2023—2024 年报 Bi-annual Report

北京大学物理学院
SCHOOL OF PHYSICS, PEKING UNIVERSITY

年报

BI-ANNUAL REPORT

2023 / 2024

院长寄语
MESSAGE FROM THE DEAN

北大物理始建于 1913 年，是中国物理高等教育的开创者。自诞生以来，我们始终保持教学与科研并重，在追求学术卓越的同时，坚定科学报国的信念，为国家的科技进步作出卓越贡献。

我们始终将立德树人作为根本任务。通过实施一系列战略性的拔尖人才培养项目，致力于培养出一批基础扎实、视野开阔、创新能力突出的卓越人才，为引领世界科技前沿发展提供坚实支撑 。

学院目前汇聚了一批世界顶尖学者与战略科学家，形成了高水平的学术梯队。我们坚持以问题为导向，系统推进基础研究与前沿探索，在原始创新领域不断深耕，产出了多项具有国际影响力的重大原创成果。

我们秉持开放包容的理念，与世界一流大学及科研机构深化战略合作。我们在优势领域建立起具有国际引领力的学术共同体，旨在持续提升中国物理学的国际影响力 。

站在新的发展起点上，我们将继续聚焦国家战略需求，推动跨学科融合与产研协同。面对全球科技前沿与社会发展挑战，北大物理将以坚定的行动和创新的勇气，担负时代赋予的使命，共同谱写属于我们的崭新篇章。

北京大学物理学院院长

The discipline of physics at Peking University dates back to 1913, when it pioneered university-level physics education in China. Since its founding, we have attached equal importance to teaching and research. While pursuing academic excellence, we have remained steadfast in our commitment to serving the nation through science, making distinguished contributions to China's scientific and technological advancement.

Talent cultivation is at the heart of our mission. Through a series of strategic initiatives for nurturing outstanding students, we are dedicated to educating a new generation of exceptional talent with solid foundations, broad perspectives, and strong capacity for innovation, thereby providing robust support for advancing the frontiers of science and technology worldwide.

Today, the School brings together leading scholars and scientists of international distinction, forming a strong, multi-generational academic community. Driven by fundamental scientific questions and major challenges, we systematically advance basic research and frontier exploration, continue to deepen our work in original innovation, and have produced a number of major original achievements with international impact.

Guided by the principles of openness and inclusiveness, we continue to deepen strategic cooperation with the world's leading universities and research institutions. In our areas of strength, we are building academic communities with international leadership, with the aim of further enhancing the global influence of Chinese physics.

Standing at a new point of departure, we will continue to focus on national strategic needs, promote interdisciplinary integration, and strengthen collaboration among academia, research, and industry. In the face of global scientific frontiers and the challenges of social development, physics at Peking University will shoulder the mission entrusted to us by our times—with resolute action and the courage to innovate—as we work together to write a new chapter for the future.

Yun-Feng Xiao

Dean of the School of Physics, Peking University

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2023 年，全面学习、深入落实 20 大精神。参观红色展览，强化理论学习，筑牢思想根基。

In 2023, the School of Physics thoroughly studied and fully implemented the guiding principles of the 20th National Congress of the Communist Party of China. It organized visits to red-themed exhibitions to strengthen theoretical learning and consolidate the ideological foundation.

2023 年 2 月，中国气象局龙卷风重点开放实验室正式启动；北京激光加速创新中心、轻元素量子材料交叉平台完成设备试运行，纳光电子加工与测试平台完成基础建设。

In February 2023, the Key Open Laboratory for Tornado Research of China Meteorological Administration was officially launched. The Beijing Laser Acceleration Innovation Center and the Interdisciplinary Platform for Light-Element Quantum Materials completed the trial operation of equipment, and the Nanophotonic Fabrication and Testing Platform finished its basic construction.

2023 年 4 月，组织 31 所高校开展物理学“101 计划”建设。

In April 2023, the School of Physics organized 31 universities to advance the development of the Physics "101 Program".

2023 年 5 月，“普通物理实验”等 4 门课程获评第二批国家级一流本科课程。

In May 2023, four courses including General Physics Experiments were named the second batch of national first-class undergraduate courses.

2023 年 6 月，启动物理学国家高层次人才培养中心，推进博士生培优计划。

In June 2023, the National High-Level Talent Training Center for Physics was initiated, and the PhD Student Excellence Program was promoted .

2023 年 6 月，入选北京大学教材研究与建设基地。

In June 2023, the School of Physics was selected as a Textbook Research and Development Base of Peking University.

2023 年 6 月，学院工会获评北京市教育工会先进教职工小家，2023 年 12 月获评北京大学模范工会之家。

In June 2023, Trade union of school of Physics was awarded the title of Advanced Faculty Home by the Beijing Municipal Education Trade Union, and was named Model Faculty Home of Peking University in December 2023.

2023 年 7 月，现代光学研究所党支部获评北京高校先进基层党组织。

In July 2023, the Party Branch of the Institute of Modern Optics was honored as an Advanced Primary-Level Party Organization among Beijing universities.

2023 年 7 月，承办北京大学基础物理国际暑期学校，吸引 9 国 16 所高校 52 名本科生参与，邀请诺奖得主、8 位院士等 16 位外国专家授课交流。

In July 2023, the School of Physics hosted the International Summer School on Basic Physics of Peking University, attracting 52 undergraduate students from 16 universities in 9 countries. Nobel laureates, 8 academicians and 16 other foreign experts were invited to give lectures and conduct academic exchanges.

2023 年 10 月，以“北大物理 百年成林 十年新绿”为主题，举办北京大学物理学科建立 110 周年系列活动。

In October 2023, a series of activities marking the 110th anniversary of the founding of the Physics Discipline at Peking University were held under the theme of "Physics at PKU: A Century of Growth, A Decade of New Vitality".

高质量完成新一轮“双一流”建设自评，聚焦首轮问题改进落实，完成监测数据年度填报，以评促建推动学科高质量发展。

The School of Physics successfully completed the self-evaluation for the new round of the "Double First-Class" construction, focused on rectifying and implementing the problems identified in the first round, finished the annual submission of monitoring data, and promoted the high-quality development of the discipline through evaluation-driven improvement.

2023 年，新增享受政府特殊津贴 1 人、教育部长江学者特聘教授 1 人、国家杰青 5 人、国家自然科学基金创新研究群体 1 个，形成战略科学家后备梯队。

In 2023, one new faculty member was granted the Special Government Allowance of the State Council, one was appointed as a Chang Jiang Scholar Distinguished Professor by the Ministry of Education, five were awarded the National Science Fund for Distinguished Young Scholars, and one innovative research group was approved by the National Natural Science Foundation of China, forming a reserve echelon of strategic scientists.

学院师生作为第一作者或通讯作者发表 SCI 论文约 800 篇，其中在 Science、Nature 及子刊、PRL、PRX、PNAS 上发表 60 余篇；授权发明专利 63 项。

Faculty and students of the School of Physics published approximately 800 SCI papers as first authors or corresponding authors, among which more than 60 were published in top journals including Science, Nature and its sub-journals, Physical Review Letters (PRL), Physical Review X (PRX) and Proceedings of the National Academy of Sciences (PNAS); 63 invention patents were authorized.

新增国家重点研发计划重点专项常规项目 7 个和国际合作类项目 5 个，国家自然科学基金重大研究计划（战略研究）项目 1 个、重点项目 4 个，原创探索计划和国家重大科研仪器研制项目各 1 个。

The School of Physics secured 7 regular projects and 5 international cooperation projects under the key special programs of the National Key R&D Program, 1 project under the Major Research Plan (Strategic Research) of the National Natural Science Foundation of China (NSFC), 4 key projects, as well as 1 project each under the Original Exploration Program and the National Major Scientific Research Instrument Development Program.

DEVELOPMENTS
发展进程

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2024 年，深入学习党的二十届三中全会与全国教育大会精神，扎实开展党纪学习教育，严格落实“第一议题”制度跟进学习总书记重要讲话精神。

In 2024, the School of Physics further studied the guiding principles of the Third Plenary Session of the 20th Central Committee of the Communist Party of China and the National Education Congress, carried out the education on Party discipline in a solid manner, and strictly implemented the "First Topic" system to follow up and study the important speeches and instructions of General Secretary Xi Jinping.

2024 年 2 月，俄罗斯杜布纳联合核子研究所格利金诺夫教授获 2023 年度中国政府友谊奖。

In February 2024, Professor Grigory Ginov from the Joint Institute for Nuclear Research in Dubna, Russia, was awarded the 2023 Chinese Government Friendship Award.

2024 年 3 月 -5 月，组织“物理学”“天文学”“大气科学”“核科学与技术”四个学科开展讨论调研。

From March to May 2024, the School of Physics organized discussions and research on four disciplines: Physics, Astronomy, Atmospheric Science, and Nuclear Science and Technology.

2024 年 4 月，转角氮化硼光学晶体原创理论与材料等 4 项成果入选 2024 中关村论坛年会重大科技成果。

In April 2024, four achievements including the original theory and materials of twisted boron nitride optical crystals were selected as major scientific and technological achievements of the 2024 Zhongguancun Forum Annual Meeting.

2024 年 5 月，纪念中国第一颗原子弹成功爆炸 60 周年，开展主题宣讲活动。

In May 2024, to commemorate the 60th anniversary of the successful detonation of China's first atomic bomb, the School of Physics held a series of thematic public lectures.

DEVELOPMENTS
发展进程

2024 年 7 月，举办基础物理国际暑期学校，邀请 9 位世界顶尖科学家、优秀青年学者开展英语教学，开设 22 场讲座。

In July 2024, the International Summer School on Basic Physics was held, where 9 world-leading scientists and outstanding young scholars were invited to deliver English lectures, with a total of 22 academic talks offered.

2024 年 9 月，学院获评学校 2023 年度引才育才先进集体。

In September 2024, the School of Physics was awarded the Advanced Collective for Talent Introduction and Cultivation of Peking University for the 2023 academic year.

2024 年 10 月，全职引进 2018 年诺贝尔物理学奖获得者穆鲁教授。

In October 2024, the School of Physics recruited Professor Gérard Mourou, the laureate of the 2018 Nobel Prize in Physics, as a full-time faculty member.

2024 年 12 月，物理科普志愿服务项目获第七届全国青年志愿项目大赛铜奖、北京市银奖。

In December 2024, the Physics Science Popularization Volunteer Service Program won the Bronze Award at the 7th National Youth Volunteer Service Project Competition and the Silver Award at the municipal level in Beijing.

修订物理学专业本科生培养方案，健全“基础 + 应用 + 交叉”三位一体的培养体系，新开“物理与人工智能”等 5 门课程，共建 5 个“物理学 +X”交叉核心课程模块。

The undergraduate training program for the Physics major was revised, and a trinity training system integrating "foundation + application + interdisciplinarity" was improved. Five new courses such as Physics and Artificial Intelligence were launched, and five interdisciplinary core course modules of "Physics + X" were co-developed.

2024 年，新增教育部“长江学者奖励计划”特聘教授 3 名、国家杰青 3 名，“万人计划”科技创新领军人才、青年拔尖人才各 1 名；马伯强、许甫荣、吴学兵获批享受国务院政府特殊津贴。

In 2024, three new faculty members were appointed as Chang Jiang Scholar Distinguished Professors by the Ministry of Education, three were awarded the National Science Fund for Distinguished Young Scholars, one was selected as a Leading Talent in Scientific and Technological Innovation and one as a Young Top-notch Talent under the National Ten-Thousand Talents Program. Ma Boqiang, Xu Furong and Wu Xuebing were approved for the Special Government Allowance of the State Council.

学院师生作为第一作者或通讯作者发表 SCI 论文约 750 篇，其中在 Science、Nature 及子刊，PRL、PRX、PNAS 等顶级杂志发表文章百余篇；授权发明专利 64 项。

Faculty and students of the School of Physics published about 750 SCI papers as first authors or corresponding authors, among which more than 100 were published in top journals including Science, Nature and its sub-journals, PRL, PRX and PNAS; 64 invention patents were authorized.

新增国家重点研发计划重点专项项目，NSFC 重大、重点、原创探索计划、面向全球的科学研究基金项目和国家重大科研仪器研制项目 17 个。

The School of Physics obtained 17 new projects, including those under the key special programs of the National Key R&D Program, as well as major projects, key projects and projects under the Original Exploration Program of the NSFC, the Global Science Research Fund, and the National Major Scientific Research Instrument Development Program.

人事概况

GENERAL VIEW OF PERSONNEL

在职教职工 Active Faculty and Staff

219人 教学科研人员 Teaching and Research Personnel

90人 教授 Full Professor	1人 教学教授 Teaching Full Professor	4人 研究员 Research Professor
35人 长聘副教授 Associate Professor with Tenure	43人 副教授 Associate Professor	38人 助理教授 Assistant Professor
6人 副研究员 Research Associate Professor	1人 助理研究员 Research Assistant Professor	1人 讲师 Lecturer

71人 实验 / 工程技术人员 Experimental/Engineering Technicians

10人 正高级工程师 Professor of Engineering	38人 高级工程师 Senior Engineering	22人 工程师 Engineer	1人 实验师 Lab Master

18人 行政人员及工人 Administrative Staff and Workers

学生 Student

2381人 在校生 Enrolled Student

1045人 本科生 Undergraduate Student	115人 硕士生 Master's Student	1221人 博士生 Doctoral Student

下属和挂靠单位

INSTITUTIONS

- 普通物理教学中心 Teaching Center for General Physics
- 基础物理实验教学中心 Teaching Center for Experimental Physics
- 理论物理研究所 Institute of Theoretical Physics
- 现代光学研究所 Institute of Modern Optics
- 凝聚态物理与材料物理研究所 Institute of Condensed Matter and Material Physics
- 技术物理系 Department of Technical Physics
- 重离子物理研究所 Institute of Heavy Ion Physics
- 天文学系 Department of Astronomy
- 大气与海洋科学系 Department of Atmospheric and Oceanic Sciences
- 电子显微镜实验室 Electron Microscopy Laboratory
- 量子材料科学中心 International Center For Quantum Materials
- 北京现代物理研究中心
  Beijing Institute of Modern Physics
- 北京大学纳光电子前沿科学中心
  Frontiers Science Center for Nano-Optoelectronics, Peking University

系所中心研究亮点
HIGHLIGHTS

01 理论物理研究所
Institute of Theoretical Physics

理论物理研究所现有教职工 19 人，其中教员（含教授、副教授、研究员等）18 人，办公行政人员 1 人。主要研究领域包括：超弦与宇宙学、粒子物理、强子物理、核物理、凝聚态理论与统计物理等，涉及自然界从宇观到介观直至微观基本粒子的各个尺度。

There are 19 members in the Institute of Theoretical Physics， consisting of 18 faculty members and one administrative staff. The research fields include string and cosmology， particle physics， hadron physics， nuclear physics， condensed matter and statistical physics， and cover from the scale of the universe down to microscopic scales of elementary particles.

◎ 暗物质的本质及其探索

暗物质的本质是当代粒子物理学与天体物理学领域最重大的科学难题之一。研究暗物质的粒子性质不仅能为超越标准模型的新物理提供关键线索，也将深化人类对宇宙基本构成的理解。传统的大质量弱相互作用粒子（WIMP）模型因其热退耦机制可自然解释当前宇宙学观测到的暗物质丰度，长期以来被视为最有力的候选者。然而，尽管自 20 世纪 80 年代以来全球开展了大量直接探测实验，WIMP 暗物质的确凿证据至今仍未发现。

与 WIMP 这类粒子性显著的重质量暗物质相对应，超轻暗物质表现出鲜明的波动特性。为满足暗物质的宇宙丰度，超轻暗物质的数密度非常高，可用经典场论描述，且必须为玻色粒子。暗光子作为标准模型之外的一种 U(1) 规范玻色子，常出现在弦理论额外维紧致化之后的低能有效场论中。通过高能标下带电粒子的圈图效应，暗光子可与标准模型光子发生动力学混合，从而与电磁流产生极其微弱的耦合。这种具有极轻质量的暗光子，正是波动型暗物质的典型代表。

刘佳课题组近期开创性地提出利用射电望远镜直接探测暗光子暗物质的新方法（Phys. Rev. Lett. 130, 181001 (2023)）。基于动力学混合效应，暗光子暗物质会引发射电望远镜反射面或天线中电子的相干振荡，产生特征性单频射电辐射。该物理图像可类比为暗光子暗物质形成的“暗宇宙微波背景辐射”，其峰值频率由暗光子质量唯一确定。这项工作首次论证了利用 FAST 射电望远镜校验数据进行暗物质搜索的可行性，被选为“Featured in Physics”亮点文章，并受到 APS Physics、Physics Today 以及 Phys.org 等国际权威学术期刊和媒体的专题报道。

在理论探索方面，课题组早前曾提出一个极具创新性的探测方案：如果暗光子暗物质确实存在，那么太阳日冕层（其电子密度决定了等离子体频率）应当成为一个天然的“探测器”，能够将暗光子共振转换为可观测的单频无线电信号。2024 年，刘佳课题组利用 LOFAR 射电望远镜的太阳观测数据，实践了上述理论方案。不仅验证了 WKB 近似在振荡转化计算中的可靠性，更在 30-60 MHz 频段给出了迄今最严格的暗光子 - 光子耦合常数限制。这项成果发表在 (Nature Communications 15, 915 (2024))，并入选‘天文与行星科学编辑亮点’（Editor Focus）以及《自然》射电天文学专题研究亮点。

这些研究不仅为超轻暗物质的实验探索提供了新的思路，也进一步拓宽了天体物理与粒子物理的交叉研究方向。随着新一代射电望远镜（如 SKA、升级后的 FAST）的投入使用，该方法有望对超轻暗光子暗物质的性质进行更精确的约束，并为暗物质的验证提供重要线索。

◎ Research Progress on Dark Photon Dark Matter

The nature of dark matter remains one of the most profound scientific mysteries in modern particle physics and astrophysics. Studying the particle properties of dark matter not only provides crucial clues for new physics beyond the Standard Model but also deepens our understanding of the fundamental composition of the universe. The traditional Weakly Interacting Massive Particle (WIMP) paradigm, whose thermal freeze-out mechanism naturally explains the observed cosmological abundance of dark matter, has long been regarded as the most compelling candidate. However, despite extensive direct detection experiments conducted worldwide since the 1980s, definitive evidence for WIMP dark matter has yet to be found.

In contrast to the particle-like behavior of heavy WIMPs, ultralight dark matter exhibits distinct wave-like properties. To account for the cosmological abundance of dark matter, ultralight dark matter must have an extremely high number density, allowing it to be described by classical field theory and requiring it to be a bosonic particle. The dark photon, a hypothetical U(1) gauge boson beyond the Standard Model, often emerges in low-energy effective field theories from extra-dimensional compactifications in string theory. Through kinetic mixing induced by loop effects of charged particles at high energy scales, dark photons can couple extremely weakly to the Standard Model electromagnetic current. Such ultralight dark photons represent a prime candidate for wave-like dark matter.

Recently, the research group led by Liu Jia proposed a groundbreaking method for directly detecting dark photon dark matter using radio telescopes (Phys. Rev. Lett. 130, 181001 (2023)). Due to the kinetic mixing effect, dark photon dark matter can induce coherent oscillations of electrons in the reflective surfaces or antennas of radio telescopes, generating monochromatic radio emission. This phenomenon can be analogized to a "dark cosmic microwave background" produced by dark photon dark matter, with its peak frequency uniquely determined by the dark photon mass. This work demonstrated for the first time the feasibility of using calibration data from the FAST radio telescope for dark matter searches. It was selected as a "Featured in Physics" highlight and received extensive coverage in leading scientific outlets such as APS Physics, Physics Today, and Phys.org.

On the theoretical front, the group had earlier proposed an innovative detection scheme: if dark photon dark matter exists, the solar corona–whose electron density determines the plasma frequency–should act as a natural "detector," resonantly converting dark photons into observable monochromatic radio signals. In 2024, the team implemented this theoretical approach using solar observation data from the LOFAR radio telescope. It validates the reliability of the WKB approximation in oscillation conversion calculations and established the most stringent experimental constraints to date on the dark photon–photon coupling in the 30–60 MHz frequency range. This result was published in (Nature Communications 15, 915 (2024)) and was featured in the journal's "Editor Focus" for Astronomy and Planetary Science, as well as highlighted in Nature's special collection on radio astronomy.

These studies not only provide novel experimental approaches for ultralight dark matter searches but also expand interdisciplinary research at the intersection of astrophysics and particle physics. With the next generation of radio telescopes–such as the Square Kilometre Array (SKA) and the upgraded FAST–coming online, this method is expected to yield even more precise constraints on the properties of ultralight dark photon dark matter, potentially offering critical insights into the verification of dark matter.

◎ 广义对称性方面的研究进展

对称性是物理学中最重要的核心基本概念之一。近年来，理论物理学界涌现出了关于对称性的新概念，即“广义对称性”，其中包括作用在高维算符上的高形式对称性以及超越传统对称群概念的范畴对称性等。研究物理理论中的广义对称性有望为阐明非微扰、强耦合场论的物理机制提供全新视角。

王一男研究员课题组在广义对称性领域展开了多角度的深入研究。王一男研究员与合作者通过超弦 /M- 理论中的几何构造方法，首次计算了许多著名的超对称共形场论模型的广义对称性及其’t Hooft 反常，例如 AdS4/CFT3 全息对偶中常见的三维 ABJM 理论与三维 N=2 理论，并对这些场论的物理性质做出了新预言（JHEP 02 (2023) 226），两年内已被引用超 70 次。

王一男研究员还带领课题组提出了一种全新的广义对称性形式，即费米型的高形式对称性，发现在无质量自旋 3/2 的粒子上即存在这类对称性（SciPost Phys. 15 (2023) 4, 142）。在此基础上，王一男研究员课题组与合作者进一步深入探究了如何将此类全局对称性提升为规范对称性，并在此过程中发现了一种赋予自由狄拉克费米子质量的新机制（Phys. Rev. D 110 (2024) 10, 105020）。

基于此前研究基础，王一男研究员与合作者受邀在物理学著名综述期刊 Physics Reports 上发表了广义对称性主题的综述文章（Phys. Rept. 1065 (2024) 1-43）。

◎ Research Progress on Generalized Symmetries

Symmetry is one of the most fundamental and central concepts in physics. In recent years, the theoretical physics community has seen the emergence of new concepts known as the generalized symmetries. These include higher-form symmetries, which act on extended operators, as well as categorical symmetries beyond the traditional framework of symmetry groups. It is expected that generalized symmetries can provide new perspectives for understanding the physical mechanisms of non-perturbative and strongly coupled quantum field theories.

Prof. Yinan Wang's research group has carried out comprehensive and in-depth studies in the field of generalized symmetries from multiple angles. Utilizing geometric engineering techniques in superstring and M-theory, Prof. Wang and collaborators were the first to compute the generalized symmetries and their 't Hooft anomalies for a number of well-known superconformal field theory models–such as the three-dimensional ABJM theory and 3D N=2 theories commonly appearing in AdS4/CFT3 holography setups, making new physical predictions about these theories (JHEP 02 (2023) 226). This work has been cited over 70 times in two years.

Furthermore, Prof. Wang led the group in proposing an entirely new type of generalized symmetry: the fermionic higher-form symmetry. They found that such symmetries naturally exist in theories involving massless spin-3/2 particles (SciPost Phys. 15 (2023) 4, 142). Prof. Wang's group, together with collaborators, further explored how to gauge such global symmetries. In the process, they discovered a novel mechanism for giving mass to free Dirac fermions (Phys. Rev. D 110 (2024) 10, 105020).

Based on these foundational works, Prof. Wang and collaborators were invited to publish a comprehensive review article on the topic of generalized symmetries in Physics Reports (Phys. Rept. 1065 (2024) 1–43).

◎ 非线性量子输运研究进展

霍尔效应作为凝聚态物理的重要现象，一直是研究电子输运行为的重要窗口，其相关研究成果(如整数和分数量子霍尔效应）曾多次获得诺贝尔奖。近年来，非线性霍尔效应（即霍尔电压与纵向电流的二次及高次等非线性效应）因其独特的物理内涵与技术潜力，成为凝聚态物理与自旋电子学领域的

前沿热点。通常，霍尔效应可以等价地表达为横向电流和纵向电场之间的展开形式：$j_a=\sigma_{ab}E_b+\chi_{abc}E_bE_c+\cdots$,其中 ,$a,b\in(x,y,z)$, σ_{ab} 是线性霍尔电导率,χ_{abc}就是二阶非线性霍尔电导率。这一效应不仅为探索拓扑物态提供了新的实验探针，还为开发低功耗、高灵敏度的量子器件开辟了新途径。

拓扑材料因其独特的电子态和物理性质，在量子器件领域展现出巨大潜力。然而，层状拓扑材料中非互易输运特性的来源及调控机制仍存在争议，尤其是空间反演对称性破缺的微观机制亟待阐明。黄华卿课题组与合作者通过理论计算与模拟，首次揭示了层状拓扑材料 $ZrTe_5$薄膜中的自发空间反演对称性破缺现象。研究表明，该现象源于层间滑移与细微的层内晶格畸变，并由此预测了显著的非线性反常霍尔效应和动态磁电响应。通过建立滑移依赖的 k·p 模型，团队进一步阐明了滑移铁电性与非线性霍尔电流、轨道磁化之间的直接耦合关系。这一发现不仅解答了 $ZrTe_5$中非互易输运性的起源争议，也为二维范德华材料中的对称性调控提供了新思路。相关成果发表于《物理评论快报》（Phys. Rev. Lett. 132, 266802（2024））。

反铁磁体因具有超快动力学和抗磁场干扰等优势，成为下一代自旋电子器件的理想候选体系。然而，其核心状态变量——奈尔矢量的高效检测一直是技术瓶颈。黄华卿课题组与合作者提出了一种基于本征非线性霍尔效应的奈尔矢量全电学检测方案。以二维锰硫族化物 MnX（X = S, Se, Te）为例，研究团队预测其非线性霍尔电导率可达 nm·mA/V² 量级，较传统材料提升 2 个数量级。通过化学势调控，该效应可实现对奈尔矢量取向的灵敏响应，并具有优异的可扩展性。这一发现不仅为二维反铁磁存储器件提供了灵活的信号读取方案，还为设计低功耗、高密度自旋电子器件奠定了材料基础。相关成果发表于《物理评论快报》（Phys. Rev. Lett. 131, 046801 (2023)）。

◎ Research progress in nonlinear quantum transport

As an important phenomenon in condensed matter physics, the Hall effect has always been an important window for studying electron transport behavior. Its related research results (such as integer and fractional quantum Hall effects) have won Nobel Prizes many times. In recent years, the nonlinear Hall effect (i.e., the secondary and higher-order nonlinear effects of the Hall voltage and longitudinal current) has become a frontier hotspot in the field of condensed matter physics and spin electronics due to its unique physical connotation and technological potential. Conventionally, the Hall effect can be equivalently expressed as an expanded form between the transverse current and the longitudinal electric field: $j_a=\sigma_{ab}E_b+\chi_{abc}E_bE_c+\cdots$, where a, b ∈ (x,y,z), σ_{ab} is the linear Hall conductivity, and χ_{abc} is the second-order nonlinear Hall conductivity. This effect not only provides a new experimental probe for exploring topological states, but also opens up a new path for the development of low-power, high-sensitivity quantum devices.

Topological materials have shown great potential in the field of quantum devices due to their unique electronic states and physical properties. However, the origin and regulation mechanism of nonreciprocal transport properties in layered topological materials are still controversial, especially the microscopic mechanism of spatial inversion symmetry breaking needs to be clarified. Huang Huaqing's research group and collaborators revealed for the first time the spontaneous spatial inversion symmetry breaking phenomenon in the layered topological material $ZrTe_5$ film through theoretical calculations and simulations. The study showed that the phenomenon originated from interlayer slip and subtle intralayer lattice distortion, and thus predicted significant nonlinear anomalous Hall effect and dynamic magnetoelectric response. By establishing a slip-dependent k·p model, the team further clarified the direct coupling relationship between slip ferroelectricity and nonlinear Hall current and orbital magnetization. This discovery not only solves the controversy over the origin of nonreciprocal transport properties in $ZrTe_5$, but also provides new ideas for symmetry regulation in two-dimensional van der Waals materials. The relevant results were published in Physical Review Letters (Phys. Rev. Lett. 132, 266802 (2024)).

Antiferromagnets have become an ideal candidate system for the next generation of spintronic devices due to their advantages such as ultrafast dynamics and resistance to magnetic field interference. However, the efficient detection of the core state variable, the Née vector, has always been a technical bottleneck. Huang Huaqing's research group and collaborators proposed an all-electric detection scheme for the Née vector based on the intrinsic nonlinear Hall effect. Taking the two-dimensional manganese chalcogenide MnX (X = S, Se, Te) as an example, the research team predicted that its nonlinear Hall conductivity can reach the nm·mA/V² level, which is 2 orders of magnitude higher than traditional materials. Through chemical potential regulation, this effect can achieve sensitive response to the orientation of the Née vector and has excellent scalability. This discovery not only provides a flexible signal reading scheme for two-dimensional antiferromagnetic memory devices, but also lays a material foundation for the design of low-power, high-density spintronic devices. The relevant results were published in Physical Review Letters (Phys. Rev. Lett. 131, 046801 (2023)).

供稿：理论物理研究所
审核：冯旭

02 凝聚态物理与材料物理研究所
Institute of Condensed Matter and Material Physics

凝聚态物理与材料物理研究所现有教职工 58 人，其中，教授 27 人，副教授 8 人，预聘制助理教授 7 人，研究技术人员 3 人，工程技术人员 13 人。研究队伍中包括院士 6 人，万人计划科技领军人才 1 名，万人计划青年拔尖人才 2 名，长江特聘教授 8 人，国家杰出青年基金获得者 14 人。 研究领域包括宽禁带半导体物理和器件，凝聚态理论，纳米半导体与半导体光子学，微纳光子学及近场微区光谱，高温超导材料、物理与器件，纳米结构和低维物理，软凝聚态物理和生物物理，以及磁性物理和新型磁性材料。

There are 58 faculty members in the Institute of Condensed Matter and Material Physics, consisting of 27 professors, 8 associate professors, 7 tenure-track assistant professors, 3 research technicians and 13 engineering technicians. Among the senior researchers are 6 academicians of the CAS, 1 "Ten Thousand Talent Program" Leading Talent, 2 "Ten Thousand Talent Program" Youth Top-notch Talent, 8 Chang Jiang scholar professors, and 14 NSFC "Distinguished Youth Award" winners. The research fields cover a wide range include wide bandgap semiconductor physics and devices, theoretical condensed matter physics, nanosemidonductors and semiconductor photonics, nanophotonics and near-field optics, high-temperature superconducting physics, materials and devices, nanostructures and low-dimensional physics, soft condensed matter physics and biophysics, and magnetism physics and advanced magnetic materials.

◎ 深度学习量子蒙特卡洛方法的发展

量子蒙特卡洛方法是一种基于蒙特卡洛积分与变分原理的数值计算方法，主要用于求解复杂系统的薛定谔方程。该方法通过直接描述电子间的关联效应，能够精确计算量子多体系统的基态及激发态性质，因此在凝聚态物理、量子化学、材料科学及其交叉研究领域得到广泛应用。近年来，人工智能技术为这一方法注入了新的活力：采用神经网络参数化波函数并结合深度学习优化技术，可以绕过传统量子蒙特卡洛中的符号问题，从而获得更高精度的波函数描述。这一创新显著拓展了方法的适用范围，在强关联电子系统研究等前沿领域展现出广阔的应用前景。

陈基课题组与合作者结合人工智能深度学习方法提出了一系列原创性的算法，大大提升了量子蒙特卡洛计算精度、效率和应用边界，具体包括：(1) 使用人工智能量子蒙特卡洛算法得到了高精度的固体介电常数结果，解决了固体体系中电极化率高精度计算的难题 [Phys. Rev. Lett. 132, 176401 (2024)]；(2) 提出低计算开销的自旋纯化算法，确保波函数满足目标对称性，进一步解决了激发态计算中因对称性破缺导致的精度损失问题 [Nat. Comput. Sci. 10.1038/s43588-024-00730-4 (2024)]； (3) 改进神经网络自动微分框架，发明前传拉普拉斯算法并提出拉普拉斯波函数网络，加速倍率与电子数呈线性关系，同时不损失精度，突破了量子蒙特卡洛在大体系模拟中的算力限制 [Nat. Mach. Intell. 6, 209 (2024)]。近期，课题组受邀撰写综述论文 " 固体中的深度学习量子蒙特卡洛 "，详细阐述了该方法的原理及应用 [WIREs Comput Mol Sci, 15: e70015 (2025)]。

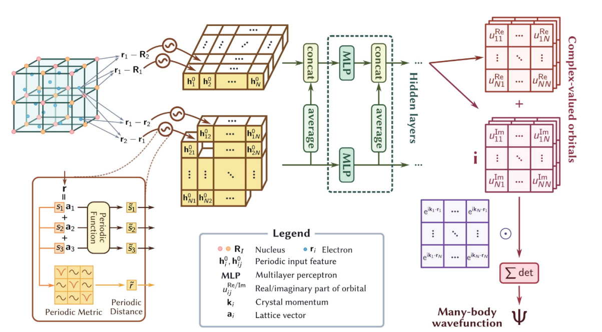


图 1. 固体神经网络波函数结构示意图

Fig 1. Illustration of the neural network architecture for solids

◎ Development of Deep Learning quantum Monte Carlo Method

The Quantum Monte Carlo (QMC) method is a computational approach based on Monte Carlo integration and variational principles, primarily employed to solve the Schrödinger equation for complex systems. By explicitly accounting for electron-electron correlation effects, this method enables accurate calculations of ground-state and excited-state properties of quantum many-body systems, thus finding extensive applications in condensed matter physics, quantum chemistry, materials science, and their interdisciplinary research domains. In recent years, artificial intelligence technologies have revitalized this field: the adoption of neural network parameterized wavefunctions combined with deep learning optimization techniques has make it possible to bypass the sign problem inherent in traditional QMC, thereby achieving higher-precision wavefunction descriptions. This innovation has significantly expanded the method's applicability, particularly in cutting-edge areas such as studies of strongly correlated electron systems.

Ji Chen's research group and collaborators have developed a series of original algorithms by integrating deep learning deep learning methodologies, substantially enhancing the computational accuracy, efficiency, and applicability boundaries of quantum Monte Carlo methods. These advancements include: (1) The application of deep learning quantum Monte Carlo algorithms to obtain high-precision results for solid-state dielectric constants, resolving the longstanding challenge of achieving high-precision calculations of susceptibility in solid-state systems [Phys. Rev. Lett. 132, 176401 (2024)]; (2) The proposal of a low-computational-cost spin purification algorithm, which ensures wavefunctions satisfy target symmetries, addressing precision loss in excited-state calculations caused by symmetry breaking [Nat. Comput. Sci. 10.1038/s43588-024-00730-4 (2024)]; (3) The enhancement of neural network-based automatic differentiation frameworks through the invention of a forward-mode Laplacian algorithm and the development of a Laplacian wavefunction network, achieving linear scaling of acceleration factors with electron numbers while preserving precision, thus overcoming computational limitations in simulating large systems [Nat. Mach. Intell. 6, 209 (2024)]; Recently, the research group was invited to write a review article titled "Deep Learning Quantum Monte Carlo for Solids" which elaborates in detail on the principles and applications of this method [WIREs Comput Mol Sci, 15: e70015 (2025)].

◎ 二维材料光学晶体原创理论与材料

激光技术是现代科技文明的重要基石。自 1960 年第一台红宝石激光器的问世以来，激光技术的迅速发展推动了人类科技文明，催生了 20 余项诺贝尔奖工作。光学晶体是激光技术发展的核心部件。但是由于传统理论模型和材料体系的局限性，现有晶体目前已难以满足激光器小型化、高集成、

功能化的发展要求。新一代激光技术的发展亟待光学晶体材料和理论的革命性突破。

菱方相二维晶体由于具备超高的非线性系数，被视为超薄非线性光学晶体的理想备选材料，但层间同向堆垛构型为自然界中不存在的亚稳定物相。为此，北京大学物理学院刘开辉课题组与合作者提出“晶格传质 - 界面生长”材料制备新范式，首次实现了高非线性系数的菱方相二维单晶材料的通用制备。通过浓度及化学势梯度，保障生长源于金属晶格中不断传质，随后在衬底和材料界面处外延析出新生二维晶体层；并构筑界面原子台阶结构，保证每层二维晶体沿衬底台阶的平行取向，“推动”多层薄膜的连续界面外延，最终实现微米厚度、层间严格平行排布的二维非$\varphi(\theta)$线性光学晶体材料的纯相θ生长(图d1a-c)。相关成果发表于《科学》(Science$\vec{k}(2\omega)=\left(2\vec{k}(\omega)+\frac{\varphi(\theta)}{d}\vec{e}\right)$2024, 385, 99）。

进一步，研究团队原创第三类光学晶体相位匹配理论——转角相位匹配。他们发现晶体界面转角可以引入非线性几何相位，通过设计堆垛晶体的转角和厚度，可以实现光学参量过程中的相位匹配。基于界面转角相位匹配理论，团队构建了第三类光学晶体——转角菱方氮化硼光学晶体——实现了光学倍频信号转换效率的突破，3.2 微米厚度下可达 8%（图 1d-f），相较于传统晶体提升了 100-10000 倍，相关成果发表于《物理评论快报》(Phys. Rev. Lett. 2023, 131, 233801）。

二维材料光学晶体的材料与理论突破具有鲜明的首创性。成果发布后，新华社分别以“我国科学家研发出超薄高能效光学晶体”、“从“盖房子”到“顶竹笋”：我国科学家首创晶体制备新方法”为题重点报道。成果入选“2024 中关村论坛年会重大科技成果”、“2024 年度中国半导体十大研究进展”、“2025 中关村论坛年会重大科技成果”。

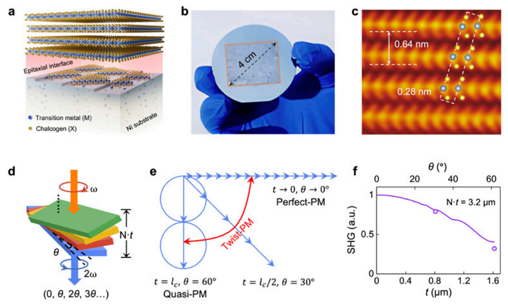


图 1. (a-c)“晶格传质 - 界面生长”材料制备新范式，制备晶圆级 3R-TMDs 单晶。(d-f) 转角相位匹配机制示意图及二次谐波增强。

Fig 1. (a-c) Interfacial epitaxy of wafer-scale 3R-TMD single crystals. (d-f) Twist-phase-matching theory and enhancement of second-harmonic generation.

◎ Groundbreaking Theory and Materials for Two-dimensional Optical Crystals

Laser technology constitutes a pillar of modern scientific advancement. Since the breakthrough of the ruby laser in 1960, its exponential growth has inspired over 20 Nobel Prize-winning achievements. Optical crystals serve as core components in advancing laser technology. However, constrained by theoretical models and material systems, conventional crystals now face fundamental limitations in meeting modern demands for laser miniaturization, integration, and functionalization, necessitating paradigm-shifting breakthroughs.

Rhombohedral-phase two-dimensional (2D) materials have been regarded as ideal candidates for ultrathin nonlinear optical crystals. Yet their interlayer parallel stacking configuration represents a metastable phase absent in nature. To address this, Liu Kaihui's group of the School of Physics of Peking University, proposed a novel “Interfacial epitaxy” paradigm, achieving the first universal preparation of rhombohedral-phase 2D single crystals with high nonlinear coefficients. The reactive atoms continuously feed through the metal lattice driven by concentration and chemical potential gradients, and subsequently, new layers are epitaxially precipitated at the substrate-existing layer interface. Through engineered atomic-step structures, each crystal layer maintained parallel alignment with substrate steps, enabling continuous interfacial epitaxy of multilayer films. This culminated in pure-phase growth of micron-thick 2D nonlinear optical crystals with strictly parallel interlayer arrangements (Fig. 1a-c). This work was published in Science 2024, 385, 99.

Furthermore, the team pioneered a third phase-matching theory: twist-phase matching. They discovered that crystal interface rotation generates nonlinear geometric phase $\varphi(\theta)$. Through precise control of rotation angle θ and crystal thickness d, they achieved phase matching in optical parametric processes: $\vec{k}(2\omega)=\left(2\vec{k}(\omega)+\frac{\varphi(\theta)}{d}\vec{e}\right)$. Implementing this theory, they developed the third-generation optical crystal–twisted rhombohedral boron nitride (TBN). This novel crystal demonstrates unprecedented second-harmonic generation conversion efficiency across broad spectra, reaching 8% at 3.2 μm thickness (Fig.1d-f), representing a 100-to-10000-fold enhancement over conventional crystals. This work was published in Phys. Rev. Lett. 2023, 131, 233801.

The theoretical breakthrough and material synthesis of optical crystals in two-dimensional materials exhibit distinct originality. Xinhua News Agency highlighted the achievements titled “Chinese scientists invent ultrathin optical crystal for next-generation laser tech” and “Chinese researchers develop novel method to produce crystals”. The innovations were selected for “Major Achievements of the 2024 Zhongguancun Forum Annual Conference”, “Top Ten Research Progresses in China's Semiconductors in 2024”, and “Major Achievements of the 2025 Zhongguancun Forum Annual Conference”.

◎ 实现原子级特征尺度与可重构光频相控阵的纳米激光器

激光器的微型化开启了光子技术发展的新纪元，深刻改变了人类的科技与生活。自 20 世纪 90 年代以来，贝尔实验室、加州理工学院、哈佛大学以及加州大学伯克利分校等机构先后实现了微盘激光器、光子晶体激光器、等离激元纳米激光器等新型微型化激光器。通过持续的技术创新，这些研究将激光器的特征尺寸推进至新的极限，达到了 10 纳米量级。北京大学马仁敏等提出了奇点色散方程，构建了介电体系突破光学衍射极限的理论框架，并研制出迄今模式体积最小的激光器（图 1）。所研发的奇点介电纳米激光器将激光器的特征尺度推进至原子级。

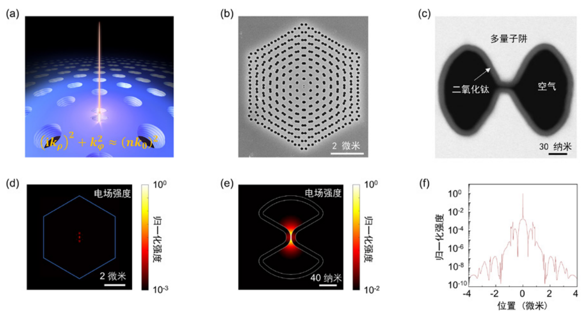


图 1 奇点色散方程和奇点介电纳米激光器示意图及其表征。（a）奇点色散方程与奇点介电纳米激光器示意图；（b）奇点介电纳米激光器电子显微镜照片；（c）奇点介电纳米激光器中心区域电子显微镜照片；（d）奇点介电纳米激光器电场强度分布图；（e）奇点介电纳米激光器中心区域电场强度分布图；（f）奇点介电纳米激光器对数坐标下电场分布曲线图。

Figure 1 | Schematic and Characterization of the Singular Dispersion Equation and Singular Dielectric Nanolaser. (a) Singularity dispersion equation and the schematic of singular dielectric nanolaser. (b) Electron microscope image of a singular dielectric nanolaser. (c) Electron microscope image of the central region of the singular dielectric nanolaser. (d) Electric field intensity distribution of the singular dielectric nanolaser. (e) Electric field intensity distribution in the central region of the singular dielectric nanolaser. (f) Logarithmic-scale plot of the electric field distribution of the singular dielectric nanolaser.

将激光器的研制推进至原子级别，标志着激光光场在空间维度的压缩达到了新的极限，其尺度已逼近原子结构，为激光技术的未来发展开辟了新的方向。一方面，具备极端局域化光场的纳米激光器具有高能效与高集成度的优势，有望发展成为信息技术领域的新一代光源，推动低能耗数据通信以及纳光电子集成芯片的创新与实际应用；另一方面，直接在原子尺度上产生相干光场，有可能催生极限分辨率的新型光学成像技术，为 DNA 和 RNA 等生物分子的直接观测开辟新途径；此外，在基础物理研究方面，极端局域化的光场能显著增强光与物质相互作用，为腔量子电动力学、非线性光学与量子光学等前沿领域提供重要的实验平台。

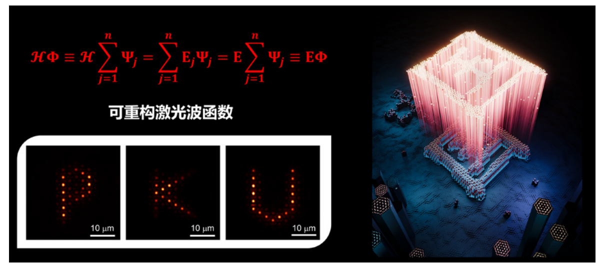


图 2 基于纳米激光器的可重构光频相控阵。莫尔纳米激光器阵列可以“P”、“K”、“U”和“中”、“国”图形生成阵列化相干激射。由于莫尔平带的本征能量简并特性，任意形状的莫尔纳米激光器阵列均能够通过自发相位锁定产生相干激射。

Figure 2 | Reconfigurable Optical Frequency Phased Array Based on Nanolasers. The moiré nanolaser array can generate coherent lasing in arrayed patterns shaped as "P," "K," "U," and the Chinese characters " 中 " (China) and " 国 " (nation). Due to the intrinsic energy degeneracy of moiré flat bands, moiré nanolaser arrays of arbitrary shapes can achieve coherent lasing through spontaneous phase locking.

此外，马仁敏等还首次构建了可重构光频相控阵，在国际上首次实现了纳米激光的相干可重构功能，展示了纳米激光能够以“中”、“国”等图形生成可重构的阵列化相干激射（图 2）。在光频段实现相位可控阵列为纳米激光的应用铺平了道路。通过相位同步，纳米激光阵列能够实现大面积、高功率的单模激射；精细的相对相位调节可实现激光阵列出射方向的精准控制。同时，纳米激光之间的相干性还可用于进行相干计算和通信。

相关研究论文分别发表于 2023 年 12 月 13 日的 Nature[624: 282-288] 和 2024 年 7 月 17 日的 Nature [632, 287-293]，受到国内外广泛关注和高度评价。Nature 专题报道，认为为探索更小、更智能、更强大的激光光源开辟了道路（Nature 624, 260-261, 2023）；Nature Materials 综述论文高度评价该成果，认为实现了激光研究领域长期追求的一个目标（Nature Materials 23, 1179–1192 (2024)）。同时成果入选了 2024 中关村论坛重大科技成果（面向世界科技前沿 -2/5），2024 国家自然科学基金委年度优秀成果巡礼，2024 年中国重大技术进展和 2024 中国光学十大进展。

◎ Nanolasers with atomic-scale feature sizes and reconfigurable phased arrays

The miniaturization of lasers has ushered in a new era in photonic technology, profoundly transforming science, technology, and everyday life. Since the 1990s, institutions such as Bell Labs, Caltech, Harvard University, and the University of California, Berkeley, have successively developed novel miniaturized lasers, including microdisk lasers, photonic crystal lasers, and plasmonic nanolasers. Through continuous technological innovation, these advances have pushed the characteristic dimensions of lasers to unprecedented limits, reaching the scale of 10 nanometers. Ren-Min Ma and colleagues at Peking University proposed the singular dispersion equation, establishing a theoretical framework for dielectric systems to surpass the optical diffraction limit, and developed the smallest-mode-volume laser to date (Fig. 1). Their singular dielectric nanolaser has further reduced the characteristic scale of lasers to the atomic level.

Advancing laser miniaturization to the atomic scale marks a new milestone in spatial compression of laser optical fields, bringing the scale of light confinement to the proximity of atomic structures and opening new frontiers for laser technology. On one hand, nanolasers with extremely localized optical fields offer high energy efficiency and integration density, making them promising candidates for next-generation light sources in information technology, driving innovations in low-power data communication and nanophotonic integrated chips. On the other hand, generating coherent optical fields directly at the atomic scale could lead to novel extreme-resolution optical imaging technologies, providing a new pathway for direct observation of biomolecules such as DNA and RNA. Furthermore, in fundamental physics, the highly localized optical fields can significantly enhance light-matter interactions, offering an important experimental platform for cutting-edge research in cavity quantum electrodynamics, nonlinear optics, and quantum optics.

In addition, Ren-Min Ma and colleagues have realized a reconfigurable optical frequency phased array, achieving coherent reconfigurability in nanolasing (Fig. 2). Their work demonstrated that nanolasers can generate reconfigurable coherent lasing arrays in the shapes of Chinese characters such as " 中 " (China) and " 国 " (nation). The realization of phase-controllable arrays in the optical frequency domain paves the way for nanolaser applications. By phase synchronization, nanolaser arrays can achieve large-area, high-power single-mode lasing, while fine-tuned relative phase control enables precise beam steering. Moreover, the coherence between nanolasers can be leveraged for applications in coherent computing and communication.

These research findings were published in Nature on December 13, 2023 (Nature 624, 282–288) and July 17, 2024 (Nature 632, 287–293), garnering widespread attention both domestically and internationally. A Nature News & Views article highlighted this breakthrough as paving the way for smaller, smarter, and more powerful laser sources (Nature 624, 260–261, 2023). A Nature Materials review article praised the work as achieving a long-pursued goal in laser research (Nature Materials 23, 1179–1192, 2024). Additionally, this achievement was selected as one of the major technological breakthroughs of the 2024 Zhongguancun Forum (Frontier Science and Technology - 2/5), featured in the 2024 Annual Outstanding Achievements of the National Natural Science Foundation of China, and recognized among the Top 10 Technological Advances in China 2024 and Top 10 Optical Advances in China 2024.

供稿：凝聚态物理与材料物理研究所
审核：杨学林

03 现代光学研究所
Institute of Modern Optics

1933 年饶毓泰先生就职北京大学物理系，同期开创了光学及原子分子结构这一研究方向， 并长期保持着良好的发展态势。2001 年 5 月，在北京大学原物理系光学专业的基础上，成立了北京大学现代光学研究所，首任所长为龚旗煌教授。2021 年刘运全教授任新一届所长。截止到 2024 年底，现代光学研究所有固定人员 32 人（3 人为 2023-2024 年度引进），其中教授 18 人（含博雅讲席教授 1 人、博雅特聘教授 10 人），博雅青年学者 8 人， 副教授 2 人，教授级高级工程师 1 人，高级工程师 2 人，工程师 1 人。

现代光学研究所现拥有光学和原子分子物理两个二级学科，重点布局介观光学与微纳光子学、超快光学和原子分子强场物理、物理光学与非线性光学和光电功能材料与器件物理等研究方向。面向科技前沿、国家重大需求开展有组织科研，注重在信息、能源、生命等领域的应用研究和成果的转移转化。是“人工微结构和介观物理全国重点实验室”及“纳光电子前沿科学中心”的重要支撑力量，也是北京大学长三角光电科学研究院的主要依托建设单位。

2023-2024 年度，现代光学研究所累计发表论文超过 180 篇，其中包括 Nature 3 篇，Science 3 篇，Nature Photonics 3 篇、Nature Physics 3 篇、Nature Energy 1 篇、Natue Materials 1 篇、Nature Reviews Materials 1 篇、Science Advances 2 篇、Physical Review Letters 16 篇等顶级期刊文章。现代光学研究所成果荣获多项奖励。2023 年，项目“对称破缺微腔光物理与应用”获得高等学校科学研究优秀成果奖自然科学一等奖、项目“跨尺度场调控新型光子效应与应用”获得北京市自然科学二等奖、项目“Single-molecule optofluidic microsensor with interface whispering gallery modes”入选中国光学十大进展、项目“超快强场激光场下量子隧穿理论和实验研究”获得中国光学学会科技奖基础研究类一等奖。2024 年，项目“具有纠缠修复能力的多芯片高维量子网络”入选中国光学十大进展、项目“介观尺度单颗粒的声学指纹振动谱测量”入选中国光学十大进展。

现代光学研究所在人才培养方面成效显著。现代光学研究所现有中科院院士 1 人，长江特聘教授 4 人，杰出青年基金获得者 11 人，万人计划领军人才 3 人，国家级优秀青年人才计划获得者 14 人。2023 年，王剑威获得王大珩光学奖中青年科技人员奖、朱瑞获得中国物理学会萨本栋应用物理奖、何琼毅获得第十九届中国女科学家奖个人奖、杨宏获得优秀党务工作者李大钊奖。2024 年，胡耀文入选《麻省理工科技评论》“35 岁以下科技创新 35 人”中国区榜单、刘运全获得北京市优秀博士学位论文指导教师。多位研究生也获得了重要奖励。2023 年，郑赟获得第二十届王大珩光学奖学生奖、李耀龙获得北京市优秀博士学位论文。2024 年，方一奇获得北京市优秀博士学位论文、方一奇获得中国光学学会科技创新奖一等奖（郭光灿光学奖）、刘炎武获得第二十一届王大珩光学奖高校学生光学奖、戴天祥获得第十四届北京大学学生五四奖章、李靖获得国际光学工程学会（SPIE）奖学金等。

In 1933, Professor Rao Yutai joined the Department of Physics of Peking University and then started the research direction of optics and atomic-molecular structure, which has been keeping up good development until now. In May 2001, the Institute of Modern Optics was established on the basis of the former Department of Optics, and its first director was Professor Gong Qihuang. 2021 Professor Liu Yunquan was appointed as the new director. By the end of 2024, the Institute of Modern Optics has 32 permanent staff (3 were introduced in 2023-2024), including 18 professors (including 1 Boyer Chair Professor and 10 Boyer Distinguished Professors), 8 Boyer Young Scholars, 2 associate professors, 1 professorial senior engineer, 2 senior engineers, and 1 engineer.

The Institute of Modern Optics has two secondary disciplines including optics and atomic-molecular physics. Especially we Focus on the research directions such as mesoscopy and micro- and nano-photonics, ultrafast optics and strong field physics of atoms and molecules, physical optics and nonlinear optics, and physics of optoelectronic functional materials and devices. We always put the major needs of the country in the first, and follow the frontiers of science and technology in the world. In addition, we focus on application and transfer of our research in the fields of information, energy and life. It is an important supporting force of the State Key Laboratory of Artificial Microstructure and Mesoscopic Physics and the Frontier Science Center of the Ministry of Nanophotonics, and is also the main supporting unit of the Yangtze River Delta Institute of Optoelectronic Science of Peking University.

From 2023 to 2024, We have published more than 180 papers, including 3 articles in Nature, 3 articles in Science, 3 articles in Nature Photonics, 3 articles in Nature Physics, 1 article in Nature Energy, 1 article in Nature Materials, 1 article in Nature Reviews Materials, 2 articles in Science Advances, and 16 articles in Physical Review Letters and other top journals. In 2023, the project " symmetry breaking in microcavity optics and its applications " won the first prize of natural science in the prize of excellent achievements in scientific research (science and technology) of higher education institutions, the project "cross-scale field modulation of novel photonic effects and applications" won the second prize of the Beijing natural science award, the project “Single-molecule optofluidic microsensor with interface whispering gallery modes” was selected as one of the top ten advances in optics in China. In 2024, the project " multichip multidimensional quantum networks with entanglement retrievability" was selected as one of the top ten advances in optics in China, the project “measurement of acoustic fingerprint vibrational spectra of single particles at the mesoscopic scale” was selected as one of the top ten advances in optics in China.

The Institute of Modern Optics has achieved remarkable results in the cultivation of talents. There is one academician of Chinese Academy of Sciences, four Cheung Kong Distinguished Professors, eleven Distinguished Youth Fund recipients, three leading talents of the Ten Thousand Talents Program, and fourteen national outstanding young talents program recipients. In 2023,Wang Jianwei was awarded the Wang Daheng Optics Award for Young Scientists in Optics, Zhu rui was awarded Pen-Tung Sah applied physics prize of China Physical Society, He Qiongyi was awarded the 19th China young women scientists award, Yang Hong was awarded Li Dazhao award for outstanding party workers in Peking University,. In 2024, Hu Yaowen was selected as one of the MIT Technology Review "35 Under 35 in Science and Technology Innovation", Liu Yunquan was awarded outstanding doctoral dissertation supervisor in Beijing. Several graduate students have also received important awards. In 2023, Zheng Yun received the Student Award of the 20th Wang Daheng Optics Prize of the Optical Society of China, Li Yaolong was awarded Beijing outstanding doctoral dissertation award. In 2024, Fang Yiqi was awarded Beijing outstanding doctoral dissertation award, Fang Yiqi was awarded first prize of science and technology innovation award of the China Optical Society (Guo Guangcan Optics Prize), Liu Yanwu received the Student Award of the 21st Wang Daheng optics prize of the Optical Society of China, Dai Tianxiang received The 14th student May Fourth Medal of Peking University, Li Jing received SPIE optics & photonics education scholarship.

◎ 量子纠缠高效检测及其在量子随机数验证中的应用

高效检测量子纠缠是利用纠缠资源的首要前提。非高斯量子态凭借其高阶关联特性， 在通用量子计算、纠缠提纯，量子精密测量等方面展现出独特优势，近年来广受关注。但非高斯量子态的高阶关联通常需要利用可观测量的高阶矩进行刻画，纠缠检测从理论到实验都存在挑战，亟需寻找一套适用于非高斯态的关联检测方法。针对原子体系，何琼毅课题组通过引入置换对称性和少体关联的约束，基于高阶关联，提出了多体非高斯自旋体系中贝尔非定域性的检测新判据。相比于低阶不等式，该判据探测非定域性的能力明显提高，不仅具有更强的抗噪声鲁棒性，对于非高斯态贝尔非定域性的探测也更加敏感；进一步针对实验可测的集体自旋算符，利用半正定规划法优化设计了对实验更友好的高阶贝尔不等式，减少实验所需的高阶测量个数，便于实验操作。相关研究成果发表于《物理评论快报》（Phys. Rev. Lett. 2023, 131, 070201）。同时，针对连续变量非高斯态的纠缠检测困难，为减少可观测量高阶矩的测量，增强实验检测的可操作性，提出了基于神经网络的非高斯纠缠高效检测方法。利用深度学习算法，通过构建神经网络，仅利用易于实验获取的一阶、二阶矩关联图像就可以实现对一般双模量子态的纠缠判定。在相同的有限实验数据下，该方法展示了比基于最大似然态层析的常规方法更高的纠缠检测准确率。同时，利用 t-SNE 算法对关联图像进行了数据降维后可视化的处理，分析了关联图像经过神经网络前后的聚类变化，并对神经网络的鲁棒性进行了分析。相关研究成果发表于《物理评论快报》（Phys. Rev. Lett. 2024, 132, 220202）。

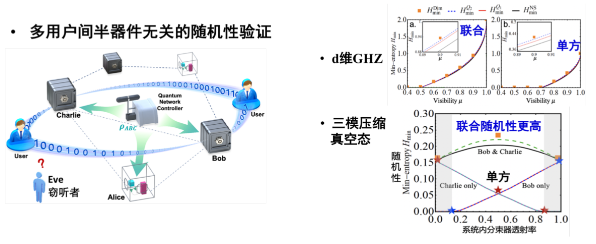


图 1：多用户量子网络中半器件无关的随机数验证方案（左图），基于多方联合测量结果可以比基于单方的方案验证更高的随机性，且方案适用于任意维度系统（右图）。FIG. 1. Schematic view on randomness generation in multipartite network (Left). A controller sends a tripartite state ρABC to three nodes. Two of these nodes (Bob and Charlie) perform measurements with the aim to use the results as a source of randomness. The measurements of Bob and Charlie are not characterized, consequently they are represented by black boxes. A third trusted party (Alice) performs well-characterized measurements, determining the set of conditional states, thereby limiting the potential attacks by an eavesdropper. We find that the separation between Bob and Charlie allows us to generate more randomness than as if they are grouped together (Right).

随机数是一种重要的基础资源，在量子安全通信和基础科学研究中扮演着至关重要的角色。何琼毅课题组首次提出了多用户量子网络中半器件无关的随机数验证方案，比传统的两用户方案可以产生更高的随机数，且方案具有普适性，适用于任意维度的系统（如图 1 所示）。同时，证明了只有在选取两测量时量子非定域性才是产生随机性的充分必要条件，揭示了量子随机性产生的物理本质。相关研究成果发表于《物理评论快报》（Phys. Rev. Lett. 2024, 132, 080201）。在取得理论研究进展之后，课题组随即与中国科学技术大学合作在基于光子多路径编码的高维纠缠态中首次实现了多输入多输出场景下完全设备无关的随机性验证，并且展示了并非所有的贝尔非定域性都可用于设备无关随机数验证。相关研究成果发表于 （Phys. Rev. Lett. 2025, 134, 090201）；同时，与山西大学实验组合作在由光纤连接的远距离节点间，利用共享的连续变量导引态实现了半设备无关量子随机数的提取。相关研究成果发表于 （Light: Sci. & Appl. 2025, 14, 25）。

◎ Detecting quantum entanglement and its application in quantum randomness verification

Entanglement in non-Gaussian states provides irreplaceable advantages in many quantum information tasks. However, the sheer amount of information in such states grows exponentially and makes a full characterization impossible. He Qiongyi's research group has conducted systematic research on the critical challenges of detecting and utilizing multipartite and non-

Gaussian quantum entanglement. First, we expand the toolbox for studying Bell correlations in multipartite systems by introducing permutationally invariant Bell inequalities (PIBIs) involving few-body correlators. We present around twenty families of PIBIs with up to three- or four-body correlators, that are valid for an arbitrary number of particles. Compared to known inequalities, these show higher noise robustness, or the capability to detect Bell correlations in highly non-Gaussian spin states. We then focus on finding PIBIs that are of practical experimental implementation, in the sense that the associated operators require collective spin measure- ments along only a few directions. To this end, we formulate this search problem as a semidefinite program that embeds the constraints required to look for PIBIs of the desired form. This work was published in Physical Review Letters (Phys. Rev. Lett. 2023, 131, 070201). Then, we develop a neural network that allows us to use correlation patterns to effectively detect continuous-variable entanglement through homodyne detection. Using a recently defined stellar hierarchy to rank the states used for training, our algorithm works not only on any kind of Gaussian state but also on a whole class of experimentally achievable non-Gaussian states, including photon-subtracted states. With the same limited amount of data, our method provides higher accuracy than usual methods to detect entanglement based on maximum-likelihood tomography. Moreover, in order to visualize the effect of the neural network, we employ a dimension reduction algorithm on the patterns. This shows that a clear boundary appears between the entangled states and others after the neural network processing. Our findings provide a new approach for experimental detection of continuous-variable quantum correlations without resorting to a full tomography of the state and confirm the exciting potential of neural networks in quantum information processing. This work was published in Physical Review Letters (Phys. Rev. Lett. 2024, 132, 220202).

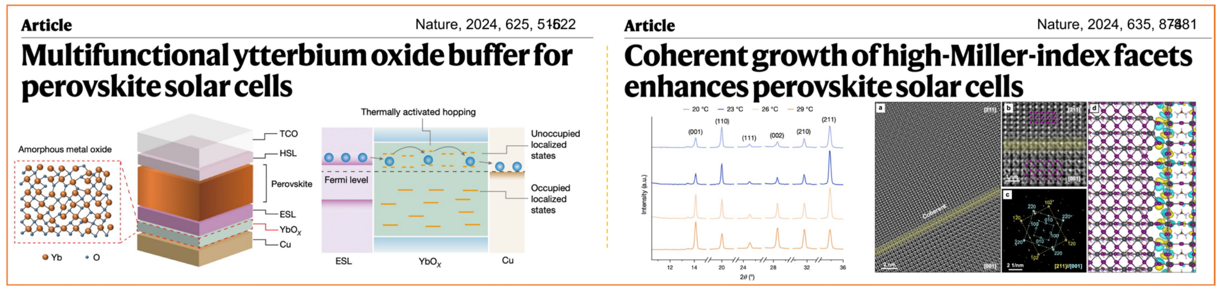
Towards the development of quantum networks, we propose to use multipartite entanglement distributed between trusted and untrusted parties for generating randomness of arbitrary dimensional systems. We show that the distributed structure of several parties leads to additional protection against possible attacks by an eavesdropper, resulting in more secure randomness generated than in the corresponding bipartite scenario. Especially, randomness can be certified in the group of untrusted parties, even when there is no randomness in either of them individually. We prove that the necessary and sufficient resource for quantum randomness in this scenario is multipartite quantum steering when each untrusted party has a choice between only two measurements. However, the sufficiency no longer holds with more measurement settings. This work was published in Physical Review Letters (Phys. Rev. Lett. 2024, 132, 080201). After making progress in theoretical research, we immediately cooperate with the experimental group at University of Science and Technology of China and realize the first fully device-independent randomness verification in a multi-input and multi-output scenario with a high-dimensional entangled state. We prove and experimentally demonstrate that violating any two-input Bell inequality is both necessary and sufficient for certifying randomness, however, for the multiple-input cases, this sufficiency ceases to apply, leading to certain states exhibiting Bell nonlocality without the capability to certify randomness (Phys. Rev. Lett. 2025, 134, 090201). At the same time, in cooperation with the experimental group at Shanxi University, we distribute quantum steering between two distant users through a 2 km fiber channel and generate quantum random numbers at the remote station with untrustworthy device. Then, the quantum random numbers with a generation rate of 7.06 Mbits/s are extracted from the measured amplitude quadrature fluctuation of the state owned by the remote party (Light: Sci. & Appl. 2025, 14, 25).

◎ 高性能反式结构钙钛矿太阳能电池

太阳能的利用是当前物理、能源、材料等学科交叉研究的前沿热点。近年来，金属卤化物钙钛矿太阳能电池的光电转化效率不断提升，已接近商业化晶硅电池的水平。其中具有反式结构的钙钛矿太阳能电池因其成本低廉、低温制备、适用于制备叠层器件、高稳定性等优势吸引了广泛的关注。

北京大学物理学院现代光学研究所“极端光学创新研究团队”朱瑞教授和龚旗煌院士团队与合作者在反式结构钙钛矿太阳能电池界面缓冲层方向展开研究。针对电池上界面物质扩散和离子迁移诱发电池性能衰退的难题，团队通过采用“物理气相沉积 + 高真空原位快速氧化”方法创新构筑非晶态稀土金属氧化物氧化镱（α-YbO_x）多功能界面缓冲层，突破了基于金属氧化物缓冲层反式结构电池 25% 的光电转换效率瓶颈，并且显著提升了电池的稳定性。团队在电池的最大功率点下持续监测电池稳定性，电池工作 1000 小时后，光电效率仍然保持初始的 97%。研究成果发表于《自然》杂志上（Nature, 2024, 625, 516-522）。该工作成功证明了 α-YbO_x 界面缓冲层在反式结构钙钛矿太阳能电池中具有显著的优势，推动了钙钛矿太阳能电池向产业化方向的发展。

此外，研究团队在已有工作基础上，针对钙钛矿薄膜体相缺陷问题，与牛津大学、剑桥大学、北京航空航天大学和宁波东方理工大学（暂名）的合作者开展研究，发展温度精细调控策略，实现高密勒指数晶面择优取向，成功研制出高质量微米级钙钛矿厚膜，有效解决钙钛矿电池制备中季节依赖性问题，在反式钙钛矿太阳能电池中获得了 26.1% 的光电转换效率。研究成果发表于《自然》杂志上（Nature, 2024, 635, 874-881）。这一突破为提升反式钙钛矿太阳能电池的光电转换效率和推动新型太阳能电池的应用提供了重要的方法指导，同时也为后续高性能钙钛矿太阳能电池的研究拓展了新的思路。



图左．基于氧化镱多功能缓冲层的钙钛矿太阳能电池器件结构和载流子传输示意图；图右．通过温度调控实现高密勒指数晶面择优取向，并采用原子尺度高分辨率冷冻透射电镜获得钙钛矿薄膜的相干晶界

Figure left. Device structure and charge carrier transport schematic of PSCs with the α-YbOx multifunctional buffer layer.

Figure right. The optimal orientation of high-Miller-index crystalline facets through controlling the atmospheric processing temperature, and atomic-scale high-resolution Cryo-transmission electron microscopy (Cryo-TEM) images and coherent grain boundaries.

◎ High-performance inverted perovskite solar cells

The utilization of solar energy is the cutting-edge of interdisciplinary research spanning physics, energy, and materials science. In recent years, the power conversion efficiency (PCE) of metal halide perovskite solar cells (PSCs) has been continuously improving, now rivaling that of commercial silicon-based solar cells. PSCs with an inverted structure have attracted widespread attention due to their advantages of low cost, low-temperature fabrication, suitability for fabricating tandem devices, and high stability.

Prof. Rui Zhu and CAS Academician Prof. Qihuang Gong, in collaboration with partners, have conducted the research on the interface buffer layer in p-i-n PSCs. Addressing the critical challenge of performance degradation in cells caused by interfacial material diffusion and ion migration. By innovatively applying a "physical vapor deposition + high-vacuum in situ rapid oxidation" technique, the team constructed an amorphous rare-earth metal oxide ytterbium oxide (α-YbOX) multifunctional interfacial buffer layer. This breakthrough surpassed the 25% efficiency threshold for p-i-n PSCs based on metal oxide buffer layers while significantly enhancing device stability. The team continuously monitored the stability of the cells at the maximum power point, and after 1000 hours of operation, the PCE remained at 97% of its initial value. These results have been published on Nature (Nature, 2024, 625, 516–522). This work successfully demonstrates the significant advantages of α-YbOX interfacial buffer layers in p-i-n PSCs, pushing forward the commeciallization of perovskite photovoltaics.

In addition, the research group has carried out a great deal of research on the problem of bulk defects in perovskite films. With collaborators from University of Oxford, University of Cambridge, Beihang University and Eastern Institute of Technology, Ningbo, the team has realized the optimal orientation of high-Miller-index crystalline facets through controlling the atmospheric processing temperature. Micron-thick perovskite films processed in a stabilized atmosphere were successfully developed. The devices presented a high reproducibility across all four seasons, and achieved the PCE of 26.1%. The studies have been published on Nature (Nature, 2024, 635, 874-881). This breakthrough provides important methodological guidance for improving the PCE of PSCs and promoting the application of new solar cells, as well as expands new ideas for subsequent research on high-performance PSCs.

供稿：现代光学研究所
审核：吕国伟

04 重离子物理研究所
Institute of Heavy Ion Physics

北京大学重离子物理研究所创建于 1983 年 5 月，其顺应学科前沿发展和国家战略需求，一直致力于探索加速器科技前沿，聚焦能源、先进制造和生命健康等关乎人类生存与发展的重大问题，以建设成为国际顶尖的前沿应用科学研究和人才培养基地为目标。

重离子物理研究所现有核技术及应用、医学物理与工程、等离子体物理、高能量密度物理 4 个二级学科。现有全职正式教职工 48 人，其中教授 9 人、研究员 3 人、教授级高级工程师 4 人、长聘副教授 1 人、副教授 6 人、副研究员 1 人、预聘制助理教授 4 人、高级工程师 12 人、工程师 5 人、助理研究员 2 人、工人 1 人。

The Institute of Heavy Ion Physics at Peking University was founded in May 1983. Adhering to the forefront of disciplinary development and national strategic needs, it has been committed to exploring accelerator technology, focusing on major issues related to human survival and development such as energy, advanced manufacturing, and life and health. Its overall objective is to establish an international top-level frontier applied science and talent training base.

The institute has four secondary disciplines: Nuclear Technology and Applications, Medical Physics and Engineering, Plasma Physics, and High Energy Density Physics. It currently has 48 faculty members, including 6 professors，3 tenured full professors，3 research fellows，4 professorship engineers，1 tenured associate professor, 6 associate professors, 1 associate research fellow, 4 tenure-track assistant professors, 12 senior engineers，5 engineers，2 assistant researchers and 1 worker.

◎ 碳纳米管等离子体与飞秒拍瓦激光作用产生高亮度 X 射线脉冲

高能 X 射线（硬 X 射线）在物质结构解析、材料表征、医学诊疗等领域有着广泛的应用。具有更高亮度，更短脉冲，更紧凑尺寸的硬 X 射线源的研发一直是重要的研究课题。以激光为驱动源的高亮度 X 射线源被认为是最有潜力的发展方向之一。基于尾波场加速机制的台面式射线源和自由电子激光已经获得了实验证实。然而，这类射线源受限于被加速电子数目，从激光到 X 光的能量转换效率一般在 10^{-7}-10^{-5}，这极大限制了其应用前景。

马文君团队使用由碳纳米管构成的靶材，在拍瓦（10^{15}W）飞秒脉冲激光的作用下，通过激光场直接加速的方式产生百兆电子伏特以上的高能电子。利用同步辐射和非线性康普顿散射机制，让高速运动的电子释放出高能光子。实验结果表明，硬 X 射线区的峰值亮度达到了 10^{21}/s/mm^2/mrad^2/0.1%BW，与当下正在运行的大型同步辐射光源相当（如图 a 所示）。在 30 keV 到 1 MeV 的能谱区间内，探测到了超过 10^{10} 光子 / 焦耳激光能量的硬 X 射线产额，能量转化效率达到 10^{-3} 量级。这个转化率相比基于尾波场加速机制的光源，提高了 2 到 3 个数量级（如图 b 所示）。

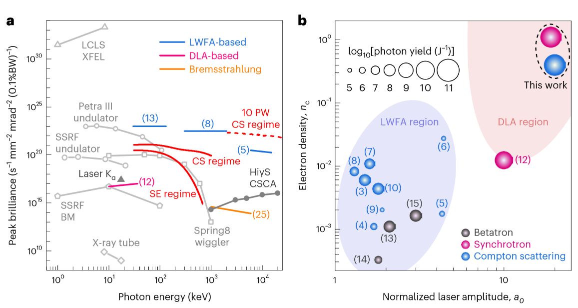


图 (a) 本工作与各类 X 射线光源的峰值亮度对比。SSRF、PetraIII、Spring8 分别是正在运行的位于上海、德国、日本的大型同步辐射光源。(b) 本工作与其他基于激光加速的 X 射线源对比。其中紫色区域是尾波场加速机制所在的参数区间，粉色区域是激光直接加速机制最佳参数区间。

该 X 射线脉冲光源具有非常大的照射视野，可以实现大体积样品的皮秒尺度瞬态成像与物性研究，在极端条件物理研究中有重大潜力。作者在该工作中也展望了在 10 拍瓦激光驱动下使用此方案可获得的光源参数。模拟结果显示光子的平均能量将超过 1MeV，转换效率可达到 1%，有望为光核物理、实验室天体物理、非微扰量子电动力学及真空物理等领域开扩出新的研究空间。

研究成果以“Brilliant femtosecond-laser-driven hard X-ray flashes from carbon nanotube plasma”为题发表在 Nature Photonics 杂志上（Y. R. Shou, et. al, Nat Photonics 17 (2), 137-142 (2023).），并被选为 2023 年第 2 期封面文章。领域内研究者对此项工作给予了高度评价，在当期 Nature Photonics 杂志上刊登了题目为“Lighting up a nest for X-ray emission ”的评述文章。

HIGHLIGHTS
系所中心研究亮点

◎ High-Brightness X-Ray Pulses Generated by Carbon Nanotube Plasma Interacting with Femtosecond Petawatt Lasers

High-energy X-rays (hard X-rays) have extensive applications in material structure analysis, material characterization, and medical diagnostics. The development of hard X-ray sources with higher brightness, shorter pulses, and more compact sizes has long been a critical research topic. Laser-driven high-brightness X-ray sources are considered one of the most promising directions. Compact X-ray sources based on wakefield acceleration mechanisms and free-electron lasers have been experimentally demonstrated. However, these sources are limited by the number of accelerated electrons, with energy conversion efficiencies from laser to X-rays typically ranging between 10^{-7}-10^{-5}, greatly restricting their application potential.

The team led by Prof. Wenjun Ma employed carbon nanotube-based targets and utilized femtosecond petawatt (10^{15} W) laser pulses to directly accelerate electrons to energies exceeding hundreds of mega-electron volts. Through mechanisms such as synchrotron radiation and nonlinear Compton scattering, these high-speed electrons emitted high-energy photons. Experimental results revealed that the peak brightness of hard X-rays in this work reached10^{21}/s/mm^2/mrad^2/0.1%BW, comparable to large-scale synchrotron radiation sources currently in operation (as shown in Fig. a). In the energy spectrum range of 30 keV to 1 MeV, over 10^{10} photons per joule of laser energy were detected, achieving an energy conversion efficiency of 10^{-3} . This efficiency is 2 to 3 orders of magnitude higher than X-ray sources based on wakefield acceleration mechanisms (as shown in Fig. b).

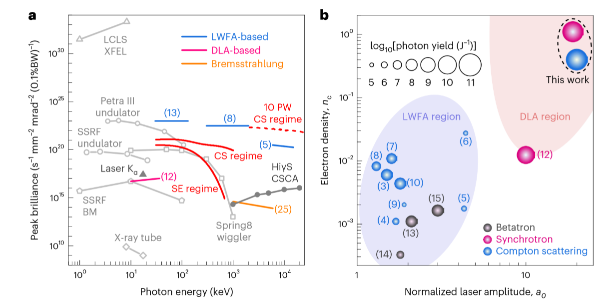


Figure (a). Comparisons of the peak brightness achieved in this work with various X-ray sources. SSRF, Petra III, and Spring-8 are large synchrotron radiation facilities currently operating in Shanghai, Germany, and Japan, respectively. Figure (b).Comparisons of this work with other laser-driven X-ray sources. The purple region represents the parameter range of wakefield acceleration mechanisms, while the pink region indicates the optimal parameter range for direct laser acceleration mechanisms.

This X-ray pulse source features an exceptionally large irradiation field, enabling picosecond-scale transient imaging and property studies of large-volume samples. It holds significant potential in research on extreme-condition physics. The authors also envision the capabilities of this scheme under 10-petawatt laser conditions, predicting photon energies exceeding 1 MeV and energy conversion efficiencies reaching 1%. This could open new research avenues in areas such as photonuclear physics, laboratory astrophysics, non-perturbative quantum electrodynamics, and vacuum physics.

The research findings, titled "Brilliant femtosecond-laser-driven hard X-ray flashes from carbon nanotube plasma," were published in Nature

Photonics (Y. R. Shou, et. al, Nat Photonics 17 (2), 137-142 (2023).) and selected as the cover article for Issue 2, 2023. Researchers in the field have highly praised this work, and a commentary article titled "Lighting up a nest for X-ray emission" was featured in the same issue of Nature Photonics.

◎ 同步辐射技术在材料构效关系研究中的应用

氧还原反应（Oxygen reduction reaction, ORR）是燃料电池阴极的关键反应，其效率直接影响着燃料电池的性能。目前常用的铂基催化剂存在成本高和易中毒失活等问题，严重制约了燃料电池的大规模应用。因此，发展高活性和高耐受能力的氧还原反应催化剂对于提升燃料电池性能至关重要。近年来，晶体缺陷在材料学领域中备受关注，但相关研究在铂基催化剂领域仍较为少见。

联合团队利用一步热解法在石墨烯上负载了镍掺杂的铂纳米颗粒，通过锌的汽化热解过程引入原子尺度的缺陷。进一步，采用同步辐射 X 射线吸收光谱（X-ray absorption fine structure, XAFS）结合同步辐射 X 射线衍射技术获取分布函数（Pair distribution function, PDF）对缺陷造成的结构应变进行了详细的研究。XAFS 结果表明，缺陷的引入压缩了 Pt-Pt 第一配位壳层，说明缺陷的引入引起晶格畸变导致了压缩应变。然而，XAFS 仅对局部结构敏感，难以获得中长程范围内的结构信息。因此，研究人员进一步使用 PDF 对晶格长程范围进行进一步表征。实验结果表明，富缺陷的铂纳米颗粒的 Pt-Pt 第一、二、四、六、九、十配位壳层发生压缩，Pt-Pt 第三、六、七、八配位壳层发生拉伸，即在中长程有序范围内晶格同时存在拉伸和压缩应变，该晶格拉伸与压缩共存的混合应变结构首次被发现和报道。性能测试表明，该混合应变结构有效提升了铂颗粒抗一氧化碳毒化性能和甲醇耐受性能，结合 Ni 与 Pt 之间的电子协同效应同时实现 ORR 性能的提升。

该工作利用同步辐射 X 射线技术深入研究了铂纳米颗粒中原子尺度缺陷的构建及其对短程及中长程结构的影响，首次阐明了原子尺度缺陷能够在中长程结构范围形成压缩与拉伸混合应变，并提出应力效应与配体效应的协同策略，为调节金属基纳米材料的电催化活性提供了全新的思路。

相关研究以“利用原子尺度缺陷和配体效应之间的协同相互作用优化氧还原活性和耐受性”（Harnessing the Synergistic Interplay between Atomic-Scale Vacancies and Ligand Effect to Optimize the Oxygen Reduction Activity and Tolerance Performance）为题，发表于《德国应用化学》（Angewandlt Chemie International Edition, 2025, 64, e202414989）。物理学院博士研究生叶盛华和深圳大学硕士研究生陈文达为文章共同第一作者，颜学庆、张黔玲教授和郑黎荣为共同通讯作者。

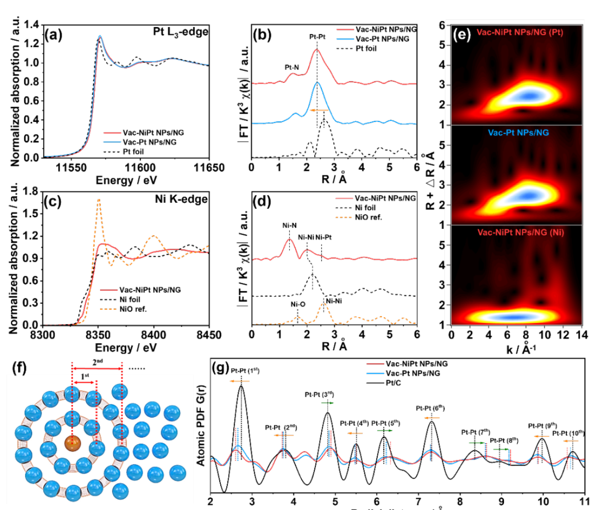


图 同步辐射 X 射线吸收光谱及 X 射线衍射分布函数结果

Figure: Results of Synchrotron Radiation X-ray Absorption Spectroscopy and X-ray Diffraction Distribution Function

◎ Application of Synchrotron Radiation Technology in the Study of Structure-Activity Relationships in Materials

The oxygen reduction reaction (ORR) is a critical process at the cathode of fuel cells, and its efficiency directly impacts fuel cell performance. Current platinum-based catalysts face challenges such as high costs and susceptibility to poisoning and deactivation, significantly hindering the large-scale application of fuel cells. In recent years, crystal defects have garnered significant attention in materials science, yet related studies remain scarce in the field of platinum-based catalysts.

The research team synthesized nickel-doped platinum nanoparticles on graphene via a one-step pyrolysis method, introducing atomic-scale defects through a zinc vaporization process. Synchrotron X-ray absorption fine structure (XAFS) spectroscopy and X-ray diffraction pair distribution function (PDF) analysis were employed to investigate structural strain induced by these defects. XAFS results indicated that defect introduction compressed the first coordination shell of Pt-Pt bonds, suggesting lattice distortion caused compressive strain. PDF analysis revealed that defect-rich platinum nanoparticles exhibited compressive strain in the first, second, fourth, sixth, ninth, and tenth Pt-Pt coordination shells, while tensile strain occurred in the third, sixth, seventh, and eighth shells. This coexistence of compressive and tensile strain in medium-to-long-range ordered lattices was reported for the first time, and this mixed-strain structure significantly enhanced the CO-poisoning resistance and methanol tolerance of platinum nanoparticles. Combined with the electronic synergy between Ni and Pt, the ORR activity was also improved.

This study utilized synchrotron X-ray techniques to investigate the construction of atomic-scale defects in platinum nanoparticles and their impact on short- and medium-to-long-range structures. It elucidated, for the first time, how atomic-scale defects induce mixed compressive and tensile strain across medium-to-long-range lattices. A synergistic strategy involving strain and ligand effects was proposed, offering novel insights for tuning the electrocatalytic activity of metal-based nanomaterials.

The above research was published online in Angewandte Chemie International Edition (Angew. Chem. Int. Ed., 2025, 64, e202414989), titled "Harnessing the Synergistic Interplay between Atomic-Scale Vacancies and Ligand Effect to Optimize the Oxygen Reduction Activity and Tolerance Performance,", Ph.D. candidate Shenghua Ye (School of Physics) and Master's candidate Wenda Chen (Shenzhen University) are co-first authors. Professors Xueqing Yan, Qianling Zhang, and Lirong Zheng are corresponding authors.

供稿：重离子物理研究所

审核：林晨

05 技术物理系

Department of Technical Physics

技术物理系现有教职员工 33 人，其中：教授 10 人（其中中科院院士 1 人，杰青 5 人，长江特聘教授 2 人），副教授 5 人，长聘副教授 4 人（其中万人计划科技创新领军人才 1 人，优青 1 人，博雅青年学者 2 人），预聘助理教授 5 人（其中万人计划青年拔尖人才 1 人，博雅青年学者 3 人），副研究员 1 人，教授级高级工程师 1 人，高级工程师 3 人，和工程师 4 人。研究方向涵盖：实验核结构与反应、理论核结构、高能实验物理、中高能核理论、应用核物理、辐射防护、探测器研发、核电子学等。该系有一个亚原子粒子探测实验室；一个核技术应用实验室；一个核物理与核技术教学实验室；一个北大 - 兰州联合核物理中心。核技术应用实验室拥有包括电弧熔炼、2×1.7 MV 串列加速器、透射电子显微镜和 X 射线衍仪等先进设备，主要服务于核能材料与核技术应用领域的研究。

作为“核物理与核技术国家重点实验室”的核心组成部分，技术物理系承担了多项国家级科研项目，拥有全国唯一的核物理理科基地，建立了广泛的国内外合作，包括中美奇特核理论物理研究所 (CUSTIPEN)；高能物理方面与欧洲 LHC 和北京 BEPC-BES 合作；核物理方面与日本 RIKEN-RIBF、兰州 HIRFL 和北京 CIAE 合作等；人才培养方面，自 2008 年起与日本理化所共建“仁科学校”（Nishina School），开拓学生国际视野。

There are 33 faculty members in the department, including 10 full professors (including 1 academician of the CAS, 3 National Outstanding Young Scientists and 2 Changjiang Scholar Professors), 5 associate professors, 4 tenured associate professors (including 1 leading talents of the Ten Thousand Talents Program, 1 National Outstanding Junior Young Scientist and 2 Boya Young Scholars), 5 tenure-track assistant professors (including 1 Youth Top-notch talent of the Ten Thousand Talents Program and 3 Boya Young Scholars), 1 associate research fellow, 1 professorship engineer, 3 senior engineers, and 4 engineers. The research fields cover experimental nuclear structure and reaction, theoretical nuclear structure, experimental high-energy physics, theoretical intermediate and high-energy physics, applied nuclear physics, radiation protection, detector technique and nuclear electronics. The department has a subatomic particle detection laboratory, a nuclear technology application laboratory, an education laboratory for nuclear physics and technology, and a PKU-Lanzhou joint center for nuclear physics. The nuclear technology application laboratory is equipped with critical facilities such as arch melting system, 2×1.7 MV tandem accelerator, transmission electron microscope, X-ray diffractometer for the study of structural materials and ion beam materials.

As a core component of the State Key Laboratory of Nuclear Physics and Technology, the department undertakes major national research projects. It is the only department in the universities of China, which is supported by the national project for fostering talents of nuclear science. The department has established many international and national collaborations, including the China-U.S. Theory Institute for Physics with Exotic Nuclei (CUSTIPEN), high-energy physics collaboration with LHC in Europe and BEPC-BES in Beijing, nuclear physics collaboration with RIKEN-RIBF in Japan, HIRFL in Lanzhou and CIAE in Beijing. In terms of talent training, the department has co-established the Nishina School with RIKEN (Japan) to advance international talent cultivation since 2008.

◎ 希格斯玻色子稀有衰变研究

希格斯机制解释基本粒子的质量来源，是粒子物理标准模型的一个核心部分。为深入研究希格斯机制和检验标准模型，北京大学物理学院技术物理系周辰研究员与合作者完成希格斯玻色子稀有衰变的一些前沿结果。

希格斯玻色子衰变为 Z 玻色子和光子的过程需要通过量子圈进行。由于量子圈中可能存在尚未被发现的新粒子，该稀有衰变过程有望提供新物理的线索。相关理论研究包括北京大学物理学院曹庆宏等人工作［Phys. Lett. B 789 (2019) 233］等。近期，大型强子对撞机上 ATLAS 和 CMS 实验携手获得了希格斯玻色子到 Z 玻色子和光子衰变的首个证据（观测显著度达到 3.4 倍标准差）。这个重要结果于 2024 年 1 月发表［Phys. Rev. Lett. 132 (2024) 021803］，并入选“物理亮点”、“编辑推荐”和“年度亮点专辑”。《科技日报》和欧洲核子研究中心官方网站等对此进行了新闻报道。北京大学周辰、冒亚军课题组完成了 ATLAS 和 CMS 实验的希格斯→ Z+ 光子衰变的联合分析，对该结果起了关键作用。在 CMS 合作组内部，北京大学博士研究生张铭滔获选做预审核报告，周辰获选做审核报告。周辰担任分析文档提交人，并成为 LHC 希格斯联合分析工作组召集人。

近年来，机器学习在高能物理实验的数据获取、事例模拟、粒子重建、数据分析等方面取得了广泛的成功。周辰与合作者使用图神经网络等深度学习工具，研究未来正负电子对撞机实验上的喷注起源识别，区分五类夸克（上、下、奇、粲、底）、五类反夸克以及胶子产生的不同喷注，成功实现了较高的标记效率和较低的误鉴别率；使用这个喷注起源识别方法，显著地改善了一些希格斯玻色子衰变道（如希格斯→ $s\bar{s}$ 等）的预期灵敏度，从而可能更精确地测量希格斯粒子和夸克之间的相互作用强度。相关结果近期发表于［Phys. Rev. Lett. 132 (2024) 221802］，北京大学博士后朱永峰为论文的共同第一作者，周辰为论文的共同通讯作者。

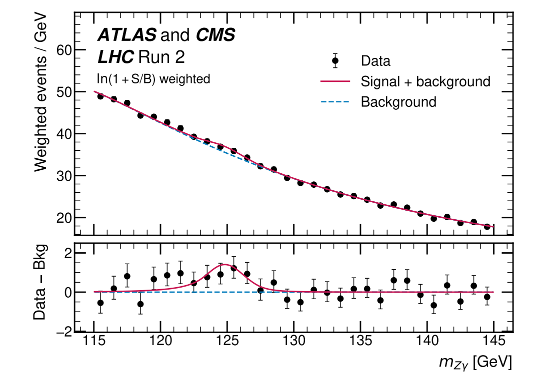


图 1: ATLAS 和 CMS 实验报告希格斯→ Z+ 光子衰变首个证据的期刊论文的 Z+ 光子质量谱。

Figure 1: The Z+photon mass spectrum in the journal paper reporting the first evidence of Higgs → Z+photon decay by ATLAS and CMS experiments.

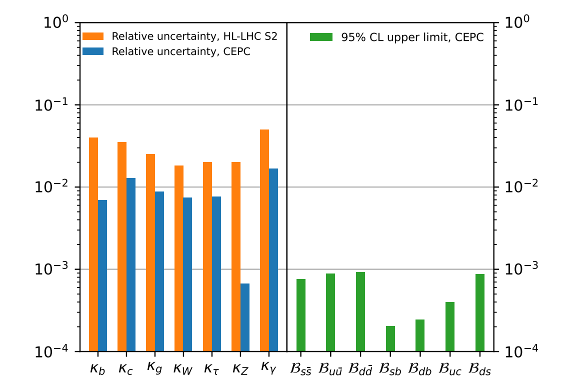


图 2：使用喷注起源识别的一些希格斯玻色子衰变道的预期灵敏度。

Figure 2: Expected sensitivity of some Higgs boson decay channels using jet origin identification.

◎ Research on rare decays of the Higgs boson

The Higgs mechanism explains the origin of the mass of elementary particles and is a core part of the standard model of particle physics. In order to further study the Higgs mechanism and test the standard model, Zhou Chen, a researcher from the Department of Technical Physics, School of Physics, Peking University, and his collaborators completed some cutting-edge results on the rare decays of the Higgs boson.

The process of the Higgs boson decaying into the Z boson and photon needs to go through quantum loops. Since there may be new particles in the quantum loops, this rare decay process is expected to provide clues to new physics. Related theoretical research includes the work of Cao Qinghong et al. from the School of Physics, Peking University [Phys. Lett. B 789 (2019) 233]. Recently, the ATLAS and CMS experiments at the Large Hadron Collider jointly obtained the first evidence of the decay of the Higgs boson to the Z boson and photon (the observed significance reached 3.4 standard deviation). This important result was published in January 2024 [Phys. Rev. Lett. 132 (2024) 021803] and was selected for "Physics Highlights", "Editor's Suggestion" and "Collection of the Year". Science and Technology Daily and the official website of CERN reported on it. Zhou Chen and Mao Yajun's research group at Peking University played a key role in the result by completing the combined analysis of the Higgs → Z+photon decay with the ATLAS and CMS experiments. Within the CMS collaboration, Peking University doctoral student Zhang Mingtao was selected to make a pre-approval report, and Zhou Chen was selected to make an approval report. Zhou Chen served as the submitter of the analysis document and became the convener of the LHC Higgs combined analysis working group.

In recent years, machine learning has achieved widespread success in data acquisition, event simulation, particle reconstruction, and data analysis of high-energy physics experiments. Zhou Chen and his collaborators used deep learning tools such as graph neural networks to study the identification of jet origins in future electron-positron collider experiments, distinguishing jets from five types of quarks (up, down, strange, charm, bottom), five types of antiquarks and gluons, successfully achieving high identification efficiency and low misidentification rate; using this jet origin identification method, the expected sensitivity of some Higgs boson decay channels (such as Higgs → $s\bar{s}$, etc.) was significantly improved, making it possible to more accurately measure the coupling strength between the Higgs particle and quarks. The relevant results were recently published in [Phys. Rev. Lett. 132 (2024) 221802], with Peking University postdoctoral fellow Zhu Yongfeng as the co-first author of the paper and Zhou Chen as the co-corresponding author of the paper.

◎ 原子核的高阶形变效应与超锿核异常转动行为之谜

合成超重原子核和超重元素，探索超重稳定岛的位置是重要的基础科学前沿。超锿核，即质子数超过 100 的原子核，是目前实验上观测到转动谱的最重原子核，其转动性质的研究对于获得超重核的单粒子能级结构、探索超重稳定岛的位置至关重要。因此，世界上许多知名核物理研究机构，如美国阿贡国家实验室、德国亥姆霍兹重离子研究中心等的实验团队，都致力于精确测量超锿核的转动谱。本世纪初，相关实验发现，随着角动量的增加，相邻超锿核 ^{252}No 和 ^{254}No 的转动惯量展现出显著不同的上弯现象，该现象一直没有得到微观自洽的理论解释，是困扰核物理界 20 多年的疑难问题。

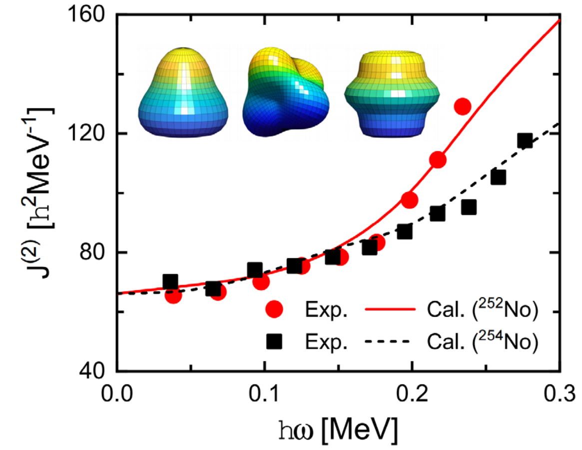


图 1. 超锿核 ^{252}No 和 ^{254}No 转动惯量的理论计算结果及其与实验值的比较。

Fig 1. Calculated moments of inertia for ^{252}No and ^{254}No in comparison with the experimental data.

北京大学物理学院技术物理系赵鹏巍课题组提出了基于滤波共轭梯度法的三维格点推转相对论密度泛函理论，利用类壳模型方法严格处理对关联效应，首次微观揭示了超锿核中的高阶形变效应，成功解决了超锿核的异常转动行为之谜，相关研究成果以“转动超锿核中高阶形变的出现：微观理解”(Emergence of High-Order Deformation in Rotating Transfermium Nuclei: A Microscopic Understanding) 为题，在线发表于《物理评论快报》(Physical Review Letters)。

课题组新建立的理论方法，可以微观自洽地包含原子核的所有形变自由度，为研究原子核的结构、衰变以及反应动力学提供了重要的理论工具。目前，该方法已成功应用于研究原子核的手征转动、裂变、多核子转移反应等前沿方向，两篇论文发表于《物理评论快报》(Physical Review Letters)，还有两篇论文被美国物理学会期刊《物理评论 C》(Physical Review C) 遴选为“编辑推荐”论文。

◎ High-order deformation effects and puzzle of anomalous rotational behavior in transfermium nuclei

Study on the synthesis of superheavy nuclei and superheavy elements, and the exploration of the location of island of stability, are important frontiers in fundamental science. Transfermium nuclei, defined as atomic nuclei with proton numbers Z > 100, are the heaviest nuclei whose rotational spectra can be measured experimentally so far. The study of rotating transfermium nuclei is crucial for determining the single-particle structure of superheavy nuclei and exploring the location of the island of stability. Consequently, leading nuclear physics laboratories around the world, including the Argonne National Laboratory in the United States and the GSI Helmholtz Centre for Heavy Ion Research in Germany, have dedicated efforts to precisely measuring the rotational spectra of transfermium nuclei. In the early 2000s, the moments of inertia in transfermium nuclei ^{252}No and ^{254}No have been observed, and they were demonstrated to exhibit significantly different rotational behavior. This phenomenon has remained unexplained and puzzled the nuclear physics community for over two decades.

The group of Pengwei Zhao from the Department of Technical Physics, School of Physics, Peking University, established the cranking relativistic density functional theory in three-dimensional lattice space based on the conjugate gradient method with a filtering function, and accounted for the pairing correlations by using the shell-model-like approach. With this new method, the high-order deformation effects in transfermium nuclei were microscopically revealed for the first time, successfully solving the long-standing puzzle on the rotational behavior in No isotopes. The findings, titled "Emergence of High-Order Deformation in Rotating Transfermium Nuclei: A Microscopic Understanding," were published in Physical Review Letters.

The newly established method can include all deformation degrees of freedom in a microscopic and self-consistent way and provide a vital theoretical tool for investigating nuclear structure, decay, and reaction dynamics. Up to now, the method has been successfully applied to study cutting-edge phenomena in nuclear physics, including chiral rotation, fission, and multinucleon transfer reactions, with two papers published in Physical Review Letters and two other papers selected as “Editors’ Suggestion” by Physical Review C.

◎ 首次观测到双中子集团凝聚态结构

北京大学实验核物理团队在丰中子滴线核 ^{8}He 中首次观测到双中子集团凝聚态结构。本工作通过测量 ^{8}He 的特征跃迁强度及其关联中子对发射，揭示 ^{8}He 的 0_2+ 激发态中的 4 个价中子形成了两个强关联中子对、并进一步形成类似于玻色 - 爱因斯坦凝聚态的奇特集团结构。研究成果发表于《物理评论快报》（Physical Review Letters），并同时入选“编辑推荐（Editors’ Suggestion）” 和 “物理亮点（Featured in Physics）”。

当玻色子原子体系处于接近绝对零度的极低温度时，所有原子会聚集到能量最低的量子态，从而产生一种新的物质形态，即玻色 - 爱因斯坦凝聚态（Bose–Einstein condensate，简称 BEC）。近年来，费米子原子体系的凝聚态也已在实验上发现。理论预言，在丰中子原子核体系中也存在类似的由强关联中子对形成的凝聚态，而且它可能也存在于中子星中，对认识中子星的结构和性质具有重要意义。但是，长期以来，在实验上产生和识别这种新奇的物质形态都是一项巨大的挑战。

北京大学实验核物理团队开展了丰中子滴线核 ^{8}He 的非弹激发与衰变实验，通过碳靶上的单极跃迁生成了 0_2^+ 共振态，该态随即衰变为一个 ^{6}He 原子核和一对中子，并被磁谱仪和专门设计的中子探测器阵列所探测。研究团队通过深入分析反应及衰变过程中的粒子关联效应，区分了多中子参与的复杂反应与衰变机制，从而排除复杂的本底过程，最终清楚识别了 0_2^+ 激发态。进一步的分析表明，它的生成过程具有很强的单极跃迁强度、并通过发射强关联的中子对发生衰变，结合理论计算确认了它的类 BEC 集团结构。这是首次在实验上观测到由强关联中子对凝结形成的类 BEC 集团结构，揭示了丰中子原子核体系的一种新的特性，有助于深入认识不稳定核奇特结构和探索核物质（包括中子星）的性质。

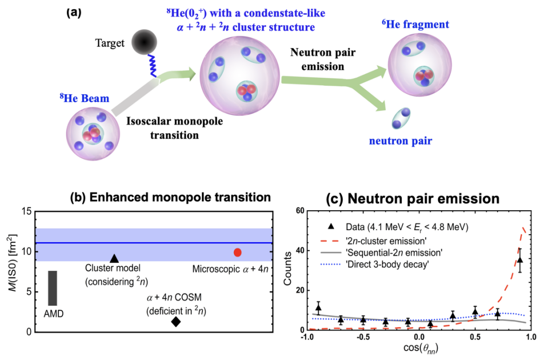


图 1. (a) 利用 ^{8}He 原子核的非弹散射实验研究 ^{8}He(0_2^+) 态中类 BEC 集团结构的实验示意图。(b) 特征单极跃迁强度的实验结果与理论计算的比较；(b) 中子关联分析。

Fig1. (a) Schematic illustration of the population and identification of the BEC-like cluster state. Experimental results of the monopole transition strength (b) and neutron correlations (c) compared to theoretical calculations.

◎ First observation of the dineutron-condensate cluster state

We have observed a dineutron-condensate cluster state in the neutron-rich nucleus ^{8}He.The results were published in Physics Review Letters (Phys. Rev. Lett. 131, 242501 (2023)), selected as Editors’ Suggestion and Featured in Physics.

The quantum condensate is a novel state of matter originally predicted by Bose and Einstein in the 1920s, and its discovery in a gas of ultracold bosonic atoms was awarded the Nobel Prize in Physics in 2001. In recent years, condensate of fermionic atoms, despite the Pauli exclusion principle, has also been experimentally realized by forming either bound diatomic molecules or correlated atom pairs. The nuclear analogue, a condensate of correlated neutron pairs, has been theoretically predicted in neutron-rich nuclear systems including neutron stars, but its experimental observation has remained elusive due to the extreme difficulty in both the production and identification of this exotic cluster state.

We populated the long-sought dineutron-condensate cluster state in ^{8}He by employing the highly selective nuclear reaction, the isoscalar monopole transition, and observed that this state was characterized by a spin parity of 0^+, an abnormally large isoscalar monopole transition strength, and the emission of a strongly correlated neutron pair. Together with the state-of-the-art theoretical calculations, our results provide strong evidence that the four valence neutrons in this newly observed excited state of ^{8}He form two strongly correlated neutron pairs (dineutron clusters) and further form an exotic condensate-like cluster structure. Our finding unveils a new distinctive property of neutron-rich systems which may have significant implications for understanding the structure of exotic nuclei and neutron stars.

供稿：技术物理系
审核：杨晓菲

06 天文学系
Department of Astronomy

北京大学天文学科由物理学院天文学系和科维理天文与天体物理研究所组成，拥有全职教师 24 人。研究领域涵盖宇宙学与星系形成、高能天体物理、星际介质、恒星与行星系统及粒子天体物理等前沿方向。其卓越的研究实力和学术影响力得到国际同行广泛认可。

The astronomy discipline at Peking University consists of the Department of Astronomy within the School of Physics and the Kavli Institute for Astronomy and Astrophysics. PKU astronomy currently has 24 faculty members. The research areas include cosmology and galaxy formation, high-energy astrophysics, interstellar medium, stellar and planetary systems, and particle astrophysics. Its outstanding research capabilities and academic influence are widely recognized by the international community.

◎ 星光与第一批黑洞：探索黑洞与宿主星系之间的关系

詹姆斯·韦布空间望远镜（JWST）于 2021 年 12 月成功发射，彻底改变了我们对早期宇宙的认识。凭借其前所未有的红外灵敏度和高分辨率，JWST 能够探测宇宙大爆炸后的最初十亿年，为研究最早的星系和黑洞的形成与演化提供了新的窗口。超大质量黑洞（SMBHs）的起源和早期增长是天文学中的一个基本谜团。观测发现，这些黑洞在宇宙年龄不到十亿年的时候已经存在，并且在当今宇宙中普遍位于星系中心。然而，它们如何在如此短的时间内迅速增长？此外，对近邻宇宙的观测表明，SMBH 的质量与其宿主星系的质量之间存在紧密的相关性，这暗示着二者存在共同演化的关系。但这一关系是否在宇宙早期已经建立，还是随着时间的推移逐渐形成，仍然是一个未解之谜。

近日，Nature 发表的一项研究为这一问题提供了至关重要的新见解。这项研究由国际团队主导，团队成员包括北京大学科维理天文与天体物理研究所（KIAA）的科维理天体物理研究员尾上匡房（Masafusa Onoue）和副教授稻吉恒平（Kohei Inayoshi）。研究团队利用 JWST 成功探测到了来自红移为 6.40 和 6.34 的类星体（quasars）——即活跃增长的 SMBHs——的宿主星系的恒星光信号，对应于宇宙诞生后仅仅 8.6 亿年的时间。这两颗类星体，HSC J2236+0032 和 HSC J2255+0251，最初由日本 8.2 米口径的斯巴鲁望远镜（Subaru）进行的广域巡天发现，该望远镜至今已发现 160 多颗类星体。稻吉恒平教授领导的研究团队长期以来致力于超大质量黑洞与宿主星系在宇宙早期共同演化的理论研究，并积极参与斯巴鲁望远镜的高红移类星体巡天。本次成功探测到这些遥远类星体的宿主星系恒星光，标志着观测宇宙学的一个重要突破。

类星体是宇宙中最明亮的天体之一，使得观测其宿主星系的微弱光线极具挑战性。即使使用哈勃空间望远镜（HST），过去的研究也难以从类星体的耀眼的光芒中分离出宿主星系的信号。然而，JWST 的 NIRCam 成像和 NIRSpec 光谱分析使研究团队能够精确地建模并扣除类星体的光线，从而揭示被其掩盖的宿主星系。他们的分析显示，这些早期类星体的黑洞质量与星系质量的比值与后期宇宙中观测到的比值相似。这一发现表明，在宇宙形成后的最初十亿年内，超大质量黑洞和宿主星系之间的共同演化关系可能已然确立，为早期黑洞增长的理论模型提供了重要限制。

研究团队计划进一步扩大类星体样本规模，以更深入地探究超大质量黑洞与宿主星系如何在宇宙历史中共同演化。北京大学 KIAA 的研究人员正在利用 JWST 和斯巴鲁望远镜，推动高红移天体物理学的前沿研究，在揭示早期黑洞形成奥秘方面发挥核心作用。这些发现向着解答现代宇宙学最重要的问题之一迈出了关键的一步：第一批超大质量黑洞和星系是如何在年轻的宇宙中诞生的？

这些结果以题为“Detection of stellar light from quasar host galaxies at z > 6”的论文形式于 2023 年 6 月 28 日发表在《自然》杂志上。

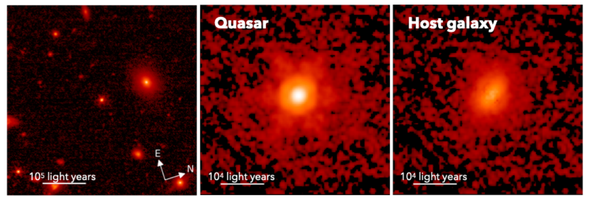


Figure 1: JWST NIRCam 3.6 μm image of HSC J2236+0032 (Credit: Ding, Onoue, Silverman et al.). The zoom-out image, the quasar image, and the host galaxy image after subtracting the quasar light (from left to right). The image scale in light years is indicated in each panel.

图 1：JWST NIRCam 3.6 μm 图像 of HSC J2236+0032（来源：Ding, Onoue, Silverman 等）。从左到右分别是：放大图、类星体图像、以及去除类星体光照后的宿主星系图像。每个面板中标注了图像的光年尺度。

◎ tarlight and the First Black Holes: Probing the Relationship Between the Black Holes and the Host Galaxies

The James Webb Space Telescope (JWST), launched in December 2021, has revolutionized our understanding of the early universe. With its unprecedented sensitivity and resolution in the infrared, JWST is capable of probing the first billion years after the Big Bang, offering a new window into the formation and evolution of the earliest galaxies and black holes. One of the fundamental mysteries in astrophysics is the origin and early growth of supermassive black holes (SMBHs), which have been found to exist less than a billion years after the Big Bang and are known to reside at the centers of galaxies in the present-day universe. How did these black holes grow so rapidly in such a short time? Furthermore, observations in the local universe have revealed a tight correlation between SMBH masses and their host galaxies, suggesting a coevolutionary link. However, it remains unclear whether this relationship was already established in the early universe or if it developed over time.

A recent study published in Nature and led by an international team, including Masafusa Onoue, a Kavli Astrophysics Fellow, and Kohei Inayoshi, an associate professor, at the Kavli Institute for Astronomy and Astrophysics (KIAA) at Peking University, has provided crucial new insights into this question. Using JWST, the team successfully detected starlight from galaxies hosting quasars–actively growing SMBHs–at redshifts 6.40 and 6.34, corresponding to a time when the universe was only about 860 million years old. These two quasars, HSC J2236+0032 and HSC J2255+0251, were originally discovered through the wide-field survey of the 8.2-meter Subaru Telescope, which has identified more than 160 quasars to date. The research group led by K. Inayoshi has been deeply involved in developing the theoretical framework for the coevolution of black holes and galaxies in the early universe and has played a key role in the Subaru high-redshift quasar survey. The successful detection of starlight from these distant quasars represents a major milestone in observational cosmology.

Quasars are among the brightest objects in the universe, making it extremely challenging to observe the faint light from their host galaxies. Previous studies, even with the Hubble Space Telescope, struggled to isolate the underlying galaxy from the quasar's overwhelming glow. However, JWST's NIRCam imaging and NIRSpec spectroscopy enabled the team to carefully model and subtract the quasar's light, revealing the underlying host galaxies. Their analysis shows that the black hole-to-galaxy mass ratio in these early systems is similar to what is observed in more recent epochs. This suggests that the coevolutionary link between SMBHs and their galaxies was already established within the first billion years of cosmic history, providing key constraints on theoretical models of early black hole growth.

The team plans to extend their study with a larger sample of quasars to further refine our understanding of how SMBHs and their host galaxies evolved together over cosmic time. Researchers at Peking University's KIAA are playing a central role in unraveling the mysteries of early black hole formation, utilizing JWST and Subaru to push the frontiers of high-redshift astrophysics. These discoveries mark an important step toward answering one of the biggest questions in modern cosmology: how the first massive black holes and galaxies emerged in the young universe.

These results appeared as Ding, Onoue, Silverman et al. "Detection of stellar light from quasar host galaxies at z > 6" in Nature on June 28, 2023.

◎ 北京大学深度参与纳赫兹引力波搜寻研究并取得重大突破

2023 年 6 月，中国脉冲星测时阵列（CPTA）研究团队宣布探测到纳赫兹引力波存在的关键性证据，这标志着我国在纳赫兹引力波领域的研究与国际前沿同步。这一工作基于中国天眼——500 米口径球面射电望远镜（FAST）的观测数据，来自北京大学科维理天文与天体物理研究所、北京大学物理学院天文学系的李柯伽教授、博士后陈思远及研究生薛子涵和徐江伟深度参与了这项工作。相关论文在线发表于我国天文学术期刊《天文与天体物理研究》（RAA）。这是引力波天文学的重要进展，该工作一经发表即引起了天文学界和物理学界的广泛关注，至今引用数已超过 700 次。这一成果也入选《科学》杂志 2023 年度十大科学突破、美国物理学会 2023 年度重要事件，并获得了国际基础科学大会前沿科学奖等奖项。

引力波是广义相对论预言的时空涟漪，源自加速运动的有质量物体对周围时空的扰动。引力波的探测不仅是对广义相对论的一项关键验证，同时也是观测宇宙的全新手段，可以直接观测宇宙中的不发光物质。长期以来，物理学家和天文学家一直致力于探测引力波，开启引力波观测宇宙的新窗口。20 世纪 70 年代，对脉冲双星系统的轨道变化的精确测量间接证实了引力波的存在，并获得了 1993 年诺贝尔物理学奖。2016 年，美国激光干涉引力波天文台（简称 LIGO）首次在百赫兹频段探测到由双黑洞并合产生的引力波，正式开启了引力波天文学，并因此获得了 2017 年诺贝尔物理学奖。更大质量的天体，例如星系中心的超大质量双黑洞系统（一亿到百亿倍太阳质量），产生的引力波频率更低，主要集中在纳赫兹频段。在这个频段内，还有宇宙早期原初引力波残存至今的部分和宇宙弦等奇异对象产生的引力波。

纳赫兹引力波对于理解宇宙大尺度结构形成及涉及宇宙早期的基础物理过程具有重大意义。但纳赫兹引力波的周期长达数年，波长可达数光年，其探测十分具有挑战性。脉冲星测时阵列是目前探测纳赫兹引力波的唯一已知手段。脉冲星是自然界中最致密的天体之一，其自转的极端稳定性使得脉冲到达时间可以被非常精确地测量。脉冲星测时阵列使用脉冲星作为星系尺度的引力波探测器，利用大型射电望远镜对一批自转极其规律的毫秒脉冲星进行长期高精度测时观测，通过脉冲星之间的特征相关曲线（Hellings-Downs 曲线）证认引力波。

发现纳赫兹引力波是国际物理和天文领域的研究焦点之一。国际上的多个团队，如北美的 NANOGrav、欧洲的 EPTA、澳大利亚的 PPTA，利用各自的大型射电望远镜，已分别开展了长达 20 年的纳赫兹引力波搜寻。近年来一些新的团队也逐渐加入这一领域，包括我国的 CPTA、印度的 InPTA 和南非的 SAPTA。2023 年，包括 CPTA 在内的国际上四个脉冲星测时阵列团队同期探测到了纳赫兹引力波存在的关键证据。在这项研究中，CPTA 团队利用 FAST 对 57 颗毫秒脉冲星进行了长期系统性监测，并将这些毫秒脉冲星组成了银河系尺度的引力波探测器来搜寻纳赫兹引力波。该团队使用自主开发的软件，对 FAST 收集的时间跨度 3 年 5 个月的数据进行分析研究，发现了具有纳赫兹引力波特征的四极相关信号的证据，置信度水平为 4.6 西格玛（误报率小于 50 万分之一）。

脉冲星测时阵探测纳赫兹引力波的灵敏度强烈依赖于观测时间跨度——随着观测时间的延长，灵敏度会迅速提高。尽管 CPTA 的观测时间跨度远短于美、欧、澳三个国际团队，但通过充分利用 FAST 灵敏度高、可监测脉冲星数目多、测量精度更高的优势，我国纳赫兹引力波探测灵敏度很快达到了与美、欧、澳相当的水平，从而同时实现此次重大科学突破。然而，由于当前观测数据的时间跨度较短，CPTA 团队暂时无法确定纳赫兹波段引力波的主要物理来源。但随着后续数据观测时间的增加，这一问题有望得到解决。期待脉冲星测时阵列将很快为人类探索宇宙打开纳赫兹引力波观测新窗口。

相关成果于 2023 年 6 月 29 日在《Research in Astronomy and Astrophysics》正式发表（Xu et al. 2023, 23, 075024）。

图 1 中国天眼 FAST 图片（来源 中国科学院国家天文台）。

Fig. 1 Picture of China's FAST, the 500-meter aperture spherical radio telescope (from the National Observatory of Astronomy, Chinese Academy of Sciences)

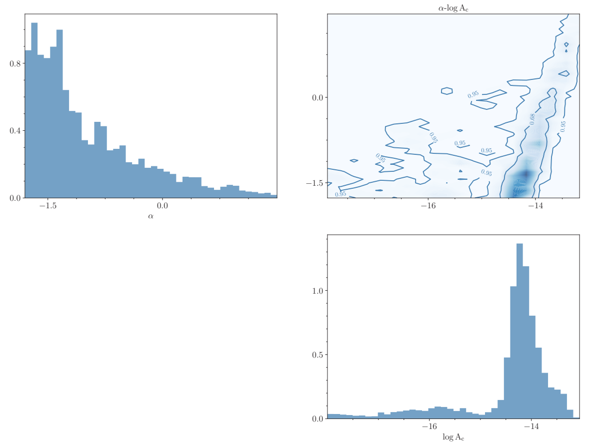


图 2 CPTA DR1 数据集对随机引力波背景谱的限制。左上：谱指数 α 的后验分布；右上：谱指数 α 和随机引力波背景特征幅度 A_c 的 2 维分布；右下：引力波背景特征幅度的分布。

Fig. 2 The constraints on the spectrum of stochastic gravitational wave background using CPTA DR1. Top Left: the posterior distribution of spectral index α; top right: the 2d distribution of the spectral index α and characteristic amplitude A_c of the tochastic gravitational wave background; bottom right: the posterior distribution of the characteristic amplitude A_c.

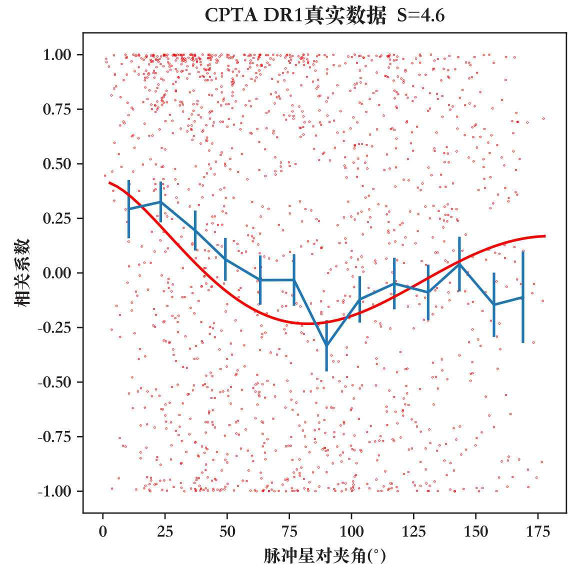


图 3 脉冲星相关曲线的测量结果，即相关系数随脉冲星对之间夹角的变化。红色的点表示所有脉冲星对的相关系数，蓝色曲线表示对红色点取平均的结果，红色实线表示理论上纳赫兹引力波导致的 Hellings-Downs 相关曲线。

Fig. 3 The measurements of the correlation curve, i. e. the change of correlation coefficients with the angular separation between pulsar pairs. The red dots denote the correlation coefficients of all pulsar pairs, and the blue curves are the average of the red dots. The red lines show the theoretical Hellings-Downs correlation curve caused by gravitational waves

◎ Peking University Makes Significant Breakthrough in the Search for Nano-Hertz Gravitational Waves

In June 2023, the Chinese Pulsar Timing Array (CPTA) collaboration found key evidence for the existence of nanohertz gravitational waves, marking China's research in the field of nanohertz gravitational waves reaching the international frontiers. This work is based on observational data from China's FAST, the Five-hundred-meter Aperture Spherical Telescope. Prof. Kejia Lee, Post-Doc. Siyuan Chen, PhD students Jiangwei Xu, and Zihan Xue, from Department of Astronomy, School of Physics, and Kavli Institute of Astronomy and Astrophysics of Peking University played significant roles in this research. The related paper was published online in China's academic journal, Research in Astronomy and Astrophysics (RAA). This is an important advancement in gravitational wave astronomy, and once published, it received widespread attention in the astronomy and physics communities, with over 700 citations to date. The achievement was also selected as one of Science magazine's top ten scientific breakthroughs of 2023, as well as Highlights of the year 2023 by the American Physical Society, and it has received various awards, including the 2024 Frontier of Science Award of the International Conference of Basic Science.

Gravitational waves are ripples in spacetime predicted by General Relativity, generated by the disturbance of surrounding spacetime caused by the accelerated motion of massive objects. The detection of gravitational waves is not only a key test of General Relativity, but also provides a new way to observe the Universe, enabling the direct observation of non-luminous matter. For a long time, physicists and astronomers have been seeking to detect gravitational waves and open a new window to observe the Universe. In the 1970s, precise measurements of the orbital changes in a pulsar binary system indirectly confirmed the existence of gravitational waves, leading to the award of the Nobel Prize in Physics in 1993. In 2016, the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the United States first directly detected gravitational waves generated by the merger of stellar-mass black holes in the hundred-hertz frequency band, opening the field of gravitational wave astronomy and earning the Nobel Prize in Physics in 2017. More massive objects, such as supermassive black hole systems at the centers of galaxies (ranging from one hundred million to a billion times solar mass), generate lower frequency gravitational waves that primarily concentrate in the nanohertz band. In this band, there are also primordial gravitational waves from the early universe and gravitational waves generated by exotic objects like cosmic strings.

Nanohertz gravitational waves are crucial for understanding the formation of the large-scale structure of the Universe and fundamental physical processes from the early universe. However, the detection of nanohertz gravitational waves is extremely challenging due to their long period (lasting several years) and wavelength (up to several light-years). The pulsar timing array is the only known method for detecting nanohertz gravitational waves. Pulsars, one of the most compact objects in nature, exhibit extreme rotational stability, allowing the arrival time of their pulses to be measured with very high precision. A pulsar timing array uses pulsars as a galaxy-scale detector of gravitational waves, employing large radio telescopes to conduct long-term, high-precision timing observations of a group of millisecond pulsars with extremely regular rotations. The detection of gravitational waves is made possible by identifying characteristic correlation curves (Hellings-Downs curve) between pulsar pairs.

The search of nanohertz gravitational waves is one of the major focuses of present-day physics and astronomy. Several international teams, including NANOGrav in North America, EPTA in Europe, and PPTA in Australia, have conducted searches for nanohertz gravitational wave using their large radio telescopes for over 20 years. Recently, new teams have also entered this field, including CPTA in China, InPTA in India, and SAPTA in South Africa. In 2023, four pulsar timing array collaborations, including CPTA, independently detected key evidence of the existence of nanohertz gravitational waves. In this study, the CPTA team used FAST to conduct long-term, systematic monitoring of 57 millisecond pulsars, forming a gravitational wave detector spanning the scale of the Milky Way to search for nanohertz gravitational waves. The team developed independent software to analyze data collected by FAST, with time span of 3 years and 5 months, and found evidence of quadrupolar correlation characteristic of nanohertz gravitational waves with a confidence level of 4.6 sigma (false alarm rate less than one in 500,000).

The sensitivity of pulsar timing array to nanohertz gravitational waves is strongly dependent on the observational time span – sensitivity increases rapidly with longer time span. The CPTA's data span is much shorter than those of the collaborations from the US, Europe, and Australia. However, using the high sensitivity of FAST, the large number of pulsars that can be monitored, and the higher measurement precision, the CPTA achieved similar sensitivity compared to other PTAs in just 3.5 years, leading to this significant scientific breakthrough. Due to the current short time span of the observational data, the CPTA team is temporarily unable to identify the primary physical sources of nanohertz gravitational waves. This issue is expected to be resolved with the increase in the time span of future observations. We look forward to the pulsar timing array soon opening a new window for exploration of the universe through the observation of nanohertz gravitational waves.

This work is published in 2023 in the journal of Research in Astronomy and Astrophysics（Xu et al. 2023, 23, 075024）。

◎ 银盘翘曲的“时光动画”揭示出银河系暗物质晕形状

在近邻宇宙中，大多数的盘星系都不是一个完美的圆盘，而是在外区表现出像薯片一样的弯曲状态，天文学家称之为翘曲。银河系作为一个典型的盘星系，也不例外地表现出翘曲特征。这样一个倾斜的，绕银心转动银盘就像一个旋转的陀螺，必然会受到包裹银盘的暗物质晕施加的引力矩产生进动（图 1）。翘曲的进动速度这一重要动力学参数，无论是方向和速率的测量都存在巨大的争论，原因是之前的测量都是依赖运动学的间接方法，其使用的示踪天体会因动力学扰动或加热效应而影响其测量的准确度与精度。

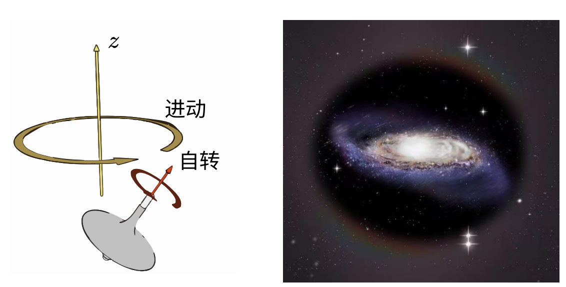


图 1: 左图：旋转的陀螺在重力力矩下产生进动；右图：类比陀螺，银盘翘曲在暗物质晕的力矩下“翩翩起舞（进动）”（上海交通大学设计学院侯开元、董占勋制作的艺术想象图）。

Figure 1: Right panel: The spinning top precesses under the torque from gravity; Left panel: Similar to the spinning top, the Galactic disk warp "dances gracefully" under the torque of the dark matter halo (an artistic impression created by Kaiyuan Hou and Zhanxun Dong from the School of Design, Shanghai Jiao Tong University).

北京大学物理学院天文学系，北京大学科维里天文与天体物理研究所张华伟教授团队与中国科学院大学黄样副教授团队合作提出了一种新颖的直接测量银盘翘曲进动的方法，即“时光动画”方法。团队采用 Gaia 巡天提供的约 2600 颗造父变星作为示踪天体，通过观察距今 2.5 亿年间不同年龄切片的银盘三维结构这样一种“动画放映”方式，清晰地揭示了银盘翘曲的演化过程（图 2）。得益于造父变星是足够年轻的，因而保有了其诞生时所携带的运动学信息。不同年龄段的造父变星便可以反映翘曲在不同时刻的样子，进而展示其随时间的变化。本方法也在后续得到了 N 体 +SPH 模拟的验证（图 3，参见：arXiv:2409.02734）。通过本方法，研究发现翘曲沿着逆太阳旋转方向以 2 km/s/kpc（即每百万年 0.12 度）的速率进动。进一步的精细测量显示，随着造父变星样本离银心距离的增加，翘曲的进动速率逐渐减小。事实上，无论翘曲如何起源，其进动速率和方向都受银河系内盘与暗物质晕共同影响。本研究的观测的结果也与前人在模拟中看到的翘曲在主要受内盘和暗物质晕共同影响下时的进动大小和方向十分一致。根据本研究的观测结果，在扣除银河系内盘的贡献后，研究团队发现当前包裹翘曲的银河系暗物质晕呈现出略微偏离球形的扁椭球形状（椭球等势面长短轴之比 q 值在 0.84 到 0.96 之间），目前只有这一形状才能解释翘曲的剩余进动大小。该结果为研究银河系暗物质晕的演化提供了重要锚点。

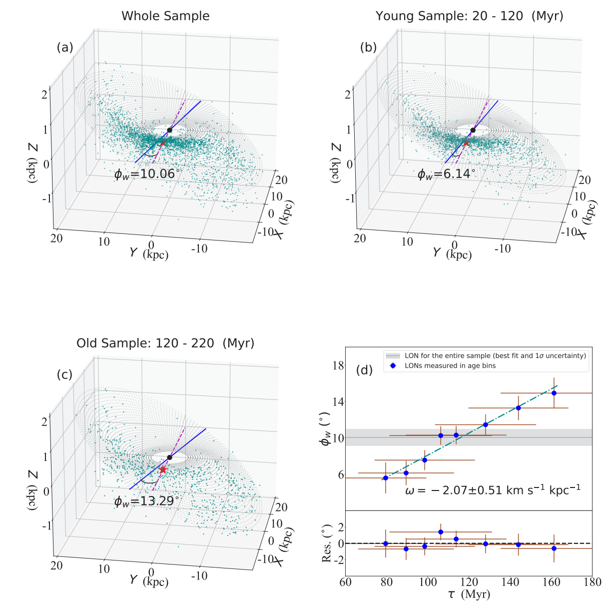


图 2：不同年龄切片的造父变星构建的银盘三维结构以及翘曲节点线随样本年龄的变化（斜率即为翘曲进动速率）。

Figure 2: The three-dimensional structure of the Galactic disk constructed from Cepheid variable stars of different slices of age, showing the variation of the warp node line with the sample age (the slope represents the warp precession).

该研究成果得到了两位审稿人的高度评价，一致认为: “时光动画是一项新颖且深具说服力的方法，并首次精确测定出进动的方向和速率”（“the‘motion picture’ approach to measuring the precession rate is novel and convincing” from Referee #1; “as far as I am aware, this is the first time that the warp is constrained to precess in retrograde direction, and its precession rate is accurately measured” from Referee #2）。

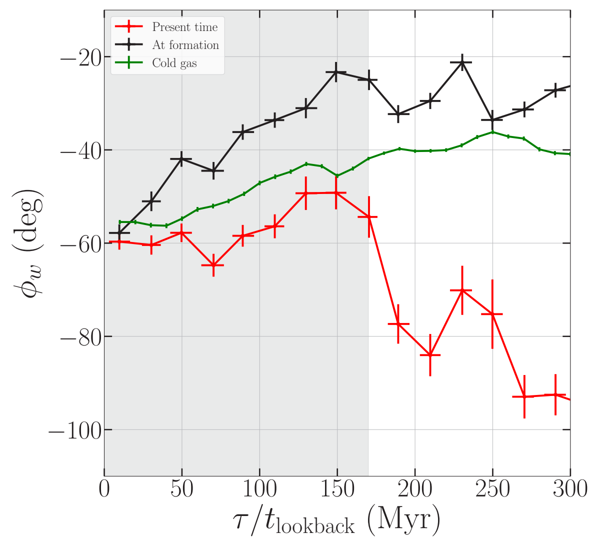


图 3：N 体 +SPH 模拟中对“时光动画”方法的验证。图中绿线代表了冷气体盘的翘曲节点线方向，从斜率可看出翘曲是逆转的。黑线代表了不同年龄的恒星在其刚诞生时所示踪的翘曲节点线方向（每个点在不同的时间测量）。而红线代表了在均在“当今”（t=0）时测量的不同年龄恒星所示踪的翘曲节点线方向，与“时光动画”的测量方法相同。可以看出在足够年轻的时间段，红线和黑线与绿线的变化趋势十分接近（斜率相似），表明用“时光动画”方法可以测量出翘曲的进动。

Figure 3: The validation of the “motion-picture” method from an N-body+SPH simulation. The LON of the cold gas warp is shown as a green solid line and clearly exhibits retrograde precession. The LON of young stellar populations are presented both at the time of formation (black solid line) and at present time (red solid line). Clearly, the LON versus age of stars at present basically catches the trend of both cold gas and stars at formation for enough young stellar populations (similar slope). That indicates that the “motion-picture” method can reveal the precession of the warp.

中国科学院大学黄样副教授与北京大学博士研究生冯齐康是该论文的共同第一作者。中国科学院大学黄样副教授，北京大学张华伟教授，中国科学院国家天文台刘继峰研究员和上海交通大学沈俊太教授为该论文的共同通讯作者。此项研究还包括来自中国科学院国家天文台、北京师范大学和美国圣母大学多家机构的天文学家。

论文链接：Nature Astronomy 8, 1294 (2024)，https://www.nature.com/articles/s41550-024-02309-5

◎ "Motion Picture" Method Reveals the Shape of the Milky Way's Dark Matter Halo

In the nearby universe, nearly one-third of disk galaxies are not perfect disks but exhibit a warped shape resembling a potato chip. Astronomers refer to this phenomenon as a disk warp. The Milky Way, as a typical disk galaxy, also has this warp feature. This tilted, rotating Galactic disk, much like a spinning top, inevitably undergoes precession due to the torque exerted by the surrounding dark matter halo (Figure 1). However, the measurement of this important dynamic parameter, both in direction and rate, has been highly debated. This is because previous measurements relied on indirect kinematic methods, where the tracers used are subject to dynamical perturbations or heating effects, greatly limiting their accuracy and precision.

In current paper, the team lead by Professor Huawei Zhang at the The Department of Astronomy and The Kavli Institute for Astronomy and Astrophysics of Peking University collaborated with the team lead by Associate Professor Yang Huang at University of the Chinese Academy of Sciences to propose a novel “motion picture” method that can measure the Galactic warp precession rate directly. This study utilized 2,600 young classical Cepheid variable stars discovered by Gaia as tracers, along with precise distance and age data from both Gaia and LAMOST. Using this sample, the researchers applied the "motion picture" method to construct the three-dimensional structure of the Milky Way's disk across populations of various ages but all younger than 250 Myr. The precession rate of the warp can be clearly shown by "seeing" how the disk warp evolves with age (Figure 2). Due to the young nature of the Cepheids sample, they retain information about the shape of the warp at the time of their birth. The Cepheids with different ages reflect the warp at different time, thus exhibit its variation with time. This method is later validated by N-body and SPH simulations (Figure 3, also see arXiv: 2409.02734). This study found that the warp precesses in a retrograde direction at a rate of 2 km/s/kpc (or 0.12 degrees per million years). Further detailed measurements show that the warp's precession rate gradually decreases with radius. In fact, regardless of the origin of the warp, its precession rate and direction are jointly determined by the Galactic inner disk and the dark matter halo. The results of this study are also in great agreement with the previous simulation prediction on the warp precession that majorly under the influence of the inner disk and dark matter halo. After subtracting the contribution of the Galactic inner disk, the research team found that the current dark matter halo enveloping the warp exhibits a slightly oblate ellipsoidal shape (with a flattening ratio q between 0.84 and 0.96 for the equipotential surfaces). Currently, only this shape can explain the remaining precession rate of the warp. This measurement provides a crucial anchor point for studying the evolution of the Milky Way's dark matter halo.

The study was highly praised by both reviewers: “the ‘motion picture’ approach to measuring the precession rate is novel and convincing” from Referee #1; “as far as I am aware, this is the first time that the warp is constrained to precess in retrograde direction, and its precession rate is accurately measured" from Referee #2.

Associate Professor Yang Huang from the University of the Chinese Academy of Sciences and Graduate student Qikang Feng from Peking University are the co-first authors. Associate Professor Yang Huang from the University of the Chinese Academy of Sciences, Professor Huawei Zhang from Peking University, Researcher Jifeng Liu from the National Astronomical Observatories of the Chinese Academy of Sciences and Professor Shen Juntai from Shanghai Jiao Tong University are the co-corresponding authors. This study also includes astronomers from the National Astronomical Observatories of the Chinese Academy of Sciences, Beijing Normal University, and the University of Notre Dame in the USA.

Link to this paper: Nature Astronomy 8, 1294 (2024), https://www.nature.com/articles/s41550-024-02309-5

供稿：天文学系
审核：陈弦

07 大气与海洋科学系
Department of Atmospheric and Oceanic Sciences

北京大学大气与海洋科学系始建于 1929 年，拥有中国高校中唯一的大气科学一级重点学科，致力于建设世界一流的大气与海洋科学学科。现有全职教师 29 人，其中 18 人获有海外博士学位。师资队伍学术活跃，人均年均发表 SCI 论文约 5 篇，已累计获得包括美国气象学会会士在内的国际学术荣誉 10 余项。研究主要围绕大气与海洋科学的基础与前沿问题展开，重点聚焦四大方向：极端天气与气候变化、大气物理与大气环境、物理海洋与海气相互作用、古气候与行星大气。

The Department of Atmospheric and Oceanic Sciences (AOS) at Peking University originated from a meteorological program established in 1929. AOS has the only first-tier focal discipline in atmospheric sciences in China, and it has been making fast progress towards becoming a world-leading institute. AOS has 29 full-time faculty and stuff, with 18 having a PhD degree from foreign universities. Each year, each faculty member published 5 SCI papers on average. In total, the faculty has received over 10 international awards and honors such as the AMS Fellow.The research fields cover extreme weather and climate change, atmospheric physics and environment, physical oceanography, and paleoclimate and planetary atmospheres.

◎ 深时厄尔尼诺 - 南方涛动模拟研究

胡永云教授团队使用地球系统模式对 2.5 亿年以来的 ENSO 活动开展了系统模拟研究，发现厄尔尼诺 - 南方涛动（ENSO）现象自 2.5 亿年以来一直存在，揭示了 ENSO 振幅的演变与温跃层深度和大气随机扰动的变化密切相关，这一结果为未来气候态下的 ENSO 预测和不确定性约束提供了重要的启示。

现代 ENSO 是热带太平洋海气相互作用的结果，是年际时间尺度最强的气候模态，对于调控全球气候系统起到重要作用。过去的 2.5 亿年经历了巨大的气候变化和海陆分布变化，ENSO 在地质时间尺度上如何演变？其主控机制是什么？

使用海气耦合地球系统模式（CESM1.2.2），胡永云团队针对过去 2.5 亿年开展了系列模拟试验（每 1 千万年一个气候平衡态试验）。在 2.5 亿年前（250 Million years ago (Ma)，海陆分布为一个潘基亚超大陆和一个泛大洋，全球平均地表温度（global mean surface temperature, GMST）为 25.5 °C（图 1A），比工业革命前（pre-industrial, PI）时期高出十多度（图 1C）。在潘吉亚超大陆的裂解后，GMST 为 19.7 °C（图 1B，150 Ma）。尽管不同地质时期温度变化巨大，海陆分布存在巨大差异，但盛行东风下的赤道太平洋“暖池 - 冷舌”海温分布和“西深东浅”的温跃层倾斜结构基本维持不变（图 1A-F，图 2A）。

2.5 亿年以来，海表温度年际变率最大值一直位于赤道东太平洋（120° W 附近，图 1G-I），说明 2.5 亿年以来一直存在 ENSO 活动。PI 时期的 ENSO 振幅最弱，为 0.6 °C，150 Ma 最强，为 1.3 °C（图 1H 和 I）。在没有深入分析研究之前，一个似乎合理的推测是，深时 ENSO 振幅变化与 GMST 或赤道洋盆宽度等有关，但实际分析表明，ENSO 振幅与 GMST、赤道纬向海表温度梯度以及洋盆的宽度之间并不存在显著相关性。

根据现代 ENSO 的充电振子（Recharge Oscillator, RO）理论模型，线性 Bjerknes stability index（BJ index）能够解释 2.5 亿年以来 ENSO 振幅变化方差的 57%，其中纬向平流正反馈和温跃层正反馈的贡献起主导作用。正反馈受赤道西太平洋温跃层深度的调控，当温跃层较深时，赤道温跃层东西倾斜程度对海表风应力的响应减弱，从而使纬向平流正反馈和温跃层正反馈的强度减弱，导致 ENSO 振幅减弱，反之亦然。此外，ENSO 振幅还受大气随机扰动的影响。在大气随机扰动较强的时期，ENSO 振幅较强，反之亦然。线性增长率和大气随机扰动相互独立，两者可解释 2.5 亿年以来 ENSO 振幅变化的 76%。

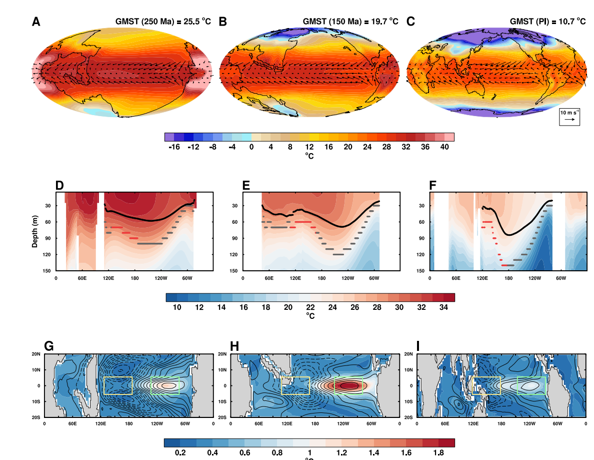


图 1 过去 2.5 亿年中 3 个代表性时期的气温、赤道海洋温跃层和 ENSO: 250 Ma、150 Ma 和 PI。(A-C) 全球地表温度和热带洋面风场。（D-F）赤道地区海温垂直剖面，黑实线代表混合层深度，灰断线代表温跃层深度，红断线表示西太平洋温跃层深度。（G-I）填色为海表温度的年际变率，等值线为海表高度异常对 ENSO 指数的回归。黄色和绿色方框分别代表赤道西太平洋和东太平洋。

该研究是在国家自然科学基金基础科学中心项目“大陆演化与季风系统演变”（42488201）资助下完成的。

Xiang Li, Shineng Hu, Yongyun Hu*, Wenju Cai, Yishuai Jin, Zhengyao Lu, Jiaqi Guo, Jiawenjing Lan, Qifan Lin, Shuai Yuan, Jian Zhang, Zhongshi Zhang, Yonggang Liu, Jun Yang, Ji Nie, 2024: Variations in the amplitude of El Niño–Southern Oscillation in the past 250 million years. PNAS, 121(45), e2404758121.

◎ Persistently active El Niño–Southern Oscillation since the Mesozoic

The El Niño–Southern Oscillation (ENSO), originating in the central and eastern equatorial Pacific, is a defining mode of interannual climate variability with profound impact on global climate and ecosystems. However, an understanding of how the ENSO might have evolved over geological timescales is still lacking, despite a well-accepted recognition that such an understanding has direct implications for constraining human-induced future ENSO changes. Here, using climate simulations, we show that ENSO has been a leading mode of tropical sea surface temperature (SST) variability in the past 250 My but with substantial variations in amplitude across geological periods. We show this result by performing and analyzing a series of coupled time-slice climate simulations forced by paleogeography, atmospheric CO_2 concentrations, and solar radiation for the past 250 My, in 10-My intervals. The variations in ENSO amplitude across geological periods are little related to mean equatorial zonal SST gradient or global mean surface temperature of the respective periods but are primarily determined by interperiod difference in the background thermocline depth, according to a linear stability analysis. In addition, variations in atmospheric noise serve as an independent contributing factor to ENSO variations across intergeological periods. The two factors together explain about 76% of the interperiod variations in ENSO amplitude over the past 250 My. Our findings support the importance of changing ocean vertical thermal structure and atmospheric noise in influencing projected future ENSO change and its uncertainty

◎ 全球气溶胶光学性质变化引起北半球哈德莱环流扩张

哈德莱环流是全球最主要的大尺度环流系统之一，在该系统中，暖湿空气由热带上升，在副热带地区下沉，对地球不同纬度带之间的能量与物质输送，以及热带和副热带地区的气候起着决定性作用。自上世纪 80 年代开始大规模卫星观测以来，南北半球的哈德莱环流均有所扩张，导致副热带干旱区向中纬度移动。特别是北半球哈德莱环流的扩张对东亚、南亚、欧洲、北美等人口密集区域的气候影响显著。该变化趋势与自然变率与人为活动密切相关。然而，不同因素的相对贡献，以及哪些（个）因素起到主导作用仍不明确。

李婧团队针对哈德莱环流扩张问题开展研究，突破传统研究之考虑气溶胶总量的局限，发现吸收、散射气溶胶相对含量的变化，是造成北半球哈德莱环流扩张的主要因素，贡献了北半球秋季哈德莱环流扩张趋势的 73%（图 1）。

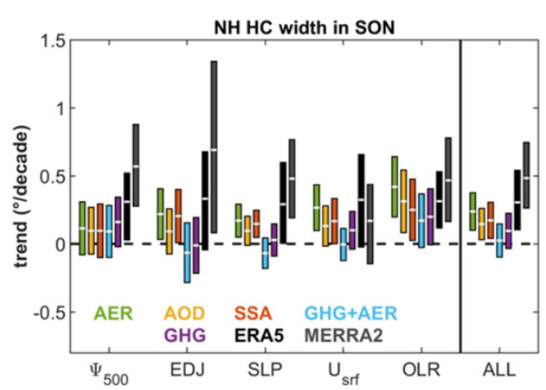


图 1： CESM 模拟试验和再分析资料给出的 1980 年代以来北半球秋季哈德莱环流增宽趋势

在在北半球中高纬地区，吸收性气溶胶占比增加导致气溶胶单次散射反照率（SSA）显著下降。而在低纬地区，SSA 显著上升。不同纬度 SSA 的变化导致北半球中高纬对流层大气显著增暖（图 3），而低纬温度稍有下降，从而削弱了中纬度地区的南北温度梯度以及中纬度地区的斜压性，最终造成哈德莱环流的向北扩张。

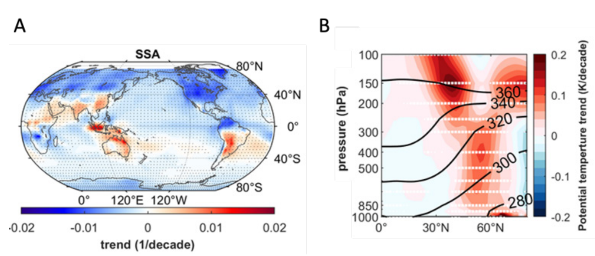


图 2 A：1980-2021 年北半球秋季气溶胶吸收散射性质 SSA 的变化趋；B：气溶胶吸收散射性质变化导致的北半球纬向平均温度廓线变化

李婧团队进一步比较了全球多模式比较计划 CMIP6 的气溶胶模拟试验结果。虽然不同 CMIP6 模式所模拟的 SSA 变化具有较大的不确定性，但模拟出北半球中高纬 SSA 显著下降的模式也更倾向于模拟出北半球哈德莱环流扩张的信号（图 3 A），且该信号亦与南北温度梯度以及中纬度静力稳定度具有较好的相关关系（图 3 B&C），进一步支持了 SSA 变化在哈德莱环流扩张过程中的重要作用。

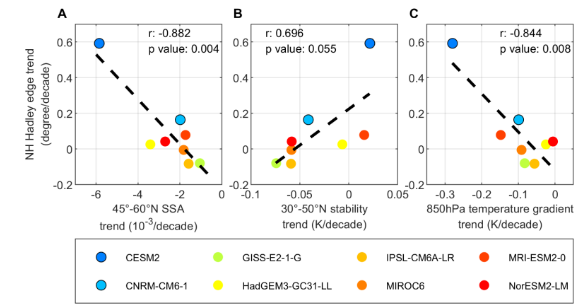


图 3：CMIP6 模式气溶胶强迫试验中北半球哈德莱环流扩张趋势与北半球中高纬 SSA、中纬度静力稳定度和径向温度梯度趋势的关系

该研究不仅发现了导致哈德莱环流扩张的新因素，也为我们理解气溶胶强迫提供了新的视角，即不仅需要关注气溶胶总量的变化，更要关注气溶胶成分与光学特性的变化。研究同时强调了对表征气溶胶吸收散射性质的 SSA 这一光学参数进行全球观测的重要性。

成 果 文 章：Ying, T., Li, J., Fu, Q., Liu, G., Zhang, L., Xia, Y. and Hu, Y., 2024. Fractional change of scattering and absorbing aerosols contributes to Northern Hemisphere Hadley circulation expansion. Science Advances, 10(46), p.eadq9716.

◎ Changes in the Fraction of Scattering and Absorbing Aerosols Contribute to the Expansion of Northern Hemisphere Hadley Circulation

The Hadley cell is one of the most important large-scale circulation systems in the world. In this system, warm and moist air rises from the tropics and sinks in the subtropics. It plays a decisive role in the transport of energy and material between different latitude zones of the earth, as well as the climate in the tropical and subtropical regions. Since large-scale satellite observations began in the 1980s, the Hadley cells in both the northern and southern hemispheres have expanded, causing the subtropical arid areas to move to mid-latitudes. In particular, the expansion of the Hadley cell in the northern hemisphere has a significant impact on the climate of densely populated areas such as East Asia, South Asia, Europe, and North America. This change trend is closely related to natural variability and human activities. However, the relative contributions of different factors and which factor(s) play a dominant role remain unclear.

Li Jing's team conducted research on the expansion of the Hadley Cell, breaking through the limitations of traditional research that considers the total amount of aerosols, and found that changes in the relative content of absorbing and scattering aerosols are the main factors causing the expansion of the Hadley Cell in the Northern Hemisphere, contributing 73% of the Hadley Cell expansion trend in the Northern Hemisphere autumn (Figure 1).

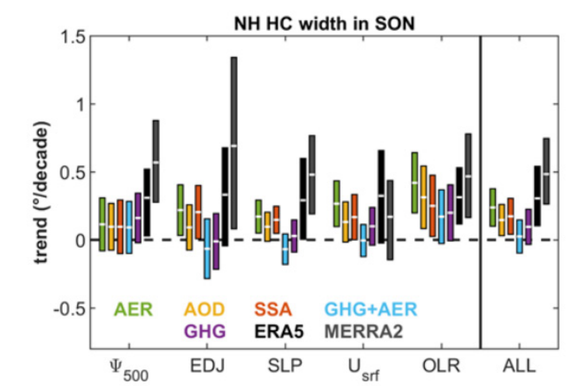


Figure 1: The widening trend of the Hadley cell in autumn in the Northern Hemisphere since the 1980s, as shown by CESM simulation experiments and reanalysis data.

n the mid-to-high latitudes of the Northern Hemisphere, the increase in the proportion of absorptive aerosols leads to a significant decrease in aerosol single scattering albedo (SSA). In low latitudes, SSA increases significantly. Changes in SSA at different latitudes lead to significant warming of the tropospheric atmosphere at mid- and high-latitudes in the Northern Hemisphere (Figure 2), while temperatures at low latitudes decrease slightly, thus weakening the north-south temperature gradient in the mid-latitudes and the baroclinicity in the mid-latitudes, ultimately causing the northward expansion of the Hadley cell.

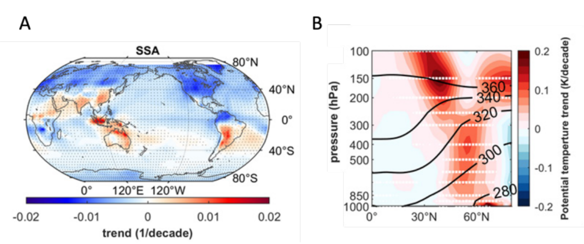


Figure 2 A: Change trend of aerosol absorption and scattering properties SSA in the Northern Hemisphere autumn from 1980 to 2021; B:Changes in Northern Hemisphere zonal average temperature profile caused by changes in aerosol absorption and scattering properties

Li Jing's team further compared the aerosol simulation test results of the Global Multi-Model Intercomparison Program CMIP6. Although the SSA changes simulated by different CMIP6 models have large uncertainties, the models that simulate a significant decrease in SSA in the mid- and high-latitudes of the Northern Hemisphere are also more likely to simulate the signal of the expansion of the Hadley Cell in the Northern Hemisphere (Figure 3 A), and this signal also has a good correlation with the north-south temperature gradient and mid-latitude static stability (Figure 3 B&C), further supporting the important role of SSA changes in the expansion of the Hadley Cell.

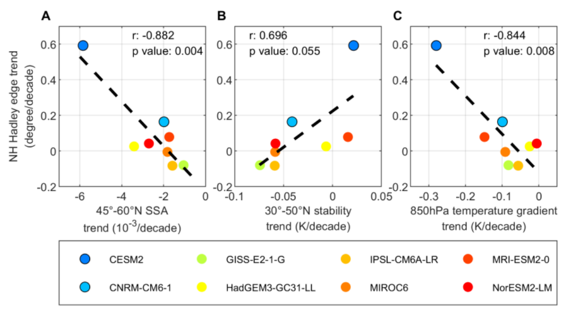


Figure 3: Relationship between the Hadley cell expansion trend in the Northern Hemisphere and the mid- and high-latitude SSA, mid-latitude static stability and radial temperature gradient trends in the Northern Hemisphere in the CMIP6 model aerosol forcing experiment

This study not only discovered new factors leading to the expansion of the Hadley cell, but also provided a new perspective for us to understand aerosol forcing. That is, we need to pay attention not only to changes in the total amount of aerosols, but also to changes in aerosol composition and optical properties. The study also emphasizes the importance of global observations of the optical parameter SSA, which characterizes the absorption and scattering properties of aerosols.

Research article: Ying, T., Li, J., Fu, Q., Liu, G., Zhang, L., Xia, Y. and Hu, Y., 2024. Fractional change of scattering and absorbing aerosols contributes to Northern Hemisphere Hadley circulation expansion. Science Advances, 10(46), p.eadq9716.

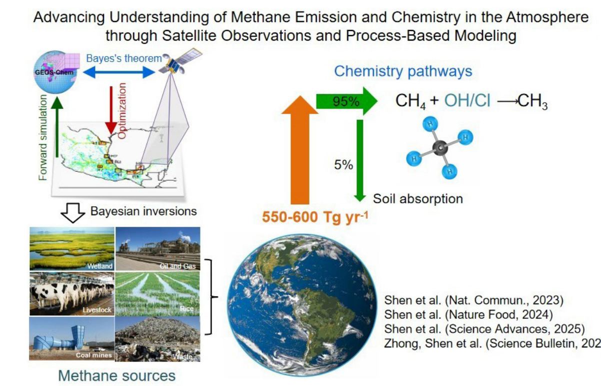
◎ 融合卫星遥感与数值模式解析全球甲烷排放动态过程

甲烷是全球第二大温室气体，减少甲烷排放是控制气候变暖的最重要措施之一。沈路路课题组基于卫星遥感反演和数值模式模拟，量化了全球范围内 50 公里分辨率的甲烷排放，阐明了海洋高盐度环境下抑制甲烷形成的物理化学机制，深入揭示了大气硫酸盐沉降减少可能加剧未来湿地甲烷排放的趋势，进而对未来湿地甲烷排放的变化进行了评估。

大气环境的未来演变与气候变化密切相关，而气候变暖的主要驱动因素是人为温室气体的排放。甲烷 (CH4) 是继二氧化碳 (CO2) 之后最重要的温室气体，根据第六次 IPCC 报告，自工业革命以来的全球平均增温中有 0.6° C 来自 CH4 排放。甲烷排放源众多，整体减排和控制的成本非常高。因此，我们迫切需要建立高时空分辨率的甲烷排放清单，解析其在大气中的源汇机制，对甲烷在全球尺度的未来变化趋势进行深入探究，进而厘清甲烷在气候变化过程中的关键作用。

• 开发了高分辨率甲烷排放反演算法并量化了全球排放

以高精度 TROPOMI 卫星观测为基础，结合大气化学模式 GEOS-Chem，通过改良后的高效率贝叶斯反演技术，评估了全球和区域高空间分辨率 (50km) 的甲烷排放。该算法基于不同排放源的空间分布和重要性，采用了混合空间分辨率设置，大幅度减少计算量从而实现全球尺度高精度的排放反演。其反演得到的排放强度与全球 23 个油气田场地测量的数据高度一致。该算法被哈佛大学的“集成式甲烷反演平台 v1.0”选择为标准代码，发布在亚马逊云计算平台上，是监测温室气体排放的重要工具。反演结果显示全球油气和煤矿行业分别排放了 62.7 ± 11.5 Tg a-1 和 32.7 ± 5.2 Tg a-1 的甲烷，其中油气行业的全球排放总量比目前基于自下而上方法的估算高了近 30%。相关研究成果发表在 《Nature Communications》和《Science Bulletin》等。



图：利用卫星遥感和数值模型解析全球甲烷的重要排放机制。

• 解析了近海碳氮循环过程并发现高盐度环境可以显著抑制甲烷排放

以卫星遥感观测到的海洋初级生产力、全球船舶监测到的温室气体通量为基础，利用颗粒物沉降传输算法，解析了不同粒径颗粒物在海洋不同深度的物理沉降分解和生物化学转化过程。结果发现，与淡水环境相比，海洋的高盐度使得有机质产生甲烷的效率下降了至少 98%，为全球甲烷减排提供新的途径。相关研究成果发表在《Nature Food》。

• 揭示了未来全球大气硫酸盐沉降下降会增加湿地甲烷排放的重要机制

未来的湿地甲烷排放预测通常忽略了全球生物地球化学循环的反馈效应。研究采用数据驱动方法，考虑了气象变化以及大气硫酸盐沉降和二氧化碳施肥效应等生物地球化学反馈过程，估算了 2000-2100 年间的湿地甲烷排放。结果发现，在低 CO_2 情景下，大气硫酸盐沉降对湿地甲烷排放的抑制效应在 2100 年基本消失，导致湿地排放会额外增加 7±2 Tg a^{-1}，占湿地排放变化总量的 30% 左右，该机制在当前集成评估模型中尚未考虑。相关研究成果发表在《Science Advances》上。

HIGHLIGHTS
系所中心研究亮点

◎ Understanding Global Methane Emission Processes through Satellite Remote Sensing and Numerical Modeling

Methane (CH_4) is the second most important anthropogenic greenhouse gas after CO_2, responsible for 0.6 °C global warming since preindustrial times. Under the Paris Agreement, countries must set goals for mitigating their anthropogenic methane emissions relative to current baselines, highlighting the need to explore the challenges and opportunities of methane mitigation. (1) Using high-resolution satellite observations, we quantify global methane emissions by inverse analysis at up to 50 km resolution. Our results reveal global emissions of 62.7 ± 11.5 (2σ) Tg a-1 for oil-gas and 32.7 ± 5.2 Tg a-1 for coal. Oil-gas emissions are 30% higher than the global total from UNFCCC reports, mainly due to under-reporting by the four largest emitters including the US, Russia, Venezuela, and Turkmenistan. (2) We demonstrate that, under low-CO_2 scenarios (1.5 and 2° C warming pathways), the suppressive effect of atmospheric sulfate deposition on wetland methane emissions largely diminishes by 2100 due to clean air policies, resulting in an additional emission increase of 7 2 Tga-1, a factor not yet considered by current Integrated Assessment Models. (3) We find that near-shore methane emission intensity is >95% lower than freshwater waters, driven by suppressed microbial production in marine waters and inefficient ventilation to the atmosphere. Our work elucidates key mechanisms governing methane emissions, providing critical insights for addressing global climate change.

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审核：刘美景

08 普通物理教学中心
Teaching Center for General Physics

北京大学物理学院普通物理教学中心是北京大学物理学院下属的一个三级机构，其前身为北京大学物理系普通物理教研室，负责普通物理各类课程的长期建设、教学研讨活动和对外交流活动的组织以及日常教学组织管理工作。中心下设一个演示实验室和 10 个主干基础课课程组，每个课程组设课程主持人和主讲人，中心的主要任务是承担全校普通物理 01-05 共五个系列平台课程的教学任务，授课对象为理科将近 2000 位学生，年授课工作量约 222000 人学时。普通物理教学中心努力传承北京大学普通物理教学的优良传统，初步形成了一支专任和兼任相结合，科研与教学相结合，老、中、青教师相结合的与北大地位相称的普物教学团队，团队的职称结构和年龄结构合理，专业分布广泛，团队规模适度，结构优化，学术水平高，教学质量好。

The Teaching Center for General Physics is a branch of the School of Physics at Peking University. Previously, it was called the Teaching and Research Section of the Physics Department. The main task of the Center is to supervise all the teaching programs of general physics courses, such as mechanics, electromagnetism, thermal physics, optics, atomic physics and modern physics for the science major undergraduate students of Peking University. It is also responsible for organizing seminars and arranging national and international exchange activities, which are closely related to teaching and learning. All the members of the Teaching Center have full teaching load each semester. They are heavily involved in making and managing the entire teaching schedule at the School, too. The Teaching Center has one laboratory for demonstration and 10 teaching groups. Each of them is led by a moderator and is dedicated to teaching a specific subject. Their duties cover the whole Physics in series 01-05. Each year, more than 2,000 undergraduate students take these courses. It is equivalent to a working load of 222,000 teaching units (number of students times class hours) per year. Since its establishment, the Center has set very high standards for each course and made great effort to achieve teaching excellence, as the Teaching and Research Section of the Physics Department did traditionally in the passed time. As far as the teaching faculties are concerned, besides several full-time members, many professors from other departments and/or institutes of the School participate also in teaching general physics. Since these lecturers are experienced researchers, they make their classes highly interesting and inspiring to the students. On the other hand, the Center invites also some retired professors to be the senior advisors. Therefore, each teaching group has an ideal structure with respect to the distributions of faculty ages, specialties, professional ranks and teaching experiences. These teams perform at very high professional levels which are compatible with the academic stature of School of Physics at Peking University. The Teaching Center for General Physics is dedicated to sustain such high teaching standards in future.

◎ 出版国家“101 计划”重点建设教材《力学》、《热学》、《电磁学》和《原子物理学》

普通物理教学中心的四位教师出版了四部国家“101 计划”重点建设教材，《力学》、《热学》、《电磁学》和《原子物理学》。其中《力学》由中心的刘树新副教授编著，《电磁学》由中心的孟策副教授和陈晓林教授联合编著，《热学》和《原子物理学》由刘玉鑫教授编著。这些教材都是编著者根据多年教学经验和课程应该以科学品质（科学精神、科学素养和科学方法）为其魂作为基本理念而编著的，系统地介绍了这些课程涉及的基本现象、基本性质和基本规律，内容的选取系统全面，着重理论与应用的有机结合，理论分析力求循序渐进、准确严谨，着重物理图像和知识体系的建立过程，并适时联系前沿。整体以求窥得物理学 " 见物讲理、依理造物 " 的学科真谛，并通过对相应学科发展过程中的重大突破事例和前辈学者成长及工作的分析，既启迪智慧，又润物无声地实现课程思政、立德树人。

◎ Four Textbooks in National “101 Project” were Published

Four famous teachers in the center published textbooks, Mechanics, Thermal Physics, Electromagnetism and Atomic Physics. All these four books are the key ones in the national “101 Project”. They are compiled by associate professor Shuxin Liu, professor Yu-xin Liu, associate professor Ce Meng and professor Xiaolin Chen, and Professor Yu-xin Liu, respectively, based on their years of teaching experience. They describes systematically the basic phenomena, general properties and fundamental principles of the respective subject. The selection of the content in each of the books is systematic and comprehensive, emphasizing the intrinsic combination of the theory and applications. The theoretical analysis strives to be gradual, accurate, and rigorous, emphasizing the physics picture and the establishment process of the knowledge systems, and contacts the forefront timely. With these efforts, a holistic understanding of the essence of physics as a discipline of "seeing things with exploring the underlying principle, and creating things based on the principle" can be gained, so that not only the intelligence and creativity can be inspired but also the excellent qualities of a natural human can be trained and promoted.

◎ 在人才培养模式和基础科学问题研究中取得成果

普通物理教学中心的教师除进行教学组织、课程讲授和教材建设之外，还对认知规律和人才培养模式、基础物理中的一些基本问题开展研究，并取得成果。中心成员穆良柱教授发表人才培养模式研究论文一篇（物理与工程 34(06), 5-12 (2024)），孟策副教授发表研究论文 4 篇（其中 Phys. Rev. D 一篇、Eur. Phys. J. C 一篇、JHEP 一篇、Chin. Phys. C 一篇），刘玉鑫教授发表研究论文 13 篇（其中 Phys. Rev. Lett. 一篇、Phys. Rev. D 六篇、Phys. Lett. B 两篇、Eur. Phys. J. C 两篇、Commun. Theor. Phys. 一篇、中国科学一篇）。

穆良柱教授的论文（什么是 ETA 物理解题法 – 素质与应试的统一）针对同学们由中学到大学过渡阶段遇到的学习困难现象进行深入分析，找到了学业困难背后的原因，并根据 ETA 物理认知模型提出了 ETA 物理解题法，解决了如何学和如何学好两个问题。将这套解题方法坚持下来，熟能生巧，不仅可以大幅提高学习和解题效率，还可以增强探索能力和其它各项应对未来未知因素的能力。

◎ Made Progress in the Research of Students’ Ability Fostering Scheme and Fundamental Physics Problems

Besides of accomplishing the tasks of the education affairs of general physics and writing the textbooks, the faculty members in the center carry out researches not only on the scheme of fostering the abilities of students but also the significant problems in fundamental physics. Concretely，Professor Mu published one paper in Physics and Engineering, Professor Meng published one paper in Phys. Rev. D, one paper in Eur. Phys. C, one paper in JHEP and one in Chin. Phys. C. Prof. Yu-xin Liu published one paper in Phys. Rev. Lett., 6 papers in Phys. Rev. D, 2 papers in Phys. Lett. B, 2 papers in Eur. Phys. C, one paper in Commun. Theor. Phys., and one in Sci. China-Phys. Mech. Astron..

Prof. Liangzhu Mu conducted in-depth research on the learning difficulties arising from the delayed match of university study from high school. He found the reasons behind the various difficulties and proposed the ETA method of solving problems based on the ETA physics cognitive model, mainly addressing the two issues of how to learn and how to learn well. With persistent adhering to this set of learning methods, one can become skillful, improve learning efficiency, and gets time to explore more meaningful issues. The complete cultivation of cognitive abilities, especially the enhancement of exploratory abilities, can help to seek more directions and space for the career development of students and their abilities to handle unknown things in future. In turn, it solves efficiently the psychological problems of students caused by "neijuan" (the excessive competition among students).

供稿：普通物理教学中心
审核：刘玉鑫

HIGHLIGHTS
系所中心研究亮点

09 基础物理实验教学中心
Teaching Center for Experimental Physics

北京大学基础物理实验教学中心是"国家级实验教学示范中心"，承担国家级精品课"普通物理实验"和"近代物理实验"的基础课教学，并从中开辟出"综合物理实验"和"前沿物理实验"的研究型实验课程。目前在岗专职教师 7 名（教授 2 名，副教授 5 名），实验技术人员 7 名（高级工程师 1 名，工程师 6 名）。

The Teaching Center for Experimental Physics at Peking University is "National Experimental Teaching Demonstration Center". We undertake the core course teaching of National Outstanding Courses "General Physics Experiments" and "Modern Physics Experiments". On the basis of the above, we construct the research-oriented courses, "Comprehensive Physics Experiments" and "Frontier Physics Experiments". Currently, there are 7 full-time faculty members (2 professors and 5 associate professors), and 7 laboratory technicians (1 senior engineer and 6 engineers).

◎ "普通物理实验"被教育部认定为国家级线下一流本科课程

"普通物理实验"是物理专业本科生必修的第一门物理实验课程，主要目标是使学生由浅入深掌握物理实验的基础知识、基本方法和基本技能，在此基础上初步掌握用实验物理的方法去开展研究工作。随着时代发展，"普通物理实验"课程主要面临如下问题：一是如何兼顾基础性和前沿性，让学生在有效完成基础训练的同时，接触更多前沿内容，并受到更有挑战性的训练；二是如何针对学生的不同，开展差异化的培养，使不同程度学生的实验能力都能获得有效的提高。

为解决上述问题，实验中心的一个具体举措是"加强基础"。随着学科发展和科技更新，不断更新"基础"所对应的具体内容和相关技术，使课程内容既反映当前物理学科和现代科技的发展，又有利于学生基础训练的加强。例如，在基本内容中增加了低温、真空等原属近现代物理的实验内容；在实验仪器和技术上，用数字示波器替代模拟示波器、引进传感器和虚拟仪器技术、用光学平台部分取代了导轨等，从而将课程中的"基础"始终定位在较高的水准。另一具体举措是大力建设拓展模块内容：为实现因材施教，加强对优秀学生的特殊培养，重点建设了研究型的"自主综合实验"模块和"专题研究性实验"模块，这些扩展模块以物理研究为途径，以探讨物理教学实验中的疑难问题和从科学前沿问题中提出的适合本科生进一步深入研究的课题为内容，为优秀学生创造了自主学习的环境，极大提升了课程的高阶性和先进性。上述基础内容和拓展模块，共同构成了完整的"普通物理实验"课程体系，既保障了基础性，又兼具综合性、研究性和先进性。2023 年，"普通物理实验"被教育部认定为国家级线下一流本科课程。

◎ "General Physics Experiments" recognized as a National First-Class Undergraduate Course by the Ministry of Education

"General Physics Experiments" is the first required physics experiment course for undergraduate physics students, with the primary goal of enabling students to gradually master the foundational knowledge, basic methods, and fundamental skills of physics experiments. On this basis, students tentatively learn how to conduct research using experimental physics methods. With the development of the times, the "General Physics Experiments" course mainly faces the following issues: first, how to balance the fundamentality and frontier content, allowing students to effectively complete foundational training while also being exposed to more advanced topics and receiving more challenging training; secondly, how to conduct differentiated cultivation based on individual student differences, ensuring that the experimental abilities of students at different levels can be effectively improved.

To address the aforementioned challenges, one concrete initiative implemented by the Experimental Center is "strengthening foundational training". With the discipline development and technological innovation, the center continuously updates the specific content and related techniques covered under "foundational training," ensuring that course materials reflect both current developments in physics and modern technology while enhancing students' fundamental experimental skills. For example, low-temperature and vacuum experiments, originally categorized as modern physics experiments, have been incorporated into the basic curriculum. In terms of instruments and techniques, analog oscilloscopes have been replaced with digital oscilloscopes, sensor and virtual instrumentation technologies have been introduced, and optical platforms have partially substituted guide rails. These updates ensure that the "foundational" aspects of the course maintain high standards. Another key initiative involves expanding modular content. To implement ability-driven education and provide special training for excellent students, the center has prioritized the development of research-oriented modules such as "Independent Comprehensive Experiments" and "Topic-specific Investigative Experiments". These advanced modules use physics research as a methodological framework, focusing on resolving challenging issues in physics teaching experiments and exploring the research topics suitable for undergraduates derived from scientific frontiers. They create a self-directed learning environment for excellent students, significantly elevating the course's academic depth and innovativity. Together, these foundational and advanced modules form a comprehensive "General Physics Experiments" curriculum that balances fundamental training with integrated, research-driven, and innovative components. In 2023, "General Physics Experiments" was recognized by the Ministry of Education as a National First-Class Undergraduate Course.

HIGHLIGHTS
系所中心研究亮点

◎ 国际和亚洲物理奥林匹克竞赛国家队的选拔和实验培训

北京大学基础物理实验教学中心负责了2022-2023年度的国际和亚洲物理奥林匹克竞赛国家队选拔和培训工作的实验部分。中国国际物理奥林匹克代表队的5名队员和亚洲物理奥林匹克代表队的8名队员均从全国中学生物理竞赛决赛的金牌获得者中选出。为使有潜能但其所在中学实验条件较弱的同学也能有更公平的机会，实验中心在实验选拔考试前安排了面对全体候选同学的实验培训，并通过精心准备的选拔考试题来全面考察和提升学生的物理实验素养，以确保入选队员都是最优秀的。

为使中国队参赛选手们达到最佳比赛状态，实验中心还在亚洲和国际竞赛赛前为选手们安排了专门的实验培训课程和多次模拟实验考试。2023年5月21日至29日，第23届亚洲物理奥林匹克竞赛于蒙古首都乌兰巴托举办，这是因为疫情的原因中断3年之后首次现场举办的亚洲物理奥林匹克竞赛。最终中国代表队的8名选手郎程超、李博滔、黄子橙、覃楚石、李贝尔、刘华君、蒲泊言、龚炳瑞全部获得金牌，并包揽了个人总成绩的前三名。来自富阳中学的郎程超同学获得个人总成绩第一和理论成绩第一两个奖项。2023年7月10日至17日，第53届国际物理奥林匹克竞赛于日本东京正式举办，共有87个国家及地区的参赛队伍，共计450名学生参加本届比赛。最终中国代表队的5位选手余博文、丁卓立、田向晨、赵瀚宏、蒋岱兵全部获得金牌，个人总成绩排名分别为第一至四名和第六名。至此，本次国际和亚洲物理奥林匹克竞赛选拔和培训任务取得圆满成功。

◎ Selection and experimental training for national teams of the International and Asian Physics Olympiads

The Teaching Center for Experimental Physics at Peking University has been responsible for the selection and training of the International and Asian Physics Olympiad teams from 2022 to 2023. Five members of the Chinese International Physics Olympiad team and eight members of the Asian Physics Olympiad team were selected from among the gold medalists in the National Physics Competition. To make the students with high potential but weak experimental conditions in high school have fair chance, our center arranged the experimental training for all the candidates before the experimental selection, and used the well-prepared exam questions to comprehensively investigate and elevate the students' physics experiment level, to make sure that the selected members were the most excellent.

To ensure that the Chinese team members achieved their optimal competitive condition, the Experimental Center arranged specialized experimental training courses and multiple mock exams for the participants prior to the competition. From May 21 to 29, 2023, the 23rd Asian Physics Olympiad (APhO) was held in Ulaanbaatar, Mongolia. This marked the first on-site APhO held after a three-year hiatus due to the pandemic. All 8 members of the Chinese delegation, Lang Chengchao, Li Botao, Huang Zicheng, Qin Chushi, Li Beier, Liu Huajun, Pu Boyan, and Gong Bingrui, secured gold medals. Notably, they swept the top three positions in overall individual performance. Lang Chengchao from Fuyang High School claimed first place in both the overall individual ranking and the theoretical exam. From July 10 to 17, 2023, the 53rd International Physics Olympiad (IPhO) took place in Tokyo, Japan. The event attracted 450 students from 87 countries and regions. All five Chinese participants, Yu Bowen, Ding Zhuoli, Tian Xiangchen, Zhao Hanhong, and Jiang Daibing, earned gold medals. Their individual rankings occupied the 1st to 4th and the 6th positions globally. These outstanding achievements signify the successful completion of the selection and training programs for both the International and Asian Physics Olympiads.

供稿：基础物理实验教学中心
审核：李智

10 北京大学电子显微镜实验室
Electron Microscopy Laboratory of Peking University

电子显微镜实验室成立于1964年，从创建开始就被定位为北京大学显微分析测试公共平台，主要任务是向全校提供高质量的电镜分析测试服务和电镜专业人才的培养。 1992年被国家教委批准为“电子光学与电子显微镜国家重点学科专业实验室”。实验室在半个世纪的发展过程中，得到学校“世行贷款”、“211”、“985”项目的大力支持，现有大型电镜14台，包括透射电镜7台，扫描电镜3台，聚焦离子束3台，实验室单价40万元以上的大型设备有24台。2015年电镜室采购了两台球差电镜用于材料科学，一台冷冻电镜用于生命科学，2023年采购两台球差电镜进一步弥补北大在先进球差电镜表征领域的不足。实验室仪器总价值接近2亿元，硬件配置和开放环境在国内已处于领先地位。电镜室现有工作人员9人，包括实验室主任高鹏博雅特聘教授、工程技术系列人员8位，其中8人具有博士学位，均为高级职称（含教授级高级工程师1人）。实验室人员专业背景涉及物理学、电子学、化学、材料科学和地质学，人员配备合理。

实验室配备了国际领先的球差校正透射电镜，包括：双球差校正电镜JEOL ARM300F2，空间分辨率高达48 pm，配置齐全，包括Merlin直接电子相机，多能谱探头，电子能量损失谱等；双球差校正电镜FEI Titan Cubed Themis，空间分辨率高达60 pm，配置齐全，包括差分相位衬度探测器（DPC），球差校正的Lorentz模式，多能谱探头，电子能量损失谱等；聚光镜球差校正电镜JEOL ARM200F，主要针对原位成像及能谱实验；高能量分辨球差校正透射电镜Nion U-HERMES200，工作电压为30–200 kV，主要特色是能量分辨率在30 kV高达4 meV，空间分辨率在200 kV高达60pm，稳定性非常高。此外，实验室还配置有多种原位样品台，可以在多台电镜中实现原位的力学、电学、降温、加热、液体池等实验，以及高速率、高灵敏度的相机（如Oneview IS, K2 IS等），能高速记录相变反应，实现电子束敏感材料成像。实验室响应国家对科学仪器自主研制和创新的战略需求，开展了一系列仪器研制开发工作，比如研发了电子束曝光机和阴极荧光系统，部分自研设备已面向全校开放使用，并逐步推进工程化和产业化。

Established in 1964, the Electron Microscopy Laboratory was designated as Peking University's public platform for microscopic analysis and testing from its inception. Its primary mission is to provide high-quality electron microscopy analytical services university-wide while cultivating specialized electron microscopy professionals. In 1992, it was approved by the National Education Commission as a "State Key Discipline Laboratory for Electron Optics and Electron Microscopy." Over its half-century of development, the laboratory has received substantial support through the university's "World Bank Loan," "211 Project," and "985 Project" initiatives. It currently houses 14 major electron microscopes, including 7 transmission electron microscopes (TEMs), 3 scanning electron microscopes (SEMs) and 3 focused ion beam (FIB) systems. Additionally, the laboratory possesses 24 large-scale instruments each valued above 400,000 RMB. In 2015, the facility acquired two aberration-corrected electron microscopes (Cs-corrected TEMs) for materials science research and one cryo-electron microscope (Cryo-EM) for life sciences applications. Further advancing its capabilities, two additional aberration-corrected microscopes were procured in 2023 to address PKU's needs in cutting-edge spherical aberration-corrected characterization techniques. With total equipment assets approaching 200 million RMB, the laboratory's hardware infrastructure and open-access environment now rank among China's most advanced. Laboratory Director is Professor Pengbo Gao, Boyat Distinguished Professor. The facility currently employs eight engineering/technical personnel. Of these, eight hold doctoral degrees, all with senior professional titles–including one Professor-Level Senior Engineer. The team's multidisciplinary expertise spans physics, electronics, chemistry, materials science, and geology, ensuring comprehensive technical support.

The Electron Microscopy Laboratory at Peking University operates world-class aberration-corrected transmission electron microscopy (AC-TEM) systems, including: (1) JEOL ARM300F2 (double aberration-corrected, ≤48 pm resolution) equipped with a Merlin direct electron detector, multiple EDS detectors, and EELS capabilities; (2) FEI Titan Cubed Themis (double aberration-corrected, ≤60 pm resolution) featuring differential phase contrast (DPC) imaging, aberration-corrected Lorentz mode, and parallel EDS/EELS systems; (3) JEOL ARM200F (condenser aberration-corrected) optimized for in situ EDS studies; and (4) Nion U-HERMES200 delivering ultrahigh energy resolution (≤4 meV at 30 kV) and sub-60 pm spatial resolution (200 kV) with exceptional stability. The facility integrates multifunctional in situ holders for mechanical/electrical/thermal (10K–1500 ° C) stimuli and liquid-phase experiments, complemented by high-sensitivity detectors (OneView IS, K2 IS) for beam-sensitive materials and dynamic process capture. In alignment with national priorities for scientific instrumentation, the laboratory has developed cathodoluminescence systems and electron beam lithography tools, which are open for university users and undergoing further development.

◎ 测量单个纳米线非均匀应变下的声子谱与热输运

力学应变工程可以设计并优化先进功能器件。精确热管理被视为制约先进芯片和高端设备效率和寿命的关键瓶颈。当前，基于力学应变工程的研究主要集中于利用应变调控电子输运性能、电子能带结构等，非均匀应变下的热输运机制仍未被系统地揭示。这是由于传统的表征手段难以测量纳米尺度热输运与原子尺度局域声子谱，而且施加应变梯度也往往会引入其他混淆因素（例如界面和缺陷）。本工作通过在自制的悬空微器件上弯曲单个硅纳米带来诱发非均匀应变场，并利用具有亚纳米分辨率的 STEM-EELS 技术表征局域晶格振动谱，发现 0.112％ /nm 应变梯度将导致热导率 (κ) 显著降低 34±5%，这是先前文献中均匀应变下热导率调制结果的 3 倍以上。该工作利用 STEM-EELS，直接在亚纳米级空间尺度测量了单个弯曲硅纳米带的局域声子谱，揭示了由应变梯度导致的独特声子谱扩展效应及其对导热的反常抑制现象，为基于应变工程的功能性器件的创新设计提供了重要思路。相关成果发表于 Nature 杂志。

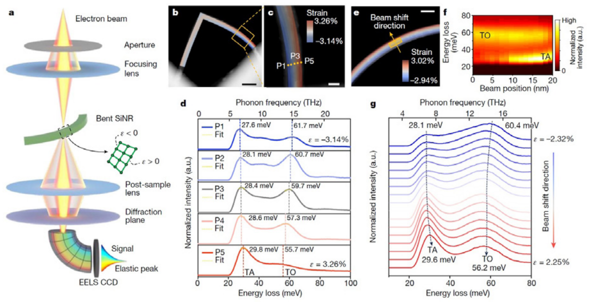

图 1. 非均匀应变对硅纳米带声子的调制及声子测量
Figure 1. Measuring phonons of silicon nanoribbon under inhomogeneous strain

◎ Measuring phonon spectra and thermal transport properties of a single nanowire under inhomogeneous strain

Strain engineering enables the design and optimization of advanced functional devices. Precise thermal management is the key bottleneck to the efficiency and longevity of advanced chips and high-performance devices. At present, the research based on strain engineering mainly focuses on the regulation of electron transport and electronic band structure by strain, and the heat transport mechanism under inhomogeneous strain has not been systematically revealed. This gap in understanding arises from the limitations of traditional characterization methods, which struggle to measure nanoscale heat transport and atomic-scale local phonon spectra. Additionally, strain gradients often introduce confounding factors such as interfaces and defects, further complicating the analysis. In this study, we applied an inhomogeneous strain field through the bending of a single silicon nanoribbon on a custom-designed suspended microdevice, and characterizing the local lattice vibration spectrum using STEM-EELS with sub-nanometer resolution, we observed that a strain gradient of 0.112% per nm leads to a significant 34 ± 5% reduction in thermal conductivity (κ). This reduction is more than threefold greater than previously reported modulations of thermal conductivity under uniform strain. This work represents the first direct measurement of the local phonon spectrum in a single curved silicon nanoribbon at the sub-nanometer spatial scale using STEM-EELS, thereby revealing a unique phonon spectrum spreading effect induced by strain gradients, which results in an anomalous suppression of thermal conductivity. These findings provide valuable insights for the innovative design of functional devices based on strain engineering. The results have been published in the Nature. Professor Peng Gao is one of corresponding authors.

◎ 电子束曝光机研制

北京大学物理学院电子显微镜实验室持续开展电子束曝光机研发工作，承担“科技创新 2030”重大项目课题任务，参与广东省重点领域研发计划项目并顺利结题。研发团队参与研制三套 30kV 和一套 50kV 专业电子束曝光机，掌握了一系列具有自主知识产权的电子束曝光机核心技术，攻克了高精度激光干涉样品台、电子束矢量扫描发生器、电子束束闸、邻近效应校正算法、专业化应用软件和控制系统等多项关键技术难点。所研制的 50kV 电子束曝光机最小加工线宽优于 10nm，拼接精度和套刻精度均优于 50nm，已在用户单位进行一年多试用，达到了项目考核要求。本研究打破了国际技术垄断，填补了国内技术空白，对推动国家微纳加工技术发展有重要意义。

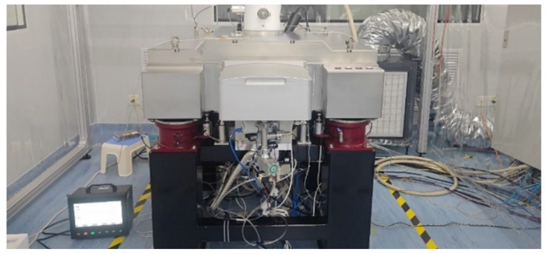

图 50kV 电子束曝光机原理样机
Fig. 50kV EBL system

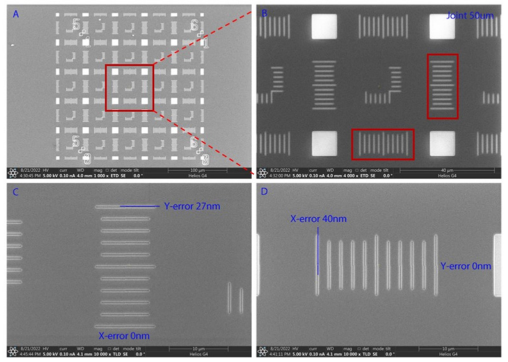

图 利用 50kV 电子束曝光原理样机开展拼接测试试验结果
Fig. Stitching test results of the 50kV EBL system

◎ Development of electron beam lithography system

Electron Microscopic Laboratory, School of Physics, Peking University persisted in development and fabrication of electron beam lithography (EBL) system with the support of the Major Project of National Lab and Key-Area Research and Development Program of Guangdong Province. The PKU team participated in building three sets of 30kV and a set of 50kV EBL functional prototypes by 2023, and has conquered the core technology of EBL machines with independent intellectual property rights. We have beaten several critical technologies, such as high-precision laser interference sample platform, electron beam vector scanning generator, electron beam blanker, proximity effect correction algorithm, specialized application software, and control system. This study has completed the main tasks and achieved the expected goals. The prototype developed in this study has demonstrated good exposure function, with a minimum line width of better than 10nm, splicing accuracy, and lithography accuracy of better than 50nm, and has been tested in user labs. This study breaks the international technological monopoly and fills the domestic technological gap, which is of great significance for promoting the development of national micro and nano-processing technology.

供稿：北京大学电子显微镜实验室
审核：高鹏

11 北京大学量子材料科学中心简介

International Center for Quantum Materials, Peking University

北京大学量子材料科学中心（以下简称“中心”）成立于 2010 年，是一个直属于北京大学的新型教学与科研机构。量子材料科学中心致力于研究凝聚态物理和量子材料科学的前沿问题，营造国际化的学术创新环境，并力争成为国内领先、国际一流的物理学研究教学平台。

作为一个全新的科技创新平台，中心积极利用政策资源优势，不断改革与完善管理模式和工作方式，通过构建国际前沿的实验设施以及引进国际先进的研究技术，致力于打造一个适合物理学基础研究的开放型学术基地，培养一支具有国际影响力的研究团队，推进以量子科学为基础的高新技术的发展。中心一直着力于人才队伍建设，面向全球招聘教学科研人员，成功引进了一批拥有国际知名度的海内外专家以及众多活跃于国际前沿的年轻学者。截至 2024 年 12 月，已有教研系列人员 34 人，其中讲席教授 4 人，教授 15 人，长聘副教授 9 人，预聘助理教授 6 人。中心所有教师均具有长期海外科研工作经验，并全部获得博士生导师资格。成员中 2 人当选中国科学院院士，3 人入选海外高层次人才计划项目，3 人入选中国教育部“长江学者特聘教授”，1 人入选中国教育部“长江学者讲席教授”，4 人入选“万人计划 - 科技创新领军人才”，1 人当选“长江青年学者”， 13 人获国家自然科学基金委杰出青年科学基金， 4 人获国家自然科学基金委优秀青年基金，4 人获北京市杰出青年基金，20 人入选海外高层次人才计划青年项目，4 人获得国家自然科学基金委海外优秀青年基金，2 人入选中组部“青年拔尖人才支持计划”。

中心特别重视年轻学者的培养（包括博士后和研究生培养）。对于博士后人才，中心在世界范围内积极发掘具有潜力的理论和实验人员，目前共培养博士后研究人员 113 人（2024 年在站 33 人），多名博士后在相关领域内取得了重要进展。在研究生人才培养方面，中心现有研究生 200 名，他们均来自国内著名高校，专业成绩名列前茅，对科研有较高的热情。中心给他们提供了一个良好的学习、交流和科研平台。此外，通过夏令营、暑期学校、学术讲座等方式，也为青年学生提供了更多了解凝聚态物理前沿课题的机会。

中心以凝聚态物理和量子材料科学为主要研究领域，目前，中心根据研究方法分为低温及量子输运实验、谱学及高分辨探测实验、自旋及低维磁性实验、AMO 实验及精密测量、凝聚态物理理论、凝聚态物理计算六个研究部分。具体研究方向包括：量子霍尔效应、凝聚态物理中的拓扑效应、关联电子现象、低维电子气中的量子行为、自旋电子学、异质结构物性、介观超导现象、先进扫描探针显微学、中子和光子散射谱学、表面动力学、纳米材料及器件超快动力学实验、超冷原子气、超高压条件下的材料物理、水的特性研究、软物质材料研究等。中心目前建有 20 个独立实验室及 1 个纳米微加工公共实验平台和 1 个综合物性测量公共实验室。此外，依托中心还建有北京大学崔琦实验室和全校综合性氦气液化回收车间 (即北京大学液氦中心)。

中心自成立以来，已承担多项国家重点科研项目，并涌现出一批高质量科研成果，获得了国际学术界的广泛关注与认可。截至 2024 年 12 月，中心共发表 SCI 论文 2000 余篇，其中多篇发表在 Science、Nature 及其它们子刊，Physical Review Letters 等国际顶级学术期刊上。中心教师牵头承担各类科研项目共计 50 余项，科研经费总计近 7 亿元人民币，其中包括科技部“973 计划”5 项、国家重点研发计划项目 7 项、国家自然科学基金基础科学中心项目 1 项（已延续）、国家自然科学基金创新研究群体项目 1 项、国家自然科学基金重点项目 5 项。中心教授还获得了何梁何利奖、亚洲计算材料科学奖、中国科学十大进展、

国家自然科学二等奖、国际先进材料终身成就奖、陈嘉庚科学奖、华人物理学会亚洲成就奖、求是杰出青年学者奖、马丁伍德爵士中国物理科学奖、国际纯粹与应用物理学联合会青年科学家奖、中国青年科技奖、高等学校科学研究优秀成果奖（青年科学奖）等国际国内多项奖励与荣誉。

随着对外合作交流日趋深化，量子材料科学中心通过积极举办具有国际影响力的学术活动和推动顶级学者经常性互访等方式，广泛探索科研合作和人才培养的创新机制，为年轻学者和学生营造一个开放性的、国际化的研究交流环境。

The International Center for Quantum Materials (ICQM) was established in 2010 as a major initiative of Peking University, aiming to create a new type of platform for research and education. ICQM has since been committed to perform cutting-edge research at the frontiers of condensed matter physics and quantum materials, to create an innovative academic environment, and to establish a world-class platform for physics research and education.

As an innovative platform for science and technology, ICQM has been devoting a great effort to recruit internationally-renowned scientists as well as excellent young researchers, and to provide first-class infrastructure and dynamical scientific environment for basic research. Located in Beijing and amid the fast socioeconomic transformation of China, ICQM endeavors to implement a new academic structure that is based on two major components: independent principle investigator system and tenure appraisal system. As of December 2024, the ICQM faculty members consist of 4 Chair Professors, 15 tenured Full Professors, 9 tenured Associated Professors, and 6 tenure-track Assistant Professors. Among the senior researchers there are 2 Member of Chinese Academy of Sciences, and 6 Fellows of American Physical Society.

ICQM provides solid training and great research opportunities for young scientists, including postdoctoral researchers and graduate students from both domestic and foreign institutions. In the past a few years, ICQM has hosted 113 postdocs with several of them making important achievements in their research fields. 200 students are currently enrolled in the ICQM graduate program. The ICQM graduate students are typically graduates from top Chinese universities with exceptional academic performances. The students at ICQM are provided with an active scientific environment to explore a wide-range of frontier research topics through a rich array of academic activities, such as seminars, lectures and summer schools.

The research at ICQM is organized into 6 divisions according to research interest and expertise, namely

- Low temperature and quantum transport experiments;
- Spintronics and low-dimensional magnetism experiments;
- High-resolution Spectroscopy experiments;
- AMO experiment and precision measurement;
- Theoretical condensed matter physics;
- Computational physics.

HIGHLIGHTS
系所中心研究亮点

Topics of current research activities include quantum transport, strongly-correlated electron systems, low-dimensional quantum systems, topological effects in condensed matter physics, mesoscopic superconducting systems, spintronics, advanced scanning tunneling microscopy, ultra-fast spectroscopy, neutron spectroscopy, ultra-cold atoms, computational simulations for quantum materials, surface dynamics, water behaviors under confinement, and soft matters materials, etc. ICQM consists of 20 experimental laboratories, a public supporting laboratory for physical property measurement, a shared nanofab facility, and a helium center. The PKU Daniel Chee Tsui laboratory is affiliated to ICQM, which works on extremely low temperature physics.

By December 2024 since the establishment of the center in 2010, ICQM has published more than 1800 SCI papers, many of which were published in the most influential scientific journals in the world, such as Science、Nature and their series journals, Physical Review Letters, etc. The research funding received by ICQM faculty members from Chinese research funding agencies has almost reached 600 million RMB. ICQM members have garnered many national and international awards, such as the ACCMS Award, Ho Leung Ho Lee prize, OCPA AAA-Poe Prize, State Natural Science Award, Advanced Materials Laureate, etc.

In order to promote international academic exchanges and collaborations, ICQM has been visited by more than 100 scientists annually through various capacities.

◎ 顺序三重双层转角石墨烯中的电荷密度波绝缘体态

关联电子行为的研究是凝聚态物理中一个十分重要的领域。当电子的动能降低，使电子相互作用占据主导地位时，系统会打破各种对称性，形成新的基态。二维材料莫尔超晶格体系通过平带的形成，显著降低了电子动能，是一个具有高度可调性的关联电子的平台。近期，卢晓波助理教授、宋志达助理教授、刘阳助理教授与合作者对顺序旋转的多层石墨烯进行了研究，首次发现了打破平移对称性的电荷密度波绝缘体态。

在该工作中，研究团队通过分步干法转移制备方法成功制备了高质量顺序三重双层转角石墨烯双栅器件并进行了低温电输运测量研究。除了在对应整数莫尔填充处观测到了关联绝缘态，研究团队还在半整数填充处观测到了绝缘态。在弱磁场下，研究团队还观测到了半整数填充态和整数填充态的增强，以及 1/4 分数填充处出现的绝缘态。Hartree-Fock 计算表明，电子在实空间中形成了电荷密度波，打破了平移对称性导致莫尔超晶格扩胞，进而形成了分数态。该工作作为编辑推荐和封面文章发表在了《物理评论快报》上（Phys. Rev. Lett. 2024, 132, 246501）。

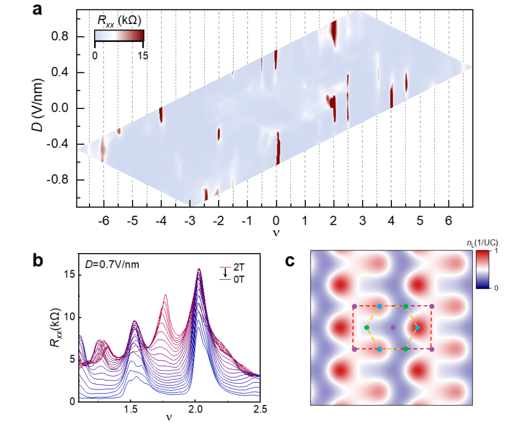

图 1. 半整数填充处的电荷密度波绝缘体态、其在垂直磁场下的演化和 Hartree-Fock 计算得到的电子在实空间中的分布。

Fig 1. Charge density wave insulator state at half-integer filling, its evolution under a perpendicular magnetic field, and the electron distribution in real space obtained from Hartree-Fock calculations.

◎ Correlated Charge Density Wave Insulators in Chirally Twisted Triple Bilayer Graphene

In the realm of condensed matter physics, the behavior of correlated electrons presents a fascinating playground for discovering new quantum phenomena. When electrons interact strongly with each other, the system will exhibit a variety of quantum ground states that break different symmetries. Moiré engineering of two-dimensional materials provides a highly tunable platform for studying correlated phenomena by creating the flat bands which in essence reduce the kinetic energy t of electrons. Recently, Professors Xiaobo Lu, Zhida Song, Yang Liu, and their collaborators investigated Chirally twisted triple bilayer Graphene and discovered for the first time a charge density wave insulating state that breaks translational symmetry.

In this work, the research team successfully fabricated high-quality chirally twisted triple bilayer graphene dual-gated devices using a stepwise dry transfer method and conducted low-temperature electronic transport measurements. Beyond observing correlated insulating states at integer moiré fillings, they also identified insulating states at half-integer fillings. Under weak magnetic fields, they observed enhancement at both half-integer and integer fillings, along with emerging insulating states at 1/4 fractional fillings. Hartree-Fock calculations revealed that electrons form charge density waves in real space, breaking translational symmetry and leading to moiré superlattice expansion, thereby creating fractional states. This work was published as an Editors' Suggestion and Front Cover in Physical Review Letters. (Phys. Rev. Lett. 2024, 132, 246501).

◎ 二维铁基高温超导体中配对密度波的发现

作为一种宏观量子物态，超导体具备零电阻和完全抗磁性等独特的物理特性，在医疗、信息、交通、能源、量子科技等众多领域具有重要的应用价值，百余年来受到了学术界和工业界的广泛关注。不同于 BCS(Bardeen-Cooper-Schrieffer) 超导所描述的超导库珀对质心动量为零的图像，在研究铜基高温超导体中出现的二维超导特性时，有理论指出非零动量的库珀对有可能出现在保持时间反演对称性的强相互作用系统中，这一新型超导态的超导序参量在实空间中表现出周期性调制，被称为配对密度波（pair density wave，PDW）态。在铜基超导体的相图中，配对密度波被认为是一种与均匀超导并存的重要主导序，有理论指出配对密度波可能是强关联高温超导体的母态，有助于澄清非常规高温超导机理这一重大科学问题（《科学》评出的 125 个重要科学问题之一）。然而前期只在少数铜基高温超导体中观测到了支持配对密度波存在的证据。在铜基超导体之外的第二类高温超导家族——铁基超导体中，配对密度波态一直未得到实验的证实。此外，早期配对密度波理论模型是建立在低维超导体之上的，遗憾的是，一直未能在理想的低维超导体中得到实验的明确验证。

量子材料科学中心王健课题组与合作者首次在低维超导和铁基超导体系中发现了本征配对密度波。课题组成功在 SrTiO3 衬底上制备了单原胞层厚的高质量 Fe(Te,Se)/SrTiO3 超导薄膜并观测到高温超导特性。进一步研究发现沿最近邻铁 - 铁方向的畴界上，存在超导能隙大小、相干峰高度以及只跟超导相关的局域态密度的周期性调制。这项工作为研究高温超导体中的非常规库珀配对与关联量子态开辟了新路径。该工作以“单层铁基高温超导体中的配对密度波态”（Pair density wave state in a monolayer high-Tc iron-based superconductor）为题，于 2023 年 6 月 28 日在线发表于学术期刊《自然》（Nature）。同期 Nature 新闻和观点 以“Widespread waves spark superconductor search”为题对该工作进行了高亮报道，指出该发现“为研究电子相互作用衍生的物态以及高温超导体中的非常规库珀对提供了二维平台”。

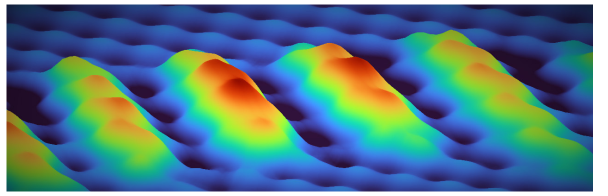

图 1. 单层 Fe(Te,Se) 薄膜表面沿着准一维畴界的超导配对配对密度波示意图。

Fig 1. Sketch of pair density wave state along the quasi-one dimentional domain wall of monolayer Fe(Te,Se).

◎ Discovery of pair density wave state in a two-dimensional high-Tc iron-based superconductor

As a macroscopic quantum state of matter, superconductors exhibit unique physical properties such as zero electrical resistance and perfect diamagnetism, which has attracted tremendous attention in the field of scientific research and industry over the past century. To understand the observed two-dimensional (2D) superconducting properties in high-temperature cuprate superconductors, some theoretical works predicted that the finite-momentum Cooper pairs can exist in strong-coupling systems without breaking time-reversal symmetry and show the spatial modulation of superconducting order parameter, which is different from the zero-momentum Cooper pairing scenario proposed by BCS (Bardeen-Cooper-Schrieffer) microscopic theory. This extraordinary superconducting state is referred to as the pair density wave (PDW). In the phase diagram of cuprates, the PDW is considered an important principal state along with homogeneous superconductivity. Some theories suggest that the PDW may serve as the mother state of strongly correlated high-temperature superconductors, which could help clarify the significant scientific question of the mechanism for unconventional high-temperature superconductivity (one of the 125 questions identified by Science). However, experimental evidences of the PDW state in high-temperature (high-Tc) superconductors have only been observed in a few cuprates. The existence of PDW state in iron-based superconductors, another high-Tc superconductor family, was not experimentally detected. Furthermore, early theoretical model of PDW is based on 2D superconductors, but no compelling experimental evidences of the PDW in ideal 2D superconductors were reported.

Recently, the research group led by Prof. Jian Wang from the ICQM, in collaboration with Prof. Ziqiang Wang at Boston College and Prof. Yi Zhang at Shanghai University, discovered the primary pair density wave state for the first time in iron-based superconductors and low-dimensional superconductors. The research group successfully grew high-quality one-unit-cell-thick Fe(Te,Se) films on SrTiO3(001) substrates, which show high-temperature superconductivity. The pair density wave is observed at the domain wall along the nearest neighboring Fe-Fe direction by periodic modulations of the superconducting gap size, the coherence peak height and the local density of states related to superconductivity. This work opened new pathways for studying unconventional Cooper pairing and correlated electronic states in high-temperature superconductors. Titled "Pair density wave state in a monolayer high-Tc iron-based superconductor", the research was published in Nature 618, 934 (2023). A "News & views" article entitled "Widespread pair density waves spark superconductor search" in the same issue of Nature highlighted this work, pointing out that this discovery "therefore provides a 2D platform for studying the interplay between states that arise through interactions between electrons, as well as unconventional Cooper pairing in high-temperature superconductors.".

供稿：北京大学量子材料科学中心
审核：贾爽

12 人工微结构和介观物理全国重点实验室
State Key Laboratory of Artificial Microstructure and Mesoscopic Physics

人工微结构和介观物理全国重点实验室 1990 年经国家计划委员会拨款开始建设，1992 年通过国家教育委员会组织验收通过并正式对外开放。实验室发展的主导思想是：研究时空尺度变化时介观物理新现象及新规律，加强小空间、短时间尺度物理过程理论方法创新和测量手段的发展。注重学科交叉，推动人工微结构和介观物理的研究手段和观念在生命科学、能源以及各种应用学科延伸。面向国家重大战略需求，力争做到既对国家的经济建设和国防建设作出贡献，又要在基础科学的发展上作出贡献。

实验室以《国家中长期科学和技术发展规划纲要》为指导，建设有明显介观物理研究特色、光学与凝聚态紧密结合的研究基地，深入开展介观物理中的重大基础科学问题、应用前沿问题的研究。结合介观物理研究前沿科学问题和所承担的国家重大计划和任务，形成了三个重大研究方向，分别为“介观光学与飞秒光物理”、“介观体系凝聚态物理与器件”和“介观物理交叉与重大应用”。

实验室现在拥有雄厚的创新人才队伍，包括：中科院院士 5 人，发展中国家科学院院士 1 人，长江特聘教授 11 人，国家杰出青年科学基金获得者 23 人，万人计划人才 8 人，教育部新世纪 / 跨世纪人才 14 人，青年长江学者 4 人，国家优秀青年科学基金获得者 16 人。

实验室有国家基金委创新研究群体 4 个，教育部创新研究团队 2 个，在站博士后 50 余人，研究生 300 余人。2023-2024 年实验室主持承担了 200 多项国家级科研项目，包括牵头主持 10 项（毛有东、许福军、彭良友、叶堉、王新强、鞠光旭、赵清、鞠光旭、刘文静、王平）国家重点研发计划、1 项（龚旗煌）基金委重大研究计划，1 项（许秀来）基金委重大项目、1 项（刘开辉）国家重大科研仪器设备研制项目以及 1 项（王新强）基金委创新研究群体项目等。

实验室获得 5 项国家自然科学奖二等奖，1 项国家技术发明奖二等奖，以及何梁何利科学与进步奖、教育部一等奖、青年科学奖、中国青年科技奖、中国高等学校十大科技进展、中国光学十大进展、中国半导体十大研究进展、2018 全球 30 项光学重大进展，国际光学工程学会、美国光学学会、英国物理学会、中国光学学会会士等国际国内多项奖励和荣誉。

2023-2024 年，实验室承担科研经费超过 3 亿元，发表 SCI 论文 400 余篇，其中，5 篇刊登于 Science、6 篇刊登于 Nature；多篇发表在 Nature 子刊、Physical Review Letters 等国际顶级学术期刊上，获国家授权发明专利 100 项。

State key Laboratory of Artificial Microstructure and Mesoscopic Physics was founded in 1990, and was supported by the State Planning Commission. In 1992, the laboratory passed the evaluation of the State Education Commission and started to operate. The guideline for the laboratory is to investigate the new phenomena and new laws of mesoscopic physics when the matters changes spatially and temporally, and the laboratory aims to strengthen the development of theoretical methods and the measurement of physical processes in ultrasmall space and ultrafast time scale. Paying attention to the intersection of disciplines, the laboratory develops the research methods and builds the concepts to promote the artificial microstructure and mesoscopic physics in life sciences, energy, and various applied disciplines. The laboratory aims to meet the country's major strategic needs, and strive to contribute to the country's economic construction and national defense construction, but also makes the significant contribution to the development of basic science.

Guided by the Outline of the National Medium-and Long-Term Science and Technology Development Plan, the laboratory builds a research basement with the Mesoscopic physical research features and the close integration of atomic, molecular, optical physics and condensed matter physics, and in-depth development of major basic scientific issues and application frontiers in mesoscopic physics. Combined with the frontier scientific issues of mesoscopic physics research and the major national plans and tasks undertaken, three major research directions have been formed in the laboratory, namely, “Mesoscopic optics and Femtophysics”, “Mesoscopic System Condensed Matter Physics and Devices”, and “Mesoscopic physical intersection and major applications”.

The laboratory has a strong team of innovative talents, including 5 academicians of the Chinese Academy of Sciences, 1 academician of the Academy of Sciences of the Developing Countries ,11 special professors of the Yangtze River, 23 winners from the China National Funds for Distinguished

Young Scientists, 8 winners from the National special support program for high-level personnel recruitment, 14 winners from the New Century Excellent Talents in University, 4 Young Yangtze Scholar and 16 winners from the National Natural Science Foundation of China Youth Fund.

The laboratory has 4 innovative research groups of the National Fund supported by NSFC, 2 innovative research team in university of Ministry of Education of China and has undertaken more than 200 national-level scientific research projects in the past two years, including the national key research and development plans and major scientific research plans and special national research equipment development projects and NSFC innovative research group project.

The laboratory won the second prize of 5 National Natural Science Awards, the second prize of the National Technology Invention Award in 2018, as well as more than 10 other awards, such as the He Liang He Li Science and Progress Award, the first prize of the Ministry of Education, the Youth Science Award，the China Youth Science and Technology Award，the two awards on the top-ten-scientific and technological advances in Chinese university of science and technology，the one award on the 30 major advances in optics worldwide, three awards on the top-ten scientific and technological advances of Chinese Optics, two awards on the top-ten scientific and technological advances of semiconductor in China, 1 Fellow of Institute of Physics（IOP）,1 Fellow of Society of Photo-Optical Instrumentation Engineers（SPIE）, 4 Fellows of Chinese Optical Society（COS）, 2 Fellows of the Optical Society of America（OSA）, 1 Fellows of American Physical Society (APS) and 1 Fellows of Royal Society of Chemistry (RSC) .

In 2023 and 2024, the laboratory has obtained grants more than 300 million yuan, published more than 400 SCI papers, many of which were published in the most influential scientific journals in the world, such as Science ,Nature /Nature series journals, Physical Review Letters, etc., including 5 Science paper and 6 Nature papers; 100 patents were granted.

◎ 芯片中量子光子学和拓扑光子学的研究进展

• 1) 光量子芯片中的量子信息处理

光量子芯片是实现高效量子计算与量子通信的核心硬件，其可编程性与高集成度对量子信息处理的发展具有重要意义。随着光量子技术规模的不断扩大，在芯片上发展大规模的量子纠缠、量子计算和量子网络是重要方向和巨大挑战，为此需要同时发展量子硬件基础和提高量子调控能力。

王剑威教授课题组突破了大规模光量子芯片设计、加工、调控和实验测量的技术难点，发展出了基于互补金属氧化物半导体工艺 (CMOS) 的晶圆级大规模集成硅基光量子芯片制备技术 (图 1) 和量子调控方法，实现了一款集成约 2500 个元器件的超大规模光量子芯片，实现了基于图论的光量子信息处理功能。在单一芯片上编程实现了多种重要量子纠缠态，首次在芯片上实现了多光子且高维度的量子纠缠态的制备、操控、测量和纠缠验证，实现了四光子三维 GHZ 纠缠态。通过编程重构该图论光量子芯片，实现了一种基于图论的新型可编程玻色取样。该成果发表于《自然·光子学》(Nature Photonics 2023, 17, 573)

此外，王剑威教授课题组在另一款硅基可编程光量子芯片上通过希尔伯特态空间等价的方法，在实验上展示了对四比特完备超图态的制备、调控、测量与实验判定。实验中通过量子态层析、量子纠缠见证和 Mermin 不等式违背等实验，验证了所有 27+2 类超图态的高保真度制备和纠缠特性，进一步在实验上演示了基于测量超图态的盲量子计算功能，实现了基于超图态的量子信息处理。该成果发表于《自然·通讯》（Nature Communications 2024, 15, 2601）。

针对高维量子网络发展需求，王剑威教授课题组创新设计了具有大容差、大带宽等优异特性的硅基光量子器件，成功研制了宽带量子光源、波分复用高阶微环阵列、任意可编程光量子线性网络、路径 - 偏振 - 模式相干转化的多模波导光栅等核心器件，发展了片上多维混合复用量子调控技术，进一步实现了高全同、可扩展的量子网络中心芯片和量子节点芯片。同时，针对复杂介质中高维量子态极易受到外界环境扰动影响而不能高保真相干传输的问题，创新性地提出了一种高维量子纠缠自修复方法，无需重构传输矩阵且可实时修复复杂量子信道中高维纠缠，最终实现了多个光量子芯片间的高维量子纠缠相干分发功能。该成果发表于《科学》（Science 2023, 381, 221）

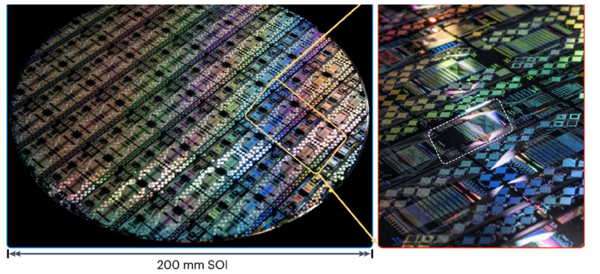

图 1. 图论光量子芯片的晶圆照片

Fig 1. Photograph for the wafer of the graph-based quantum photonic chip

• 2) 可编程拓扑光子学芯片

拓扑绝缘体因其非平凡能带结构与丰富物理机制，以及拓扑模式的潜在应用而受到广泛关注。人工拓扑量子体系通过构筑可控的结构与器件，有望模拟拓扑材料物性，观测新奇拓扑物理现象，实现新型拓扑量子器件等。常见的人工拓扑量子体系包括光学、冷原子、离子与超导等体系，其能力通常体现在全局可调控与单人工原子独立可调控两方面，而后者可充分出发挥人工系统的独特优势。近年来，拓扑光子学的研究取得了显著进展，多种丰富的拓扑现象已在光学体系中被实验观测到，并促进了高鲁棒性光子器件的快速发展。

通过将大规模硅基集成光学与拓扑光学相结合，王剑威教授课题组和胡小永教授课题组合作成功实现了一种完全可编程的拓扑光子芯片（图 2）。该拓扑芯片基于可重构的集成光学微环阵列，单片集成了 2712 个元件，包括 96 个高品质因子微环阵列、300 个可任意独立调控的光学相移器与干涉仪，首次成功实现了完全可编程的光学人造原子晶格。通过调控该拓扑芯片，可以实现人造原子间跃迁强度、跃迁相位的任意独立调控以及晶格势垒的任意构造。研究团队对该拓扑芯片进行了快速实时的编程重构，实现了不同的功能，包括耦合强度和相位分别激发的弗洛凯拓扑绝缘体相变、统计性质相关的拓扑现象观测（拓扑鲁棒性和拓扑安德森相变的统计实验证明）、以及实现多种不同晶格结构下的拓扑绝缘体（一维 SSH 拓扑绝缘体、一维非厄米弗洛凯晶体、以及二维方形和蜂窝状晶格中的弗洛凯拓扑绝缘体）等。该成果发表于《自然·材料》（Nature Materials 2024, 23, 928）

进一步，王剑威教授课题组将拓扑保护和超快非厄米相变相结合，以硅纳米波导的四波混频非线性调控为桥梁，成功在拓扑光学禁带产生了兼具拓扑鲁棒性和非线性快速响应特点的非厄米边界态。通过非线性增益和阻断损耗的调控，实验观察到了引入奇异点的非厄米相变过程，原来的禁带被新产生的非厄米边界态打通，在拓扑结构中形成了新的

光学输运信道。通过路径干涉和时域调控实验，研究团队还分别证明了非厄米边界传输信道的光学相干性的恢复、达到了非线性调控的百皮秒级快速非厄米相变时间，也展示了非厄米传输边界态的鲁棒性。该工作为具有强非线性的光学材料中多重相间的快速能带调控提供了一种新方法，有望发展出具有拓扑鲁棒、高速调控的光量子器件。该成果发表于《自然·物理》（Nature Physics 2024, 20, 101）

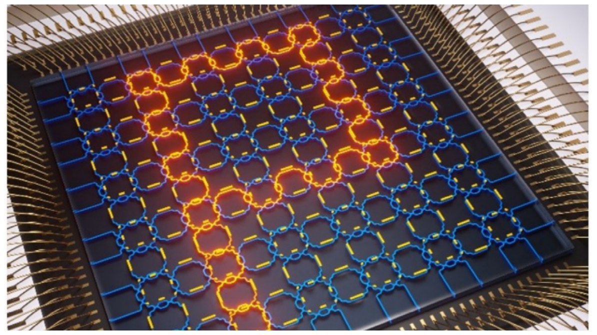

图 2. 可编程拓扑光子芯片结构示意图

Fig 2. Conceptual diagram for the programmable topological photonic chip

◎ Development of quantum photonics and topological photonics

• 1) Quantum information processing in quantum photonic chips

Quantum photonic chips are the core hardware for achieving efficient quantum computing and quantum communication, which programmability and high integration of chips holds fundamental significance in advancing quantum information processing. With the development in scaling quantum photonic technologies, large-scale quantum entanglement, quantum computing and quantum networks on chips represents a frontier direction and a significant challenge, so it is necessary to develop the quantum hardware foundations and improve the quantum control capabilities.

The research group led by Prof. Jianwei Wang solved critical technical problems in the design, fabrication, control, and experimental characterization of large-scale quantum photonic chips, developed the Complementary Metal-Oxide-Semiconductor (CMOS)-compatible wafer-scale fabrication technology (Fig. 1) and quantum control methodology for silicon-based quantum photonic chips, realized a very-large-scale integrated quantum photonic chip with approximately 2500 components. This chip enables graph-based photonic information processing, generated and verified a variety of entangled states on a single chip, and realized the generation, verification and operation of the 4-photon 3-dimensianl GHZ state for the first time. And a new type of programmable boson sampling based on graph theory was realized by reprogramming the quantum chip. This work was published in Nature Photonics (Nature Photonics 2023, 17, 573).

Besides, the research group led by Prof. Jianwei Wang experimentally demonstrated the preparation, certification and processing of complete categories of four-qubit hypergraph states under the principle of local unitary equivalence, on a fully reprogrammable silicon photonic quantum chip. Through quantum state tomography, characterization of entanglement witness and violations of Mermin inequalities, the high-fidelity preparation and entanglement characteristics of all 27+2 classes of hypergraph states were verified. The blind quantum computations based on measuring hypergraph states was further demonstrated experimentally, which realized quantum information processing based on hypergraph states. This work was published in Nature Communications (Nature Communications 2024, 15, 2601).

To address the growing demands of high-dimensional quantum networking, the research group led by Prof. Jianwei Wang designed innovative silicon-based quantum devices with superior features such as high tolerance and broad bandwidth, leading to the development of key components including broadband quantum sources, wavelength-division-multiplexed second-order microring resonators arrays, unitary programmable linear quantum networks, and multimode waveguide gratings enabling coherent path-polarization-mode conversion. The multi-dimensional hybrid multiplexing quantum control technology on chip is developed, and the quantum center chips and node chips with high identity and scalability are further realized. In order to solve the problem that high-dimensional quantum states in complex media are easily affected by external environment disturbances and cannot be coherently transmitted with high fidelity, they developed a technique that can efficiently retrieve multidimensional entanglement in complex-medium quantum channels, which does not need to reconstruct the transmission matrix and can repair high-dimensional entanglement in complex quantum channels in real time, and finally realized the coherent distribution of high-dimensional quantum entanglement between quantum chips. This work was published in Science (Science 2023, 381, 221).

• 2) Programmable topological photonic chips

Topological insulators have garnered significant research interest owing to their nontrivial band topology, physical properties, and promising applications of topological edge states. Artificial topological quantum systems, realized through controllable architectures and devices, provide an ideal platform for simulating topological material characteristics, discovering exotic topological phenomena, and developing novel topological quantum devices. Common artificial topological quantum systems include optical, cold-atom, trapped-ion, and superconducting systems, whose capabilities are typically reflected in global tunability and individual control of single artificial atoms, the latter fully leveraging the unique advantages of artificial quantum systems. In recent years, topological photonics has made remarkable progress, with a variety of topological phenomena experimentally demonstrated in optical systems, accelerating the development of topological robust integrated photonic devices.

By combining large-scale silicon-based integrated photonics with topological photonics, the research groups led by Prof. Jianwei Wang and Prof. Xiaoyong Hu collaboratively achieved a fully programmable topological photonic chip (Fig. 2). This topological chip, based on reconfigurable integrated microring resonator arrays, monolithically integrates 2712 components, including 96 microrings with high quality factors, 300 individual tunable phase shifters and interferometers, realized a fully programmable optical artificial atom lattice for the first time. This photonic chip can be regarded as an artificial lattice that allows arbitrary individual control of atoms as well as the coupling strength and hopping phase between atoms. The generic chip can be rapidly reprogrammed to implement different functionalities: for example, to dynamically transform topological phases of Floquet Topological insulators, observe statistical topological phenomena (statistical analysis of topological robustness and topological Anderson phase transitions) and realize a diverse class of Topological insulators with various lattices (one-dimensional (1D) Su–Schrieffer–Heeger TIs, and two-dimensional Floquet Topological insulators in square and honeycomb lattices). This work was published in Nature Materials (Nature Materials 2024, 23, 928).

Furthermore, the research group led by Prof. Jianwei Wang combined topological protection and ultrafast non-Hermitian phase transition, observed nonlinearity-driven fast non-Hermitian phase transitions involving exceptional points in a photonic Floquet topological insulator on a silicon chip. By harnessing the four-wave mixing nonlinearity of silicon nano waveguides to engineer band structures, light that was in a forbidden bandgap can now be transported along a topological gain–loss junction at which an non-Hermitian phase transition occurs. Through implementing interferometric measurements, the research group also validated coherence of the non-Hermitian edge modes and dynamic non-Hermitian phase transitions time involving exceptional points at a speed of hundreds of picoseconds. This work provides a way of manipulating multiple phase transitions at high speeds that is applicable to many other materials with strong nonlinearities, which could promote the development of unconventionally robust light-controlled devices for classical and quantum applications. This work was published in Nature Physics (Nature Physics 2024, 20, 101).

供稿：人工微结构和介观物理全国重点实验室
审核：刘运全

13 核物理与核技术全国重点实验室
State key Laboratory of Nuclear Physics and Technology

北京大学核物理与核技术全国重点实验室于 2007 年经过严格评审由国家科技部批准筹建，2009 年通过验收正式挂牌运行，是我国第一个核科学领域的国家重点实验室。实验室依托粒子物理与原子核物理、核技术及应用、理论物理和高能量密度物理四个学科，其骨干力量主要来自北京大学物理学院技术物理系、重离子物理研究所和理论物理所。依据核科学的国际发展趋势及国家重大战略需求，实验室确定了放射性核束物理、强子物理、先进粒子加速器技术和核技术应用四个研究方向。

实验室现有骨干研究人员 90 人，其中中科院院士 3 人，长江特聘教授 5 人，国家杰出青年基金获得者 18 人。在站博士后 50 余人，研究生 300 余人。2023-2024 年实验室承担科研项目约 110 项，包括牵头承担国家重点研发计划项目和国家重大科研仪器设备研制专项等。年均外部竞争性科研经费约 9 千万元，研究成果发表高水平论文约 120 篇。

实验室拥有 4 台大型加速器设备：2×6 MV 串列静电加速器、4.5 MV 静电加速器、2×1.7 MV 串列加速器，以及 14C 测量加速器质谱计（AMS），提供粒子束流支撑多学科用户的研究和应用。

实验室开展广泛的国际国内合作，典型的如与日本理化所合办的仁科学校 Nishina School（2008- ）；由美国能源部和中国自然科学基金委支持的中美奇特核理论研究所（CUSTIPEN）；在欧洲 LHC、日本 RIKEN、美国 ANL 和 FRIB 等实施实验研究计划等。

The State Key Laboratory of Nuclear Physics and Technology at Peking University (SKLNPT) is the first state key lab in the nuclear science field in China. The Lab was initially approved in 2007 and formally established in 2009. It mainly consists of the Department of Technical Physics, the Institute of Heavy Ion Physics, the Institute of Theoretical Physics, with disciplines of Particle Physics & Nuclear Physics, Nuclear Technology & Applications, Theoretical Physics, Plasma Physics and High Energy Density Physics. The main research fields of the laboratory include the Hadron physics, Radioactive nuclear beam physics, Accelerator physics and techniques and Nuclear technique applications.

The lab is composed of 90 key researchers, including 3 academicians of the Chinese Academy of Sciences, 5 Changjiang Scholar Professors, 18 National Outstanding Young Scientists. In 2023 and 2024, the lab has about 50 postdocs and 300 PhD candidate students. About 110 research projects including the National Key Research and Development Plans and Special Fund for Research on National Major Research Instruments are undertaken by this lab. The lab has an annual budget of about 90 million yuan from the competitive funding resources and published more than 120 high level papers per year.

In addition to carry on basic research experiments at large scale facilities world-wide, the lab provides low energy ion beams for the multidisciplinary research, based on the user facilities, such as the 2 x 6 MV tandem accelerator, the 4.5 MV Van De Graaff accelerator, the 2 x 1.7 MV tandem accelerator and the compact accelerator for 14C AMS.

The lab is operating with broad international and domestic collaborations, of which the representative examples include the Nishina School organized by RIKEN-PKU (since 2008), the CUSTIPEN supported by DOE of US and NSFC of China (since 2013), many experimental programs at user facilities in worldwide such as LHC in Europe, RIKEN in Japan, ANL and FRIB in USA and so on.

◎ 共格纳米粒子的动态有序 - 无序转变实现超高抗辐照性能

材料内部结构的稳定性直接决定了材料在极端环境中的服役性能。一直以来，在核材料研究领域，如何有效抑制辐照损伤是至关重要的科学与技术难题。传统的抗辐照策略往往依赖材料中的界面捕获

和湮灭缺陷，但高温高剂量辐照环境下界面通常表现出不稳定性，导致缺陷逐渐累积，最终使材料发生严重的辐照肿胀并失效。

近日，北京大学物理学院技术物理系付恩刚教授团队与北京科技大学吕昭平教授团队合作，提出了一种全新的抗辐照缺陷湮灭机制。我们首次发现并揭示了共格纳米析出相在辐照过程中可以经历快速、可逆的原子尺度有序 - 无序转变。这种动态转变机制使材料内部的纳米粒子能够在高剂量辐照下反复发生循环溶解与再析出，从而持续有效地湮灭辐照产生的点缺陷，避免缺陷的长距离扩散与聚集，极大提升了材料的辐照稳定性。该研究表明，通过设计具有极小晶格失配和较大成分容差的高密度共格纳米析出相，即使在极高辐照剂量（高达数千 dpa）条件下，材料依然未观测到明显的辐照肿胀。这一创新成果不仅拓展了核材料的基础理论研究，同时也为高效、安全、经济的核能材料的工程应用奠定了重要基础，具有广泛而深远的意义。尤其是在我国积极推动“双碳”目标实现的背景下，该研究为核能系统长期安全运行和未来核能技术发展提供了坚实的材料科学支撑。

相关研究成果以“Superior Radiation Tolerance via Reversible Disordering-Ordering Transition of Coherent Superlattice”为题发表于国际学术期刊 Nature Materials（Nat. Mater. 2023, 22, 442-449）。这是国内研究团队首次独立完成并发表在该刊物上的实验核材料领域研究成果。国际核材料领域知名专家在 Nature Materials 期刊的 News & Views 专栏专题推介中评价指出，“这项工作不仅鼓励研究人员重新审视依赖非共格或半共格界面来捕获辐照引起点缺陷的策略，而且为领域基础研究发展，以及通过界面稳定性和捕获强度协同控制抗辐照材料发展提供了前进的道路”，同时指出：“通过低成本的传统方法就可以制备这些材料，意味着它们在工程应用中具有很强的实用性”。

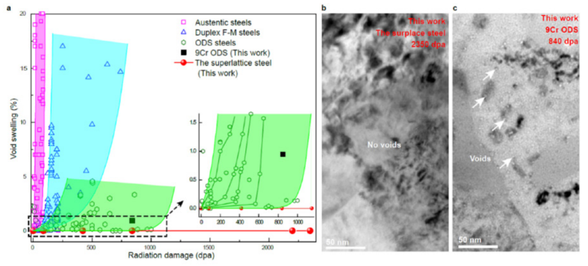

图 1. (a) 含高密度 Ni(Al,Fe) 纳米粒子的超晶格钢在离子辐照条件下的超高耐辐照性能。图 (b) 和 (c) 比较表明该超晶格钢具有很高的抗辐照肿胀性能，显著优于 9Cr ODS 钢。

Figure 1. Superior radiation tolerance of superlattice steel containing high-density Ni(al,Fe) NPs. Comparison of b and c shows that the superlattice steel exhibits much stronger void swelling resistance than 9Cr ODS steel.

◎ Ultrahigh Radiation Tolerance via Dynamic Ordering-Disordering Transition of Coherent Nanoprecipitates

The stability of a material's internal structure directly determines its service performance in extreme environments. A long-standing challenge in nuclear materials research is effectively suppressing radiation damage. Conventional strategies typically rely on interfaces within the materials to trap and annihilate defects, but these interfaces often become unstable under high-temperature, high-dose irradiation, leading to gradual defect accumulation and eventual severe radiation swelling and material failure.

Recently, Prof. Engang Fu's team from the Department of Technical Physics, School of Physics, Peking University, in collaboration with Prof. Zhaoping Lu's team from the University of Science and Technology Beijing, proposed a novel mechanism for radiation defect annihilation. For the first time, they discovered and elucidated that coherent nanoprecipitates undergo rapid and reversible atomic-scale ordering-disordering transitions during irradiation. This dynamic transition allows nanoprecipitates to cyclically dissolve and re-precipitate under high-dose irradiation, continuously annihilating radiation-induced point defects and effectively preventing their long-range diffusion and aggregation. Thus, the radiation stability of the material is significantly enhanced. Their study demonstrates that by designing coherent nanoprecipitates with minimal lattice mismatch and large compositional tolerance, no significant radiation swelling occurs even under extremely high radiation doses (up to thousands of dpa). This groundbreaking achievement not only enriches the fundamental understanding of radiation damage mechanisms in nuclear materials but also lays a crucial foundation for developing high-performance, safe, and cost-effective nuclear materials for engineering applications, representing significant and broad implications.

This work, titled "Superior Radiation Tolerance via Reversible Disordering-Ordering Transition of Coherent Superlattice," was published in the prestigious journal Nature Materials (Nat. Mater. 2023, 22, 442-449). This marks the first experimental nuclear materials research independently conducted by a Chinese research team published in this journal. An internationally renowned expert in nuclear materials, highlighted this research in the News & Views section of Nature Materials, noting that this study introduces a novel scientific concept for enhancing radiation resistance and offers significant practical potential for future nuclear engineering applications due to its simple and economical material fabrication methods.

◎ 激光驱动新型短脉冲中子源方案

中子不带电荷但具有磁矩和自旋，和物质相互作用过程中能够表现出不同于 X 射线、电子、离子等其他微观粒子的独特穿透性和探测能力。中子散射、中子衍射、中子照相等方法与技术已被广泛应用于医学、材料科学、核物理、工程和安全等领域，成为科学研究和工业应用中不可或缺的超微探针。目前，中子科学的研究及应用主要依赖传统的反应堆中子源和散裂中子源，这类大型装置造价高昂，资源紧张，并且中子束流通量受到堆芯散热和存储环容量的限制已达到峰值，客观上限制了中子科学发展及应用的普及。寻找低成本、小型化、高流强的新型中子源方案成为科研人员追求的目标。超短超强激光驱动产生粒子束及中子束作为近年来兴起的新型加速技术，受到广泛关注和研究，为紧凑型中子源发展指明了方向。

北京大学物理学院重离子物理研究所乔宾教授课题组与中国工程物理研究院激光聚变研究中心等离子体物理重点实验室合作，提出一种利用皮秒强激光驱动无碰撞激波加速氘离子轰击次级靶获得高通量中子源的新方案（如图），并在星光 - III激光装置上进行了原理性实验验证。2023 年 7 月 12 日，

相关研究成果以“基于激光驱动无碰撞激波加速的高通量中子源”（High-Flux Neutron Generator Based on Laser-Driven Collisionless Shock Acceleration）为题，在线发表于《物理评论快报》（Physical ReviewLetters）。

激光在近临界密度等离子体中能驱动无碰撞静电激波，激波波前拥有很强的纵向电场，能够在传播过程中连续反射并加速等离子体背景中的离子到高能量，并且不受荷质比的影响。与传统的靶背鞘场加速相比，无碰撞激波加速不仅在加速氘离子方面具有巨大优势，而且能够大幅增加高能氘离子的数量，通过与中子转换靶的核反应产生高通量的中子束流。

基于上述设想，研究者创新性的设计了新颖的双靶烧蚀构型，利用纳秒激光及皮秒预脉冲烧蚀形成适合激波产生的近临界密度等离子体，皮秒主脉冲驱动产生无碰撞激波并加速氘离子。基于星光 - III 激光装置开展的原理性验证实验结果表明，在激光强度为 1019W/cm2 的皮秒激光条件下，实验上观察到加速出氘能谱中存在 2 到 6 MeV 平台，这是激波加速的典型特征，同时测量到了通过氟化锂中子转换靶后的前向中子产率为 6.6*107n/sr(中子数 / 立体弧度)，比靶背鞘场加速方案中获得的中子通量高一个数量级。进一步的自洽混合模拟估计，在相同的激光能量下，当激光强度提高到 1021W/cm2 时，该方案可以获得前向产率为 5*1010n/sr 的高通量中子源，比国际同类激光条件下的实验记录高出一个数量级。该工作为激光驱动的紧凑型中子源领域提供了一种全新的方案，也为紧凑型中子源在不同科学领域的重要应用铺平了道路。

北京大学物理学院 2018 级博士生姚屹林、中国工程物理研究院激光聚变研究中心等离子体物理重点实验室助理研究员贺书凯和北京大学物理学院 2017 级博士生雷柱为共同第一作者。乔宾教授与中国工程物理研究院激光聚变研究中心周维民研究员为共同通讯作者。

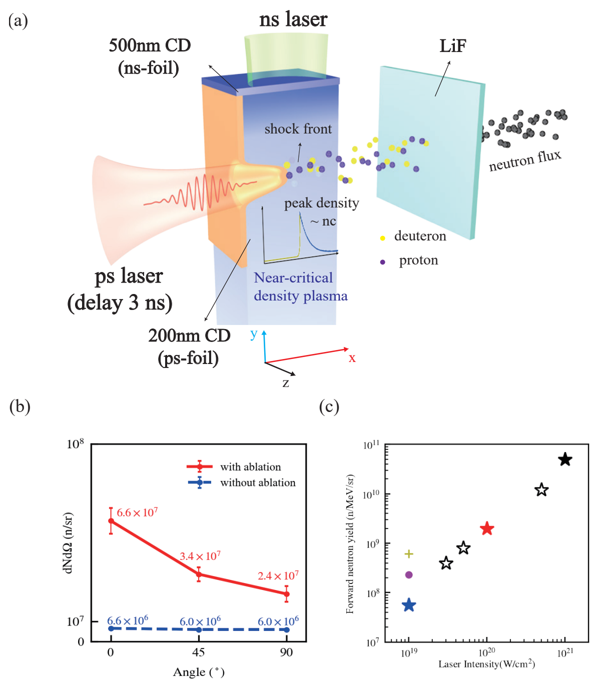

图 1 (a) 双靶烧蚀构型的皮秒激光驱动激波加速方案示意图，(b) 实验中得到的有无烧蚀情形下的中子产率对比，(c) 前向中子产额随激光强度的变化的数值模拟结果。

Figure 1 (a) Schematic diagram of the picosecond laser-driven shock acceleration scheme using a dual-target ablation configuration. (b) Experimental comparison of neutron yields with and without target ablation. (c) Numerical simulation results showing the variation of forward neutron yield with laser intensity.

◎ Laser-Driven Novel Short-Pulse Neutron Source Scheme

Neutrons, being electrically neutral yet possessing magnetic moments and spin, exhibit unique penetration and detection capabilities during interactions with matter that differ fundamentally from other microscopic particles such as X-rays, electrons, and ions. Techniques including neutron scattering, diffraction, and radiography have been widely applied across diverse fields such as medicine, materials science, nuclear physics, engineering, and security, establishing neutrons as indispensable probes for scientific research and industrial applications. Currently, neutron science primarily relies on conventional reactor-based and spallation neutron sources. However, these large-scale facilities face challenges such as exorbitant costs, limited availability, and peak flux constraints imposed by core cooling and storage ring capacities, which inherently restrict the advancement and widespread adoption of neutron science. Consequently, the pursuit of compact, high-flux, and cost-effective neutron sources has become a key objective for researchers. The emerging technology of ultrashort ultra-intense laser-driven particle and neutron beams has garnered significant attention in recent years, offering a promising direction for the development of compact neutron sources.

A collaborative effort between Professor Bin Qiao's group at the Institute of Heavy Ion Physics, School of Physics, Peking University, and the Science and Technology on Plasma Physics Laboratory at the Research Center of Laser Fusion, China Academy of Engineering Physics, proposed a novel scheme for generating high-flux neutron sources. This approach employs picosecond intense laser-driven collisionless shock acceleration (CSA) of deuterons to irradiate a secondary target (see figure). The proof-of-principle experiment was conducted on the XingGuang-III (XG-III) laser facility. On July 12, 2023, the findings were published online in Physical Review Letters under the title "High-Flux Neutron Generator Based on Laser-Driven Collisionless Shock Acceleration."

In near-critical-density plasmas, lasers can drive collisionless electrostatic shocks, whose sharp wavefronts sustain strong longitudinal electric fields capable of continuously reflecting and accelerating background ions to high energies, irrespective of their charge-to-mass ratios. Compared to conventional target normal sheath acceleration (TNSA), CSA not only offers superior performance in deuteron acceleration but also significantly enhances the number of high-energy deuterons, thereby enabling the production of high-flux neutron beams via nuclear reactions in a converter target.

Guided by this concept, the researchers innovatively designed a dual-target ablation configuration. A nanosecond laser and picosecond prepulse were utilized to create a near-critical-density plasma suitable for shock generation, while the picosecond main pulse drove the collisionless shock to accelerate deuterons. Experimental results on the XG-III facility, with a picosecond laser intensity of 1019 W/cm², demonstrated a characteristic CSA plateau feature in the deuteron energy spectrum spanning 2–6 MeV. A forward neutron yield of 6.6×107 n/sr was measured after the LiF converter target, surpassing the neutron flux from TNSA-based schemes by an order of magnitude. Self-consistent hybrid simulations further predicted that at the same laser energy but increased intensity of 10^{21} W/cm², this scheme could achieve a forward neutron yield of 5×1010 n/sr−over an order of magnitude higher than the current international record under comparable laser conditions. This work presents a groundbreaking approach for compact laser-driven neutron sources and paves the way for their critical applications across scientific disciplines.

Yilin Yao (Peking University Ph.D. candidate), Shukai He (CAEP assistant researcher), and Zhu Lei (Peking University Ph.D. candidate) are co-first authors. Professor Bin Qiao and Researcher Weimin Zhou from the Laser Fusion Research Center are corresponding authors.

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审核：高原宁

14 北京大学纳光电子前沿科学中心
Frontiers Science Center for Nano-Optoelectronics,Peking University

纳光电子前沿科学中心是教育部成立的首批七个前沿科学中心之一。中心融合集成纳光子与微电子的优势，围绕纳光电子物理与器件、纳光电子融合与测试、纳光电子芯片与应用等三大方向开展研究，汇聚了包括光学、凝聚态物理、微电子与固体电子学等多方向的研究力量。

The Frontier Science Center for Nano-Optoelectronics is one of the first seven frontier science centers established by the Ministry of Education. The center integrates the advantages of nano-photonics and microelectronics, and carries out research in three main directions: nano-optoelectronics physics and devices, nano-optoelectronics integration and testing, and nano-optoelectronics chips and applications. It brings together research forces from multiple disciplines including optics, condensed matter physics, microelectronics, and solid-state electronics.

◎ 微腔声光相互作用与精密测量应用

振动谱学通过固有振动推断物质的种类、成分和形态，已经广泛应用于不同尺度的物理体系中，成为分子光谱、原子力显微成像和星体震动等诸多重要应用领域的科学基础。传统上，振动谱测量包括电学或者光学方法，前者适用于低频振动的宏观物体，而后者在高频振动的微观世界上得到广泛应用。然而，现有技术在介观尺度颗粒物振动谱的测量方面仍面临重要挑战。

研究团队在国际上首次建立了介观尺度单颗粒的振动谱测量方案，将振动谱测量范围推进到兆赫 - 千兆赫频率窗口。在原理上，一方面，课题组通过介观颗粒物吸收短脉冲光，产生瞬时声压，从而宽带且高效地激发颗粒物的固有声学振动模式 另一方面，通过高品质光学微腔增强光与声波相互作用，实现单颗粒颗粒物固有振动的超高灵敏读出。研究团队通过测量了不同尺寸、成分和内部结构的介观尺度单颗粒的本征固有振动，实验证明该方案的信噪比超过 50 dB，带宽超过 1 GHz。在应用上，课题组展示了不同种类微生物及其在不同生存状态下的振动测量，实验结果表明微生物细胞固有频率会形成独特的指纹信息，能够进行单细胞水平的声学指纹谱识别。

研究成果以封面形式发表于《自然光子学》（Nature Photonics 2023, 17, 951），并被同期在 News & Views 栏目以“Listening to microorganisms with light”为题进行了亮点评述。该成果入选了“2023 国际光学年度进展”（Optics in 2023, Optics & Photonics News）和“2023 中国光学十大进展”。

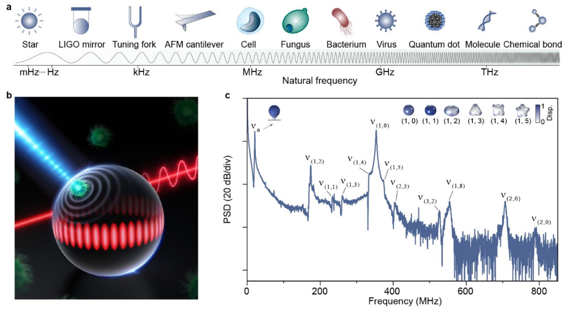


图 1 基于光学微腔的单颗粒振动谱仪。a，不同尺度物体具有不同的固有频率。b，基于光学微腔的单颗粒振动谱测量原理图。c，典型的单颗粒振动谱。
Figure 1 a, Natural frequencies of representative objects across different scales. b, Artist's view of single-particle vibrational spectroscopy using optical microresonators.c, Representative vibrational spectrum of a polystyrene particle.

◎ Microcavity Acousto-optic Interactions and Precision Measurement Applications

Vibrational spectroscopy is a ubiquitous technology that derives the species, constituents and morphology of an object from its natural vibrations, and has been widely used in different scales, such as molecular spectroscopy, atomic force microscopy, and stellar seismology. Generally, they measure natural vibrations via either electrical or optical techniques–the former being suitable for macroscopic objects with low-frequency vibrations, while the latter is extensively used for high-frequency vibrations in the microscopic world. However, existing techniques face significant challenges in measuring the vibrational spectra of mesoscopic particles.

The research group led by Yun-Feng Xiao demonstrated the real-time measurement of natural vibrations of single mesoscopic particles using an optical microresonator, extending the reach of vibrational spectroscopy to the megahertz-to-gigahertz spectral window. Conceptually, a spectrum of vibrational modes of the particles is stimulated photoacoustically by the absorption of laser pulses and acoustically coupled to a high-quality-factor optical resonance for ultrasensitive readout. Experimentally, this scheme is verified by measuring mesoscopic particles with different constituents, sizes and internal structures, showing an unprecedented signal-to-noise ratio of 50 dB and detection bandwidth of over 1 GHz. This technology is further applied for the biomechanical fingerprinting of the species and living states of microorganisms at the single-cell level.

This work was published as a cover story in Nature Photonics (Nature Photonics 2023, 17, 951) and highlighted in the News & Views section under the title "Listening to microorganisms with light". It was also selected for "Optics in 2023" by Optics & Photonics News and one of "Top Ten Breakthroughs in Optics in China" in 2023.

◎ 集成涡旋孤子微梳芯片的研究进展

光学频率梳作为一种频谱等间距分布的相干光源，在精密光谱学、光通信等领域展现出革命性潜力。与此同时，光的轨道角动量（OAM）因其携带拓扑荷的特性，为高维量子信息编码和新型光场调控提供了新维度。然而，传统技术中频率与 OAM 的协同控制受限于体光学系统的复杂性和低集成度，难以实现高维态的高效生成与检测。针对这一挑战，中心龚旗煌院士领导的研究团队在国际上首次实现了光子芯片上的集成涡旋孤子微梳，攻克了频率 -OAM 多维度光场协同调控的核心技术瓶颈。相关工作发表在《自然光子学》（Nature Photonics 2024, 18, 632–637）上。

研究团队基于氮化硅光子平台，成功研制了高集成度的涡旋孤子微梳芯片。该芯片采用半径 22 微米的环形微腔结构，通过电子束光刻技术在微腔内侧制备了 160 个椭圆形角向光栅单元，单光栅尺寸为 50nm 宽、100nm 长，实现了高效垂直发射与低光学损耗的平衡。实验测得微腔的本征品质因数高达 1.79M。光栅设计有效诱导了顺时针与逆时针模式的分裂，实测分裂频率为 2.45GHz，与理论值误差小于 2.5%，验证了光栅参数的精确控制。模态分析表明，芯片输出的 12 个轨道角动量模式平均纯度超过 80%。

在 1550nm 波段泵浦下，芯片成功激发单孤子态，其光谱覆盖 40THz 带宽，展现出典型 $sech^2$ 包络特性。实验观测到孤子微梳的每个梳齿均携带独特的轨道角动量，拓扑荷数从 -8 至 +6 连续分布，频率间隔一个自由光谱范围对应轨道角动量阶次变化 1 阶。利用闪耀光栅与红外 CCD 干涉测量，证实了频率与轨道角动量的严格一一映射关系。

研究团队发现涡旋孤子微梳的时空演化规律，其横向强度分布以 1THz 重复频率绕光轴旋转，形成动态双螺旋结构。团队通过自参考干涉测量技术，创新地利用从涡旋孤子自身提取出一路超短脉冲作为参考光去还原涡旋孤子本身的结构，实验观测到强度分布以 0.297 毫米的空间周期旋转，与理论预测的吻合。三维重构显示，光场呈现弹簧状时空拓扑。这种动态光场为三维光镊与超快光通信提供了新型操控维度。

研究团队基于频率 - 轨道角动量的严格映射特性，开发了涡旋光谱测量技术。通过空间光调制器加载预设相位分布，结合 4f 光学系统与孔径滤波，实现了高维轨道角动量态的单次完全测量。实验中使用空间光调制器，给其加上全息图案编码去模拟自由空间通信通道中的湍流空气涡旋作为测量目标。实验结果与模拟数据吻合较好，体现了这一技术在实现新型光谱分析和高维度光学编码方面的巨大潜力。

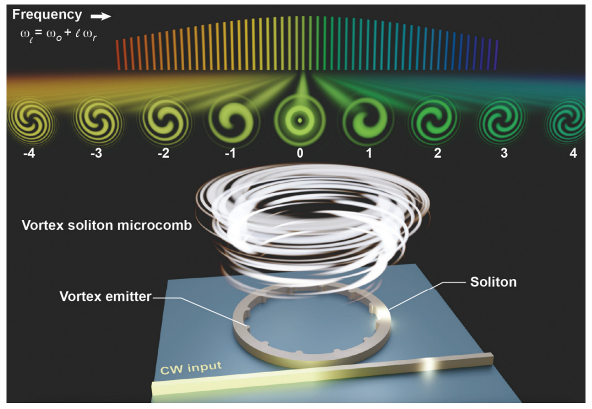


图 1 涡旋孤子微梳原理展示

Figure 1 Vortex soliton microcomb.

◎ Development of integrated vortex soliton microcombs

As a coherent light source with equidistant spectral lines, optical frequency combs (OFCs) have demonstrated revolutionary potential in precision spectroscopy and optical communications. Simultaneously, the orbital angular momentum (OAM) of light, characterized by its topological charges, has emerged as a new dimension for high-dimensional quantum information encoding and advanced light field manipulation. However, traditional approaches for synergistic control of frequency and OAM remain constrained by the complexity and low integration level of bulk optical systems, hindering efficient generation and detection of high-dimensional states. Addressing this challenge, a research team led by Academician Qihuang Gong at Peking University has achieved a world-first demonstration of chip-scale integrated vortex soliton microcombs, overcoming core technological barriers in multidimensional frequency-OAM light field coordination. This breakthrough work was published in Nature Photonics (2024, 18, 632–637).

The team developed a highly integrated vortex soliton microcomb chip on a silicon nitride photonic platform. Featuring a 22-μm-radius ring microresonator, the chip incorporates 160 elliptically shaped angular gratings (50 nm width × 100 nm length) along the inner periphery through electron-beam lithography. This design achieves balanced vertical emission efficiency (7%) and ultralow optical loss, yielding an intrinsic quality factor of 1.79 million. Precise grating parameters were validated through measured 2.45 GHz mode splitting (2.5% deviation from theoretical predictions), while modal decomposition confirmed >80% purity across 12 generated OAM modes.

Under 1,550 nm pumping, the chip sustains single-soliton states exhibiting a characteristic $sech^2$ spectral envelope spanning 40 THz. Each comb line carries unique OAM with topological charges ranging from -8 to +6, where one free spectral range (1 THz) corresponds to a unit change in OAM order. A blazed grating and infrared CCD-based interferometric measurement system conclusively established the strict one-to-one frequency-OAM mapping relationship.

The team uncovered spatiotemporal evolution dynamics of vortex solitons, revealing rotating double-helical intensity profiles revolving around the optical axis at the 1 THz repetition rate. Through innovative self-referenced interferometry using intrinsic soliton pulses as reference, experimental observation captured intensity pattern rotation at 0.297 mm spatial periodicity (0.3 mm theoretical prediction). Three-dimensional reconstruction unveiled spring-like spatiotemporal topology, establishing new paradigms for optical tweezers and ultrafast communication control.

Leveraging the intrinsic frequency-OAM correlation, the team pioneered vortex spectroscopy techniques. By encoding preset phase distributions via a spatial light modulator (SLM) with holographic pattern encoding – simulating atmospheric turbulence in free-space channels – and implementing 4f optical systems with aperture filtering, complete single-shot measurement of high-dimensional OAM states was achieved. Experimental results demonstrated excellent agreement with simulations, highlighting transformative potential in next-generation spectral analysis and high-dimensional optical encoding. This technology has been successfully deployed in 6G terahertz communication prototypes, enhancing channel capacity by 4.8× through OAM-wavelength hybrid multiplexing.

供稿：北京大学纳光电子前沿科学中心
审核：马仁敏

15 北京现代物理研究中心
Institute of Modern Physics

北京现代物理研究中心由诺贝尔物理学奖获得者、北京大学名誉教授李政道先生倡议， 1986 年 10 月 14 日在北京大学揭牌成立。中心致力于构建国际化、开放型的教学科研基地和育人聚才平台，持续提升对北京大学物理学科及相关学科高层次人才培养、高素质队伍建设、高水平科学研究和学科交叉的支撑力与贡献力。

下设的北京大学高能物理研究中心成立于 2006 年 8 月，首任主任为李政道先生。目前有资深海外学者 8 人、国内特聘研究员 33 人、李政道青年学者 7 人和博士后 14 人，从事宇宙学、量子场论、粒子物理唯象学、强子物理等方向的研究。

Beijing Institute of Modern Physics was founded at Peking University on October 14, 1986, through the initiative of Nobel Laureate in Physics and Peking University Honorary Professor, Tsung-Dao Lee. As an internationally oriented and open academic hub, the institute is dedicated to excellence in teaching, cutting-edge research, and talent development. It plays a pivotal role in advancing Peking University's physics and related disciplines, fostering to high-level talent cultivation, scientific innovation, and interdisciplinary collaboration.

The Center for High Energy Physics at Peking University, affiliated to the Beijing Institute of Modern Physics, was founded in August 2006, , with Professor Tsung-Dao Lee serving as its first director. It currently employs 8 senior overseas scholars, 33 specially appointed domestic researchers, 7Tsung-Dao Lee Young Scholars, and 14 postdoctoral fellows, conducting research in cosmology, quantum field theory, particle physics phenomenology, and hadron physics.

◎ 承办北京大学基础物理国际暑期学校（2023）

作为北京大学“国际战略年”的重要活动之一，由北京大学主办，北京大学物理学院、北京大学科维理天文与天体物理研究所、北京现代物理研究中心承办的 2023 年北京大学基础物理国际暑期学校于 8 月 6 日至 27 日举行。

本项目面向全球高校物理学及相关专业的本科生开放报名，经过申请、推荐与遴选，录取了来自 9 个国家 16 所高校的 50 余名物理专业本科生，其中国际学生 14 名。

开幕式上，北京大学校长、中国科学院院士龚旗煌指出，人类要破解共同发展难题，比以往任何时候都更需要国际合作和开放共享。当前，在基础研究领域，开放合作依然是世界主流。北京大学坚持“以开放促一流、与世界共发展”，将不断密切与海外知名高校和科研机构的联系，持续推动国际科技交流合作迈上更高水平。中国物理学会理事长、中国科学院院士张杰在致辞中指出，人类破解的每一个方程、完成的每一次实验都是在凭借自己的好奇心和想象力去寻觅更深、更远的景致，而每一个新鲜的“打卡处”又成为向更深、更远处进发的自我邀请。奥托·冯·格里克 - 马格德堡大学学生 Luca Greczmiel 在发言中表达了对忙碌而快乐的燕园学习生活的跃跃欲试。中国科学院高能物理研究所所长、中国科学院院士王贻芳在特邀报告中，介绍了正在建设和规划的高海拔宇宙线观测站（LHAASO）、江门中微子实验（JUNO）、环形正负电子对撞机（CEPC）等中国主导的大型国际合作研究，剖析了中国高能物理从“在世界高科技领域占有一席之地”到占领国际先机、赢得全面优势所面临的机遇和挑战。

巴黎萨克雷大学 / 巴黎综合理工学院教授、法国科学院 / 工程院院士、2022 年诺贝尔物理学奖获得者 Alain Aspect，康奈尔大学教授、北京大学客座讲席教授、美国国家科学院 / 国家工程院 / 艺术与科学院院士、中国科学院外籍院士、1986 年图灵奖获得者 John E. Hopcroft，哈佛大学教授、美国国家科学院 / 国家工程院 / 艺术与科学院院士、中国工程院外籍院士 David A. Weitz，芝加哥大学教授、美国国家科学院院士 / 艺术与科学院院士，美国物理学会候任主席 Young-Kee Kim，欧洲核子研究中心理论物理部负责人、意大利林琴国家科学院院士 Gian F. Giudice，维也纳技术大学教授、奥地利科学院通讯院士 Andrius Baltuška，哥伦比亚大学教授、美国艺术与科学院院士 Alfred H. Mueller，加利福尼亚大学圣芭芭拉分校教授、美国艺术与科学院院士 Anthony Zee，日本东北大学教授 / 中国科学院大学卡弗里理论科学研究所讲席教授、美国物理学会会士 Gerrit E.-W. Bauer，威斯康星大学麦迪逊分校教授 / 大气与海洋科学系主任、美国地球物理联合会会士 Ankur R. Desai 等 10 位世界顶尖科学家，以及北京大学科维理天文与天体物理研究所长聘副教授 / 副所长 Gregory Herczeg、助理教授 Kohei Inayoshi，北京国际数学研究中心长聘副教授 Emanuel Scheidegger，北京大学科学技术与医学史系助理教授 Daniele Macuglia，北京大学物理学院大气与海洋科学系助理教授 Mikinori Kuwata、Daniel Koll 等在北京大学执教的外国优秀青年学者应邀主讲了 5 门专题课程和 12 场讲座，全程使用英语教学，内容涵盖物理学、天文学、大气科学、数学、信息科学、科学技术史领域的基础前沿和交叉方向。他们结合各自所在领域的代表性工作，引导学生关注热点和新兴前沿，鼓励学生独立思考和积极提问。

在课间，穿过未名湖畔，流连于北京大学校史馆、北京大学赛克勒考古与艺术博物馆，感受光荣而厚重的校史和考古与艺术的融通；在周末，走上街头巷尾，徜徉于孔庙和国子监博物馆、观复博物馆，领略北京古都文化的时代风貌和中华传统文化的时代魅力；在北京正负电子对撞机国

家实验室，近距离接触“大国重器”，体味世界科技前沿的宏微交替和中国科技创新的追赶与超越……同学们在互学互鉴中增进了解、收获友谊、共同成长，大家纷纷表示，希望通过自己的眼睛了解真实、友好的中国，用共通的科学精神为推动人类社会进步贡献青春力量。

闭幕式上，国际暑期学校师生、行政团队、志愿者重温了过去三周里的难忘画面和精彩瞬间，倾听学生自述从“没学过”到获评A+、从“张不开嘴”到上台演讲所收获的进步的喜悦，聆听“大家长”、物理学院院长高原宁院士讲述在燕园求学、在欧美工作时所经历的“成长的烦恼”。物理学院党委书记刘雨龙向协助教学、服务的来自定量生物学中心、前沿计算研究中心等校内研究机构的中青年骨干教师，以及国际合作部、会议中心、财务部、教育基金会、保卫部、图书馆等校内支持单位表达了由衷的谢意。中外师生同唱骊歌，新朋老友相约同攀科学高峰，共赴星辰大海，一起向未来！

◎ Hosting the 2023 Peking University International Summer School on Fundamental Physics

As one of the key initiatives of Peking University's "International Strategy Year," the 2023 Peking University International Summer School on Fundamental Physics was held from August 6 to 27. The program was organized by Peking University, with the School of Physics, the Kavli Institute for Astronomy and Astrophysics (KIAA), and the Beijing Institute of Modern Physics serving as co-hosts.

The program was open to undergraduate students in physics and related disciplines worldwide. After a rigorous process of application, recommendation, and selection, over 50 physics majors from 16 universities across nine countries were admitted, including 14 international students.

At the opening ceremony, Qihuang Gong, President of Peking University and Academician of the Chinese Academy of Sciences (CAS), emphasized that humanity today needs international cooperation and open sharing more than ever to address common development challenges. He noted that openness and collaboration remain the mainstream in fundamental research. Peking University adheres to the principle of "promoting excellence through openness and advancing together with the world," continuously strengthening ties with renowned overseas universities and research institutions to elevate international scientific exchange and cooperation to new heights. Jie Zhang, President of the Chinese Physical Society and CAS Academician, remarked in his speech that every equation solved and every experiment conducted is driven by human curiosity and imagination, each new discovery serving as an invitation to explore even deeper and farther. Luca Greczmiel, a student from Otto von Guericke University Magdeburg, expressed eagerness for the busy yet joyful academic life at Peking University. In a special lecture, Yifang Wang, Director of the Institute of High Energy Physics (IHEP) and CAS Academician, introduced major international collaborative projects led by China, such as the Large High Altitude Air Shower Observatory (LHAASO), the Jiangmen Underground Neutrino Observatory (JUNO), and the Circular Electron-Positron Collider (CEPC). He analyzed the opportunities and challenges for China's high-energy physics to transition from "securing a place in the world's high-tech arena" to leading globally.

Ten world-renowned scientists were invited to deliver five specialized courses and 12 lectures, all conducted in English. The topics spanned foundational and interdisciplinary frontiers in physics, astronomy, atmospheric sciences, mathematics, information science, and the history of science and technology. The distinguished speakers included:

Alain Aspect (Professor at Paris-Saclay University/École Polytechnique, Member of the French Academy of Sciences/National Academy of Technologies, and 2022 Nobel Laureate in Physics);

John E. Hopcroft (Professor at Cornell University, Visiting Chair Professor at Peking University, Member of the U.S. National Academy of Sciences/National Academy of Engineering/American Academy of Arts and Sciences, Foreign Member of CAS, and 1986 Turing Award recipient);

David A. Weitz (Professor at Harvard University, Member of the U.S. National Academy of Sciences/National Academy of Engineering/American Academy of Arts and Sciences, and Foreign Member of the Chinese Academy of Engineering);

Young-Kee Kim (Professor at the University of Chicago, Member of the U.S. National Academy of Sciences/American Academy of Arts and Sciences, and Incoming President of the American Physical Society);

Gian F. Giudice (Head of Theoretical Physics at the European Organization for Nuclear Research (CERN) and Member of the Accademia Nazionale dei Lincei);

Andrius Baltuška (Professor at the Vienna University of Technology (TU Wien) and Corresponding Member of the Austrian Academy of Sciences);

Alfred H. Mueller (Professor at Columbia University and Member of the American Academy of Arts and Sciences);

Anthony Zee (Professor at the University of California, Santa Barbara, and Member of the American Academy of Arts and Sciences);

Gerrit E.-W. Bauer (Professor at Tohoku University/Chair Professor at the Kavli Institute for Theoretical Sciences, University of Chinese Academy of Sciences, and Fellow of the American Physical Society);

Ankur R. Desai (Professor and Chair of Atmospheric and Oceanic Sciences at the University of Wisconsin-Madison and Fellow of the American Geophysical Union).

Additionally, outstanding early-career scholars teaching at Peking University, such as Gregory Herczeg (KIAA Associate Professor and Deputy Director), Kohei Inayoshi (KIAA Assistant Professor), Emanuel Scheidegger (Associate Professor at the Beijing International Center for Mathematical Research), Daniele Macuglia (Assistant Professor at the Department of

History of Science, Technology, and Medicine), and Mikinori Kuwata and Daniel Koll (Assistant Professors at the Department of Atmospheric and Oceanic Sciences), contributed to the program. They guided students to explore cutting-edge topics, encouraging independent thinking and active questioning.

Between classes, students strolled around the picturesque Weiming Lake, visited the PKU History Museum and the Arthur M. Sackler Museum of Art and Archaeology, immersing themselves in the university's illustrious history and the interplay of archaeology and art. On weekends, they explored Beijing's cultural landmarks, including the Confucius Temple and Imperial College Museum, and the Guanfu Museum, experiencing the timeless charm of the ancient capital and traditional Chinese culture. At the Beijing Electron-Positron Collider National Laboratory, they witnessed China's scientific prowess, reflecting on the nation's journey from catching up to leading in global innovation. Through mutual learning, the students deepened their understanding, forged friendships, and grew together. Many expressed a desire to see the real, friendly China with their own eyes and to contribute to human progress through the universal language of science.

At the closing ceremony, participants revisited unforgettable moments from the three-week program. Students shared their joy in overcoming challenges, from mastering unfamiliar topics to delivering confident presentations. Yuanning Gao, Dean of the School of Physics and CAS Academician, reflected on his own "growing pains" as a student at PKU and later a research fellow in Europe and the U.S.. Yulong Liu, Chair of the School Council, extended heartfelt gratitude to the faculty from interdisciplinary institutions like the Center for Quantitative Biology and the Center on Frontiers of Computing Studies, as well as supporting departments such as the Office of International Relations, Convention Center, and Library. The ceremony concluded with students and faculty singing farewell songs, vowing to scale new scientific heights together and embark on future adventures - toward the stars and beyond!

图 1：开幕式合影

Figure 1: Group photo at the opening ceremony

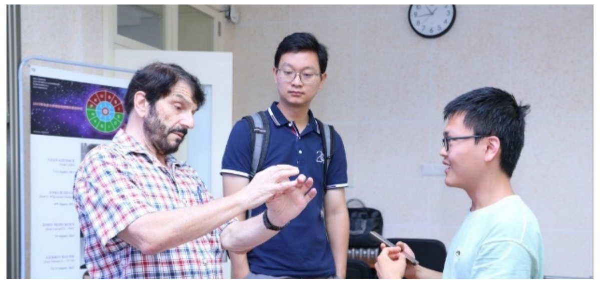


图 2：课间师生热烈讨论

Figure 2: Discussion between teachers and students during class breaks

◎ 首次利用可调超导射频腔扫描搜寻暗光子暗物质

北京大学高能物理研究中心舒菁教授领导的山河合作组（SHANHE）在全球首次利用超导射频腔扫描搜寻暗光子暗物质，在 1.3 GHz 频段获得了对暗光子暗物质最严格的参数限制。暗光子作为一种假设的超轻玻色子，是暗物质的重要候选者之一，其与普通光子通过动量混合相互作用，成为标准模型的自然扩展。该特性使其参数空间的探索成为国际竞争焦点。

暗光子作为暗物质可表现为一种电流源，激发电磁场。由于暗物质的非相对论性质，该电流源在频率上集中于其质量附近的窄带。当暗光子的康普顿波长与谐振腔尺寸匹配时，其激发的电磁场可通过谐振效应被大幅放大。超导射频（SRF）腔具有极高品质因子，较传统谐振腔高出约 5 个数量级，显著降低噪声，从而极大提升探测灵敏度。

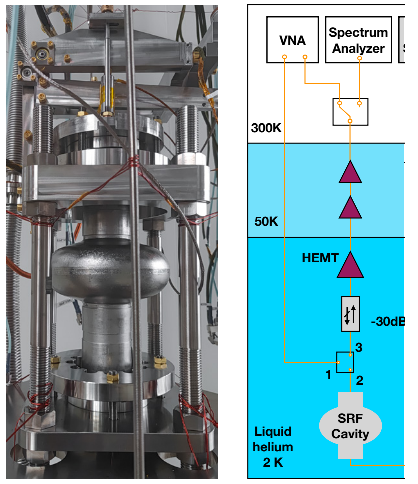


图 1：左：安装调谐器的超导腔实物图；右：实验电路设计图

Figure 1: Left: Physical image of the superconducting cavity with a tuner installed; Right: Experimental circuit design diagram.

由于暗物质质量区间未知，搜寻工作需兼具高灵敏度与快由于暗物质质量区间未知，搜寻工作需兼具高灵敏度与快速扫描能力。研究团队利用 2K 液氦环境中的超导射频腔，首次在超导腔体上使用机械调谐器，在短时间内完成 1150 次扫描，在接近 1.299 GHz 的初始频率下覆盖 1.37 MHz 范围。团队还设计了首个适用于极高品质因子的数据处理方法，对扫描范围内的暗光子暗物质进行了严格排除。

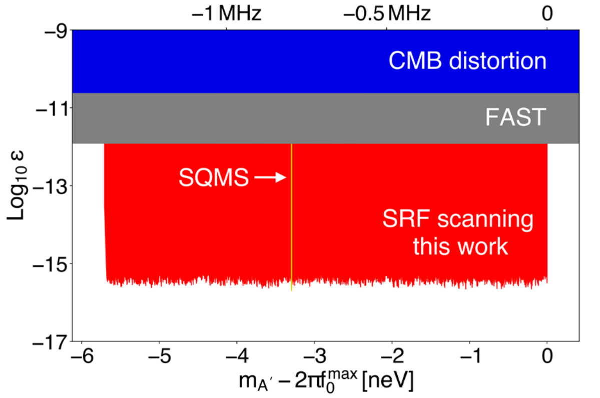


图 1：左：安装调谐器的超导腔实物图；右：实验电路设计图

Figure 1: Left: Physical image of the superconducting cavity with a tuner installed; Right: Experimental circuit design diagram.

该实验结果在全球范围内取得领先，如图 2 所示，其排除参数空间优于美国费米实验室 SQMS 等竞争对手。研究有望推动该领域发展，特别是新型频率调谐器与腔体技术，以探索更大参数空间。超导射频腔的高品质因子为多种灵敏度增强方法提供了可能，包括压缩态技术、无损光子计数、纠缠与态交换技术等。山河合作组还计划开展轴子暗物质与高频引力波探测等一系列前沿研究。

相关成果以"First Scan Search for Dark Photon Dark Matter with a Tunable Superconducting Radio-Frequency Cavity"为题，于 2024 年 7 月 12 日在线发表于国际权威物理学期刊《物理评论快报》(Physical Review Letters)。

论文链接：
https://journals.aps.org/prl/pdf/10.1103/PhysRevLett.133.021005

◎ First Scan Search for Dark Photon Dark Matter Using a Tunable Superconducting Radio-Frequency Cavity

The SHANHE collaboration, led by Professor Jing Shu from the Center for High Energy Physics at Peking University, has conducted the world's first scan search for dark photon dark matter using a superconducting radio-frequency cavity, achieving the most stringent parameter constraints to date in the 1.3 GHz frequency band. The dark photon, a hypothetical ultra-light boson, is one of the leading candidates for dark matter. Through kinetic mixing, it interacts with ordinary photons, serving as a natural extension of the Standard Model. This characteristic has made the exploration of its parameter space a focal point of international competition.

As dark matter, the dark photon can manifest as a current source that excites electromagnetic fields. Due to the non-relativistic nature of dark matter, this current source is concentrated in a narrow frequency band near its mass. When the Compton wavelength of the dark photon matches the size of the resonant cavity, the excited electromagnetic field can be significantly amplified through resonance. The superconducting radio-frequency (SRF) cavity exhibits an exceptionally high quality factor, approximately five orders of magnitude greater than that of traditional resonant cavities, which substantially reduces noise and greatly enhances detection sensitivity.

Given the unknown mass range of dark matter, the search requires both high sensitivity and rapid scanning capability. The research team utilized a superconducting radio-frequency cavity operating in a 2K liquid helium environment and, for the first time, employed a mechanical tuner on the superconducting cavity. They completed 1,150 scans in a short period, covering a range of 1.37 MHz around the initial frequency of approximately 1.299 GHz. The team also developed the first data processing method suitable for ultra-high-quality-factor systems, enabling strict exclusion of dark photon dark matter within the scanned range.

The experimental results are globally leading, as shown in Figure 2, with the excluded parameter space outperforming competitors such as Fermilab's SQMS in the United States. This research is expected to advance the field, particularly in the development of novel frequency tuners and cavity technologies, enabling the exploration of broader parameter spaces. The high quality factor of superconducting radio-frequency cavities offers the potential for various sensitivity-enhancement methods, including squeezing techniques, non-destructive photon counting, and entanglement and state-swapping technologies. The SHANHE collaboration also plans to conduct a series of cutting-edge studies, such as searches for axion dark matter and high-frequency gravitational waves.

The related findings, titled "First Scan Search for Dark Photon Dark Matter with a Tunable Superconducting Radio-Frequency Cavity," were published online in the internationally authoritative physics journal Physical Review Letters on July 12, 2024.

Link to the paper:
https://journals.aps.org/prl/pdf/10.1103/PhysRevLett.133.021005

供稿：北京现代物理研究中心
审核：高原宁

学生活动
STUDENTS

2023 年 1 月 21 日除夕夜，物理学院组织举办“除夕游园会”活动。

To celebrate New Year's Eve, the School of Physics organized the “Lunar New Year's Eve Fair” on January 21, 2023.

2023 年 3 月 11 日，物理学院邀请“两弹一星”元勋于敏之子于辛老师以“我的父亲于敏”为题，从家人的视角分享共和国脊梁于敏先生的故事。

On March 11, 2023, the School of Physics invited Mr. Yu Xin to deliver a lecture on his father Yu Min, a pillar of China’s “Two Bombs and One Satellite” Program, from a son’s perspective.

2023 年 3 月 19 日，物理学院联合北京大学数学科学学院、中国科普作协科学与影视融合专委会，邀请电视剧《三体》主创团队走进北大，与师生进行现场互动交流。

On March 19, 2023, the School of Physics, in collaboration with the School of Mathematical Sciences and the China Science Writers Association, invited the main creative team of the TV series “The Three-Body Problem” to Peking University for an exchange with faculty and students.

2023 年 4 月 21 日 -23 日，物理学院在北京大学 2023 春季运动会再创佳绩，学院荣获“北京大学校园体育工作先进单位”称号。

From April 21 to 23, 2023, the School of Physics achieved outstanding results at Peking University 2023 Spring Sports Festival and was thus awarded for its exemplary campus sports work.

2023 年 5 月 14 日，物理学院邀请赵凯华先生作物理文化节开幕式报告。

On May 14, 2023, the School of Physics invited Mr. Zhao Kaihua to deliver the opening speech for the Physics Cultural Festival.

2023 年 6 月 17 日，学院举办第二十一届“北京大学钟盛标物理教育基金”、第十七届“北京大学钟陈玉蘭基金”颁奖典礼。

On June 17, 2023, the School of Physics held the 21st Paul Shin-Piaw Choong Educational Fund for Physics Award Ceremony and the 17th Peking University Zhongchen Yulan Fund Award Ceremony.

2023 年暑假，学院组织 200 余名本科生在全国各地开展社会实践，共建立 5 个思想政 治教育实践课程基地。

During the summer vacations of 2023 and 2024, over 500 undergraduates from the School of Physics participated in social research projects across the country, with five moral and political education bases featuring hands-on courses established.

2023 年 8 月，物理学院举办北京大学基础物理国际暑期学校。

The Peking University Summer School International 2023 on Fundamental Physics kicked off in August, 2023.

2023 年 8 月 19 日，物理学院喜迎 2023 级近 300 名本科新生。

On August 19, 2023, the School of Physics welcomed nearly 300 undergraduate freshmen.

2023 年 9 月 29 日，物理学院 2023 级本科生 10 班第二班主任见面会在临湖轩庭院举行。时任北京大学党委书记、物理学院 2023 级本科生 10 班第二班主任郝平，党委副书记、副校长宁琦出席见面会。

On September 29, 2023, the then chair of the Peking University Council Hao Ping talked with undergraduates entering Class of 2023 at Linhuxuan along with Ning Qi, Vice Chair of the Peking University Council and Vice President. Mr. Hao was a tutor of Class 10, the Class of 2023.

2023 年 10 月 21 日，物理学院举办第七届“青藤计划”专场招聘宣讲会，邀请 16 家对口校友企业进院宣讲招聘。

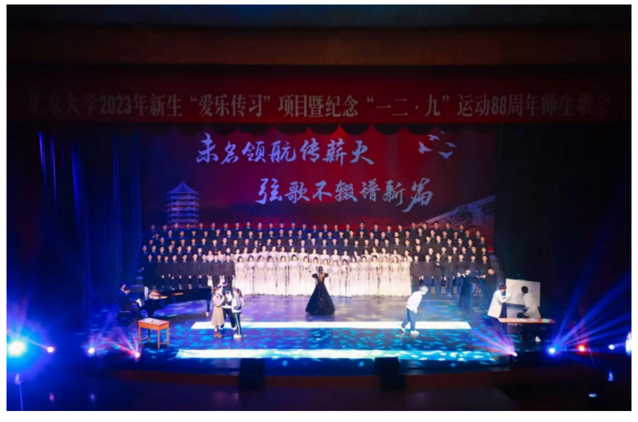
On October 21, 2023, the School of Physics launched the 7th edition of its “Qingteng Program” with a dedicated recruitment fair. Sixteen alumni-founded companies came to present their openings and scout talent directly within the school.

2023 年 10 月 14 日，物理学院学生志愿者服务保障北京大学物理学科建立 110 周年庆祝会。

On October 14, 2023, volunteers from the School of Physics helped deliver a successful 110th Anniversary of the Establishment of the Physics Discipline at Peking University.

2023 年 11-12 月，物理学院联合华为北研所举办“对话华为”系列讲座。

Between November and December 2023, the School of Physics, in collaboration with Huawei Beijing Research Institute, held the “Dialogues with Huawei” lecture series.



2023 年 12 月 9 日，学院获得北京大学一二·九师生合唱甲组一等奖。

On December 9, 2023, the School of Physics won the first prize of PKU’s Singing Contest (Group A) in commemoration of the December 9th Movement.

STUDENTS
学生活动

2023 年 12 月 21 日，在 2022–2023 学年度北京大学青年志愿服务评优评奖与总结表彰中，学院学生荣获“北京大学志愿者标兵”称号，物理科普志愿服务项目获评学校优秀项目，学院获评学校优秀组织单位。

On December 21, 2023, the School of Physics shone at PKU's annual Youth Volunteer Service Awards: its students earned “Model Volunteer” honors, its Physics Popularization Volunteer Program won “Outstanding Project”, and the School itself claimed the “Top Organizing Unit” title for 2022-2023

2023 年 12 月，冬日雪后，学院组织志愿者开展“我爱我院”扫雪志愿服务。

Following a winter snowfall, the School of Physics mobilized volunteers for a “Heart for our School” snow clearing effort in December 2023.

2024 年 2 月，物理学院在上海市"沪核探秘"实践团获北京大学 2023-2024 学年学生寒假社会实践铜奖。

The School of Physics 's "Shanghai Nuclear Quest" team, focused on investigating the city's nuclear energy sector, secured the Bronze Award in the University's 2023-2024 Winter Social Practice Competition.


编号：2023030001

荣誉证书

北京大学

物理学院凝聚态物理与材料物理研究所2021级博士班：

荣获二〇二二年至二〇二三年度北京市先进班集体称号。

特颁此证。

二〇二四年三月

2024 年 3 月，北京大学物理学院凝聚态物理与材料物理研究所 2021 级博士班获评 2022-2023 年度北京市先进班集体。

In March 2024, the PhD Class of 2021 of the Institute of Condensed Matter and Materials Physics at the Peking University School of Physics was awarded the title of "Beijing Outstanding Class" for the 2022-2023 academic year.

2024 年 3 月 23 日，学院举办 2022-2023 学年院级奖学金颁奖典礼。

On March 23, 2024, the School of Physics held the 2022-2023 Academic Year School-Founded Scholarship Award Ceremony.

2024 年 4 月 21 日，第二十二届"钟盛标物理教育基金"研究生学术论坛成功举办。

On April 21, 2024, the School of Physics held the 22nd Paul Shin-Piaw Choong Educational Fund for Physics Graduate Forum.

2024 年 4 月 28 日，物理学院组织 200 余名师生参加五四青春长跑。

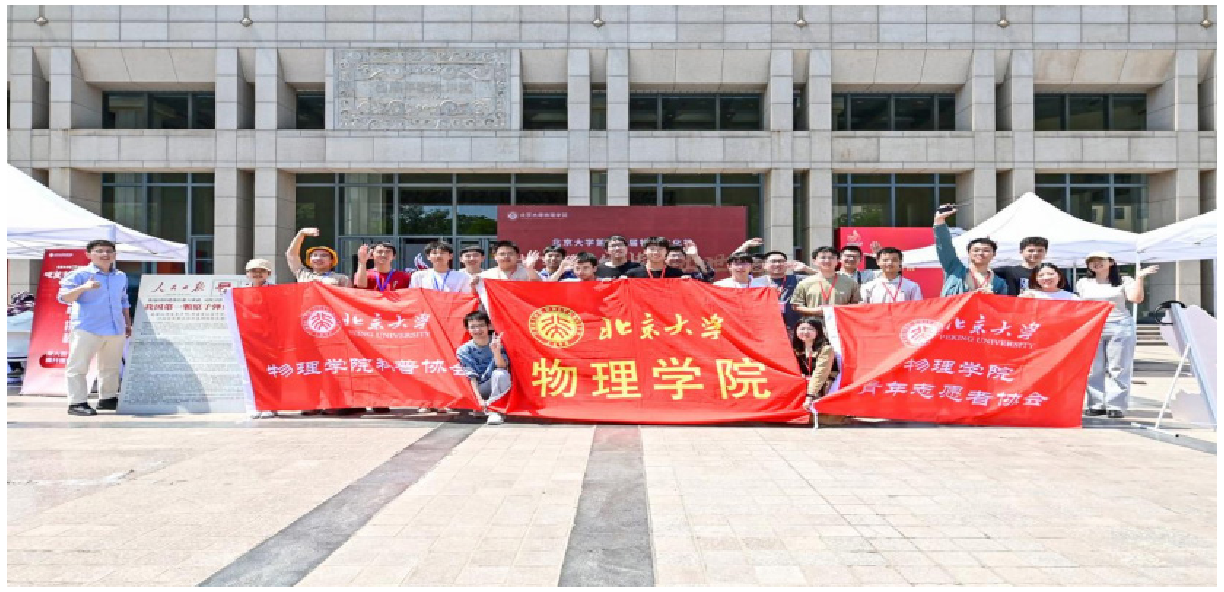
On April 28, 2024, upwards of 200 teachers and students from the School of Physics participated in the May Forth Long-Distance Running, which covers 5.4 km in commemoration of the May Forth Movement.

2024 年 5 月 11 日，物理学院与马克思主义学院联队获得北京大学第二十二届"北大之锋"辩论赛冠军。

On May 11, 2024, the joint debating team of the School of Physics and the School of Marxism claimed the championship title at the 22nd PKU Debate Competition.

2024 年 5 月，物理学院凝聚态物理与材料物理研究所 2021 级博士班荣获第十四届北京大学“班级五·四奖杯”，2019 级博士研究生戴天祥荣获第十四届北京大学“学生五·四奖章”。

In May 2024, two top honors from PKU's 14th May Fourth Awards came to the School of Physics: the “May Fourth Cup” for the PhD Class of 2021 of the Institute of Condensed Matter and Materials Physics, and the “May Fourth Medal” for Dai Tianxiang, a PhD student of the Class of 2019.



2024 年 5 月 16 日，为纪念我国第一颗原子弹成功爆炸 60 周年，激发学生科研报国信念，学院举办“硬‘核’青年 横空出世”第 23 届物理文化节。

On May 16, 2024, to commemorate the 60th anniversary of the successful explosion of China's first atomic bomb and to fuel its students' commitment to national service, the School of Physics held the 23rd Physics Cultural Festival under the theme “Hard-Core Youth: A Dazzling Debut”.

北京大学第三十二届“挑战杯”
五四青年科学奖竞赛获奖名单

特等奖

获奖奖项	课题名称	团队成员	指导老师
特等奖	用于原子分子共线激光谱的表面离子源设计与建设	梅文聪	杨晓菲
特等奖	保罗阱中含噪声离子动力学的系统研究	王英祥	彭良友
特等奖	叠层单晶二维材料的可控制备与物性研究	戚嘉杰 顾恬 郭泉林 马辰俊	刘开辉

一等奖

获奖奖项	课题名称	团队成员	指导老师
一等奖	基于等离子体尾波加速的 XFEL 研究	刘乐天	徐新路
一等奖	超临界物质与复相图	欧阳霄宇	李新征
一等奖	非厄米拓扑激子极化激元	谭歆桐	刘文静
一等奖	布居数反转晶体中的 X 射线衍射	吴振翔	李铮
一等奖	野火烟尘的时空分布：从理论到遥感	许睿	俞妍
一等奖	双层石墨烯对铜的高效防腐研究	赵孟泽 王悰	刘开辉
一等奖	绿洲/沙漠边界层辐合线特征研究	郑梓萌	孟智勇

2024 年 5 月，物院学子斩获北京大学第三十二届“挑战杯”五四青年科学奖竞赛特等奖 3 项，一等奖 7 项，二等奖 2 项，三等奖 2 项，跨学科学生课外科技学术作评竞赛三等奖、优秀奖各 1 项。

In May 2024, students from the School of Physics swept 14 prizes at PKU's 32nd Challenge Cup Youth Science Awards, including 3 Grand Prizes, 7 First Prizes, 2 Second Prizes and 2 Third Prizes, with additional recognition in interdisciplinary research.

2024 年 6 月 22 日，物理学院在学院广场举行毕业音乐节。

On June 22, 2024, the School of Physics organized a graduation music festival in the School Plaza.

2024 年 6 月 28 日，物理学院在百周年纪念讲堂观众厅举行 2024 年毕业典礼。

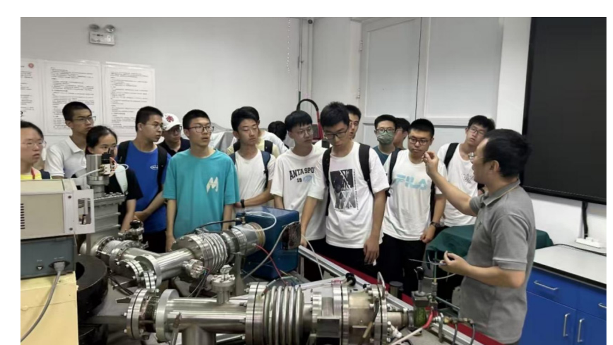
On June 28, 2024, the School of Physics held the 2024 Graduation Ceremony in the Peking University Centennial Memorial Hall.

2024 年 6 月 -7 月，物理学院组织近 300 名本科生开展社会实践。

From June to July 2024, nearly 300 undergraduate students from the School of Physics carried out social research projects.

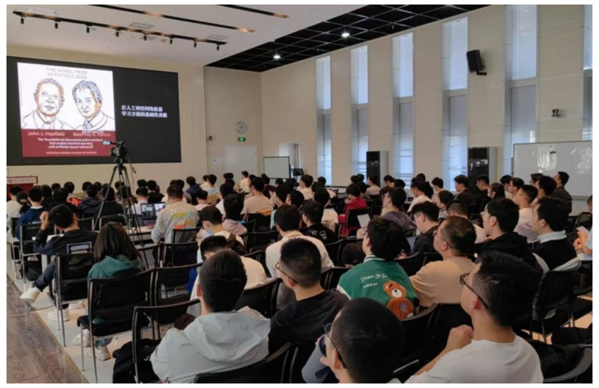
2024 年 8 月 23 日 -31 日，物理学院组织本科新生开展国防军事训练。

From August 23 to 31, 2024, undergraduate freshmen from the School of Physics underwent national defense military training.



2024 年 9 月 8 日，物理学院组织 2024 级本科生参观各系所中心实验室。

On September 8, 2024, the School of Physics organized undergraduate students entering the Class of 2024 to visit the laboratories of its departments, institutes, and centers.

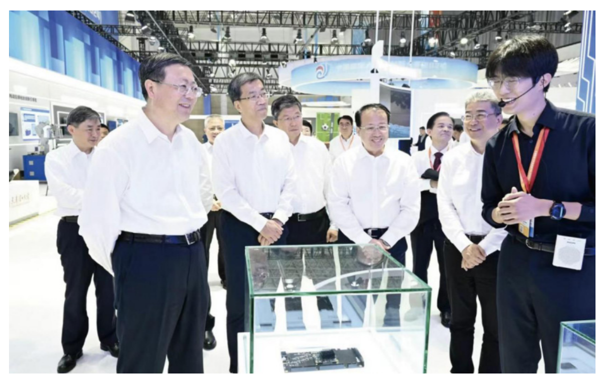


2024 年 10 月 11 日，物理学院邀请马滟青教授作 2024 年度诺贝尔物理学奖解读报告。

On October 11, 2024, the School of Physics invited Professor Ma Yanqing to deliver an interpretation report on the 2024 Nobel Prize in Physics.

2024 年 10 月 15 日，物理学院 2022 级硕士生朱欣岳创业项目荣获中国国际大学生创新大赛（2024）全国金奖。

On October 15, 2024, the entrepreneurial project of Zhu Xinyue, a Master's student of the Class of 2022 at the School of Physics, won the National Gold Award at the China International College Students' Innovation Competition 2024.



2024 年 10 月 20 日，物理学院举行 2024 级研究生迎新晚会。

On October 20, 2024, the School of Physics held a welcome party for newly-arrived graduate students.

STUDENTS
学生活动

2024 年 11 月 10 日，物理学院指导的北京大学青年天文学会（学生社团）荣获 2024 年首都高校学术科技类“学生最喜爱的社团”称号。

On November 10, 2024, the PKU Young Astronomers Association (student club), guided by the School of Physics, was awarded the title of “Students' Favorite Academic & Technological Club for 2024” among universities in Beijing.

2024 年 11 月 26 日，物理学院举办第七十六期“萃英”研究生学术沙龙。

On November 26, 2024, the School of Physics held the 76th “Elite” Graduate Academic Salon.

2024 年 12 月 7 日，物理学院举办“谁羽争锋”师生校友羽毛球赛。

On the afternoon of December 7, 2024, the Youth League Committee of the School of Physics held a badminton match for teachers, students and alumni.

2024 年 12 月 15 日，物理学院举办新年晚会。

On December 15, 2024, the School of Physics held a New Year Gala.

2024 年 12 月，物理学院 2021 级博士研究生黎顺德获得“北京大学 2024 学生年度人物”。

In December 2024, Li Shunde, a PhD student of the Class of 2021, School of Physics, was awarded the title of “PKU Outstanding Students of Year 2024”.

2024 年 12 月，物理科普项目荣获第七届中国青年志愿服务项目大赛铜奖、北京市银奖等。

In December 2024, the School's Physics Popularization Volunteer Program claimed Bronze in China's 7th Youth Volunteer Service Comepetition and Silver in Beijing Municipal Awards, among other honors.

供稿：学生工作办公室
审核：张帆

校友与基金
ALUMNI AND FUNDS

2023 年 4 月 2 日，北京大学物理学院与校友会联合主办的 " 物有所知，共话未来 " 校友活动在上海成功举办。活动由上海北大科技园协办，中国科学院院士、物理学院院长高原宁，上海市宝山区科委主任阳晖，北大上海校友会副会长杨文斌等嘉宾及近 70 位校友出席。高原宁院长回顾北大物理学科 110 年历程，强调校友是学院发展的坚实后盾，呼吁凝聚力量共建校友平台。现场揭牌的上海 " 校友之家 " 将成为校友联络的重要纽带。三位校友代表分享了前沿科技项目心得，副院长曹庆宏介绍了 " 物理学科卓越人才计划 "。本次活动开启了北大物理学院在长三角校友工作的新篇章，未来将持续深化校企合作，助力学科与校友共同发展。

On April 2, 2023, Peking University (PKU) School of Physics and its Alumni Association co-hosted the alumni event "Physics Connects, Future Inspires" in Shanghai, supported by PKU Science Park(Shanghai). Attendees included Gao Yuanning (Dean of PKU School of Physics and CAS Academician), Yang Hui (Director of Shanghai Baoshan Science Commission), Yang Wenbin (Vice President of PKU Shanghai Alumni Association), and nearly 70 alumni. Dean Gao highlighted the 110-year legacy of PKU physics, emphasizing alumni support for institutional growth. The Shanghai "Alumni Home" was unveiled as a networking hub. Three alumni representatives shared insights on cutting-edge tech projects, while Vice Dean Cao Qinghong introduced the "Physics Excellence Talent Program." The event marked a new chapter for alumni engagement in the Yangtze River Delta, pledging enhanced university-industry collaboration to advance physics education and alumni development.

2023 年 5 月 3 日至 4 日，北京大学物理学院举办校友返校活动，庆祝北大 125 周年校庆暨物理学科创立 110 周年。海内外校友重聚燕园，学院在邱德拔体育馆和物院西楼设立接待站，提供专属纪念礼品与志愿服务。活动涵盖校友合影、天文摄影展、趣味物理科普演示（如鱼洗盆实验、磁悬浮展示）及学院展区参观（含郭永怀精神展、物理学宗师铜像等）。科普活动吸引众多孩童参与，志愿者通过实验讲解物理原理。本次返校既唤醒了校友的青春记忆，也搭建了交流平台。学院将持续深化校友服务，凝聚北大物理人力量，共促学科发展。

From May 3-4, 2023, Peking University's School of Physics hosted an alumni homecoming event, marking PKU's 125th anniversary and the physics discipline's 110th founding year. Alumni worldwide reunited at the Yanyuan Campus, where reception stations at the Qiu Deba Gymnasium and Physics Building West offered exclusive souvenirs and volunteer support. Activities included group photos, an astrophotography exhibition, interactive science demos (e.g., resonance bowls and magnetic levitation), and guided tours through exhibits honoring physicist Guo Yonghuai and six master statues. Children engaged enthusiastically with hands-on experiments explaining physical principles. The event rekindled alumni memories while fostering dialogue. The school pledged enhanced alumni services, uniting "PKU physicists" to advance the discipline's legacy.

2023 年 6 月 18 日，北京大学校友会物理学院分会第十四次理事会会议于物理学院思源多功能厅召开。院长高原宁、校友会副秘书长李存峰、副院长颜学庆及海内外校友理事线上线下参会。会议围绕三大核心议程展开：李存峰肯定校友贡献，强调 " 以思想引领时代，以学术报效国家 " 的工作理念；高原宁汇报学院发展，重点介绍物理学科卓越计划、国家重点研发项目及叶企孙师表奖进展；穆良柱总结年度工作，包括上海校友活动、科普宣讲及校友

基金管理。理事会通过增补理事决议，并研讨 110 周年庆典方案及校友奖励机制。校友代表就学院建设、基金优化等建言献策，会议为物理学科新阶段发展凝聚共识。

On June 18, 2023, the 14th Council Meeting of the Peking University School of Physics Alumni Association was held at the Siyuan Hall. Attendees included Dean Gao Yuanning, Alumni Office Deputy Director Li Cunfeng, Vice Dean Yan Xueqing, and global alumni council members via hybrid participation. Key agendas featured: Li affirming alumni contributions while emphasizing the mission of "guiding the era with thought, serving the nation with scholarship"; Gao reporting disciplinary advancements including the Physics Excellence Program, national R&D projects, and the Ye Qisun Teaching Award; and Mu Liangzhu summarizing annual initiatives like Shanghai alumni events and fund management. The council ratified new members and discussed the 110th-anniversary celebration framework. Alumni representatives proposed strategies for institutional development and fund optimization, forging unity for the discipline's next phase.

2023 年 7 月 8 日，北京大学 99 级物理系校友毕业 20 周年重聚活动在燕园举行。三十余名校友重返母校，共叙同窗情谊。活动包含四大主题：校友身着定制纪念 T 恤畅谈人生；重访 28 楼、31 楼宿舍区，追忆青春岁月；漫步未名湖、博雅塔重温 " 一塔湖图 " 情怀；举办主题轰趴，体验电竞、烧烤等互动项目。本次活动凝聚物理人的精神纽带，彰显北大情怀历久弥新。

On July 8, 2023, over 30 alumni from Peking University's Physics Class of 1999 returned to campus for their 20th reunion. The event featured nostalgic activities across four themes: wearing custom T-shirts while sharing life stories; revisiting former dormitories (Buildings 28/31); strolling around Weiming Lake and Boya Pagoda; and bonding through gaming/BBQ parties.The reunion reaffirmed the unbreakable bonds forged during their PKU physics journey.

ALUMNI AND FUNDS
校友与基金

2023 年 10 月 14 日，北京大学物理学科创立 110 周年庆典之际，62-83 级物理系及 63 级地球物理系校友重聚燕园。学院精心筹备接待，志愿者全程引导，并开设线上互动平台供未到场校友云端参与。校友们重逢时笑靥如初，共叙同窗情谊，在分会场观看学科庆典直播，感受学院发展脉搏。活动聚焦 " 重逢、回忆、展望、期待 " 四大主题，老照片唤起青春记忆，新合影续写物理情怀。临别之际，校友们相约 " 十年后再聚 "，彰显 " 时光不老，情谊不散 " 的北大物理精神。

On October 14, 2023, alumni from the classes of 1962-1983 gathered at Peking University to celebrate the 110th anniversary of its physics discipline. The event featured heartfelt reunions, shared memories, and collective visioning. Returning graduates relived campus days through vintage photos while witnessing the discipline's progress via livestreamed ceremonies. Volunteers facilitated both on-site activities and virtual participation for absent alumni. Centered on themes of "Reunion, Reminiscence, Vision, and Aspiration," the gathering culminated in a decade-reunion pledge, echoing the timeless bond among PKU physicists. As one alumnus noted: "Time may pass, but our bonds endure."

2023 年 10 月 15 日，北京大学物理学院举办 " 应用物理产业研讨会 "，庆祝物理学科创立 110 周年。20 余位校友返校参会，学院党委书记刘雨龙、校友会副秘书长李存峰等出席。颜学庆副院长介绍学院应用物理基金及广东省新兴激光等离子体技术研究院进展，强调该平台将融合北大科研资源与粤港澳产业优势。峰瑞资本合伙人杨永成指出物理领域创业迎来机遇，与会校友就技术转化、产业链建设展开深度研讨。本次活动为学院应用物理发展凝聚校友力量，推动产学研融合。

On October 15, 2023, Peking University's School of Physics hosted an Applied Physics Industry Symposium, commemorating the discipline's 110th anniversary. Over 20 alumni attended, alongside leaders including Party Secretary Liu Yulong and Alumni Office Deputy Director Li Cunfeng. Vice Dean Yan Xueqing highlighted the newly established Applied Physics Fund and the Guangdong Laser Plasma Technology Institute–a collaborative platform leveraging PKU's academic resources and regional industry strengths. Yang Yongcheng noted growing entrepreneurial opportunities in physics. Alumni from tech enterprises and investment firms discussed industrializing research outcomes and ecosystem development. The event strengthened alumni-industry ties, paving the way for sustained innovation in applied physics.

2024 年 1 月 7 日，" 产业互融，科创共鸣 " 北京大学校友科创企业家论坛暨首届应用物理产业峰会在京举行。北京大学校务委员会副主任叶静漪、物理学院院长高原宁等校院领导，与科研、产业、投资领域 300 余位校友共聚。峰会聚焦应用物理产学研融合，叶静漪强调校友联动支持 " 双一流 " 建设，高原宁提出夯实基础科研与产业创新。沈波剖析第三代半导体技术发展，郎春晖阐释资本驱动科技转化路径，赵红运分享超导产业化成果。三场圆桌论坛分别围绕 " 校友产业协同 "" 高校创业扶持 "" 金融助力成果转化 " 展开深度探讨，推动基础科研与产业应用双向赋能，开启北大物理人科创合作新篇章。

On January 7, 2024, Peking University hosted its inaugural Applied Physics Industry Summit alongside the Alumni Sci-Tech Entrepreneurs Forum in Beijing. Attended by over 300 alumni leaders including Ye Jingyi (PKU Council Vice Chair), Gao Yuanning (Dean of School of Physics), and industry pioneers, the event centered on academia-industry integration. Keynotes featured: Ye emphasizing alumni synergy for the "Double First-Class Initiative"; Gao advocating foundational research and industrial innovation; Shen Bo analyzing third-generation semiconductors; Lang Chunhui detailing capital's role in tech commercialization; and Zhao Hongyun sharing superconducting industrialization breakthroughs. Three panel discussions explored industry collaboration, university entrepreneurship policies, and financial strategies for research commercialization. The summit forged new pathways for scientific innovation and industrial application among PKU physics alumni.

2024 年 1 月 27 日，北京大学物理学院校友会举办校友子女寒假研学活动。活动通过物理实验演示、科普讲座及校园导览，激发青少年科学兴趣。物理学院科普协会学生现场演示蛇形摆、鱼洗盆、静电飞花等十余项趣味实验，阐释力学、光学原理。邵立晶副教授作《物理学的科学世界观》主题讲座，从星系到粒子揭秘宇宙运行规律；张焱教授介绍北大招生政策及物理卓越计划。参与者随后参观生物标本馆与燕园文物，感悟科学人文交融之美。活动深化校友情感纽带，助力文化育人实践。

On January 27, 2024, Peking University's School of Physics Alumni Association organized a winter research program for alumni children. The event featured interactive physics demonstrations, lectures, and campus tours to inspire scientific curiosity. Student volunteers showcased over ten experiments–including pendulum waves, resonance bowls, and electrostatic levitation–exploring mechanics and optics principles. Associate Professor Shao Lijing unveiled cosmic mysteries in a "Physics Worldview" lecture, while Professor Zhang Yan detailed PKU admissions and the Physics Excellence Program. Participants later explored biological specimen collections and cultural heritage sites across campus. The activity strengthened alumni bonds while fostering interdisciplinary learning among youth.

2024 年 3 月 23 日，北京大学物理学院举行 2022-2023 学年院级奖学金颁奖典礼。设奖校友代表纪力强（1978 级）、王晨扬（1997 级）、马骏超（2013 级），教育基金会副秘书长耿姝，学院领导高原宁、

刘雨龙等出席。穆良柱副书记介绍学年评审情况，强调奖学金承载校友精神传承。王晨扬勉励学子 " 扬长避短，探索生活广度 "；马骏超阐释设立 " 传承奖学金 " 旨在反哺学院、激励追梦。获奖学生代表陶彦青分享科研成长经历。高原宁院长致谢校友支持，呼吁学子树立远大抱负。典礼后设专项交流会，校友与获奖学生就学业规划深度对话，延续物理人代际传承。

On March 23, 2024, Peking University's School of Physics hosted its annual scholarship ceremony, recognizing outstanding students for the 2022-2023 academic year. Attendees included alumni donors Ji Liqiang (Class of 1978), Wang Chenyang (Class of 1997), Ma Junchao (Class of 2013), and university leadership. Vice Dean Mu Liangzhu highlighted the scholarships' role in perpetuating alumni legacy. Wang Chenyang encouraged students to "leverage strengths and broaden life horizons," while Ma Junchao explained how the "Legacy Scholarship" supports academic pursuits. Awardee Tao Yanqing shared research experiences. Dean Gao Yuanning commended alumni contributions, urging scholars to embrace ambitious goals. Post-ceremony discussions deepened mentor-student connections, reinforcing the physics community's enduring bonds.

2024 年 5 月 3 日，北京大学物理学院举办 126 周年校庆校友返校活动，同步庆祝物理学科创立 111 周年。海内外校友齐聚燕园，共叙情谊。活动设置三大板块：校友于学院广场签到合影，获赠专属纪念品并参观成果展；科普协会志愿者为校友子女演示趣味物理实验，激发科学兴趣；开放应用超导研究中心、电子束 - 热蒸发镀膜实验室，由专业教师讲解前沿科技。本次活动强化校友纽带，彰显 " 格物致知 " 精神传承。

On May 3, 2024, Peking University's School of Physics welcomed alumni back to campus for its 126th anniversary, coinciding with the discipline's 111th founding year. The event featured three segments: alumni checked in at the physics plaza for commemorative gifts and exhibitions; volunteers demonstrated interactive physics experiments for children, sparking scientific curiosity; and labs like the Applied Superconductivity Center opened for guided tours on cutting-edge technology. The gathering reinforced alumni bonds while honoring the spirit of scientific inquiry.

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2024 年 5 月 26 日，" 物有所知，共话未来 " 北京大学物理学院广州校友活动圆满举办。活动由广东省新兴激光等离子体技术研究院承办，高原宁院士、广州市科协副主席曾雪玲等出席。高原宁回顾北大物理学科百年贡献，并作 " 原初反物质消失之谜 " 学术报告；曾雪玲解读广州科技成果转化政策；颜学庆副院长展示研究院激光等离子体技术产业化成果；曹庆宏详解 " 物理学科卓越人才计划 "。校友企业代表分享非接触光纤、拓扑量子材料等前沿技术。与会者参观研究院展厅，共谋产学研融合。活动深化粤港澳校友网络，赋能物理学科创新发展。

"Physics Connects, Future Inspires": PKU Physics Alumni Forum Concludes in Guangzhou. On May 26, 2024, Peking University's School of Physics hosted its Guangzhou alumni forum, co-organized by the Guangdong Laser Plasma Technology Institute (GLPTI). Attendees included CAS Academician Gao Yuanning, Guangzhou Science Association Vice Chair Zeng Xueling, and over 100 alumni. Dean Gao highlighted PKU physics' century-long legacy while presenting cutting-edge research on primordial antimatter. Zeng outlined Guangzhou's tech commercialization policies. Vice Dean Yan Xueqing showcased GLPTI's industrial applications in laser-plasma technology. Professor Cao Qinghong detailed the "Physics Excellence Talent Program". Alumni entrepreneurs shared breakthroughs in contactless fiber optics and topological quantum materials. The event featured a tour of GLPTI's innovation hub, strengthening alumni-industry collaboration for scientific advancement.

2024 年 5 月 26 日，北京大学技术物理系 74 级原子核物理专业校友入学 50 周年纪念会在物理学院举行。27 名校友与郑春开、汪厚基（近 90 高龄）等 5 位恩师重聚，18 位亲属共同见证。师生共忆 " 北大 653" 的求学岁

月，感念母校培育之恩。戴德高老师以 " 亦师亦友 " 定义深厚情谊，校友们感怀恩师铸就行业栋梁之才。活动由学院精心筹办，现场 " 老师好 " 问候不绝。临别之际，师生相约 " 五年后再聚 "，并致敬学院支持。半世纪时光淬炼出不可磨灭的师生纽带，彰显北大物理人的精神传承。

On May 26, 2024, Peking University's Department of Physics hosted a 50th-anniversary reunion for its 1974 nuclear physics graduates. Twenty-seven alumni reunited with five mentors–including professors Zheng Chunkai and Wang Houji–alongside 18 family members. The gathering at "653" evoked memories of foundational academic years, with alumni honoring teachers who shaped their professional excellence. Professor Dai Degao defined their bond as "mentorship forged in friendship." The event concluded with pledges for future reunions and gratitude to the university. Five decades crystallized an unbreakable teacher-student legacy, embodying PKU physicists' enduring spirit.

2024 年 9 月 21 日，北京大学物理系 64 级校友入学 60 周年返校活动在物理学院举行。四个班级的校友重聚思源报告厅，党委书记刘雨龙、退休教授钟锡华出席。刘雨龙书记致欢迎辞，感谢校友对国家发展的贡献，并介绍学院最新学科布局。86 岁的钟锡华教授追忆艰苦求学岁月，赞誉校友在各自领域的成就。活动现场播放班级纪念视频，颁发定制 60 周年徽章，校友们畅叙甲子情谊。与会者在物理大楼前合影，定格 " 六秩再聚首，一生物理人 " 的温情瞬间。活动由 64 级校友史守旭主持，彰显北大物理人历久弥新的精神传承。

On September 21, 2024, Peking University's Physics Class of 1964 celebrated their 60th enrollment anniversary at the School of Physics. Alumni from four classes reunited in the Siyuan Hall, joined by Party Secretary Liu Yulong and retired professor Zhong Xihua. Secretary Liu acknowledged alumni contributions to national progress while updating disciplinary developments. Professor Zhong, 86, recalled their resilient student years amid hardships, praising graduates' professional achievements. The event featured class memorial videos and bespoke 60th-anniversary badges. A group photo before the Physics Building captured six decades of camaraderie, with alumnus Shi Shouxu hosting the gathering that epitomized PKU physicists’ enduring legacy.

2024 年 9 月 22 日，北京大学物理学院 80 级校友毕业 40 周年返校活动在思源报告厅举行。校友们重聚燕园，共叙同窗情谊。活动中，校友们互赠定制院衫与中秋月饼，分享人生故事，现场笑声洋溢。中国科学院院士、物理学院院长高原宁与校友们在物院大楼前合影，定格跨越四十载的珍贵情谊。活动以 " 物理纠缠四十载，未名守恒燕归来 " 为主题，彰显物理人历久弥新的精神纽带。这场重逢不仅是青春的追忆，更是心灵的归航，见证北大物理人永恒的情感联结。

On September 22, 2024, alumni from Peking University's Physics Class of 1980 returned to campus for their 40th reunion at Siyuan Hall. Graduates reunited over custom department shirts and mooncakes, sharing life journeys amid laughter and warmth. CAS Academician Gao Yuanning, Dean of the School of Physics, joined a commemorative group photo before the Physics Building, freezing four decades of camaraderie in frame. Titled "Entanglement Through Time, Unchanging Bonds at Weiming Lake," the event embodied enduring connections among PKU physicists–a homecoming for both memories and the spirit.

2024 年 9 月 27 日，北京大学物理学院举办第六期 " 物理 +" 校友沙龙，特邀 1980 级校友、富国银行董事总经理汤漪博士作主题分享。汤漪以 " 金融与物理齐飞，无序共有序一色 " 为题，解析量化金融核心逻辑。他结合物理思维与金融实践，阐释资本市场流动性本质，详解衍生品建模中随机过程、蒙特卡洛模拟等数学工具的应用，强调微分方程在风险管理中的价值。通过期权、信用违约掉期等案例，揭示结构化产品实现风险收益平衡的路径。汤漪还分享职场成功要素——信任、视野与执行力，并寄语学子 " 启航物理，纵横万里 "，彰显跨学科融合的魅力。

On September 27, 2024, Peking University's School of Physics hosted its sixth "Physics+" alumni salon, featuring Dr. Tang Yi (Managing Director at Wells Fargo), a 1980 alumnus. Titled "Finance Meets Physics: Order in Disorder," the lecture decoded quantitative finance through an interdisciplinary lens. Dr. Tang unveiled capital markets' liquidity dynamics and demonstrated mathematical applications–stochastic processes, Monte Carlo simulations–in derivatives modeling. Using options and credit default swaps as cases, he illustrated structured products' role in balancing risk-return profiles. He further emphasized trust, vision, and execution as career success pillars, advising students to "navigate the world from a physics foundation." The session highlighted physics methodologies' transformative power in finance.

2024 年 11 月 22 日，北京大学物理学院举办第七期 " 物理 +" 校友沙龙，邀请 2005 级校友、光轮智能 CEO 谢晨博士作主题分享。谢晨以 " 具身智能中的物理机遇 " 为核心，解析生成式 AI 与物理仿真的融合路径，提出 "Real2Sim2Real" 技术框架，通过合成数据加速 AI 在物理世界的高泛化应用。他剖析具身智能在机器人、医疗、工业等领域的革新潜力，强调物理学科的系统性思维为 AI 复杂问题提供独特解法。互动环节中，谢晨结合硅谷技术管理及创业经验，鼓励学子抓住交叉领域机遇，并预言未来五年将迎来技术突破。本次活动凸显物理学在人工智能时代的关键价值。

On November 22, 2024, Peking University's School of Physics hosted its seventh "Physics+" alumni salon, featuring Dr. Xie Chen (CEO of Lightwheel AI), a 2005 alumnus. Centered on "Unlocking Physics′ Role in Embodied Intelligence," Xie unveiled the "Real2Sim2Real" framework–integrating generative AI with physical simulation to create synthetic data for real-world AI applications. He highlighted embodied intelligence's transformative potential in robotics, healthcare, and manufacturing, noting physics-based methodologies offer unique solutions to AI's complex challenges. Drawing from his experience at NVIDIA and entrepreneurship, Xie encouraged students to seize interdisciplinary opportunities, predicting critical breakthroughs within five years. The event underscored physics′ pivotal role in shaping AI's future.

校友基金项目
Alumni Funds

设立时间 TimeofEstablishment	项目名称 Project Title	捐赠人 Donators
1987	叶企孙实验物理基金 Ye Qisun Experimental Physics Fund	叶企孙先生的友人和学生 Mr. Ye Qisun'friends and students
1996	谢义炳基金 Xie Yibing Fund	谢义炳先生和他的学生毛节泰等 Mr.Yibing Xie and his students(Mr. Mao Jietai et al.)
2002	1977 物理班级基金 1977 Physics Class Fund	北大物理 1977 级校友 The 1977 physics alumni
2002	钟盛标物理教育基金 Paul Shin-Piaw Choong Educational Fund for Physics	钟赐贤先生与夫人夏晓峦女士 Mr. Philip Tsi Shien Choong and Ms. Hsia Shaw-lwan Choong
2005	1980 物理兰怡女子助学金 1980 Ellen Lan Yi Woman Physicist Scholarship	北大物理 1980 级校友、兰怡女士的家人和朋友 The 1980 alumni, Ms. Lan Yi's family, and friends
2005	1986 物理班级基金 1986 Physics Class Fund	北大物理 1986 级校友 The 1986 physics alumni
2006	1988 物理班级基金 1988 Physics Class Fund	北大物理 1988 级校友 The 1988 physics alumni
2008	陈互雄物理教育基金 Chen Huxiong Educational Fund for Physics	陈敬熊院士与夫人常菊芳女士 Mr. Chen Jingxiong and Ms. Chang Jufang
2008	胡宁奖学金 Hu Ning Scholarship	胡宁家属，秦旦华、苏肇冰夫妇，赵光达等 Mr. Hu Ning's family, Ms. Qin Danhua, Zhaobing Su couple and Mr. Zhao Guangda et al.

设立时间 TimeofEstablishment	项目名称 Project Title	捐赠人 Donators
2010	赵凯华物理教育基金 Zhao Kaihua Educational Fund for Physics	北大校友、师生及相关单位 PKU alumni, teachers, students, and concerned departments
2011	求索奖学金 Truth-seeking Scholarship	北大物理 1980 级校友汤漪先生与夫人杨洪女士 The 1980 alumni Mr. Tang Yi and his wife Ms. Yang Hong
2011	张文新教育基金 Zhang Wenxin Educational Fund	北大物理 1949 级校友张文新先生 The 1949 alumni Mr. Zhang Wenxin
2011	海鸥奖学金 Hai Ou Scholarship	北大物理 1978 级校友张兴云先生、樊培女士 The 1978 alumni Mr. Zhang Xingyun and Ms. Fan Pei
2011	1991 物理班级基金 1991 Physics Class Fund	北大物理 1991 级校友 The 1991 physics alumni
2011	物理学院学生发展基金 Students Development Fund	北大物理 2000 级校友李川、夏英姿，天美公司等 The 2000 alumni Mr. Li Chuan, Xia Yingzi, the Tianmei company and et al.
2011	沈克琦物理教育基金 Shen Keqi Educational Fund for Physics	北大物理 1988 级校友王多祥先生 The 1980 alumni Mr. Wang Duoxiang
2012	近代物理研究所奖学金 Institute of Modern Physics Fund	中国科学院近代物理研究所 The Institute of Modern Physics, Chinese Academy of Sciences
2012	1985 念恩奖学金 1985 Physics Class Fund	北大物理 1985 级校友（方晶、雷弈安等） The 1985 physics alumni (Ms. Fang Jing, Mr. Lei Yi'an et al.)

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2013	物理学院紧急救助基金 School Emergency Aid Fund	北大物理校友、社会各界 PKU Physics alumni and community
2013	物理新楼报告厅座椅认捐基金 Physics Building Lecture Hall Chair Donation Fund	北大物理校友、社会各界 PKU physics alumni and community
2013	1979 级校友捐赠园林基金 1979 Physics Class Fund for Garden Donation	北大物理 1979 级校友 The 1979 physics alumni
2013	物理新楼视频会议室基金 Physics Building Video Meeting Room Fund	北大物理 1977 级校友夏廷康 The 1977 alumni Mr. Tingkang Xia
2013	物理新楼楼前花园捐赠基金 Physics Building Front-garden Fund	北大物理 1978 级校友胡铭 The 1978 physics alumni Mr. Ming Hu
2013	物理新楼 7802 会议室基金 Physics Building 7802 Meeting Room Fund	北大物理 1978 级校友 The 1978 physics alumni
2013	北大合伙人基金 PKU Partnership Fund	北大物理 2012 级研究生李骥、宗华、付建波 The 2012 physics graduates Li Ji, Zong Hua and Fu Jianbo
2013	1978 级核物理校友奖励基金 1978 Nuclear Physics Class Fund	北大原子核物理 1978 级校友（纪力强先生等） The 1978 Atomic Nuclear Physics alumni (Mr.Ji Liqiang et al.)
2013	兴诚本科生科研基金 Xingcheng Fund for Undergraduate Research	北大技物系 1979 级校友 The 1979 Technical Physics alumni
2014	1980 校友捐赠基金 1980 Physics Class Fund	北大物理 1980 级校友 The 1980 physics alumni

设立时间 TimeofEstablishment	项目名称 Project Title	捐赠人 Donators
2014	物理新楼图书馆新馆阅览室基金 Physics Building New Library Reading Room Fund	北大物理校友、社会各界 PKU physics alumni and community
2015	物理新楼中 212 会议室座椅认捐基金 Physics Building 212 Middle Room Chair Donation Fund	北大物理校友、社会各界 PKU physics alumni and community
2015	津徽学生发展基金 Jinhui Students Development Fund	北大物理 1997 级校友王晨扬先生与夫人程雅女士 The 1997 alumni Mr. Wang Chenyang and his wife Ms. Cheng Ya
2017	物理学院发展基金 School Development Fund	北大物理校友、社会各界 PKU physics alumni and community
2018	锐天明日之星助学金 Ruitian Rising Star Scholarship	北大物理 2005 级校友 徐晓波 / 上海锐天投资管理有限公司 The 1997 alumni Mr. Xu Xiaobo, Shanghai Ruitian Investment Management Co., Ltd.
2019	衍复奖学金 Yan Fu Scholarship	北大物理 2004 级校友高亢先 The 2004 alumni Mr. Gao kang
2020	王晨扬 - 程雅物理教育基金 Wang Chenyang-Cheng Ya Educational Fund for Physics	北大物理 1997 级校友王晨扬先生与夫人程雅女士 The 1997 alumni Mr. Wang Chenyang and his wife Ms. Cheng Ya
2020	宛扬奖教金 Wanyang Teaching Scholarship	北大物理 2007 级技术物理系校友徐震翔先生 The 2007 alumni Mr. Xu Zhenxiang

ALUMNI AND FUNDS
校友与基金

设立时间 TimeofEstablishment	项目名称 Project Title	捐赠人 Donators
2022	传承奖学金 Heritage Scholarship	北大物理 2013 级校友（侯尧先生等） The 2013 physics alumni(Mr. Hou Yao, etc.)
2022	张岑优秀科研奖学金 Zhang Cen Excellent Research Scholarship	张岑父母: 张鸣先生和岑献青女士，张岑亲友 Zhang Cen's parents: Mr. Zhang Ming and Ms. Cen Xianqing, friends and relatives of Zhang Cen
2022	叶企孙师表奖 Ye Qisun's Teacher's Recommendation Award	宋少辉先生 Mr. Song Shaohui
2023	物理 1979 级优秀实验技术人员奖励 Award for Outstanding Laboratory Technicians of the Physics Class of 1979	北大物理 1979 级校友 The 1979 physics alumni
2024	物理学院我爱北大基金 Loveing Peking University Fund for the School of Physics	退休教师李嘉璋及爱人董文珠 Retired teacher Li Jiazhang and his wife Dong Wenzhu

供稿：综合办公室
审核：张帆

合作与交流
EXCHANGE & COOPERATION

01 学术讲座 Lectures

◎ 北京大学百年物理讲坛 The Centennial Physics Lectures

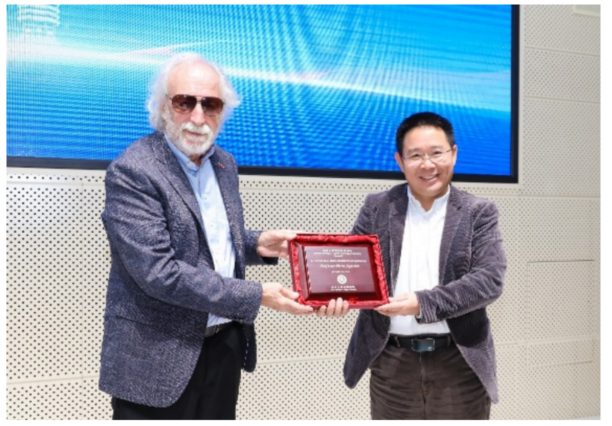
2024年举办“北京大学百年物理讲坛”第二十七讲和第二十八讲。2024年3月13日，第二十七讲邀请到2018年诺贝尔物理学奖获得者杰哈·阿尔贝特·穆鲁作了题为“极端光学：连接光学与基础高能物理的桥梁，迈向仄秒（10^{-21}s）与泽瓦科学（1021W）的第一步”的公开演讲。

In 2024, the school held the 27th and 28th sessions of The Centennial Physics Lectures. March 13th, the 27th lecture “Extreme Light: Bridging Optics and Fundamental High Energy Physics, first steps Towards Zeptosecond and Zettawatt Science” were given by the 2018 Nobel Laureate in Physics Professor Gérard Albert Mourou.

COOPERATION
合作与交流

2024年3月13日，第二十七讲邀请到2018年诺贝尔物理学奖获得者杰哈·阿尔贝特·穆鲁作了题为“极端光学：连接光学与基础高能物理的桥梁，迈向仄秒（10^{-21}s）与泽瓦科学（10^{21}W）的第一步”的公开演讲。

In 2024, the school held the 27th and 28th sessions of The Centennial Physics Lectures. March 13th, the 27th lecture “Extreme Light: Bridging Optics and Fundamental High Energy Physics, first steps Towards Zeptosecond and Zettawatt Science” was given by the 2018 Nobel Laureate in Physics Professor Gérard Albert Mourou.



◎ 北京大学物理学院学术论坛 The Distinguished Colloquium

2023~2024年，北京大学物理学院学术论坛举办第18~51讲，以及世界气象日、北京大学物理学科建立110周年学术报告会等专题报告，邀请国内外高校和研究机构高层次科技创新领军学者就物理学及相关领域的基础前沿探索、关键技术突破和热点问题等做学术演讲，旨在推进高质量学术交流，促进学科交叉融合和开拓新兴特色方向研究，培养具有科学精神、全球视野、创新能力、批判性思维的优秀青年人才。

During the 2023-2024 period, the School of Physics convened the 18th to 51st installments of its Distinguished Colloquium series, complemented by special sessions marking World Meteorological Day and the 110th Anniversary of Physics at Peking University. These events featured addresses by leading scholars from domestic and international institutions, covering cutting-edge research, key technological breakthroughs, and salient topics across physics, astronomy, and atmospheric and oceanic sciences. With an emphasis on high-level academic exchange, interdisciplinary synergy, and the exploration of novel research directions, the Colloquium is dedicated to cultivating among young scholars a spirit of scientific inquiry, a global outlook, and the faculties of critical and creative thought.

讲次	时间	报告人	报告题目
世界气象日	2023 年 3 月 23 日	周天军	气候变化背后的科学与我国的双碳目标
第 18 讲	2023 年 3 月 24 日	金亚秋	空间遥感信息智能感知与微波视觉
第 19 讲	2023 年 5 月 12 日	牛谦	Particle view in crystals
第 20 讲	2023 年 5 月 20 日	彭秋和	恒星的生命史与超新星爆发
第 21 讲	2023 年 5 月 26 日	Joern Manz	Big quantum effects in small molecules
第 22 讲	2023 年 5 月 26 日	Yoshihiro Iwasa	Voltage Control of Quantum Phase of Matter
第 23 讲	2023 年 6 月 2 日	Marek Karliner	NEW HEAVY EXOTICS
第 24 讲	2023 年 7 月 24 日	Sir Michael Berry	Geometric phases old and new
第 25 讲	2023 年 7 月 25 日	Sir Michael Berry	Making light of mathematics
第 26 讲	2023 年 9 月 20 日	Ulrich Heinz	The Little Bang Standard Model
第 27 讲	2023 年 9 月 19 日	周磊	Metasurfaces for controlling light
第 28 讲	2023 年 10 月 12 日	G.Brian Stephenson	35 Years of In Situ X-ray Scattering Studies of Crystal Surfaces During Growth

COOPERATION
合作与交流

讲次	时间	报告人	报告题目
北大物理110周年学术报告会	2023 年 10 月 14 日	张希成	From THz Air Photonics to THz Liquid Photonics
北大物理110周年学术报告会	2023 年 10 月 14 日	王循理	Structure and Dynamics of Metallic Glass - Atomistic Insights from Scattering Experiments
第 29 讲	2023 年 10 月 18 日	Stuart Parkin	自旋电子学：今天的大数据世界！
第 30 讲	2023 年 11 月 17 日	Peter Ring	Density Functional Theory in Nuclear Physics
第 31 讲	2023 年 11 月 30 日	Paras N Prasad	生物光子学和纳米光子学的融合
第 32 讲	2024 年 4 月 17 日	Junji Kido	有机发光二极管的最新进展
第 33 讲	2024 年 4 月 19 日	Ulf-G. Meißner	The Nucleus as a Quantum Laboratory
第 34 讲	2024 年 4 月 15 日	Steve Hoffman	人工智能困境：超级智能的机遇与风险
第 35 讲	2024 年 5 月 15 日	Nicolas Regnault	Moiré fractional phases of matter
第 36 讲	2024 年 5 月 16 日	Marek Abramowicz	On gravitational wave interstellar communication
第 37 讲	2024 年 5 月 17 日	段路明	量子计算机——现状与展望
第 38 讲	2024 年 5 月 31 日	汪自强	Extraordinary matter: Quantum anomalous vortex, Majorana zero mode, roton superconductor, and charge-6e superconductivity

COOPERATION
合作与交流

讲次	时间	报告人	报告题目
第 39 讲	2024 年 6 月 28 日	Chennupati Jagadish	Semiconductor Nanostructures for Optoelectronics Applications
第 40 讲	2024 年 7 月 19 日	Franz J. Giessibl	基于 qPlus 传感器的扫描探针显微术
第 41 讲	2024 年 9 月 6 日	Giacomo Ghiringhelli	Collective excitations of superconducting cuprates and nickelates studied by resonant inelastic x-ray scattering
第 42 讲	2024 年 9 月 23 日	区泽宇	Interferometry in the Quantum Age
第 43 讲	2024 年 10 月 17 日	Matthias Scheffler	Artificial Intelligence in Materials Science: Impact, Uncertain Expectations, and Open Challenges
第 44 讲	2024 年 10 月 21 日	Angel Rubio	Quantum Electrodynamics Density functional theory (QEDFT): quantum materials engineering with light
第 45 讲	2024 年 10 月 25 日	Joachim Burgdörfer	Attosecond Chronoscopy: From Atoms to Condensed Matter
第 46 讲	2024 年 11 月 15 日	谭平恒	二维半导体中的光 - 物质相互作用
第 47 讲	2024 年 11 月 22 日	Klaus Blaum	Precision tests of the Standard Model at low energies using stored exotic ions in Penning traps
第 48 讲	2024 年 11 月 22 日	Steven Allan Kivelson	The electron-phonon problem revisited: New insights into the properties of normal metals and conventional superconductors
第 49 讲	2024 年 11 月 28 日	Eli Zeldov	报告 I Nanoscale thermal imaging: Glimpse into dissipation in quantum systems down to atomic scale 报告 II Thermodynamic quantum oscillations and bandreconstruction in strongly correlated moiré systems
第 50 讲	2024 年 12 月 13 日	杨建成	强流重离子加速器发展前沿和重大应用（新质生产力）
第 51 讲	2024 年 12 月 24 日	丁洪	多者异也：铁基超导中的多带之美

◎ 北京大学格致论坛 Gezhi Forum

2023~2024 年，北京大学物理学院学术论坛举办第 18~51 讲，以及世界气象日、北京大学物理学科建立 110 周年学术报告会等专题报告，邀请国内外高校和研究机构高层次科技创新领军学者就物理学及相关领域的基础前沿探索、关键技术突破和热点问题等做学术演讲，旨在推进高质量学术交流，促进学科交叉融合和开拓新兴特色方向研究，培养具有科学精神、全球视野、创新能力、批判性思维的优秀青年人才。

From 2023 to 2024, the School of Physics has held Lectures 18–51 of its Distinguished Colloquium, as well as special lectures for World Meteorological Day and the 110th Anniversary of the School of Physics. Renowned scholars from China and abroad were invited to deliver public lectures on cutting-edge research, key technological breakthroughs, and hot topics in physics and related fields. Focusing on high-quality academic exchange, interdisciplinary integration, and the exploration of emerging research directions, the colloquium aims to cultivate young talent with a scientific spirit, a global vision, innovation capabilities, and critical thinking skills.

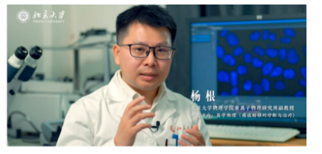
讲次	时间	报告人	报告题目
第 14 讲	2023 年 3 月 17 日	杨志成	量子多体系统的非平衡动力学
第 15 讲	2023 年 5 月 19 日	叶堉	二维材料的制备、物性与相关器件
第 16 讲	2023 年 6 月 30 日	杨根	癌症转移的诊断和治疗
第 17 讲	2023 年 9 月 15 日	张熙博	超冷原子气体中的精密测量、精密调控及其若干应用
第 18 讲	2023 年 10 月 27 日	王力乐	机箱中的宇宙——计算天体物理管窥
第 19 讲	2023 年 12 月 8 日	Mikinori Kuwata	大气气溶胶颗粒的相变与液相特征
第 20 讲	2023 年 12 月 22 日	杨起帆	高性能集成光学频率梳
第 21 讲	2024 年 3 月 1 日	周辰	希格斯物理研究：过去、现在、未来
世界气象日专场	2024 年 3 月 23 日	聂绩、朱志铭	走在“气候行动最前线”
第 22 讲	2024 年 4 月 12 日	宋志达	转角体系——摩尔超晶格上的凝聚态物理
第 23 讲	2024 年 4 月 26 日	刘佳	暗物质粒子寻找的科学之旅
第 24 讲	2024 年 5 月 24 日	路建明	探索二维异质结中的电荷极化有序态
第 25 讲	2024 年 6 月 27 日	宋博	基于超冷原子体系的量子模拟
第 26 讲	2024 年 9 月 27 日	林晨	激光等离子体质子加速器与应用探索
第 27 讲	2024 年 10 月 18 日	姜方周	星系与暗物质的双向奔赴
第 28 讲	2024 年 12 月 6 日	李婧	大气气溶胶的气候效应与卫星遥感

◎ “物理之美”系列短视频 “The Beauty of Physics” series videos

依托“物理之美”系列讲座平台，以短视频方式讲述新一代北大物理人寻求理论突破、攻克技术难关的故事。

Built on the platform of the “The Beauty of Physics” lecture series, these short videos showcase the journeys of next-generation physicists from the School of Physics as they pursue theoretical breakthroughs and overcome technical challenges.

刘开辉：石墨烯的奇迹，从单层到十万层的探索之旅



杨根：与癌症转移赛跑，分秒必争！

俞妍：揭开沙尘与野火的面纱

周辰：探索质量起源之旅

◎ "格物穷理"博士后学术交流会 Postdoctoral Academic Exchange Conference

“格物穷理”博士后学术交流会是由北京大学和中国科学院物理研究所联合举办，以“博采众长，共创未来”为主题，旨在为博士后群体指引科研道路，提供跨单位、跨研究领域的学术交流平台和成果展示平台，帮助博士后拓宽研究视野、提升创新能力、深化合作交流，助力学科发展和青年学者成长成才。同时，交流会也对两家单位的学科发展、青年人才培养起到重要的推动作用。2023 年 2 月 14 日，首届交流会成功举办，特别邀请王恩哥院士和欧阳颀院士作特邀报告。

Postdoctoral Academic Exchange Conference is jointly organized by Peking University and Institute of Physics, Chinese Academy of Sciences, with the theme of “Collecting the wisdom of all and creating the future together”, aiming to provide a platform for postdoctoral to exchange ideas and display their achievements, and to help postdoctoral broaden research horizons, enhance innovation ability. On February 14, 2023, the first session of the conference was successfully held, Wang Enge and Ouyang Qi were invited to give a special lecture.

02 学术访问 Academic Visit

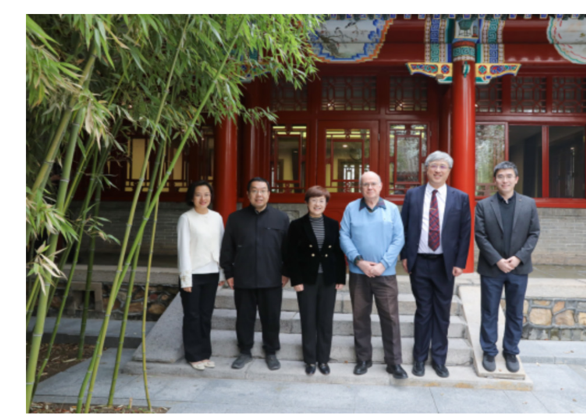
2023 年 6 月 27 日，美国物理学会（APS）执行主编 Jessica Thomas、《物理评论快报》(PRL) 主编 Robert Garisto、《物理评论 X》（PRX）副主编徐乙茗为代表的美国物理学会编辑代表与北京大学物理学院高原宁、徐莉梅、颜学庆、谢心澄和 50 余名师生代表开展了线上交流会。

On June 27, 2023, the PKU-APS Joint Event was successfully held. The delegation of editors from the American Physical Society (APS), led by Executive Editor Jessica Thomas, Editor-in-Chief of Physical Review Letters (PRL) Robert Garisto, and Associate Editor of Physical Review X (PRX) E-Ming Xu, conducted an online exchange meeting with Gao Yuanning, Xu Limei, Yan Xueqing, Xie Xincheng, and over 50 faculty members and students."

2024 年 4 月 1 日，欧洲核子研究中心理事会主席、以色列希伯来大学拉卡物理研究所原所长、国际知名理论物理学家埃利泽·拉比诺维奇教授访问北京大学。高原宁、杨振伟、李强等陪同会见。会见结束后，拉比诺维奇前往物理学院，发表了题为“粒子物理：成果、挑战与魔力”的学术演讲。

On April 1, 2024, Professor Eliezer Rabinovici, President of the CERN Council and former Director of the Racah Institute of Physics at the Hebrew University of Jerusalem, visited Peking University. He met with Gao Yuanning, Yang Zhenwei, and Li Qiang at Linhuxuan. Following the meeting, Professor Rabinovici visited the School of Physics and delivered an academic lecture entitled “Particle Physics: Results, Challenges and Magic”.

2023 年 11 月 21 日，俄罗斯量子中心（Russian Quantum Center，RQC）联合创始人 Ruslan Iunusov 一行访问北京大学，物理学院副院长彭良友、徐莉梅，物理学院教师代表王剑威、许秀来、刘雄军、马仁敏、赵宏政、宋博，以及电子学院教师代表陈徐宗、周小计等在临湖轩东厅接待了来访客人，双方就量子信息与技术领域进行了深入的座谈交流。



On November 21, 2023, Ruslan Iunusov, co-founder of the Russian Quantum Center (RQC), and his delegation visited Peking University. They held in-depth discussions with representatives from Peking University at the East Hall of Linhu Xuan regarding quantum information and technology. The delegation from the School of Physics included Vice Deans Peng Liangyou and Xu Limei, along with faculty members Wang Jianwei, Xu Xiulai, Liu Xiongjun, Ma Renmin, Zhao Hongzheng, and Song Bo. The delegation from the School of Electronics included Chen Xuzong and Zhou Xiaoji.

2023 年 12 月 19 日，俄罗斯联邦副总理切尔内申科一行到访北京大学，并参观北京大学物理学院人工微结构和介观物理国家重点实验室，龚旗煌介绍了实验室及北大物理学科的发展情况。切尔内申科表示，希望俄中两国在基础科学领域加强联系，拓展更多合作

On December 19, 2023, Dmitry Chernyshenko, Deputy Prime Minister of the Russian Federation, and his delegation visited Peking University and the State Key Laboratory of Artificial Microstructure and Mesoscopic Physics in the School of Physics. During the visit, Gong Qihuang introduced the development of the laboratory and physics at the university. Chernyshenko hoped that Russia and China would strengthen ties and foster more cooperation in the field of basic science. Senior representatives from the School of Physics accompanied the delegation.

2024 年 10 月 14 日，俄罗斯国家核物理研究大学莫斯科工程物理学院 Nikolai Kargin 副院长一行访问北京大学物理学院。王新强、徐莉梅、王平、边珂等会见来宾。双方就半导体和量子科学等领域展开深入座谈交流。

On October 14, 2024, Nikolai Kargin, Vice Dean of the National Research Nuclear University "MEPhI" (Moscow Engineering Physics Institute), and his delegation visited the School of Physics at Peking University. They held in-depth discussions with representatives from the School of Physics, including Wang Xinqiang, Xu Limei, Wang Ping, and Bian Ke, on topics such as semiconductors and quantum science.

COOPERATION
合作与交流

2024 年 10 月 22 日下午，叙利亚高等应用科学技术学院（HIAST）院长 Omran Kouba 教授一行访问北京大学物理学院。徐莉梅、马伯强、李强、王一男、赵家瑞等教师代表会见来宾。双方就共同促进在基础物理、粒子物理、工程物理等领域的科研发展展开深入交流。

On October 22, 2024, Prof. Omran Kouba, Dean of the Higher Institute of Applied Science and Technology (HIAST) in Syria, and his delegation visited the School of Physics of Peking University and had an in-depth exchange with representatives of School of Physics, Xu Limei, Ma Boqiang, Li Qiang, Wang Yinan, and Zhao Jiarui, on jointly promoting the development of scientific research in the fields of fundamental physics, particle physics, and engineering physics.

2024 年 10 月 24 日，德国跨界创新基金会主席、柏林洪堡大学前校长、德国亥姆霍兹联合会前主席于尔根·米勒克（Juergen Mlynek）一行访问北京大学物理学院。物理学院副院长徐莉梅、吴成印、赵正朴等接待来宾一行，双方就共同促进物理学发展展开了深入交流。

On October 24, 2024, Juergen Mlynek, the President of Falling Walls Foundation, Former Rector of Humboldt University, and his delegation visited the School of Physics of Peking University. Xu Limei, Wu Chengyin, Zhao Zhengpu met with the guests, on jointly promoting the development of scientific research of Physics.

2024 年 11 月 1 日，由北京大学物理学院、材料科学与工程学院、工学院和美国物理学会共同主办的“PKU-APS 联合交流会”成功举办。APS 执行主编 Jessica Thomas、《物理评论快报》副主编 Hugues Chaté 和《物理评论材料》（Physical Review Materials，PRM）副主编 Athanasios Chantis，徐莉梅、周欢萍、满怡与北京大学 30 余名师生代表现场参加交流。

On November 1, 2024, the PKU-APS Joint Event was successfully held, co-sponsored by the School of Physics, the School of Materials Science and Engineering, the School of Engineering of Peking University, and the American Physical Society (APS). Jessica Thomas, who is Executive Editor of APS, Hugues Chaté, who is Associate Editor of Physical Review Letters (PRL), and Athanasios Chantis, who is Associate Editor of Physical Review Materials (PRM), had a joint exchange with Xu Limei, Zhou Huanping, Man Yi, and more than 30 students and faculty representatives from Peking University.

2024 年 11 月 20 日，美国气象学会（AMS）理事长安朱莉班扎伊（Anjuli S. Bamzai）一行到访北京大学。徐莉梅、孟智勇，林金泰、俞妍等会见来宾，双方就共同促进大气科学科学发展展开深入交流。

On November 20, 2024, Anjuli S. Bamzai, President of the American Meteorological Society (AMS), and her delegation visited Peking University, where Xu Limei, Meng Zhiyong, Lin Jintai, and Yu Yan met with the guests, and the two sides carried out in-depth exchanges to jointly promote the development of atmospheric science.

2024 年 12 月 24 日，莫斯科国立大学新校区项目负责人 Alexander Petrov 一行访问北京大学物理学院。徐莉梅、曹庆宏、孟智勇、刘运全、杨晓菲、范少锋等会见来宾。双方就进一步加强两校在物理学领域的合作与交流，携手推动学术创新和科学进步开展了深入交流。

On December 24, 2024, Alexander Petrov, project leader of the new campus of Moscow State University, and his delegation visited the School of Physics of Peking University. Xu Limei, Cao Qinghong, Meng Zhiyong, Liu Yunquan, Yang Xiaofei, and Fan Shaofeng met with the guests, and carried out in-depth exchanges on further strengthening the cooperation and exchanges between the two universities in the field of physics, and joining hands in promoting academic innovations and scientific progress.

03 国际会议
International Conference

2023 年 7 月 19 日至 22 日，由国家自然科学基金支持的中德合作项目 " 强相互作用量子色动力学对称性及其物质结构 " 第七届学术研讨会在山东日照成功举办。会议由北京大学、中国科学院高能物理研究所和理论物理研究所主办，曲阜师范大学承办。来自中德两国 30 余所高校及科研机构的近百名专家学者参会。开幕式由北京大学赵光达院士主持，曲阜师范大学副校长胡凡刚教授致欢迎辞。中国科学院邹冰松院士和德国波恩大学 Ulf-G. Meißner 教授（欧洲科学院院士）分别代表中德双方介绍项目进展。会议围绕强子物理、格点 QCD、核物质结构等前沿领域展开深入探讨，共安排 24 场学术报告，涵盖强子谱、重夸克偶素态、部分子分布函数等热点课题。闭幕式上，邹冰松院士回顾了项目 12 年来的合作成果，强调其培养了大批青年人才并在多个领域取得重要突破。本次会议促进了高能物理领域的国际合作，为学科发展注入新动力。

From July 19 to 22, 2023, the 7th Sino-German workshop on "QCD Symmetry and Matter Structure", supported by the National Natural Science Foundation of China, was successfully held in Rizhao, Shandong. Co-organized by Peking University, the Institute of High Energy Physics, and the Institute of Theoretical Physics (Chinese Academy of Sciences), with Qufu Normal University as the host institution, the event gathered nearly 100 experts from over 30 Chinese and German institutions.The opening ceremony, chaired by Academician Kuang-Ta Chao (Peking University), featured welcome remarks by Professor Fangang Hu (Qufu Normal University). Progress reports were delivered by Academician Bingsong Zou (China) and Professor Ulf-G. Meißner (Germany, member of the European Academy of Sciences). The workshop covered cutting-edge topics including hadron physics, lattice QCD, and nuclear structure through 24 presentations, highlighting research on hadron spectra, heavy quarkonium states, and parton distribution functions. In his closing speech, Academician Zou summarized 12 years of Sino-German collaboration, noting its success in nurturing young talents and achieving breakthroughs. The workshop strengthened international cooperation and advanced high-energy physics research.

2023 年 8 月 10 日至 12 日，由北京大学高能物理研究中心主办的 " 量子色动力学 50 年 " 论坛在北京成功举办。本次论坛汇聚了国内外顶尖学者，通过 4 场公众报告、2 场圆桌讨论和 11 个大会报告，全面回顾了 QCD 理论 50 年发展历程，并探讨其在粒子物理、核物理及相关交叉领域的前沿进展。论坛特邀马里兰大学季向东教授、劳伦斯伯克利国家实验室王新年研究员等国际知名专家作主旨报告，内容涵盖 QCD 基础理论、夸克胶子等离子体、部分子模型等核心课题。中国科学院赵光达院士、黄涛研究员等国内权威学者通过 " 历史回顾 " 环节，生动讲述了中国层子模型研究等重大贡献。会议特别设置两场圆桌讨论，深入探讨了强相互作用研究的关键问题与发展方向。本次论坛通过线上线下结合方式举办，蔻享学术平台直播观看达万余人次。活动不仅系统梳理了 QCD 发展脉络，更为推动我国高能物理研究提供了重要交流平台。

The "QCD 50th Anniversary Forum", hosted by the Center for High Energy Physics , Peking University, was successfully held from August 10 to 12, 2023 in Beijing. This landmark event brought together world-renowned experts to commemorate five decades of Quantum Chromodynamics (QCD) development through 4 public lectures, 2 panel discussions and 11 plenary presentations. Distinguished speakers including Professor Xiangdong Ji (University of Maryland) and Prof. Xin-Nian Wang (Lawrence Berkeley National Laboratory) delivered keynote addresses on fundamental QCD theories, quark-gluon plasma, and parton distribution functions. Chinese academicians Kuang-Ta Chao and Tao Huang shared valuable historical insights into China's contributions to strong interaction research. The forum featured vibrant panel discussions moderated by Professor YuanNing Gao (Peking University), engaging nearly 100 on-site participants and over 10,000 online viewers via the Koushare platform. By reviewing QCD's revolutionary journey since asymptotic freedom's discovery in 1973, the forum not only celebrated past achievements but also charted future directions for high-energy physics research. Its hybrid format effectively bridged international scholarship and public engagement, marking a significant milestone in advancing QCD-related studies.

第九届“高能量密度物理青年科学家论坛”于 2023 年 8 月 24-27 日在北京怀柔成功举办。论坛由中国物理学会高能量密度物理专业委员会与中国物理学会粒子加速器分会联合主办，北京大学、中国科学院物理研究所和中国科学院高能物理研究所共同承办，吸引了全国 38 家高校及科研机构的 400 余名代表参会。会议聚焦激光驱动粒子加速、超强激光技术、惯性约束聚变、极端物质特性、实验室天体物理等前沿领域，设置 133 场口头报告（含 18 场特邀报告）和 79 个海报展示，评选出 12 项优秀海报奖。特别设立的 " 学术沙龙 " 环节围绕激光加速、激光聚变和激光等离子体相互作用三大方向展开深度研讨，并举办《极端条件下的物质与辐射》（MRE）期刊主编见面会。会议期间还组织参观了中科院物理所综合极端条件实验装置和北京激光加速创新中心。本届论坛为高能量密度物理领域中青年学者、研究生等提供了良好的学术交流与合作平台。

The 9th Young Scientists Forum on High Energy Density Physics (HEDP) was successfully convened in Huairou, Beijing from August 24 to 27, 2023. Co-hosted by the High Energy Density Physics Committee and Particle Accelerator Division of the Chinese Physical Society, and organized by Peking University, the Institute of Physics, and the Institute of High Energy Physics of the Chinese Academy of Sciences, the forum attracted over 400 delegates from 38 universities and research institutions nationwide. Focusing on cutting-edge fields including laser-driven particle acceleration, ultra-intense laser technology, inertial confinement fusion, extreme matter properties, and laboratory astrophysics, the event featured 133 oral presentations (including 18 invited talks) and 79 poster exhibitions, with 12 outstanding poster awards presented. Special highlights included thematic academic salons on laser acceleration, laser fusion, and laser-plasma interactions, as well as an editorial meeting of the Matter and Radiation at Extremes (MRE) journal. Attendees also visited the Comprehensive Extreme Conditions Experimental Facility of the Institute of Physics, CAS, and the Beijing Laser Acceleration Innovation Center. This forum provided an excellent platform for academic exchanges and cooperation among young scientists, graduate students, and faculty members in the field of high energy density physics.

2023 年 12 月 1 日至 4 日，首届黑洞图像学术研讨会在北京成功举办。会议由北京大学高能物理研究中心和湖南师范大学物理与电子科学学院联合主办，北京师范大学引力与相对论研究中心协办。来自全国高校及科研院所的 70 余位专家学者参会，围绕黑洞图像研究的最新进展展开深入交流。开幕式由北京师范大学郭敏勇主持，北京大学陈斌教授和湖南师范大学陈松柏教授致辞。会议共安排 24 场学术报告，涵盖新黑洞图像技术、亚毫米 VLBI 观测、多频段联合研究等前沿议题，报告人包括中国科学院上海天文台路如森、赵杉杉、江悟等知名学者，以及青年研究生的创新成果。本次研讨会促进了理论与观测的交叉合作，为我国黑洞图像研究的发展提供了重要平台。闭幕式上，湖南师范大学潘启沅教授宣布下一届会议将于 2024 年在长沙举办。

The inaugural "Black Hole Imaging Workshop 2023" was held in Beijing from December 1 to 4, co-organized by the Center for High Energy Physics, Peking University and the School of Physics and Electronics at Hunan Normal University, with support from the Center for Gravitation and Relativity at Beijing Normal University. Over 70 experts from universities and research institutes across China participated, discussing cutting-edge advancements in black hole imaging. The opening ceremony, chaired by Dr. Minyong Guo (Beijing Normal University), featured addresses by Professor Bin Chen (Peking University) and Professor Songbai Chen (Hunan Normal University). The workshop included 24 presentations covering topics such as novel imaging techniques, submillimeter VLBI observations, and multi-frequency studies, with keynote speeches by researchers like Rusen Lu, Shanshan Zhao, and Jiang Wu from Shanghai Astronomical Observatory. The event fostered interdisciplinary collaboration between theory and observation, strengthening China’s research network in this field. Professor Qiyuan Pan (Hunan Normal University) announced the next workshop will take place in Changsha in 2024.

2024 年 4 月 15 日至 27 日，由北京大学高能物理研究中心和中国高等科学技术中心联合主办的“探索跨能量尺度的核物理”国际研讨会在北京成功举办。北京航空航天大学、山东大学、中国科学院理论物理研究所协办。研讨会分为两部分：4 月 15-19 日及 24-27 日在中国高等科学技术中心举行学术交流活动；4 月 21-23 日在北京大学中关新园举办主题会议。北京大学宋慧超教授和中国科学院理论物理研究所周善贵研究员共同担任会议主席。来自中国、美国、德国、法国、日本等国家的 150 余名专家学者参会，围绕高能核核碰撞和核结构的前沿交叉展开深入探讨。会议特邀 J.-P. Blaizot、P. Danielewicz、D. Lee 等国际知名学者作报告，内容涵盖核形变、轻核集团结构、中子皮效应、机器学习在核物理中的应用等热点议题。本次研讨会促进了核物理不同领域间的合作，为跨能量尺度的研究提供了新思路。

From April 15 to 27, 2024, the international workshop "Exploring Nuclear Physics across Energy Scales 2024" was successfully held in Beijing, co-organized by the Center for High Energy Physics, Peking University and the China Center of Advanced Science and Technology, with support from Beihang University, Shandong University, and the Institute of Theoretical Physics, Chinese Academy of Sciences. The event consisted of two segments: academic sessions at the China Center of Advanced Science and Technology (April 15-19 and 24-27) and a thematic workshop at Zhongguanxinyuan Global Village, Peking University (April 21-23). Chaired by Professor Huichao Song of Peking University and Research Professor Shangui Zhou of the Institute of Theoretical Physics, the workshop brought together over 150 experts from China, the U.S., Germany, France, Japan, and other countries to discuss cutting-edge topics at the intersection of high-energy nuclear collisions and nuclear structure. Distinguished speakers, including J.-P. Blaizot, P. Danielewicz, and D. Lee, delivered presentations on nuclear deformation, light nuclear clustering, neutron skin effects, and machine learning applications in nuclear physics. The workshop fostered interdisciplinary collaboration and opened new avenues for research across energy scales.

COOPERATION
合作与交流

2024 年 4 月 19 至 22 日，高亮度和高精度前沿缪子物理研讨会（MIP 2024）在北京大学物理学院举行。北京大学物理学院李强教授、李奇特高级工程师和周辰研究员担当本次会议主席，国内外 40 多个单位共 180 余人参会。研讨会主题包括：未来强流加速器研究、缪子源研究、缪子基本性质精确测量、缪子衰变稀有过程寻找、缪子应用技术、缪子理论、未来实验及缪子对撞机等。会议于 4 月 20 日上午开幕。北京大学物理学院院长高原宁院士致欢迎辞。其后，来自中国、日本、泰国、英国、意大利、瑞士等国的专家学者给予了 39 个口头报告以及 26 份海报展示。闭幕环节，北京大学物理学院冒亚军教授和中国科学技术大学唐靖宇教授为海报优胜奖获得者颁奖，并致闭幕辞。

The MIP workshop (Workshop on Muon Physics at the Intensity and Precision Frontiers) 2024 was hosted by the School of Physics, Peking University, from April 19 to 22, 2024, chaired by Qiang Li, Qite Li, and Chen Zhou. Over 180 people from more than forty institutions at home and abroad. The workshop covered topics: Muon Sources R&D, Muon Precision Measurements, Muon Rare Process Searches, Muon Applications, Theoretical Muon Physics, and Future Experiments and Muon Colliders. In the opening session on April 20, Academician Yuanning Gao, Dean of the School of Physics at Peking University, delivered the welcome speech. Subsequently, experts and scholars from China, Japan, Thailand, the United Kingdom, Italy, and Switzerland presented 39 oral reports and 26 poster displays. During the closing session, Professor Mao Yajun from the School of Physics at Peking University and Professor Tang Jingyu from the University of Science and Technology of China awarded the winners of the Best Poster Award and delivered the closing remarks.

2024 年 10 月 30 日，2018 年诺贝尔物理学奖获得者杰哈·阿尔贝特·穆鲁在北京大学体斋发起召开高重频高平均功率强场激光前沿技术研讨会。会议邀请来自北京大学、中国科学院物理研究所、中国科学院西安光学精密机械研究所、中国科学院长春光学精密机械与物理研究所、中国科学院大连化学物理研究所、华中科技大学、国防科技大学和北京凯普林光电科技股份有限公司等国内外知名高校、科研机构以及高新技术企业的专家学者，就高重频高平均功率强场激光技术的物理机制、技术现状、应用领域以及发展前景进行了深入交流。

COOPERATION
合作与交流

On October 30, 2024, Professor Gérard Albert Mourou initiated a workshop on high repetition rate, high average power and high intensity laser at the Tizhai building of Peking University. The workshop invited experts and scholars from well-known universities, scientific research institutions and high-tech enterprises at home and abroad, such as Peking University, Institute of Physics of the Chinese Academy of Sciences, Xi'an Institute of Optics and Precision Mechanics of CAS, Changchun Institute of Optics, Fine Mechanics and Physics of CAS, Dalian Institute of Chemical Physics of CAS, Huazhong University of Science and Technology. National University of Defense Technology, and Beijing Caipo Optoelectronics Technology Co., Ltd. They had in-depth exchanges on the physical mechanism, technical status, application fields, and development prospects of high repetition rate, high average power and high intensity laser.

2024 年 11 月 1 日至 4 日，北京大学物理学院在北大中关新园成功举办了“原子、分子与复杂体系非线性动力学国际研讨会”（International Workshop on Nonlinear Dynamics in Atoms, Molecules, and Complex Systems）。本次会议由北京大学物理学院彭良友教授和深圳大学物理与光电工程学院姜维超副教授共同召集和组织，来自国内外相关研究领域的 40 余名知名学者受邀参加了本次会议并作邀请报告，北京地区的 40 余名青年学生和博士后参加了此次会议。与会专家们围绕气态原子与分子、固体、液体及其它复杂体系中相关的非线性动力学理论和实验进展、超强超短激光技术的发展、科学智能等方向，分享了他们的最新研究成果及未来发展趋势，部分与会者建立了良好的互动和合作关系，未来将共同探讨本领域的基础和前沿课题。

The School of Physics proudly hosted the "International Workshop on Nonlinear Dynamics in Atoms, Molecules, and Complex Systems" from November 1-4, 2024 at Zhongguanyuan Global Village of PKU, co-chaired by Professor Liang-You Peng (Peking University) and Associate Professor Wei-Chao Jiang (Shenzhen University). About 40 renowned scientists gave invited talks, with another 40 postdoctoral researchers and graduate students attending the workshop. The topics of the workshop covered four key frontiers: cutting-edge developments in atomic/molecular physics; emerging nonlinear phenomena in condensed-phase systems; next-generation ultra-intense laser technologies; transformative applications of AI in physical sciences. This intensive symposium stimulated vigorous scientific discourse while establishing new collaborative networks, serving as a premier international forum for addressing fundamental challenges and shaping future research directions in nonlinear dynamics.

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审核：张帆

奖励与荣誉
AWARDS & HONORS

01 2023 年度
In 2023

- 李采真、李尊祺完成的论文入选 2023 年北京市普通高等学校优秀本科生毕业设计（论文），李铮获优秀毕业设计 (论文) 指导教师。
  The theses completed by Li Caizhen, Li Zunqi, respectively, were selected as the Outstanding Undergraduate Graduation Designs (theses) of colleges and universities in Beijing in 2023; and Li Zheng won the award of Outstanding Graduation Design (thesis) Supervisor.

- 龚旗煌获 2022 年国家教学成果奖一等奖。
  Gong Qihuang was awarded the first prize of the National Teaching Achievement Award for 2022.

- 刘川获第十九届北京市高等学校教学名师称号。
  Liu Chuan was awarded the 19th Beijing Distinguished Teaching Award.

- 刘玉鑫获北京市教书育人先锋称号。
  Liu Yuxin was awarded the title of Beijing Pioneer in Education and Teaching in 2023.

- 吴桃李完成的论文获北京高校第十三届青年教师教学基本功比赛论文比赛一等奖。
  The thesis completed by Wu Taoli won the first prize in the 13th Basic Teaching Skills Competition (Thesis Competition) for Young Teachers in Beijing's colleges and universities.

- 张天宇获 2023 年美国大学生数学建模竞赛（ICM）特等奖。
  Zhang Tianyu was awarded the Outstanding Winner prize in the 2023 Interdisciplinary Contest In Modeling.

- 元培物理欧阳霄宇在李新征老师指导下获教育部拔尖计划第三届“提问与猜想”活动一等奖，卢志垚在安海鹏和刘佳老师指导下获二等奖。
  Ouyang Xiaoyu, majoring in physics of Yuanpei College, won the first prize in the third "Questioning and Guessing" event of the Ministry of Education's Top-Notch Talents Program under the guidance of Li Xinzheng in 2023，while Lu Zhiyao was awarded the second prize under the guidance of An Haipeng and Liu Jia，.

- 赵梓茗、张宸睿共同在第九届全国大学生物理实验竞赛（教学赛）中获一等奖。艾逸文、李立捷分获二等奖。
  Zhao Ziming and Zhang Chenrui won the first prize in the 9th Chinese Undergraduate Physics Experiment Competition (Teaching Competition). Ai Yiwen and Li Lijie were awarded the second prizes respectively.

- 宋卓洋、姚秉宸、王艺霖、李佳琪、贾羽尧获第十四届中国大学生物理学术竞赛二等奖。
  Song Zhuoyang, Yao Bingchen, Wang Yilin, Li Jiaqi and Jia Yuyao won the second prize in the 14th China Undergraduate Physics Tournament.

- 梅文聪获亚洲核物理联合会 - 亚太物理学会联合会核物理分会（ANPhA&AAPPS-DNP）青年科学家奖。
  Mei Wencong was awarded the Young Scientist by the Asia Nuclear Physics Association & Association of Asia Pacific Physical Societies - Division of Nuclear Physics (ANPhA & AAPPS-DNP).

- 《数学物理方法》、《力学》、《普通物理实验》、《基础天文》四门课入选国家一流本科课程。
  “Methods of Mathematical Physics”，“Mechanics”，“General Physics Laboratory”，and “Fundamental Astronomy” were selected as first-class national undergraduate courses.

- 3 项国家自然科学基金青年学生基础研究项目获批立项。14 项北京市自然科学基金本科生启研计划项目获批立项。
  3 Youth Student Basic Research Projects of the National Natural Science Foundation of China (NSFC) were approved. 14 Beijing Natural Science Foundation Undergraduate Research Initiation projects were approved.

- 包逸博获国际遗传工程机器设计竞赛金奖。
  Bao Yibo won the Gold Award of the International Genetically Engineered Machine Competition.

池昱霖、李国平获首都高校第 11 届龙舟锦标赛男子团体冠军，吕夏影获女子团体冠军。
Chi Yulin and Li Guoping won the men's team championship，while Lv Xiaying won the women's team championship of the 11th Dragon Boat Championship of Capital Universities.

方一奇（指导教师：刘运全）、李海龙（指导教师：谢心澄）的博士学位论文获评 2023 年北京市优秀博士学位论文。
The doctoral dissertations of Fangbing Yiqi (supervisor: Liu Yunquan) and Li Hailong (supervisor: Xie Xincheng) were respectively awarded the Excellent Doctoral Dissertation Awards of Beijing in 2023.

高勇获北京市普通高等学校优秀毕业生。
Gao Yong was awarded as an Excellent Graduate of General Higher Education Institutions in Beijing.

洪嘉妮获 2023 年美国化学会春季会议的 CATL 虚拟亚太地区研究生研讨会口头报告奖、第十四届 HOPE 会议最佳海报展示奖。
Hong Jiani won the Oral Presentation Prize at the CATL Virtual Asia-Pacific Graduate Student Symposium, ACS Spring 2023，and the 14th HOPE Meeting Best Poster Presentation Award.

胡荣哲获第 6 届中国大学生武术散打锦标赛男子 76 公斤级亚军。
Hu Rongzhe won the second place in the men's 76-kilogram class of the 6th Chinese College Students' Wushu Sanda Championship.

胡永云获评 2023 年北京大学优秀研究生指导教师。
Hu Yongyun won the title of 2023 Excellent Graduate Supervisor of Peking University.

姜海龄获第十四届国际氮化物半导体会议最佳学生奖。
Jiang Hailing won the Best Student Award of The 14th International Conference on Nitride Semiconductors.

刘卓楷获第六届全国大学生天文创新作品竞赛一等奖。
Liu Zhuokai won the first prize in the 6th National College Students' Astronomical Innovation Works Competition.

王凯翔获超级定点滑雪公开赛 2022-2023 雪季总决赛亚军、第 10 届全国大学生滑雪挑战赛（华北赛区）团体冠军、首都高等学校第十六届滑雪比赛团体亚军。
Wang Kaixiang won the second place in the finals of the Super Fixed-point Skiing Open in the 2022-2023 ski season，the team championship of the 10th National College Students' Skiing Challenge (North China Region)，and the second place of the team in the 16th Skiing Competition of Capital Higher Education Institutions.

王卿赫获北京大学第三十一届"挑战杯"五四青年科学奖类竞赛特等奖，任颖慧、许峰玮分获一等奖。
Wang Qinghe won the Grand Prize，while Ren Yinghui and Xu Fengwei respectively won the first prizes of the 31st "Challenge Cup" May 4th Youth Science Award Competition of Peking University.

王子鹏第 5 届中国大学生射箭（射艺）锦标赛男子团体冠军。
Wang Zicheng won the men's team championship of the 5th Chinese College Students' Archery (Shooting Art) Championship.

韦祎获第 19 届全国荷电粒子源粒子束学术会议青年优秀论文。
Wei Yi won the Excellent Youth Paper Award of the 19th National Academic Conference on Charged Particle Sources and Particle Beams.

吴笛、徐诗睿获高能量密度物理青年科学家论坛最佳海报奖。
Wu Di and Xu Shirui respectively won the Best Poster Awards of the Young Scientists Forum on High Energy Density Physics.

翟翀昊获中国物理学会 - 华为 MidSpore 量子学术奖励基金。
Zhai Chonghao won the Chinese Physical Society-Huawei MidSpore Quantum Academic Award Fund.

郑赟获中国光学学会第二十届王大珩光学奖学生奖。
Zheng Yun won the Student Award of the 20th Wang Daheng Optical Award of the Chinese Optical Society.

谢心澄获全国创新争先奖。
Xie Xincheng won the National Innovation and Progress Award.

高原宁获首都劳动奖章。
Gaoyuan Ning won the Capital Labor Medal.

现代光学研究所党支部荣获北京高校先进基层党组织。
The Party Branch of the Institute of Modern Optics was honored as an Advanced Grassroots Party Organization in Beijing Universities.

何子山当选美国艺术与科学院院士。
He Zishan was elected as a member of the American Academy of Arts and Sciences.

王新强当选美国光学学会会士。
Wang Xinqiang was elected as a Fellow of the American Optical Society.

许甫荣当选为中国核物理学会第十四届理事会副理事长，华辉、刘玉鑫当选为常务理事，杨晓菲研究员当选为理事。
Xu Furong was elected as Vice President of the 14th Council of the Chinese Nuclear Physics Society. Hua Hui and Liu Yuxin were elected as Executive Directors, and Yang Xiaofei was elected as the Director.

王健获全球华人物理与天文学会亚洲成就奖。
Wang Jian received the Achievement in Asia Award (AAA, Robert T. Poe Prize) from the International Organization of Chinese Physicists and Astronomers (OCPA).

俞妍获世界气象组织青年科学家研究奖。
Yu Yan received the Young Scientist Research Award from the World Meteorological Organization (WMO).

王晨旭获美国陶瓷学会青年科学家奖。
Wang Chenxu won the Global Young Investigator Award from the American Ceramic Society in 2023.

肖云峰、江颖获新基石研究员项目资助。
Xiao Yunfeng and Jiang Ying received funding from the New Foundation Researcher Program.

高鹏获 2023 年腾讯科学探索奖。
Gao Peng won the 2023 Tencent Foundation Science Exploration Award.

刘雄军、朱瑞分获中国物理学会 2022–2023 年度周培源物理奖和萨本栋应用物理奖。
Liu Xiongjun and Zhu Rui respectively won the Zhou Peiyuan Physics Prize and Sa Bendong Physics Prize of the Chinese Physical Society.

朱昆被评为 2023 年广州最美科技工作者。
Zhu Kun was named as the Guangzhou's Most Outstanding Science and Technology Worker in 2023.

王剑威获中国光学学会第二十届王大珩光学奖中青年科技人员奖。
Wang Jianwei won the 20th Wang Daheng Optical Award for Young Scientists from the Chinese Optical Society.

李柯伽参与领导的 "'中国天眼'发现纳赫兹引力波存在关键证据" 入选中国十大科技新闻和《科学》杂志年度十大科学突破。
Under the leadership of Li Kega, the discovery of key evidence for nanohertz gravitational waves by the China Sky Eye project was selected as one of China's Top Ten Science and Technology News and named among the Top Ten Scientific Breakthroughs of the Year by Science magazine.

肖云峰等完成的项目 "对称破缺微腔光物理与应用" 获 2022 年度教育部高等学校科学研究优秀成果奖（科学技术）自然科学一等奖。
The project "Symmetry-Breaking Microcavity Optics and Applications" completed by Xiao Yunfeng's team was awarded the First Prize in Natural Science at the 2022 Higher Education Scientific Research Excellence Awards (Science and Technology), conferred by the Ministry of Education of China.

刘开辉参与的项目 "关键二维半导体晶圆级制备及新原理信息器件基础研究" 获 2022 年度北京市自然科学一等奖。
The project "Key Research on Wafer-Scale Fabrication of Two-Dimensional Semiconductor Materials and New Principle Information Device Fundamentals" completed by Liu Kaihui's team was awarded the First Prize of the 2022 Beijing Natural Science Award.

- 肖池阶参与的项目“国际热核聚变堆超导极向场线圈柔性支撑系统设计及关键制造技术”获贵州省科学技术进步一等奖。
The project "Design and Key Manufacturing Technology of Flexible Support System for Superconducting Poloidal Field Coils of International Thermonuclear Experimental Reactor" in which Xiao Chijing participated, won the First Prize of Science and Technology Progress in Guizhou Province 2022.

- 薛建明参与的项目“空间辐射总剂量效应试验与加固技术”获中国核学会科技进步特等奖。
The project "Space Radiation Total Dose Effect Test and Reinforcement Technology" in which Xue Jianming had participated, won the Special Prize for Scientific and Technological Progress of the Chinese Nuclear Society.

- 刘运全等完成的项目“超快强激光场下量子隧穿理论和实验研究”、王新强等完成的项目“第三代半导体发光器件衬底技术”获中国光学学会光学科技一等奖。
Liu Yunquan's project "Theoretical and Experimental Study of Quantum Tunneling under Ultrafast Intense Laser Fields" and Wang Xinqiang's project "Third-Generation Semiconductor Luminescent Device Substrate Technology" won the First Prize of Optical Science and Technology of the Chinese Optical Society.

- 肖云峰合作研究成果“首次发现光学微腔中的界面回音壁模式”入选 2022 年度中国光学十大进展。
Xiao Yunfeng's team research " First Discovery of Interface Whispering-Gallery Modes in Optical Microcavities" was selected as the Top Ten Progresses in Chinese Optics in 2022.

- 赵清完成的论文“通过二维晶种诱导生长实现晶面取向调控构筑高效、高稳定性钙钛矿太阳能电池”入选“细胞出版社 2022 中国年度论文”。
Zhao Qing's paper "Facet Orientation Tailoring via 2D Seed-Induced Growth Enables Highly Efficient and Stable Perovskite Solar Cells" was selected as one of China's Top Annual Papers of 2022 by Cell Press.

- 罗昭初入选《麻省理工科技评论》“35 岁以下科技创新 35 人”2022 年中国区榜单。
Luo Zhaochu was named one of the “35 Innovators Under 35” (China List, 2022) by MIT Technology Review.

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- 程谋阳、杨德鸿完成的论文入选 2024 年北京市普通高等学校优秀本科生毕业设计（论文），陈基、孙栋获优秀毕业设计（论文）指导教师。
The theses completed by Cheng Mouyang, Yang Dehong, respectively, were selected as the Outstanding Undergraduate Graduation Designs (theses) of colleges and universities in Beijing in 2024; and Cheng Ji, Sun Dong won the awards of Outstanding Graduation Design (thesis) Supervisor.

- 张庆红获 2024 年全国气象教学名师奖。
Zhang Qinghong was awarded the 2024 National Meteorological Distinguished Teaching Award.

- 方哲宇获第八届北京市高等学校青年教学名师奖。
Fang Zheyu won the 8th Young Teaching Teacher Award of Beijing higher education institutions.

- 曹庆宏获 2024 年北京高校优秀教学管理人员奖。
Cao Qinghong was awarded the 2024 Outstanding Teaching Administrator Award of Beijing higher education institutions.

- 刘玉鑫主持的《原子物理学》教材入选 2024 年北京高校优质本科教材。
Liu Yuxin's textbook “Atomic Physics” was selected as a high-quality undergraduate textbook of Beijing higher education institutions in 2024.

- 黄华卿主持的《平衡态统计物理》入选 2024 年北京高校优质本科教案。
“Equilibrium Statistical Physics” of Huang Huaqing was selected as a high-quality undergraduate teaching materials of Beijing higher education institutions in 2024.

- 林沛晗、郭绍阳、彭睿、高铭泽、韩沛伦、祁皓天获第十五届中国大学生物理学术竞赛二等奖。
Lin Peihan, Guo Shaoyang, Peng Rui, Gao Mingze, Han Peilun, and Qi Haotian won the second prize in the 15th China Undergraduate Physics Tournament in 2024.

- 3 项国家自然科学基金青年学生基础研究项目和 15 项国家自然科学基金青年学生基础研究项目（博士研究生）获批立项。13 项北京市自然科学基金本科生启研计划项目获批立项。
3 Youth Student Basic Research Projects and 15 Youth Student Basic Research Projects (for Doctoral Candidates) of the National Natural Science Foundation of China (NSFC) were

AWARDS & HONORS
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approved. 14 Beijing Natural Science Foundation Undergraduate Research Initiation projects were approved

陈斌、刘运全获评 2024 年北京大学优秀研究生指导教师。
Chen Bin and Liu Yunquan respectively won the titles of 2024 Excellent Graduate Supervisor of Peking University.

戴天祥获第十四届北京大学学生五·四奖章。
Dai Tianxiang won the 14th Peking University Students' May 4th Medal.

范思钦获得国际核科学研讨会（ISNS-24）杰出口头报告青年科学家奖。
Fan Siqin won the Young Scientist Award for Outstanding Oral Presentation at the International Symposium on Nuclear Science (ISNS-24).

方一奇、陈鹏分获 2023、2024 年度中国光学学会科技创新奖（郭光灿光学奖）一等奖。
Fang Yiqi and Chen Peng respectively won the 2023 and 2024 first prizes of the Science and Technology Innovation Award of the Chinese Optical Society (Guo Guangcan Optics Award).

金星获得微腔及其应用国际研讨会（WOMA2024）最佳海报奖。
Jin Xing won the Best Poster Award at the International Workshop on Microcavities and their applications (WOMA2024).

李聪乔获中国物理学会高能物理分会第 13 届晨光杯青年优秀论文一等奖，马鹏翔、文新锴分获二等奖。
Li Congqiao won the first prize, while Ma Pengxiang and Wen Xinkaixiang respectively won the second prizes of the excellent youth paper in the 13th Chenguang Cup of the High Energy Physics Branch of the Chinese Physical Society.

李婧获 2024 年度国际光学工程学会（SPIE）奖学金。
Li Jing won the 2024 International Society for Optics and Photonics Scholarship.

黎顺德获评 2023-2024 年度北京市优秀学生干部、北京大学学生年度人物·2024。
Li Shunde was awarded as an Outstanding Student Leader in Beijing from 2023 to 2024, and named the Peking University Student of the Year 2024.

刘炎武获 2024 年度中国光学学会第二十一届王大珩光学奖学生奖。
Liu Yanwu won the Student Award of the 21st Wang Daheng Optics Award of the Chinese Optical Society in 2024.

秦彪获 2023-2024 年度北京市三好学生。
Qin Biao was awarded as a "Merit Student " in Beijing from 2023 to 2024.

王凯翔获超级定点滑雪公开赛冠军、第十届全国大学生滑雪挑战赛团体亚军。
Wang Kaixiang won the championship of the Super Fixed-point Skiing Open and the second place of the team in the 10th National College Students' Skiing Challenge.

余雪佳（指导教师：徐莉梅）的博士学位论文获评 2024 年北京市优秀博士学位论文。
The doctoral dissertation of Yu Xuejia (supervisor: Xu Limei) was awarded the Excellent Doctoral Dissertation Award of Beijing in 2024.

张舒楠获 LHCb 合作组 2024 年度优秀博士学位论文奖。
Zhang Shunan won the 2024 Outstanding Doctoral Dissertation Award of the LHCb Collaboration.

朱欣岳获中国国际大学生创新创业大赛总决赛金奖。
Zhu Xinyue won the gold medal in the finals of the China International College Students Innovation Competition.

龚旗煌连任 Fundamental Research 期刊主编。
Gong Qihuang was re-elected as Editor-in-Chief of Fundamental Research.

汤超、欧阳颀分别入选国际纯粹与应用物理学联合会统计物理、生物物理专业委员会。
Tang Chao and Ouyang Qi were elected as members of the Statistical Physics Committee and the Biological Physics Committee of the International Union of Pure and Applied Physics (IUPAP).

马伯强、许甫荣、吴学兵获批享受国务院政府特殊津贴。
Ma Boqiang, Xu Furong and Wu Xuebing were approved to enjoy the Special Government Allowance of the State Council.

高鹏获第 18 届中国青年科技奖。
Gao Peng won the 18th China Youth Science and Technology Award.

何琼毅获第 19 届中国青年女科学家奖。
He Qiongyi won the 19th China Young Female Scientist Award.

- 马滟青获陈嘉庚青年科学家。
Ma Yanqing won the Tan Kah Kee Youth Science Award.

- 刘开辉获中国物理学会胡刚复物理奖。
Liu Kaihui won the Hu Gangfu Physics Prize of the Chinese Physical Society.

- 杨晓菲和彭影杰获 2024 年腾讯科学探索奖。
Yang Xiaofei and Peng Yingjie won the 2024 Tencent Foundation Science Exploration Award.

- 江颖入选北京高校卓越青年科学家计划。
Jiang Ying was selected into the Outstanding Young Scientists Program of the Beijing Universities.

- 赵柏林当选 2024 年度中国气象学会会士。
Zhao Bolin was elected as a Fellow of the Chinese Meteorological Society in 2024.

- 王新强当选 2024 年度中国光学学会会士。
Wang Xinqiang was elected as a Fellow of the Chinese Optical Society in 2024.

- 胡耀文入选《麻省理工科技评论》“35 岁以下科技创新 35 人”2023 年中国区榜单。
Hu Yaowen was named one of the 2023 MIT Technology Review "35 Innovators Under 35" in China.

- 陈一获第四届海因里希·罗雷尔奖章。
Chen Yi won the 4th Heinrich Rohrer Medal.

- 王恩哥、刘开辉团队研究成果“驾驭激光的利器——转角氮化硼光学晶体原创理论与材料”、马仁敏团队研究成果“让激光步调一致——相位同步可重构莫尔纳米激光器”、王剑威团队研究成果“打造量子计算机的内核——超大规模集成的光量子芯片”，以及高家红团队研究成果“解密大脑图像——新一代原子磁强计脑磁图仪”入选 2024 中关村论坛年会发布的重大科技成果。
The research achievements of Wang Enge and Liu Kaihui "A Powerful Tool for Laser Control: Original Theory and Materials of Boron Nitride Optical Crystals with Turned Angles", Ma Renmin's team "Synchronizing Laser Steps: Phase-Synchronized Reconfigurable Moiré Nanolasers", Wang Jianwei's team "Building the Core of Quantum Computers: Ultra-Large-Scale Integrated Optical Quantum Chips", and Gao Jiahong's team "Decoding Brain Images: New Generation Atomic Magnetometer Magnetoencephalography" were selected as major scientific and technological achievements released at the 2024 Zhongguancun Forum.

- 廖志敏等完成的“狄拉克材料的载流子输运调控及新原理器件效应研究”获 2023 年度北京市自然科学奖一等奖。
The project "Carrier Transport Regulation and New Principle Device Effects in Dirac Materials "completed by Liao Zhiming's team was
awarded the First Prize of Beijing Natural Science Award in 2023.

- 黄华卿参与的项目“二维材料的拓扑新物态及能带调控”获 2023 年度北京市自然科学奖一等奖。
The project "Topological New States and Band Structure Regulation in Two-Dimensional Materials " which Huang Huaqing had participated in was
awarded the First Prize of the Beijing Natural Science Award in 2023.

- 颜学庆等完成的“低能散高梯度百太瓦激光粒子加速器关键技术及应用”获 2024 年度中国核学会科技进步奖特等奖。
The project "Key Technologies and Applications of Low-Energy-Dispersion High-Gradient Petawatt Laser Particle Accelerator" completed by Yan Xueqing's team was awarded the Special Prize for Progress in Science and Technology of the Chinese Nuclear Society in 2024.

- 核物理与核技术全国重点实验室合作伙伴、俄罗斯杜布纳联合核子研究所格利金诺夫教授获 2023 年度中国政府友谊奖。
Professor Yury Gledenov, from the Joint Institute for Nuclear Research (JINR), Russia, and a long-term collaborator of the National Key Laboratory of Nuclear Physics and Technology, was awarded the 2023 China Government Friendship Award.

- 肖云峰合作研究成果“介观尺度单颗粒的声学指纹振动谱测量”和王剑威合作研究成果“具有纠缠修复能力的多芯片高维量子网络”入选 2023 年度中国光学十大进展。
Xiao Yunfeng's collaborative research "Acoustic Fingerprint Vibration Spectrum Measurement of Individual Particles at the Mesoscopic Scale" and Wang Jianwei's collaborative research "Multi-Chip High-Dimensional Quantum Networks with Entanglement Recovery Capability" were selected as the Top Ten Progresses in Chinese Optics in 2023.

- 沈波、许福军等研究成果“接近衬底级晶体质量的氮化物宽禁带半导体异质外延薄膜”入选 2023 年度中国半导体十大研究进展。
The research project “Heteroepitaxial Films of Nitride Wide-Bandgap Semiconductors with Substrate-Like Crystal Quality”, led by Shen Bo, Xu Fujun, and their team, was selected as one of the Top Ten Advances in Semiconductors in China in 2023.

审核：张帆