# SCIENCE FLASH NEWS

No. 8/2025
August

# AI reveals unexpected new physics in dusty plasma

Physicists have used a machine-learning method to identify surprising new twists on the non-reciprocal forces governing a many-body system.

The journal *Proceedings of the National Academy of Sciences* published the findings by experimental and theoretical physicists at Emory University, based on a neural network model and data from laboratory experiments on dusty plasma—ionized gas containing suspended dust particles.

The work is one of the relatively few instances of using AI not as a data processing or predictive tool, but to discover new physical laws governing the natural world.

"We showed that we can use AI to discover new physics," says Justin Burton, an Emory professor of experimental physics and senior co-author of the paper. "Our AI method is not a black box: we understand how and why it works. The framework it provides is also universal. It could potentially be applied to other many-body systems to open new routes to discovery."

The *PNAS* paper provides the most detailed description yet for the physics of a dusty plasma, yielding precise approximations for non-reciprocal forces.

"We can describe these forces with an accuracy of more than 99%," says Ilya Nemenman, an Emory professor of theoretical physics and co-senior author of the paper.

"What's even more interesting is that we show that some common theoretical assumptions about these forces are not quite accurate. We're able to correct these inaccuracies because we can now see what's occurring in such exquisite detail."

https://phys.org/news/2025-08-ai-reveals-unexpected-physics-dusty.html

# Newly derived optical formula shines a light on organic crystal altermagnet candidate

Researchers have uncovered the magnetic properties and underlying mechanisms of a novel magnet using advanced optical techniques. Their study focused on an organic crystal believed to be a promising candidate for an "altermagnet"—a recently proposed third class of magnetic materials. Unlike conventional ferromagnets and antiferromagnets, altermagnets exhibit unique magnetic behavior.

"Unlike typical magnets that attract each other, altermagnets do not exhibit net magnetization, yet they can still influence the polarization of reflected light," points out Satoshi Iguchi, associate professor at Tohoku University's Institute for Materials Research. "This makes them difficult to study using conventional optical techniques."

To overcome this, Iguchi and his colleagues applied a newly derived general formula for light reflection to the organic crystal, successfully clarifying its magnetic properties and origin. The work is published in the journal *Physical Review Research*.

The group also comprised Yuka Ikemoto and Taro Moriwaki from the Japan Synchrotron Radiation Research Institute; Hirotake Itoh from the Department of Physics and Astronomy at Kwansei Gakuin University; Shinichiro Iwai from the Department of Physics at Tohoku University; and Tetsuya Furukawa and Takahiko Sasaki, also from the Institute for Materials Research.

The team's newly derived general formula for light reflection was based on Maxwell's equations and is applicable to a wide range of materials, including those with low crystal symmetry, such as the organic compound studied here.

*https://phys.org/news/2025-08-newly-derived-optical-formula-crystal.html*

# New model explains plutonium's peculiar behavior

Normally, materials expand when heated. Higher temperatures cause atoms to vibrate, bounce around and take up a larger volume. However, for one specific phase of plutonium—called delta-plutonium—the opposite inexplicably occurs: it shrinks above room temperature.

As part of its national security mission, Lawrence Livermore National Laboratory (LLNL) aims to predict the behavior of plutonium in all of its phases. Unraveling the mystery behind delta-plutonium's abnormal behavior at high temperatures is an important piece of the picture.

In a new study, published in *Reports on Progress in Physics*, researchers from LLNL demonstrate a model that can reproduce and explain delta-plutonium's thermal behavior and unusual properties. The model calculates the material's free energy, a quantity that reflects the amount of available or useful energy in a system.

"Free energy fundamentally dictates the state of a material, so it is foundational for understanding it," said LLNL scientist and author Per Söderlind. "An immense amount of effort at LLNL is dedicated to predicting the behavior of plutonium. The confidence in these predictions depends on a deep theoretical understanding of its electronic structure and free energy."

Plutonium's electronic structure is among the most complex of all elemental metals because its electrons are easily influenced by relativity, magnetism and crystal structure. The new free-energy model accounts for magnetic fluctuation effects for the first time.

"Our model is unique and novel because it includes magnetic states that are allowed to fluctuate and depend on temperature," said Söderlind.

Acknowledging those magnetic states in the theory causes it to match the odd experimental observations of contraction at high temperatures.

This methodology could be extended to other materials where dynamic magnetism plays a role, such as iron and its alloys, which are important in geophysics. Going forward, the authors plan to address the impacts of microstructures, defects and imperfections that are present in real-world material.

*https://phys.org/news/2025-08-plutonium-peculiar-behavior.html*

# Bioimaging device with nonmechanical design could improve eye and heart condition detection

If you've been to a routine eye exam at the optometrist's office, chances are you've had to place your chin and forehead up close to a bioimaging device.

It's known as optical coherence tomography (OCT), and it's widely used in eye clinics around the world. OCT uses light waves to take high-resolution, cross-sectional images of the retina in a noninvasive manner. These images can be essential for diagnosing and monitoring eye conditions.

In any bioimaging—either retinal or in-vivo imaging that takes place inside the human body—devices must be quite small and compact to produce high-quality images. However, mechanical aspects of OCT devices, like spinning mirrors, can increase the chance of device failure.

Researchers at the University of Colorado Boulder have developed a new bioimaging device that can operate with significantly lower power and in an entirely nonmechanical way. It could one day improve detecting eye and even heart conditions.

In a recent study published in *Optics Express*, the team of engineers created a device that uses a process called electrowetting to change the surface shape of a liquid to perform optical functions.

https://phys.org/news/2025-08-bioimaging-device-nonmechanical-eye-heart.html

# Novel method upgrades liquid crystals with better recall

Researchers have developed a novel way for liquid crystals to retain information about their movement. Using this method could advance technologies like memory devices and sensors, as well as pave the way to future soft materials that are both smart and flexible.

Liquid crystals, which are used in liquid crystal display (LCD) screens for TVs and phones, contain molecules that mimic the properties of both liquids and solids, giving them unique properties. While soft materials like liquids, gels and polymers have been widely used for their easy-to-process structures and lightweight properties, they tend to deform easily and often require replacement.

Everyday materials are made of molecules that align themselves in preferred directions. But liquid crystals could become much more useful if their molecules are all facing in one direction—obtaining what is called polar order.

That can be difficult to do in soft materials, said Xiaoguang Wang, an assistant professor in chemical and biomolecular engineering at The Ohio State University and co-author of the study published in *Nature Physics*.

"Soft matter can't compete with existing solid-state storage in speed, reliability or miniaturization, so the question becomes how might we control its internal structure to make it competitive or comparable to traditional hard materials," said Wang.

https://phys.org/news/2025-08-method-liquid-crystals-recall.html

# Orbital Hall effect shows how defects can improve spintronic devices

A longstanding challenge in spintronics has been the role of material defects. Introducing imperfections into a material can sometimes make it easier to "write" data into memory bits by reducing the current needed, but this typically comes at a cost: Electrical resistance increases, spin Hall conductivity declines, and overall power consumption goes up. This trade-off has been a major obstacle to developing ultra-low-power spintronic devices.

Now, the Flexible Magnetic-Electronic Materials and Devices Group from the Ningbo Institute of Materials Technology and Engineering (NIMTE) of the Chinese Academy of Sciences have found a way to turn this problem into an advantage. Their study, published in *Nature Materials*, focused on the orbital Hall effect in strontium ruthenate ($SrRuO_3$), a transition metal oxide whose properties can be finely tuned. This quantum phenomenon causes electrons to move in a way determined by their orbital angular momentum.

Using custom-designed devices and precision measurement techniques, the researchers uncovered an unconventional scaling law that achieves a "two birds with one stone" outcome: Defect engineering simultaneously boosts both orbital Hall conductivity and orbital Hall angle, a stark contrast to conventional spin-based systems.

To explain this finding, the team linked it to the Dyakonov-Perel-like orbital relaxation mechanism. "Scattering processes that typically degrade performance actually extend the lifetime of orbital angular momentum, thereby enhancing orbital current," said Dr. Zheng Xuan, a co-first author of the study.

https://phys.org/news/2025-08-orbital-hall-effect-defects-spintronic.html

# A new crystal that 'breathes' oxygen expands possibilities for clean energy and electronics

A team of scientists from Korea and Japan has discovered a new type of crystal that can "breathe"—releasing and absorbing oxygen repeatedly at relatively low temperatures. This unique ability could transform the way we develop clean energy technologies, including fuel cells, energy-saving windows, and smart thermal devices.

The newly developed material is a special kind of metal oxide made of strontium, iron, and cobalt. What makes it extraordinary is that it can release oxygen when heated in a simple gas environment and then take it back in, all without falling apart. This process can be repeated many times, making it ideal for real-world applications.

This study has been led by Professor Hyoungjeen Jeen from the Department of Physics, Pusan National University, Korea, and co-authored by Professor Hiromichi Ohta from the Research Institute for Electronic Science, Hokkaido University, Japan. Their findings were published in the journal *Nature Communications* on August 15, 2025.

"It is like giving the crystal lungs and it can inhale and exhale oxygen on command," says Prof. Jeen. Controlling oxygen in materials is crucial for technologies like solid oxide fuel cells, which produce electricity from hydrogen with minimal emissions. It also plays a role in thermal transistors—devices that can direct heat like electrical switches—and in smart windows that adjust their heat flow depending on the weather.

***https://phys.org/news/2025-08-crystal-oxygen-possibilities-energy-electronics.html***

# Thank you!

Edited by

Adrian-Sorin Gruia, Ph.D