

Physical sciences articles within *Nature Communications*

Featured

Article

24 September 2025 | [Open Access](#)**Unifying frequency metrology across microwave, optical, and free-electron domains**

Frequency metrology lies at the heart of precision measurement. Here, authors establish a phase-coherent frequency link across microwave, optical, and free-electron domains. This bridges electromagnetic waves and electron matter waves, advancing ultrahigh-precision electron spectroscopy.

Yujia Yang, Paolo Cattaneo & Tobias J. Kippenberg



Article

24 September 2025 | [Open Access](#)**Role of the real first interface in regulating ionic signal of nanochannels**

Ion transport in nanochannels is governed by distinct regions, including the 'real first interface' (RFI), whose role in regulating ionic signal remains elusive. Here, the authors design a diblock DNA probe to isolate and reveal the charge-driven contribution of the RFI to ionic current regulation.

Meihua Lin, Jing Zhao & Fan Xia



Article

24 September 2025 | [Open Access](#)**Activation entropy of dislocation glide in body-centered cubic metals from atomistic simulations**

The authors use atomistic calculations with machine-learned interatomic potentials to show that dislocation motion in metals like iron and tungsten involves a nearly constant activation entropy, challenging prior models and improving strength predictions.

Arnaud Allera, Thomas D. Swenburne & David Rodney



Article

24 September 2025 | [Open Access](#)**Kinetic selectivity in metal-organic framework chemical sensors**

This work introduces the kinetic selectivity achievable in nanoporous crystals into the field of chemical sensors, opening the door for selective VOC detection in health, safety, and environmental monitoring.

Aleksander Matyja, Margot F. K. Verbeke & Rob Ameloot



Article

24 September 2025 | [Open Access](#)**Constructing an auto triplet excitons supply system for photogenerated radicals in the solid state**

Organic radical materials have attracted significant attention for their photophysical properties and potential applications. Here, the authors show by manipulating the n- π^* transition and p- π conjugation in a poly(methyl methacrylate) matrix, long-lived excitons and stable radicals can be generated by UV irradiation.

Yujie Yang, Jiaqiang Wang & Zhen Li



Article

24 September 2025 | [Open Access](#)**Specific construction of asymmetric carbon-nickel-chlorine single-atom sites via carbon vacancy engineering for efficient CO₂ electroreduction**

Acidic CO₂ electroreduction enables high CO₂ utilization but suffers from competing hydrogen evolution. Here, the authors present selective CO₂ conversion on asymmetric C₂Ni-Cl single-atom sites, which achieves carbon-efficient CO production in strong acid.

Qi Hao, Qi Tang & Jun Lu



Article

24 September 2025 | [Open Access](#)**Modular synthesis of PAHs from aryl halides and terminal alkynes via photoinduced palladium catalysis**

Polycyclic aromatic hydrocarbons (PAHs), particularly phenanthrene derivatives, are integral to diverse applications owing to their distinctive electronic, optical, and biological properties. Here, the authors develop a visible-light-induced, palladium-catalyzed annulation of aryl halides with terminal alkynes to enable direct access to PAHs under mild conditions.

Chen Zhou, Pei-Shang Li & Ming Chen



Article

24 September 2025 | [Open Access](#)**Giant Spin-flop magnetoresistance in a collinear antiferromagnetic tunnel junction**

The intrinsic robustness to perturbations makes antiferromagnets ideal building blocks for spintronic devices, however, it also manipulation and detection of antiferromagnetic ordering difficult. Here, Xu et al demonstrate an anisotropic tunnelling magnetoresistance in an all-antiferromagnetic tunnel junction.

Shijie Xu, Zhizhong Zhang & Weisheng Zhao



Article

24 September 2025 | [Open Access](#)**An active bifunctional natural dye for stable all-solid-state organic batteries**

Incompatibility between organic electrodes and inorganic solid electrolytes limits the performance of solid-state organic batteries. Here, the authors introduce indigo natural dye as a redox-active material and molecular catalyst, enabling high capacity and long cycle life via synergistic redox reactions with sulfide electrolytes.

Qiang Yu, Yang Hu & Xia Li



Article

24 September 2025 | [Open Access](#)**Multifunctional intercalants create stable subnanochannels in MoS₂ membranes for wastewater treatment**

Designing two-dimensional membranes to achieve tailored channels while ensuring stability remains challenging. Here, the authors use multifunctional intercalants to create stable, selective subnanochannels in MoS₂ membranes, demonstrating their potential in wastewater treatment.

Hao Zhang, Ming Yong & Xiwang Zhang



Article

24 September 2025 | [Open Access](#)**Spectral signature of high-order photon processes enhanced by Cooper-pair pairing**

In superconducting circuits, the nonlinearity of Josephson junctions mediates photon interactions, but they are typically dominated by two-photon processes. Here the authors observe multi-photon interactions in a superconducting circuit with Cooper-pair pairing, revealing a new regime of microwave quantum optics.

W. C. Smith, A. Borgognoni & Z. Leghtas

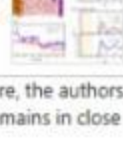


Article

24 September 2025 | [Open Access](#)**Evidence for single variant in altermagnetic RuO₂(101) thin films**

Altermagnetism arises from a combination of crystal symmetry and magnetic ordering. For the altermagnetic properties to be clear, and technologically useful, the same crystal variant must be present over the entire sample. Here, He, Wen and coauthors achieve such single variant thin films in RuO₂, confirming the altermagnetic properties via XMCD and transport measurements.

Cong He, Zhenchao Wen & Seiji Mitani



Article

24 September 2025 | [Open Access](#)**A foundation model for human-AI collaboration in medical literature mining**

Literature mining, such as systematic review and meta-analysis, is crucial for discovering, integrating, and interpreting emerging research. This study presents a specialized large language model for literature that outperforms six general LLMs and helps clinicians in study selection and data extraction tasks.

Zifeng Wang, Lang Cao & Jimeng Sun



Article

24 September 2025 | [Open Access](#)**Route-centric ant-inspired memories enable panoramic route-following in a car-like robot**

Gattaux et al. propose an ant-inspired neural framework for a car-like robot that one-shot learns low-resolution panoramic routes and repeat, shuttle or home. Offering insights into insect navigation and frugal robotic systems.

Gabriel G. Gattaux, Antoine Wyrstach & Franck Ruffier



Article

19 September 2025 | [Open Access](#)**Ferroelectric-based Pockels photonic memory**

Xu et al. report a Pockels photonic memory by integrating ferroelectric field-effect transistor with lithium niobate on insulator micro ring resonator. Through the manipulation of ferroelectric domains and the Pockels effect, the device achieves energy consumption at fJ/bit level.

Zefeng Xu, Chun-Kuai Chen & Aaron Voon-Yew Thean



Article

18 September 2025 | [Open Access](#)**Distinct solvation patterns of OH⁻ versus H₃O⁺ charge defects at electrified gold-water interfaces govern their properties**

H₃O⁺ and OH⁻ mediate electrochemical processes at water/metal electrode interfaces. Here, the authors show that these ions form distinct solvation structures on electrified gold surfaces: OH⁻ remains in close contact with the electrode, while H₃O⁺ resides farther away.

Chanbum Park, Soumya Ghosh & Dominik Marx

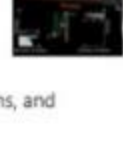


Article

18 September 2025 | [Open Access](#)**Photoinduced non-reciprocal magnetism**

In open nonequilibrium systems, interactions that break the time-reaction symmetry are ubiquitous in nature. While such nonreciprocal interactions have been implemented for quantum systems, they typically require fine microscopic control of dissipation. Here, Hanai, Ootsuki and Tazai propose a dissipation engineering scheme that induces nonreciprocal interactions in solid state materials, giving rise to a persistent many-body chase-and-runaway dynamics in layered ferromagnets.

Ryo Hanai, Daiki Ootsuki & Rina Tazai

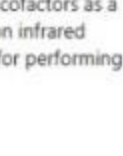


Perspective

18 September 2025 | [Open Access](#)**Risks of AI scientists: prioritizing safeguarding over autonomy**

AI scientists powered by large language models and AI agents present both opportunities and risks in automatic scientific discovery. Here, the authors examine the vulnerabilities of AI scientists, propose a risk taxonomy based on user intent and impact domains, and develop a triadic safeguarding framework emphasizing human regulation, agent alignment, and environmental feedback understanding.

Xiangru Tang, Qiao Jin & Mark Gerstein



Article

18 September 2025 | [Open Access](#)**Bioinspired transfer methylation enabled by a photoactive reagent**

Radical methylation ranks among the most important yet challenging transformations in chemistry and biology, which often involves small and unstable radical intermediates, and results in low reactivity and poor selectivity. Herein, the authors report a bioinspired transfer methylation protocol for the direct and selective C(sp³)-H methylation of heteroarenes.

Ding Zhang, Weiwei Liang & Jianbin Li



Article

18 September 2025 | [Open Access](#)**Hayabusa2 extended mission target asteroid 1998 KY₂₆ is smaller and rotating faster than previously known**

Asteroid 1998 KY₂₆ is the target of Hayabusa2 extended space mission. Here, authors show that it is smaller and rotates faster than known.

T. Santana-Ros, P. Bartczak & K. Vivas



Article

18 September 2025 | [Open Access](#)**Photonic-electronic arbitrary-waveform generation using quadrature multiplexing and active optical-phase stabilization**

The authors propose and demonstrate the concept of photonic-electronic arbitrary-waveform generation, overcoming the bandwidth limitations of all-electronic systems. The idea is to exploit quadrature multiplexing of optical waveforms and opto-electronic conversion by phase-stabilized coherent detection.

Christoph Fullner, Alban Sherif & Christian Kozes

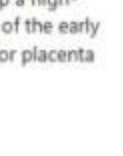


Perspective

17 September 2025 | [Open Access](#)**Magnetic microscopy for operando imaging of battery dynamics**

Quantum sensing of lithium and post-lithium batteries is introduced to visualize how electrons and ions flow and react during operation. Here, authors show how this facilitates operando imaging of heterogeneous redox reactions, buried current distributions, and dendrite formation.

Stefan Pollak, Mohamad Khoshdelam & Dennis V. Christensen



Article

17 September 2025 | [Open Access](#)**Cofactor-independent photo-enzymatic reductions with water mediated by redox-active graphene quantum dots**

Enzymatic reductions catalyzed by reductases generally depend on reduced nicotinamide cofactors as a hydride source. In this work, the authors report a hybrid photo-biocatalyst system based on infrared light, responsive redox-active graphene quantum dots and cross-linked aldo-keto reductase for performing the direct transfer of hydrogen from water to prochloral substrates.

Anning Wang, Xiaoyu Li & Roger A. Sheldon



Article

17 September 2025 | [Open Access](#)**Sensitive pathogen DNA detection by a multi-guide RNA Cas12a assay favoring trans- versus cis-cleavage**

CRISPR-based diagnostics are often limited by complex workflows and poor validation. Here the authors develop and validate a one-pot asymmetric CRISPR assay, which permits rapid and sensitive diagnosis of tuberculosis in a format which is suitable for resource-limited settings.

Zhen Huang, Zhe Song & Tony Hu



Article

15 September 2025 | [Open Access](#)**Directing selective solvent presentations at electrochemical interfaces to enable initially anode-free sodium metal batteries**

Electrolyte design faces challenges of balancing stability at both electrodes. Here, authors present an electrolyte design strategy to direct distinct solvent molecules to negative and positive electrodes respectively, delivering good stability in initially anode-free sodium metal batteries.

Qianli Xing, Jung Min Lee & Fang Liu



Article

15 September 2025 | [Open Access](#)**Operando interlayer expansion of multiscale curved graphene for volumetrically-efficient supercapacitors**

Supercapacitors are high-power energy storage devices that suffer from poor volumetric performance. Here, the authors demonstrate that unusually curved graphene crystallites exhibit rapid ion transport dynamics and enable the fabrication of thin electrodes for compact energy and power delivery.

Petar Jovanović, Meysam Sharifzadeh Mirshakari & Mainak Majumder



Article

12 September 2025 | [Open Access](#)**Asymmetric coordination enhances the photocatalytic H₂ evolution**

Photocatalytic water splitting is hindered by inefficient cooperation between catalytic sites. Here, the authors report that asymmetric Pt coordination enables a strong synergy between single-atom sites and nanoparticles, delivering efficient photocatalytic hydrogen production.

Bo Li, Hongkun Zheng & Qinggu Liu



Article

12 September 2025 | [Open Access](#)**Matrix directs trophoblast differentiation in a bioprinted organoid model of early placental development**

The placenta plays vital roles in supporting fetal development. Here, Richards et al. develop a high-throughput bioprinted trophoblast organoid model to recapitulate the microenvironment of the early placenta, enabling investigation of placenta development and evaluation of therapeutics for placenta dysfunction disorders.

Claire Richards, Hao Chen & Lana McClements

Article

10 September 2025 | [Open Access](#)**Constructing synthetic nuclear architectures via transcriptional condensates in a DNA protonucleus**

Nuclear biomolecular condensates are functional sub-compartments within the cell nucleus. Here, the authors develop a synthetic DNA protonucleus that enables RNA transcription and condensation into diverse nuclear patterns, revealing insights into phase separation in nucleus-mimetic environments.

Miao Xie, Weiliang Chen & Andreas Walther

Article

10 September 2025 | [Open Access](#)**Monatomic glass formation through competing order balance**

In this study, authors use molecular dynamics simulations to explore why Tantalum (Ta) and Zirconium (Zr) have different glass-forming abilities. It is shown that Ta's lower critical cooling rate is due to stronger competing ordering effects and local icosahedral structures, which influence crystallisation pathways.

Yuan-Chao Hu, J. T. Zhai & Hajime Tanaka

Article

10 September 2025 | [Open Access](#)**The maximum T_c of conventional superconductors at ambient pressure**

The authors reveal an inherent trade-off between logarithmic average phonon frequency and the electron-phonon coupling constant in conventional BCS superconductors. The analysis suggests that achieving room-temperature conventional superconductivity at ambient pressure is extremely unlikely.

Kun Gao, Tiago F. T. Cerqueira & Miguel A. L. Marques

Article

09 September 2025 | [Open Access](#)**DelGrad: exact event-based gradients for training delays and weights on spiking neuromorphic hardware**

It has recently been shown that synaptic transmission delays enhance the computational capabilities of spiking neural networks. In this manuscript, the authors introduce an exact, event-based training method for various types of delays and benchmark it on mixed-signal neuromorphic hardware.

Julian Gritz, Jimmy Weber & Mihail A. Petrovici



Article

08 September 2025 | [Open Access](#)**An electrically controlled single-molecule spin switch**

Huang et al. demonstrate an electrically controlled Fe-FeC₆ molecular spin switch that reversibly changes its magnetic state and shifts a nearby spin's resonance, showing potential of scalable, electrically tunable molecular quantum devices.

Wantong Huang, Kwan Ho Au-Yeung & Philip Willke

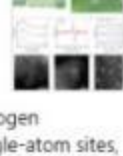


Article

08 September 2025 | [Open Access](#)**On-liquid surface synthesis of diyne-linked two-dimensional polymer crystals**

The synthesis of crystalline 2D polymers typically relies on reversible carbon-carbon coupling reactions, but achieving 2D polymers through irreversible carbon-carbon coupling reactions remains a formidable challenge. Here, the authors present an on-liquid surface synthesis method for constructing diyne-linked 2D polymers.

Ye Yang, Yufeng Wu & Xinliang Feng



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