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2025 International Congress of Basic Science opens in Beijing

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Cover Story

2025 International Congress of Basic Science opens in Beijing

Opening ceremony of ICBS 2025

On July 13, the 2025 International Congress of Basic Science (ICBS 2025) opened at the China National Convention Center in Beijing. Themed "Advancing Science for Humanity," the event was co-hosted by China's Ministry of Science and Technology, the China Association for Science and Technology (CAST), and the International Consortium of Chinese Mathematicians (ICCM), and other organizations. The congress brought together an impressive roster of attendees, including winners of the Shaw Prize, the Wolf Prize, and the Dirac Medal; more than 80 academy members from around the world; over 10 presidents and representatives of mathematics societies; and nearly 1,000 experts, scholars, and young researchers from global universities, research institutions, and academic organizations.

At the opening ceremony, the 2025 Basic Science Lifetime Achievement Award was presented to scientists who have made groundbreaking and lasting contributions to mathematics, physics, and information science and engineering, and have played a pivotal role in shaping these fields.

This year's honorees included six distinguished scholars: Samuel Chao Chung Ting, Nobel Laureate in Physics and professor at MIT; Steven Chu, Nobel Laureate in Physics and professor at Stanford University; David Jonathan Gross, Nobel Laureate in Physics; Robert Endre Tarjan, Turing Award winner; Shigefumi Mori, Fields Medalist; and George Lusztig, Wolf Prize recipient.

The ceremony also featured the presentation of the Frontiers of Science Award, which recognized 118 outstanding papers in three core areas: mathematics (75 papers), theoretical physics (16 papers), and theoretical computer and information sciences (27

papers). The recipients came from more than 20 countries and regions, representing a wide range of universities, research institutions, and companies. Awardees included Fields Medalists, Breakthrough Prize in Fundamental Physics winners, and rising talent. Researchers from 13 Chinese institutions—among them Tsinghua University, The Chinese University of Hong Kong, Fudan University, and the Chinese Academy of Sciences—collectively received 17 awards. Their work spans mathematics, theoretical physics, computational mathematics, artificial intelligence and machine learning, and interdisciplinary applications. Global AI leaders OpenAI and Meta's FAIR (Facebook Artificial Intelligence Research) were also recognized for their cutting-edge contributions.

(Source: Official WeChat account of the China Center for International Science and Technology Exchange)

Event Highlights

Physics Night explores breakthroughs and challenges in fundamental science

Panel discussion during the Physics Night

On July 14, the ICBS 2025 Physics Night was held at the Beijing Institute of Mathematical Sciences and Applications. Nearly 700 scientists and top graduate students from institutions such as the Chinese Academy of Sciences, the University of Hong Kong, Stanford University, and the California Institute of Technology (Caltech), along with other ICBS participants, gathered for an evening of thought-provoking discussion and exchange.

During the keynote session, Steven Chu, Nobel Laureate in Physics, 2025 Basic Science Lifetime Achievement Award recipient, and professor at Stanford University, shared his reflections on how

research institutions sustain long-term excellence. He emphasized that breakthroughs often emerge from fearless experimentation, and that genuine innovation demands curiosity, a willingness to take risks, and the courage to challenge established norms.

Hirosi Ooguri, professor at Caltech and a fellow of the American Academy of Arts and Sciences, addressed the ongoing challenges in string theory, which seeks to unify general relativity and quantum mechanics. He noted that progress in the field has been slow over the past 40 years due to its complexity—estimated to be more than 25 times greater than that of the Standard Model of particle physics. Comparing quantum gravity to the "final boss," Ooguri underscored that basic science is a "value-rational action" aimed at understanding the truths of nature.

In the panel discussion that followed, experts explored the theme "The Importance of Fundamental Science."

Samuel Chao Chung Ting, Nobel Laureate in Physics, Basic Science Lifetime Award recipient, and professor at MIT, highlighted that the driving force behind basic research is human curiosity and the desire to uncover the universe's underlying principles. The discoveries in fundamental science are the engine behind technological progress and social improvement.

Wang Yifang, Director of the Institute of High Energy Physics (IHEP) at the Chinese Academy of Sciences and recipient of the Breakthrough Prize in Fundamental Physics, spoke about the challenges facing basic research today, including funding constraints and obstacles to collaboration. He called on the scientific community to enhance its ability to communicate, helping the public understand the logic of scientific inquiry.

Zhang Xiang, President and Vice-Chancellor of the University of Hong Kong and a member of the U.S. National Academy of Engineering, urged deeper academic exchange and collaboration in today's complex international environment. He also encouraged scientists to embrace emerging technologies such as artificial intelligence to boost productivity.

(Source: Official website of IHEP)

Fields medalists discuss future of mathematics in the age of AI at Mathematics Night

On July 16, the ICBS 2025 Mathematics Night, hosted by the Shanghai Institute for Mathematics and Interdisciplinary Sciences (SIMIS), was held at

the Beijing Institute of Mathematical Sciences and Applications. The event brought together five Fields Medalists and attracted nearly 600 mathematicians, scholars, and science enthusiasts from around the globe for an evening that blended academic dialogue with creative exploration.

Panel discussion during the Mathematics Night

During the panel discussion, seven distinguished mathematicians shared their insights on the convergence of mathematical fields and the evolving role of mathematics in the era of artificial intelligence.

Maryna Viazovska, Fields Medalist and professor at EPFL (École Polytechnique Fédérale de Lausanne), described machine learning as an emerging "topic" in mathematics. She urged fellow mathematicians to engage with and explore these seemingly unfamiliar domains.

Andrei Okounkov, Fields Medalist, emphasized the importance of staying true to one's own natural thinking process when conducting mathematical research. He encouraged scholars to find a sustainable rhythm and personal strategy to maintain long-term passion and motivation.

Shigefumi Mori, Fields Medalist and professor at Kyoto University, noted that scientific progress is rarely linear. He compared mathematical research to a spiraling journey, fueled by curiosity, challenged by setbacks, and ultimately progressing through reflection, either along the same path or toward new directions.

George Lusztig, Wolf Prize Laureate and professor at MIT, expressed his preference for the aesthetic beauty of mathematics over its practical applications. He noted how closely connected various branches of mathematics are, and how researchers often shift fields entirely, such as topologists moving into representation theory, driven by these underlying links.

(Source: Official WeChat account of ICBS)

Tsinghua University Special Event inspires future scientists

Panel discussions at the Mathematics Forum and the Physics Forum

On July 19, as part of the ICBS 2025 Tsinghua University Special Event, the Mathematics Forum and the Physics Forum were held at Tsinghua University Auditorium. Organized by Tsinghua's Yau Mathematical Sciences Center, the event brought together leading scientists from China and around the world to share their research journeys and inspire the next generation of researchers.

At the Physics Forum, scholars held thought-provoking discussions on topics such as string theory, the unification of fundamental forces, and breakthroughs in astronomical observation.

Mirjam Cvetic, Chair Professor at the University of Pennsylvania and a fellow of the American Academy of Arts and Sciences, emphasized that string theory remains a leading candidate for unifying all fundamental forces. Her team is exploring links between string theory, particle physics, quantum mechanics, and black hole phenomena, offering fresh perspectives in theoretical physics.

In the field of astronomy, Li Di, Marcel Grossman Award recipient, Chair Professor at Tsinghua University, and Chair of the Department of Astronomy, shared recent advances in the study of fast radio bursts (FRBs). These millisec-

ond-long explosions, he noted, release as much energy as humanity would consume in a trillion years, yet their origins are still unknown. He highlighted that even a modest 20% improvement in observational precision could lead to significant breakthroughs.

At the Mathematics Forum, leading mathematicians discussed the significance of mathematics and offered guidance to aspiring young researchers.

Hugh Woodin, professor at Harvard University and a member of both the U.S. National Academy of Sciences and the American Academy of Arts and Sciences, reflected on his work in set theory. He explained that mathematics is not only about formal proofs; many truths in set theory are undecidable, and the search for such truths continues to push the boundaries of mathematical logic.

Kenji Fukaya, a member of the Japan Academy, Shaw Prize Laureate in Mathematical Sciences, and professor at Tsinghua University, emphasized that as human civilization becomes increasingly complex, there is a growing need for systematic, scientific approaches to problem-solving. Mathematics, he stated, is an essential tool that equips us to meet this challenge.

(Source: Official WeChat account of ICBS)

Scientists Face to Face explores learning and growth in the age of AI

Q&A at the "Scientists Face to Face" special event

On July 21, the ICBS 2025 "Scientists Face to Face" special event for high school students was held at the Beijing Institute of Mathematical Sciences and Applications. Nearly 200 student representatives from across China engaged with leading scholars through popular science talks and discussed how artificial intelligence is transforming the ways we learn for the future.

During the interactive Q&A session, the moderator

selected the top three questions submitted by students, prompting thoughtful responses from the invited experts.

Question 1: In the age of AI, which human abilities will decline in value, and which will become more essential?

Fang Yi, President and General Manager of Merit Interactive Co., Ltd., explained that disciplines such as physics and mathematics—those that deal with deeper-level understanding—along with humanities subjects like philosophy and history, will grow in importance. As AI takes over repetitive tasks, the ability to effectively work with AI will become a defining skill.

Question 2: If we want to work in AI, what should we start preparing for now?

Wu Fei, Dean of the Undergraduate School at Zhejiang University, emphasized that success in AI requires a blend of critical thinking, abstract reasoning, interdisciplinary knowledge, and a strong grounding in basic science. In the era of "big science," we can no longer afford to take the discipline-siloed approaches of the industrial age.

Question 3: Do students need advanced math skills to study AI? Can someone who isn't strong in math still pursue it?

Raymond Honfu Chan, Vice-President (Academics) cum Provost at Lingnan University, addressed students' concerns by noting that AI is ultimately driven by applications. A solid grasp of essential math concepts is thus needed to understand where and how to begin.

(Source: Official WeChat account of ICBS)

Insight Exchange

Information of Science Engineering Night highlights convergence of basic science and information engineering

On July 15, the ICBS 2025 Information of Science Engineering Night spotlighted the deepening intersection between fundamental science and cutting-edge technology. The event brought together some of the world's foremost scientists and leading figures from industry for in-depth discussions, emphasizing how basic science continues to drive progress in key engineering domains such as aerospace, biology, and artificial intelligence.

Rethinking algorithms: Reflections and future pathways

Robert Endre Tarjan delivering a keynote speech

Robert Endre Tarjan, recipient of the Basic Science Lifetime Award, Turing Award Laureate, a member of the U.S. National Academy of Sciences, and professor at Princeton University, delivered a keynote address titled "Thoughts on Algorithm Research." Drawing on five decades of experience in the field, Tarjan reflected on the evolution of algorithm design and shared insights into future directions.

Using computational fluid dynamics in aerodynamics as an example, Tarjan underscored the essential role algorithms play in engineering science. Transitioning from traditional wind tunnel experiments to numerical simulations, he explained, involves discretizing the Navier-Stokes equations that govern fluid motion—resulting in complex graph structures. Efficient computation on these graphs depends on algorithmic strategies such as graph partitioning, localized processing, and optimized substructure organization. As a notable example of theory translated into practice, Tarjan highlighted the Planar Separator Theorem, developed with Dick Lipton, which has become a foundational tool in computational modeling.

Tarjan also noted that while many efficient algorithms have been developed, early computer science often settled for the first "acceptable" solution. With advances in computational resources and the widespread adoption of multicore architectures, algorithm research today must broaden its design horizons and push beyond conventional approaches.

He emphasized that theoretical research should remain grounded in practical relevance. Though much of his own work is theoretical, Tarjan has consistently paid close attention to real-world algorithm performance. He defended worst-case runtime analysis for its universality and analytical clarity, even if it overlooks constant factors, and

advocated for simplicity in algorithm design whenever possible.

Closing his talk, Tarjan addressed the philosophical question "what is computer science?" He argued that it is a hybrid discipline—part science, part mathematics, part engineering—that defies any single definition. For him, programming is both an art and a form of scientific practice rooted in logic and empirical validation.

Exploring physics behind molecular motors

Steven Chu delivering a keynote speech

Steven Chu, Nobel Laureate in Physics, recipient of the Basic Science Lifetime Award, a member of the U.S. National Academy of Sciences, and professor at Stanford University, delivered a keynote speech titled "How Does Biology Work in a World Dominated by Brownian Motion and Dissipation?" His presentation examined how biological molecules perform highly precise functions in a microscopic environment governed by randomness and energy dissipation, offering insights from the perspective of statistical physics.

Guided by the fundamental question "Can life be reduced to physical laws?", Chu focused on the motor protein dynein and its transport mechanisms within neurons. Drawing on experimental data and mathematical modeling, he explored dynein's behavior through the lens of non-equilibrium statistical mechanics.

Chu explained that at the molecular scale, the equation "F=ma" in classical Newtonian mechanics no longer applies. Instead, motion is dominated by viscous drag and Brownian fluctuations. In such conditions, how do molecular motors maintain directional movement? To investigate this, his team developed a high-resolution optical tracking system based on infrared-excited nanoparticles. This system enables the real-time observation of dynein transporting vesicles along axons, without damaging live cells. The results revealed that

dynein does not move in a rigid, mechanical stepwise manner; rather, it relies on a flexible structure that enables Brownian-like searching, resulting in a statistically fluctuating force-generation process.

Chu also introduced a new dual-ATP model that challenges the prevailing assumption that dynein consumes only a single ATP molecule per cycle. He noted that publishing this model required years of experimental validation and rigorous peer review. The dual-ATP mechanism not only accounts for the experimentally observed quadratic relationship between time and step length, but also presents a testable hypothesis regarding the existence of a power stroke in dynein's movement.

(Source: Official WeChat account of ICBS)

2025 Basic Science and Artificial Intelligence Forum spotlights cross-disciplinary innovation and breakthroughs

Panel discussion at the 2025 Basic Science and Artificial Intelligence Forum

On July 20, the 2025 Basic Science and Artificial Intelligence Forum, hosted by Qiuzhen College of Tsinghua University, took place at the Zhongguancun Exhibition Center in Beijing. The event brought leading scholars from China and around the world together to exchange insights on cutting-edge topics such as generative models, energy-efficient computing, and optical computing chips, underscoring the vast potential at the intersection of basic science and artificial intelligence.

During the panel discussion, participants delved into topics ranging from causality and originality to computational limitations and next-generation architectures, offering a forward-looking perspective on the future frontiers of AI and challenges that remain to be addressed.

Correlation ≠ Causation: Addressing AI's scientific bottlenecks

When asked about the limitations and bottlenecks in AI development, Xianfeng David Gu, professor of computer science at Stony Brook Universi-

ty, highlighted current AI systems' reliance on correlation-based modeling and lack of a deep understanding of causality, an essential requirement for success in scientific modeling and mathematical problem-solving. True scientific modeling, Gu emphasized, demands a logically coherent causal framework built on minimal assumptions, rather than simple pattern recognition based on large datasets.

Liu Tie-Yan, President of Zhongguancun Academy, added that while large language models are grounded in statistical learning, they have begun to exhibit emergent causal reasoning at higher semantic levels. In tasks such as logical inference, mathematics, and argumentation, these models increasingly demonstrate structured reasoning patterns, often mirroring "because… therefore…" logic. Liu proposed adopting a more open-minded perspective toward how AI systems express causality and suggested evaluating their limits through the lens of "semantic causality."

Beyond token prediction: Does AI need a world model?

Another key topic focused on whether next-token prediction can truly support the development of artificial general intelligence (AGI). Sun Maosong, Executive Deputy Director of the Institute for Artificial Intelligence at Tsinghua University, pointed out that while text is inherently one-dimensional, images are two-dimensional, and videos add a third dimension—time. The real world, he argued, operates in four dimensions. As AI's cognitive targets grow more complex, Sun questioned whether it may be time to move beyond token prediction toward more advanced world models.

Wang Yu, Dean of Tsinghua University's Department of Electronic Engineering, offered a more optimistic view. He argued that language, as a human cognitive system, is capable of expressing even complex visual and physical concepts through two-dimensional symbolic sequences. He introduced the idea of "describability": if something can be accurately described in language, then token-based AI models could theoretically learn it; if not, neither humans nor machines can currently represent it effectively.

Liu Tie-Yan agreed that next-token prediction remains a powerful paradigm for language comprehension and generation, with generalization capacities far beyond earlier task-specific systems. However, he acknowledged that this approach has its boundaries. For non-language-based tasks, such as solving partial differential equations, model-

ing quantum systems, or optimizing industrial processes, entirely new learning goals and system architectures will be necessary.

(Source: Official WeChat account of ICBS)

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