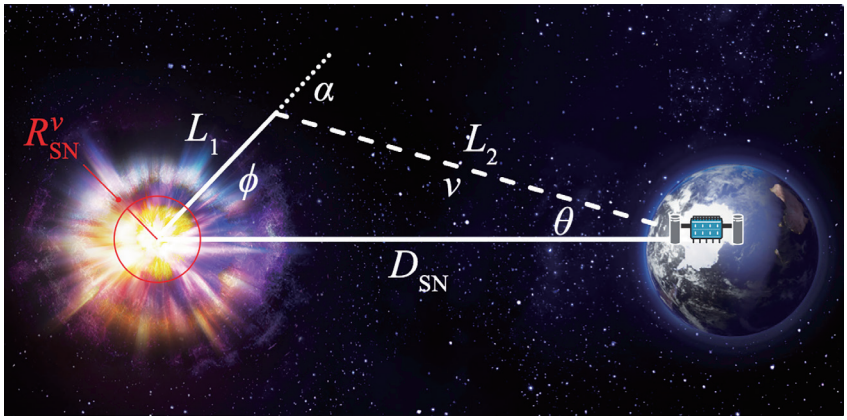
Neutrino Telescopes Provide a New Probe on New Physics beyond Standard Model

Scientists have been searching for possible new particles beyond the standard model (SM), the theory that has predicted the building bricks that have constituted the known matter world today, including the Higgs — "the last" SM particle. Neutrino telescopes might help accelerate this search, as reported by an international team in the *Physical Review Letters* on June 4 (DOI: 10.1103/PhysRevLett.134.221002).

Prof. LI Yingying from the Institute of High Energy Physics (IHEP), Chinese Academy of Sciences and her cooperators from Harvard University and Oklahoma State University of the USA and *Université catholique de Louvain* of Belgium revealed that neutrino telescopes like IceCube can be used to explore new weakly coupled states emitted from supernovae and subsequently decaying to neutrinos. Neutrino telescopes can track the decay profiles of such potential new particles at a high temporal resolution (up to around 0.01 second), and tell the time difference in their trajectory relative to what SM predicted — delayed or ahead of SM schedule. Therefore, "strange" decay profiles can be identified as new physics signals from "suspicious" particles.



Supernovae might be a source of new particles beyond the standard model (SM). Based on observational data from IceCube, Prof. LI Yingying and her cooperators reconstructed the decay geometry for the Majoron, a candidate of such new particles produced in a supernova. Both the additional distance traveled relative to the direct line of sight and the potential nonrelativistic speed of the Majoron, said the authors, indicate a delay relative to SM schedule. (Credit: IHEP)

Based on publicly available observational datasets produced by IceCube, the team simulated the detector responses and parametrized neutrino fluxes originating from SM and new physics, respectively, and unraveled two scenarios beyond SM. In the end, they demonstrated that neutrino telescopes like IceCube can capture new physics signals from particles of energies between sub-MeV and GeV, and shared with the physics community the codes they had developed to help further testing the diverse range of new physics models.

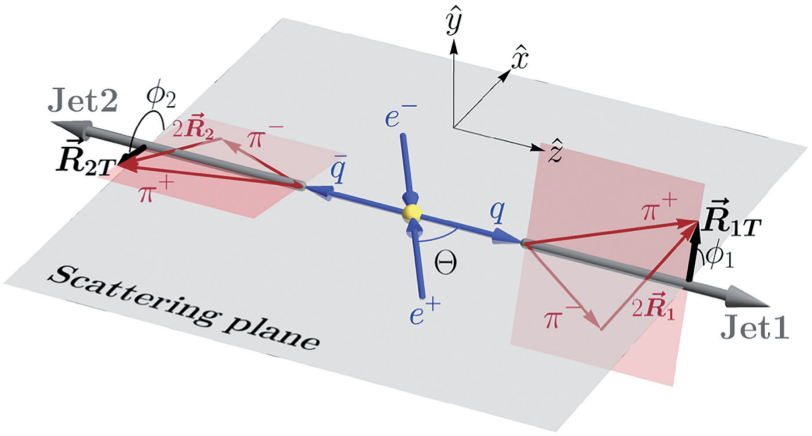
Bell Inequality Violation of Light Quarks Found in Lepton Collider Belle

A team of researchers led by Dr. YAN Bin from the Institute of High Energy Physics (IHEP), Chinese Academy of Sciences (CAS) recently revealed quantum entanglement between light quarks in the lepton collider Belle, demonstrating a violation of the Bell Inequality, and reported their discovery on July 2 in *Physical the Review Letters* (DOI: 10.1103/gmqz-v4cl). Inspiringly, the team verified quantum nonlocality at a significance of 6.2 σ via analysis of the scattering of dihadron

pairs, offering a new perspective to investigate this fundamental principle of quantum mechanics.

In the quantum world, two entangled particles can influence each other without delay even across a long distance — this "spooky action" even puzzled Albert Einstein. This mysterious action has been verified in simple systems like photon and atomic pairs, yet scarcely tested in the high-energy physics field, where quarks cannot be observed directly but are rapidly transformed into hadrons through the strong interaction.

Dr. YAN's team adopted an innovative strategy to capture the "fingerprint" of the entangled quarks. They chose to explore the Bell Inequality in massless quark pairs by analyzing the azimuthal correlations in $\pi^+\pi^-$ dihadron pair production at lepton colliders.

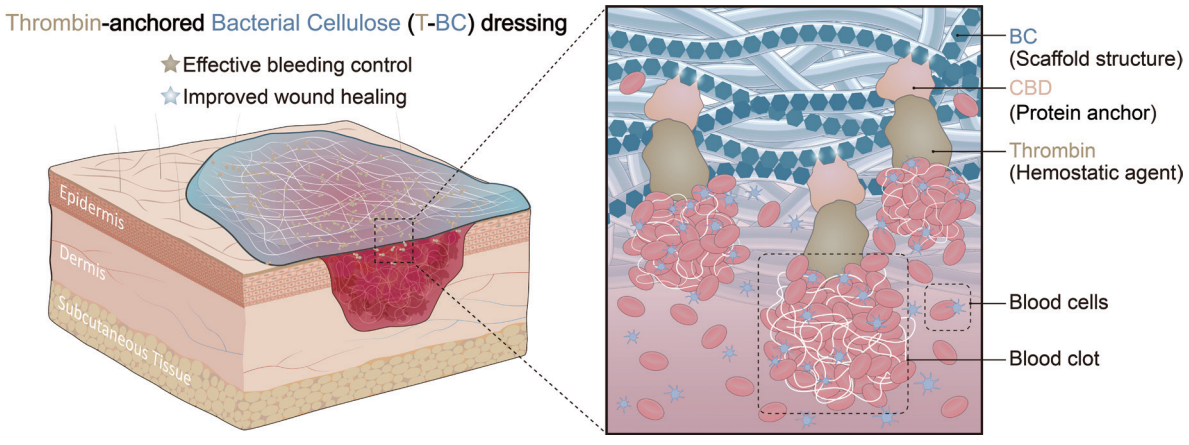


Leading-order kinematic configuration of $\pi^+\pi^-$ dihadron pair production at lepton colliders. (Credit: IHEP)

Based on data from the Belle experiment, they introduced an additional angular cut, and revealed the Bell Inequality violation in light quarks. Their analysis demonstrated that the quarks produced in the collider maintain an entangled state, violating the Bell Inequality at a significance substantially exceeding *5 σ* when considering uncorrelated systematic uncertainties. This marks the first non-decay detection of such quantum entanglement in a system dominated by strong interaction, and might open avenues for exploring the connection between particle physics and quantum informatics.

Stopping Bleeding with Bacterial Fibers

Burns often require surgical removal of damaged tissues — a procedure that causes significant bleeding. While traditional methods such as electrocautery can control bleeding, they carry a risk of thermal damage to surrounding tissues and have operational limitations. Bacterial cellulose — a natural material with a porous structure and excellent biocompatibility — has shown promise as a wound dressing, but it lacks the ability to stop bleeding on its own. Researchers from the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences and Ruijin Hospital



The application of thrombin-anchored bacterial cellulose dressing in wound therapy. (Image by SIAT)

Affiliated to Shanghai Jiao Tong University School of Medicine have now developed a bacterial cellulose dressing that combines the material's natural advantages with powerful clotting ability.

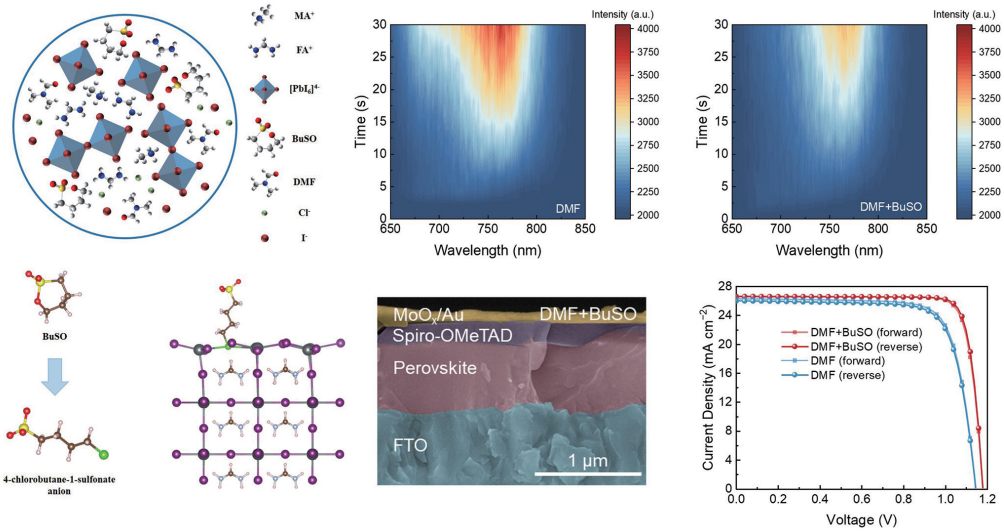
The team attached human-derived thrombin — a key protein in blood clotting — directly onto the bacterial cellulose fibers via a specialized cellulose-binding domain. This creates a composite dressing that stops bleeding within one minute in rat liver incision tests, far outperforming conventional materials. In simulated deep burn wounds, the dressing markedly accelerated healing, achieving wound closure rates 40% higher than control groups after just five days. The dressing works through three mechanisms — promoting new blood vessel formation, controlling inflammation, and rebuilding skin structure. Unlike traditional chemical methods requiring harsh conditions, the thrombin attaches through simple immersion in a mild protein solution. Safety assessments confirmed the material causes no harmful effects to cells, blood, or tissues. This innovation could improve treatment for both acute injuries and chronic wounds. The study was published in *Advanced Materials* on July 22 (doi: 10.1002/adma.202420338).

Solvent Switch Sharpens Solar Cells

Perovskite solar cells are seen as strong competitors to silicon, but defects in solution-processed films limit both efficiency and stability. A team led by Dr. MENG Lei and Dr. LI Yongfang at the Institute of Chemistry of the Chinese Academy of Sciences (ICCAS), has now shown how a simple solvent additive can overcome these obstacles. Their study appeared in *Nature Photonics* on June 16, 2025 (doi: 10.1038/s41566-025-01704-2).

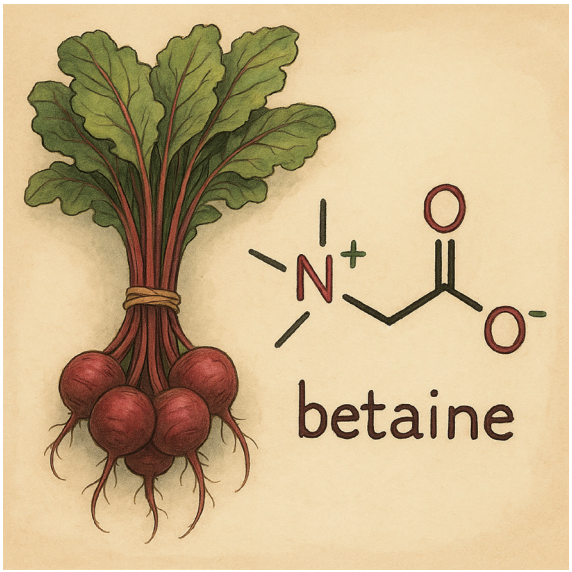
The researchers introduced 1,4-butane sultone (BuSO) into the perovskite precursor. This slowed down nucleation — thanks to a Lewis acid–base interaction — and produced uniform films with large grains and no pinholes. During annealing, BuSO underwent a ring-opening reaction, and the resulting products acted as passivators for the bulk and surface defects. Defects normally act like traps that capture electric charges before they can do useful work, lowering power and stability. Passivation heals these flaws, letting charges flow freely, and hence boosting efficiency and helping devices last longer. With this combined effect, the team achieved a power conversion efficiency of 26.5% and enhanced long-term stability.

By coupling crystallization control with defect passivation in a single solvent engineering step, this work highlights the critical role of solvents in advancing next-generation perovskite photovoltaics. "Our study highlights the critical role of the solvent in fabrication of perovskite films and provides a new pathway for developing high-performance perovskite solar cell devices," said Dr. MENG.



Precise control of crystallization process for perovskite films via solvent engineering. (Graphic: ICCAS)

The "Exercise Pill" Edges Closer, But Don't Cancel Your Gym Membership Yet



Betaine — a natural compound in common foods and a kidney-derived metabolite — not only replicates the anti-inflammatory and anti-aging effects of sustained physical exercise but also demonstrates rejuvenation potential in aged mice. (Graphic: AI generated)

The long-held dream of an "exercise-in-a-pill" has moved a step closer to reality. A new study led by researchers from the Institute of Zoology (IOZ) of the Chinese Academy of Sciences, along with their collaborators, has identified a natural compound that mimics the profound anti-aging benefits of sustained physical activity, offering hope for those who cannot exercise regularly.

Published in the journal *Cell* on June 25 (doi: 10.1016/j.cell.2025.06.001), the study pinpoints betaine, a metabolite produced by the kidneys during long-term training, as the key molecule behind these effects. Scientists discovered that unlike the stress of a single workout, a consistent exercise routine reprograms the body's metabolism and immunity, driven by a significant increase in betaine production.

To validate this, the team administered betaine to aged mice, observing remarkable functional improvements in their metabolism, cognition, and motor skills. The mechanism was traced to betaine's ability to directly bind to and inhibit TBK1, a key protein that regulates the body's inflammatory response, a major driver of aging.

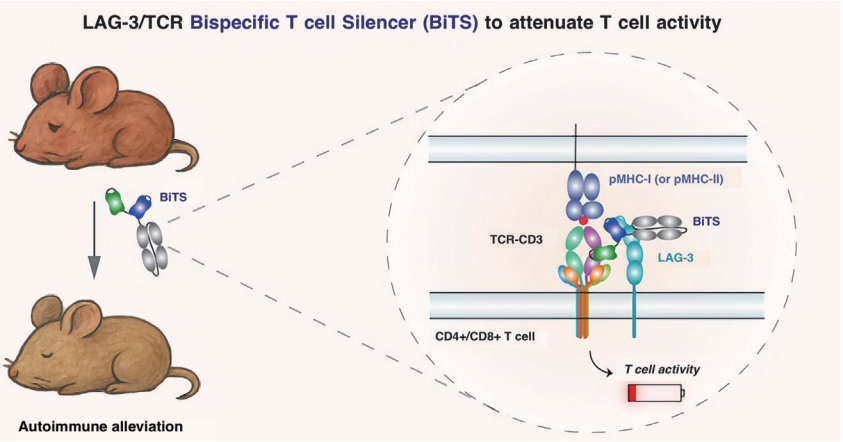
While these findings are promising, researchers emphasize that these are preliminary results from animal studies; large-scale clinical trials in humans are needed for verification. The discovery positions betaine as a potential therapeutic supplement, particularly for seniors or individuals with limited mobility. However, it is not a replacement for physical activity. For most people, engaging in actual exercise remains the best and most proven choice for maintaining health and longevity — So, don't cancel your gym membership yet.

Bispecific Antibody Tames Rogue T-Cells

The immune receptor LAG-3 is a key regulator of T cell function, but exactly how it applies the brakes on immune responses has long been a puzzle. Now, in a study published in *Cell* on June 30 (doi: 10.1016/j.cell.2025.06.004), researchers from the Institute of Biophysics of the Chinese Academy of Sciences, New York University, and Zhejiang University have discovered that its inhibitory power comes not from simple ligand binding but from its physical closeness to the T cell receptor (TCR) complex — a finding that introduces a novel strategy for designing precision immunotherapies.

This study reveals a "*cis*-proximity-dependent" mechanism — LAG-3 must be brought near the TCR by its classical ligand, MHC-II, to effectively suppress $CD4^+$ T cell activity. This discovery challenges the traditional understanding of how immune checkpoints are activated and helps explain why some LAG-3-targeting cancer therapies have had limited success.

Inspired by this insight, the researchers engineered a bispecific T cell silencer (BiTS) antibody that simultaneously targets both LAG-3 and the TCR. By forcing this proximity, the antibody selectively silences the rogue T cells that drive autoimmune disorders. This approach showed significant therapeutic effects in multiple animal models of autoimmune disease.

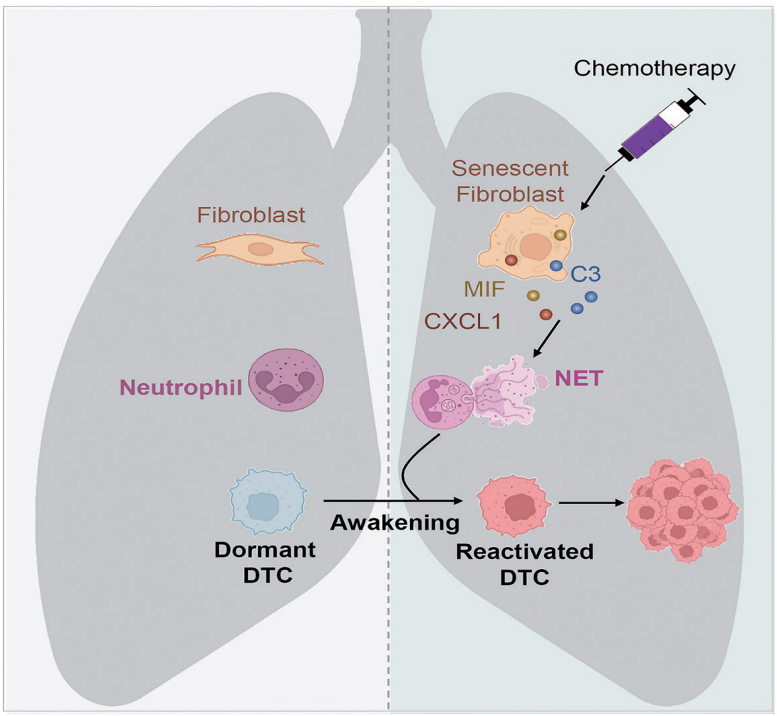


Enhancing the *cis*-proximity between LAG-3 and TCR through a LAG-3/TCR bispecific antibody (BiTS) facilitates the treatment of autoimmune diseases. (Adapted from Dr. LOU Jizhong's group)

Chemo's Hidden Hazard: Awakening Sleeping Cancer

Cancer relapse often originates from dormant tumor cells lurking in distant organs — untouched by chemotherapy. Despite predictions that dormant disseminated tumor cells (DTCs) might awaken to cause relapse after a clinically silent period, direct evidence and chemotherapy's precise role remained unknown. To solve this mystery, researchers led by Dr. HU Guohong from the Shanghai Institute of Nutrition and Health (SINH) of the Chinese Academy of Sciences developed *DormTracer*, a lineage tracing tool capturing how dormant disseminated tumor cells (DTCs) awaken. By using this system, they for the first time directly observed the awakening of DTCs after persistent dormancy and investigated the effect of chemotherapeutic drugs during the process.

Chemotherapy awakens dormant disseminated tumor cells in lung. DTC: disseminated tumor cells. (Graphic: Dr. HU Guohong's group)



Published in *Cancer Cell* (July 3; doi: 10.1016/j.ccell.2025.06.007), the study reveals that chemotherapy could drive DTCs out of dormancy by inducing senescent fibroblasts and neutrophil extracellular trap formation — triggering lung metastasis. Crucially, combining standard chemotherapy with senolytic drugs (Dasatinib and Quercetin) achieved therapeutic control of both primary tumors and lung relapse. This dual approach, now advancing to human trials, uncovers a strategy to neutralize chemotherapy's unintended pro-metastatic effects.

Robots Take Over Crop Breeding

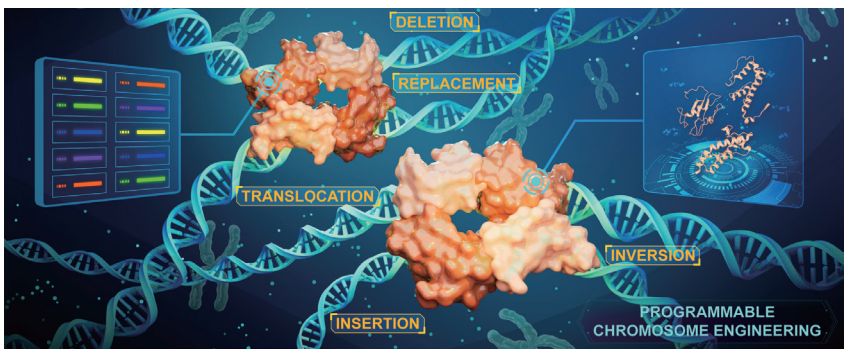
Traditional hybrid crop breeding faces inefficiencies due to labor-intensive manual pollination — especially for crops like tomatoes and soybeans with complex flowers. Researchers at the Institute of Genetics and Developmental Biology (IGDB), Chinese Academy of Sciences, have developed GEAIR (Genome Editing with Artificial-Intelligence-based Robots), an AI-robotic system that pollinates gene-edited plants 24/7. By using CRISPR to alter floral structures (e.g., creating male-sterile tomatoes with exposed stigmas), the system enables robots to perform cross-pollination, pollen collection, and plant selection. This slashes labor costs — formerly 25% of tomato breeding expenses — and accelerates hybrid development.

Robotic breeder GEAIR is working in a greenhouse. (Graphic: IGDB)

Notably, GEAIR uses deep-learning vision and a precision arm to deposit pollen around the clock; paired with speed-breeding and de-novo domestication, the approach produced new tomato lines with improved flavor and stress tolerance. This was successfully replicated in soybean, showing broad applicability. The related study was published in *Cell* (August 11; doi: 10.1016/j.cell.2025.07.028), heralding a scalable way to make hybrid breeding faster, cheaper and more sustainable.

Genome Editing at Megabase Scale

Precise chromosome engineering has traditionally relied on the Cre-Lox recombination system — an approach in which the enzyme Cre functions like molecular scissors, cutting and rejoining DNA at specific "Lox" sites to add, remove, or flip genomic DNA segments inside living cells. Yet this approach is mainly hampered by reversible reactions, the tetrameric nature of Cre recombinase that complicates engineering and hinders activity optimization, and residual Lox sites that compromise precision. Now, researchers led by Dr. GAO Caixia at the Institute of Genetics and Developmental Biology (IGDB), Chinese Academy of Sciences, have developed two programmable genome editing platforms that overcome these hurdles. The study was published online in *Cell* on August 4, 2025 (doi: 10.1016/j.cell.2025.07.011).



New genome editing tools allow scientists to insert, flip, delete, and rearrange large DNA segments with high precision. (Image by IGDB)

The team redesigned recombination sites to prevent unwanted reversals, engineered a more efficient version (with a recombination efficiency 3.5 times that of wild-type Cre) of Cre recombinase using AI-guided protein evolution, and devised a scarless editing strategy to remove residual DNA footprints. Together, these innovations yielded the PCE and RePCE systems — tools that allow targeted integration, deletion, inversion, and translocation of DNA fragments from kilobase to megabase scale in both plant and animal cells.

As a proof of concept, the researchers used this technology to generate herbicide-resistant rice carrying a 315-kilobase chromosomal inversion. With its ability to precisely manipulate large DNA regions without leaving scars, this technology opens new paths for genetic engineering and crop improvement.