasound-technology.html

Experiment uses quantum techniques to stimulate photons, enhancing search for dark matter

Scientists cannot observe dark matter directly, so to "see" it, they look for signals that it has interacted with other matter by creating a visible photon. However, signals from dark matter are incredibly weak. If scientists can make a particle detector more receptive to these signals, they can increase the likelihood of discovery and decrease the time to get there. One way to do this is to stimulate the emission of photons.

Scientists at the U.S. Department of Energy's Fermi National Accelerator Laboratory and University of Chicago reported the ability to enhance the signals from dark matter waves by a factor of 2.78 using novel quantum techniques. This technology demonstrates how advances in quantum information science can be applied, not only to quantum computing applications, but also to new physics discoveries.

This exciting result was made possible by the DOE's Quantum Information Science Enabled Discovery program, and the Heising-Simons Foundation. University of Chicago graduate student Ankur Agrawal conducted this research for his doctoral thesis supervised by Fermilab scientist Aaron Chou in collaboration with members of Professor David Schuster's group at the University of Chicago. The results were recently published in *Physical Review Letters*.

https://phys.org/news/2024-08-quantum-techniques-photons-dark.html

Thank you

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