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本期推荐报道 2022 年 2 月 Nature、Science 期刊上物理学领域的部分最新论文。

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物理学 2 月 Nature 论文

[1]**Quantum sensing for gravity cartography**

重力“制图”的量子传感器

出版信息：Nature, 24 February 2022, Volume 602, Issue 7898

作者：Ben Stray, Andrew Lamb, Aisha Kaushik, Jamie Vovrosh, Anthony Rodgers et al.

第一作者单位：Midlands Ultracold Atom Research Centre, School of Physics and Astronomy, University of Birmingham, Birmingham, UK

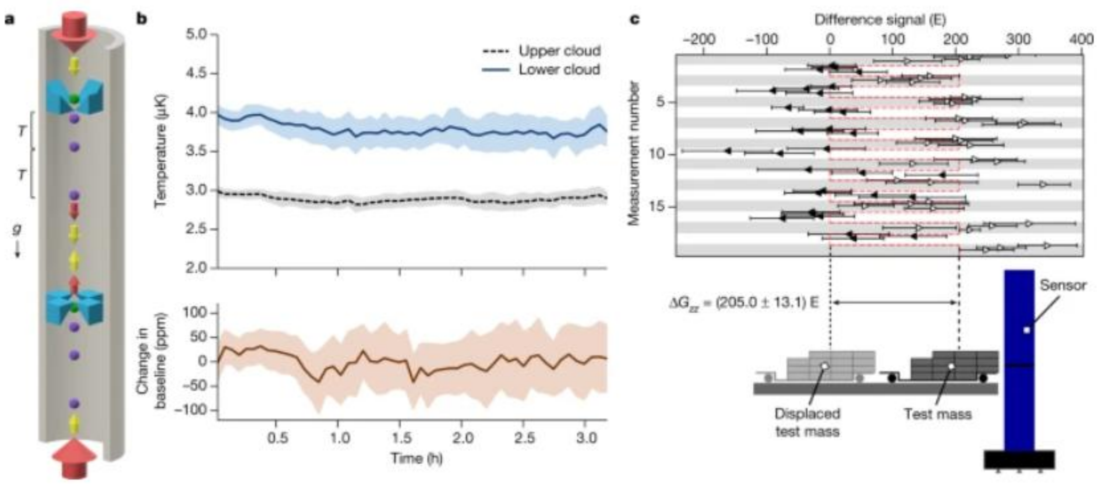
全文链接：https://www.nature.com/articles/s41586-021-04315-3

Abstract： The sensing of gravity has emerged as a tool in geophysics applications such as engineering and climate research, including the monitoring of temporal variations in aquifers and geodesy. However, it is impractical to use gravity cartography to resolve metre-scale underground features because of the long measurement times needed for the removal of vibrational noise. Here we overcome this limitation by realizing a practical quantum gravity gradient sensor. Our design suppresses the effects of micro-seismic and laser noise, thermal and magnetic field variations, and instrument tilt. The instrument achieves a statistical uncertainty of 20 E (1 E = 10−9 s−2) and is used to perform a 0.5-metre-spatial-resolution survey across an 8.5-metre-long line, detecting a 2-metre tunnel with a signal-to-noise ratio of 8. Using a Bayesian inference method, we determine the centre to ±0.19 metres horizontally and the centre depth as (1.89 −0.59/+2.3) metres. The removal of vibrational noise enables improvements in instrument performance to directly translate into reduced measurement time in mapping.

摘要翻译：重力传感已成为工程和气候研究等地球物理应用的一种工具，其用途包括监测含水层的时间变化和大地测量。然而，由于去除振动噪声所需的时间较长，使用重力制图法来解决米级地下特征是不现实的。在此，我们通过一种实用的量子重力梯度传感器，克服了这一局限性。我们的设计抑制了微地震和激光噪声、热和磁场变化以及仪器倾斜的影响。该仪器的统计不确定度为 20 E（1 E = 10−9 s−2），用于在一条 8.5 米长的线上执行 0.5 米的空间分辨率测量，检测一个 2 米的隧道，信噪比为 8。利用贝叶斯推理方法，我们确定水平中心为±0.19 米，中心深度为（1.89−0.59/+2.3）米。去除振动噪声可以改善仪器性能，缩短测量时间。

文中插图：

Fig. 1: Hourglass gradiometer.



[2]**Thermal imaging of dust hiding the black hole in NGC 1068**

活动星系核的统一模型得到确认

出版信息：Nature, Volume 602 Issue 7897, 17 February 2022

作者：Violeta Gámez Rosas, Jacob W. Isbell, Gerard Zins, etc.

第一作者单位：Université Paris-Saclay, CNRS, Laboratoire de Physique des Solides, 91405 Orsay. France.

全文链接：https://www.nature.com/articles/s41586-021-04311-7

Abstract: In the widely accepted 'unified model' solution of the classification puzzle of active galactic nuclei, the orientation of a dusty accretion torus around the central black hole dominates their appearance. In 'type-1' systems, the bright nucleus is visible at the centre of a face-on torus. In 'type-2' systems the thick, nearly edge-on torus hides the central engine. Later studies suggested evolutionary effects and added dusty clumps and polar winds but left the basic picture intact. However, recent high-resolution images of the archetypal type-2 galaxy NGC 1068, suggested a more radical revision. The images displayed a ring-like emission feature that was proposed to be hot dust surrounding the black hole at the radius where the radiation from the central engine evaporates the dust. That ring is too thin and too far tilted from edge-on to hide the central engine, and ad hoc foreground extinction is needed to explain the type-2 classification. These images quickly generated reinterpretations of the dichotomy between types 1 and 2. Here we present new multi-band mid-infrared images of NGC 1068 that detail the dust temperature distribution and reaffirm the original model. Combined with radio data (J.F.G. and C.M.V.I., manuscript in preparation), our maps locate the central engine that is below the previously reported ring and obscured by a thick, nearly edge-on disk, as predicted by the unified model. We also identify emission from polar flows and absorbing dust that is mineralogically distinct from that towards the Milky Way centre..

摘要翻译：荷兰莱顿大学的 Violeta Gamez Rosas 和合作者对临近星系中心黑洞周围浓密遮挡的尘埃进行了观察，确认了活动星系核的统一模型。作者通过对这个星系的高分辨率图像分析得到了这一结论，这些图像提供了研究活动星系核的新机遇。活动星系核是一些星系中心的高能区域，人们认为它由超大质量黑洞驱动。这些核发出的光产生的光谱特征，与光发出的区域有关；不同光谱可用于将活动星系核区分成两类：I型和II型天体。但统一模型认为，这种区分会产生，是因为观测视线可能有时被围绕和涌入中央黑洞的尘埃环遮挡了。作者观察支持了统一模型。他们获得了原型星系 NGC 1068 的高分辨率图像，统一理论最初即由此建立。他们使用一个称为 MATISSE 的仪器，结合了四台欧洲南方天文台的望远镜的光，以获得活动星系核的最佳视图。对这些图像和射电图的分析揭示了环状尘埃云的存在，并帮助确定了其特性，大多与统一模型预测相符。作者还定位了黑洞在尘埃环之下的位置，同样符合模型。

文中插图：

图 1 左侧展示了欧洲南方天文台（ESO）超大型望远镜上的 FOcal Reducr 和低色散光谱仪 2（FRS2）拍摄的活动星系 Messier 77 的耀眼景色。右侧显示的是这个星系最内部区域的放大图，即其活动星系核，也是由 ESO 超大型望远镜干涉仪上的 MATISSE 仪器拍摄的。（图片来自：ESO 的 Jaffe、Gamez-Rosas 等人）

图 2 展示了 Messier 77 的核心可能的样子。和其他活动星系核一样，Messier 77 的中心区域由一个黑洞驱动，黑洞被一个厚厚的吸积盘包围。在 Messier 77 的例子中，这个厚厚的环完全遮住了我们对超大质量黑洞的观察。这个活动星系核亦被认为有喷流和尘埃风，它们从黑洞周围的区域流出，垂直于周围的吸积盘。（图片来自：欧洲南方天文台 M. Kornmesser 和 L. Calcada）

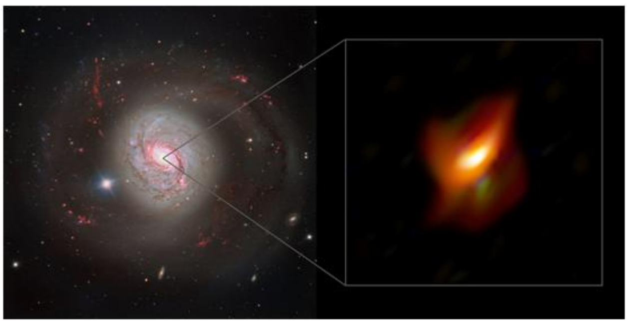


图 1

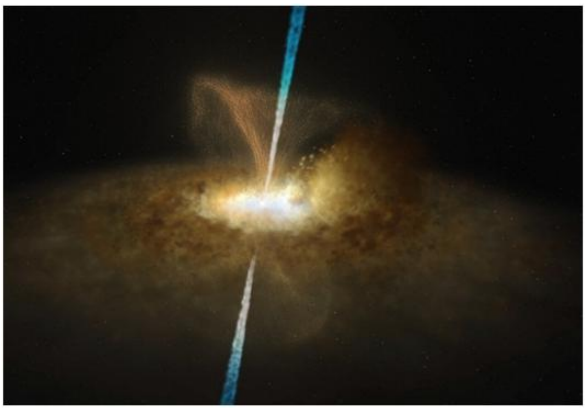


图 2

[3]**Nuclear spin-wave quantum register for a solid-state qubit**

固态量子位的核自旋波量子寄存器

出版信息：Nature, Volume 602 Issue 7897, 17 February 2022

作者：Andrei Ruskuc, Chun-Ju Wu, Jake Rochman, Joonhee Choi & Andrei Faraon

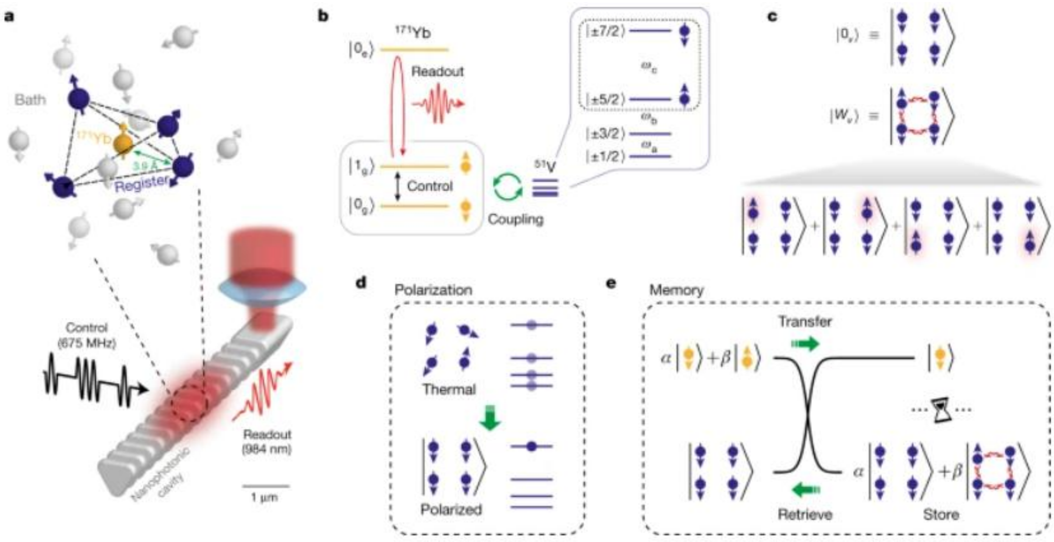
第一作者单位：Thomas J. Watson, Sr., Laboratory of Applied Physics, California Institute of Technology, Pasadena, CA, USA

全文链接：https://www.nature.com/articles/s41586-021-04293-6

Abstract： Solid-state nuclear spins surrounding individual, optically addressable qubits are a crucial resource for quantum networks, computation and simulation. Although hosts with sparse nuclear spin baths are typically chosen to mitigate qubit decoherence, developing coherent quantum systems in nuclear-spin-rich hosts enables exploration of a much broader range of materials for quantum information applications. The collective modes of these dense nuclear spin ensembles provide a natural basis for quantum storage; however, using them as a resource for single-spin qubits has thus far remained elusive. Here, by using a highly coherent, optically addressed 171Yb3+ qubit doped into a nuclear-spin-rich yttrium orthovanadate crystal, we develop a robust quantum control protocol to manipulate the multi-level nuclear spin states of neighbouring 51V5+ lattice ions. Via a dynamically engineered spin-exchange interaction, we polarize this nuclear spin ensemble, generate collective spin excitations, and subsequently use them to implement a quantum memory. Our approach provides a framework for utilizing the complex structure of dense nuclear spin baths, paving the way towards building large-scale quantum networks using single rare-earth ion qubits.

摘要翻译：围绕单个光可寻址量子位的固态核自旋是量子网络、计算和模拟的重要资源。虽然具有稀疏核自旋槽的宿主通常被用于减缓量子位退相干，但在核自旋丰富的宿主上开发相干量子系统，可为量子信息应用探索更广泛的材料。这些致密核自旋系综的集体模式为量子存储提供了自然基础，但用它们作为单自旋量子位元的资源迄今仍难以捉摸。作者通过使用一个高相干、光学寻址的 171Yb3+量子比特掺杂到一个核自旋丰富的原钒酸钇晶体中，开发了一个鲁棒的量子控制协议来操纵邻近的 51V5+晶格离子的多级核自旋态。通过动态设计的自旋交换相互作用，他们极化这个核自旋系综，产生集体自旋激发，然后使用其实现一个量子存储器。作者表示，该方法为利用高密度核自旋浴的复杂结构提供了一个框架，为利用单个稀土离子量子位构建大规模量子网络铺平了道路。

文中插图：



[4]**Magnetic control of tokamak plasmas through deep reinforcement learning**

基于深度强化学习的托卡马克等离子体磁控制

出版信息: Nature, Volume 602 Issue 7897, 17 February 2022

作者：Jonas Degrave, Federico Felici, Martin Riedmiller, etc.

第一作者单位：DeepMind, London, UK

全文链接：https://www.nature.com/articles/s41586-021-04301-9

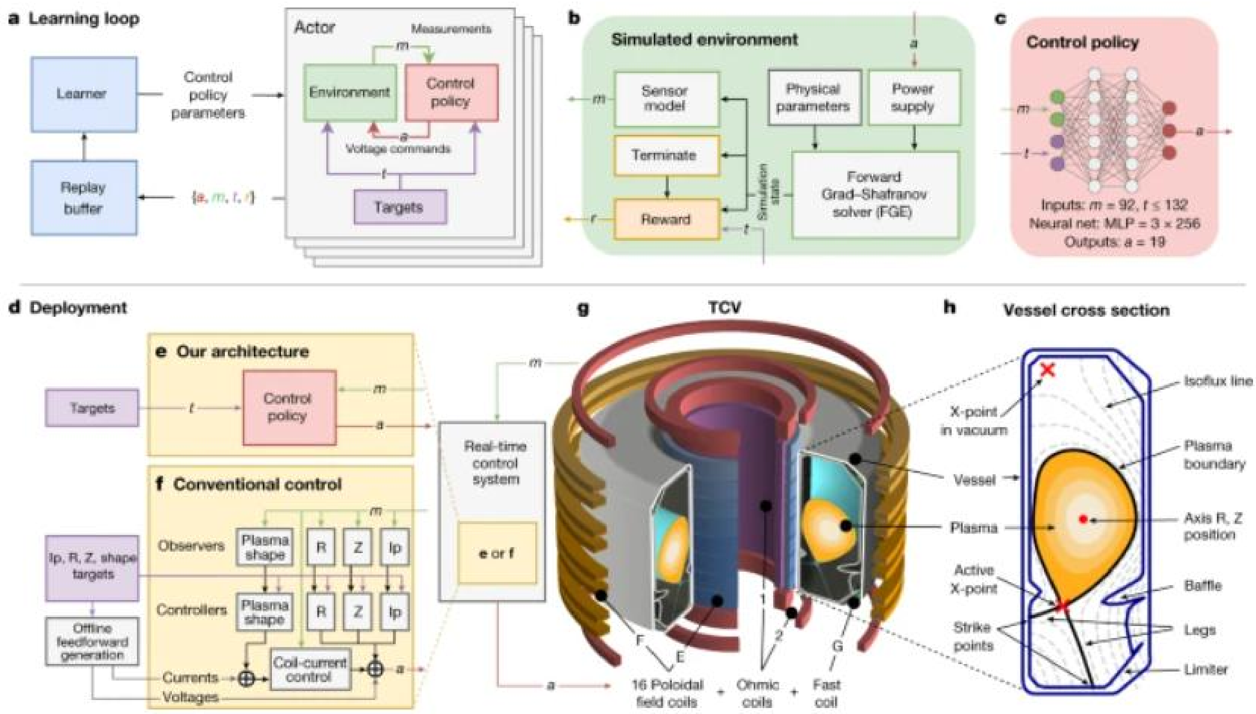
Abstract:

Nuclear fusion using magnetic confinement, in particular in the tokamak configuration, is a promising path towards sustainable energy. A core challenge is to shape and maintain a high-temperature plasma within the tokamak vessel. This requires high-dimensional, high-frequency, closed-loop control using magnetic actuator coils, further complicated by the diverse requirements across a wide range of plasma configurations. In this work, we introduce a previously undescribed architecture for tokamak magnetic controller design that autonomously learns to command the full set of control coils. This architecture meets control objectives specified at a high level, at the same time satisfying physical and operational constraints. This approach has unprecedented flexibility and generality in problem specification and yields a notable reduction in design effort to produce new plasma configurations.

摘要翻译:

磁约束核聚变，特别是托卡马克结构核聚变是一种有前景的可持续能源。一个核心挑战是塑造和维持托卡马克容器内的高温等离子体。这需要使用磁致动器线圈进行高维、高频、闭环控制，更复杂的是等离子体结构的不同要求。作者介绍了一个此前尚未描述的托卡马克磁控制器设计的架构，它可以自主学习命令全套控制线圈。该体系结构满足在高层指定的控制目标，同时满足物理和操作约束。这种方法在问题规范方面具有前所未有的灵活性和通用性，并显著减少了生产新等离子体配置的设计工作。

文中插图:



[5]**Resolving the gravitational redshift across a millimetre-scale atomic sample**

解析毫米尺度原子样本的引力红移

出版信息：Nature, Volume 602 Issue 7897, 17 February 2022

作者：Tobias Bothwell, Colin J. Kennedy, Alexander Aeppli, Dhruv Kedar, John M. Robinson, Eric Oelker, Alexander Staron & Jun Ye

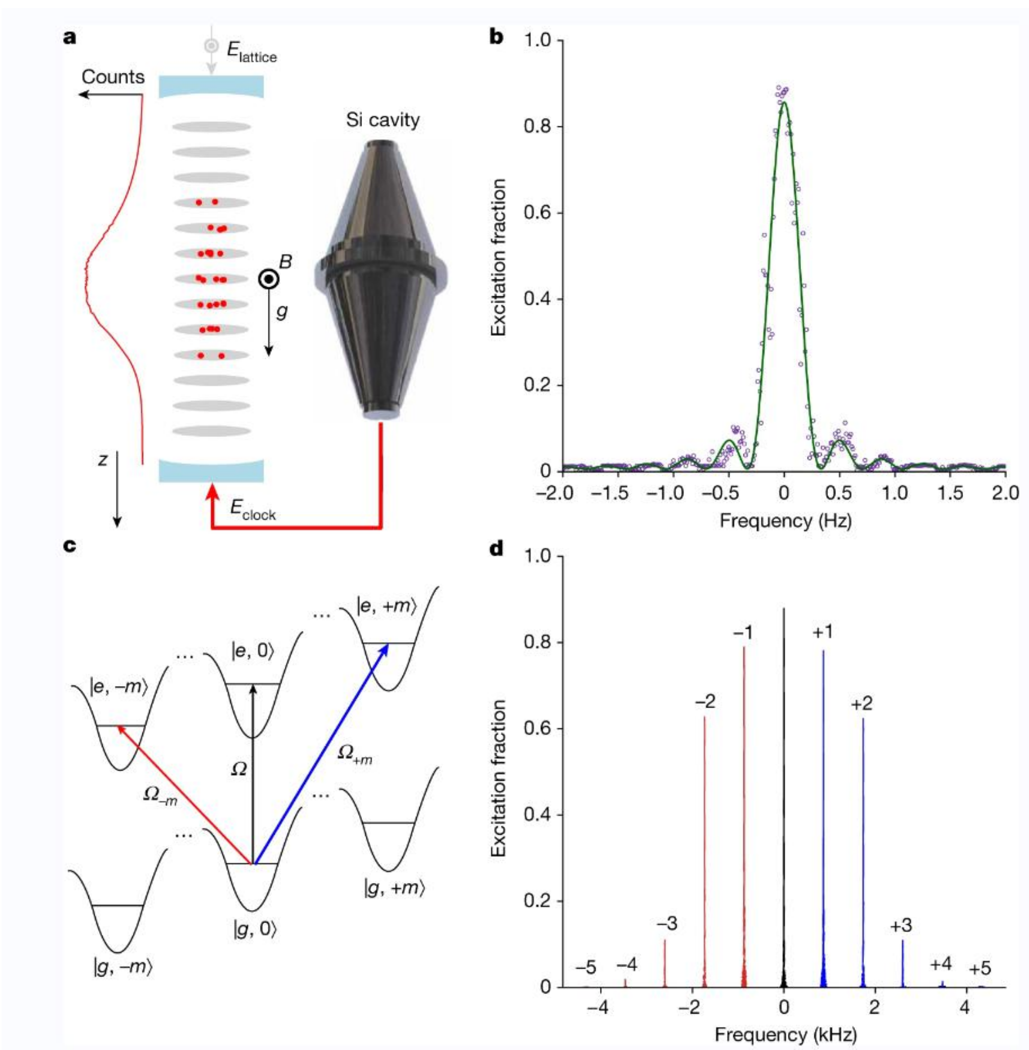
第一作者单位：DeepMind, London, UK

全文链接：https://www.nature.com/articles/s41586-021-04349-7

Abstract：Einstein' s theory of general relativity states that clocks at different gravitational potentials tick at different rates relative to lab coordinates—an effect known as the gravitational redshift. As fundamental probes of space and time, atomic clocks have long served to test this prediction at distance scales from 30 centimetres to thousands of kilometres. Ultimately, clocks will enable the study of the union of general relativity and quantum mechanics once they become sensitive to the finite wavefunction of quantum objects oscillating in curved space-time. Towards this regime, we measure a linear frequency gradient consistent with the gravitational redshift within a single millimetre-scale sample of ultracold strontium. Our result is enabled by improving the fractional frequency measurement uncertainty by more than a factor of 10, now reaching 7.6 × 10−21. This heralds a new regime of clock operation necessitating intra-sample corrections for gravitational perturbations.

摘要翻译：爱因斯坦的广义相对论指出，时钟在不同的引力势下，相对于实验室坐标的速度是不同的——这一效应被称为引力红移。作为空间和时间的基本探测器，原子钟长期以来被用于在 30 厘米到数千公里的距离尺度上检验这一预测。一旦时钟对弯曲时空中振荡的量子物体的有限波函数变得敏感，将使广义相对论和量子力学的结合研究成为可能。作者在一个毫米尺度的超冷锶样品中测量了与引力红移一致的线性频率梯度。通过将分数频率测量的不确定度提高 10 倍以上，达到 7.6 × 10−21，研究结果得以实现。这预示着一种新的时钟操作方式，需要对引力扰动进行样品内校正。

文中插图：



[6]**Real-space visualization of intrinsic magnetic fields of an antiferromagnet**

反铁磁体内禀磁场的实空间可视化

出版信息：Nature, 10 February 2022, VOL 602, ISSUE 7896

作者：Yuji Kohno, Takehito Seki, Scott D. Findlay, Yuichi Ikuhara & Naoya Shibata

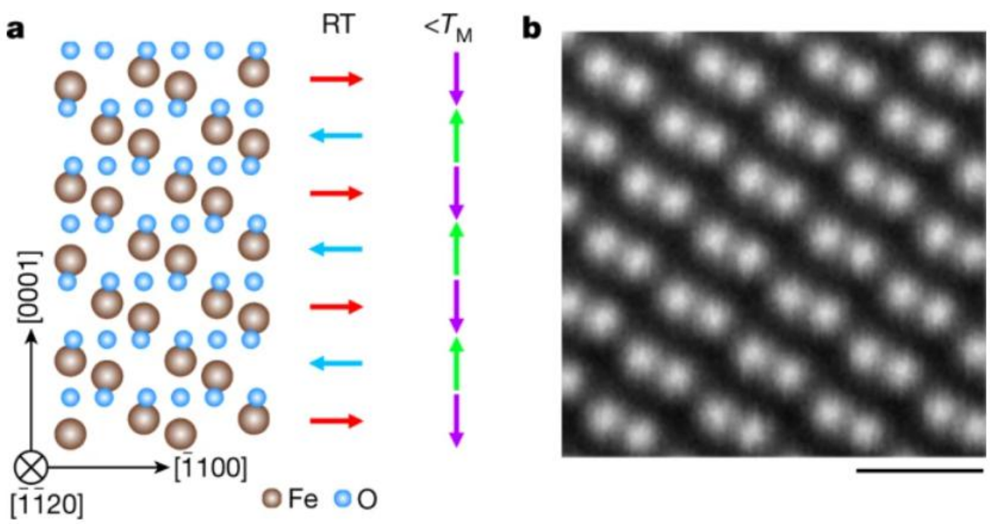
第一作者单位：JEOL Ltd., Tokyo, Japan

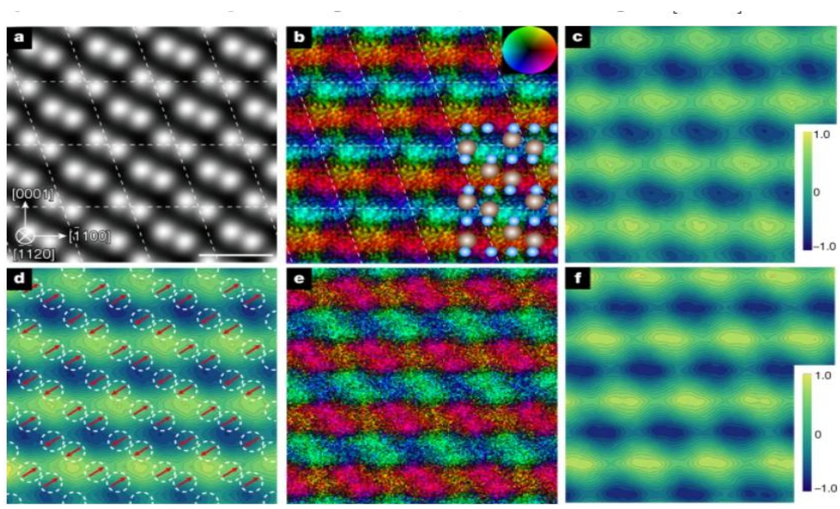
全文链接：https://www.nature.com/articles/s41586-021-04254-z

Abstract： Characterizing magnetic structures down to atomic dimensions is central to the design and control of nanoscale magnetism in materials and devices. However, real-space visualization of magnetic fields at such dimensions has been extremely challenging. In recent years, atomic-resolution differential phase contrast scanning transmission electron microscopy (DPC STEM) has enabled direct imaging of electric field distribution even inside single atoms. Here we show real-space visualization of magnetic field distribution inside antiferromagnetic haematite (α-Fe2O3) using atomic-resolution DPC STEM in a magnetic-field-free environment. After removing the phase-shift component due to atomic electric fields and improving the signal-to-noise ratio by unit-cell averaging, real-space visualization of the intrinsic magnetic fields in α-Fe2O3 is realized. These results open a new possibility for real-space characterization of many magnetic structures.

摘要翻译：原子尺度的磁性结构表征，是材料和器件中纳米磁性设计与调控的核心。然而，在该维度上，磁场的实空间可视化一直颇具挑战性。近年来，原子分辨率差分相衬扫描透射电子显微镜（DPC STEM）已能够直接成像单个原子内部的电场分布。研究组展示了在无磁场环境中使用原子分辨率 DPC STEM 实现反铁磁赤铁矿（α-Fe2O3）内部磁场分布的实空间可视化。在去除原子电场引起的相移分量并通过单元平均法提高信噪比后，研究组实现了α-Fe2O3 内禀磁场的实空间可视化。这些研究结果为许多磁性结构的实空间表征提供了新途径。

文中插图：





[7]**Ferroelectric incommensurate spin crystals**

铁电不相称自旋晶体

出版信息：Nature, 10 February 2022, VOL 602, ISSUE 7896

作者：Dorin Rusu, Jonathan J. P. Peters, Thomas P. A. Hase, James A. Gott, Gareth A. A. Nisbet, Jörg Strempfer, et al.

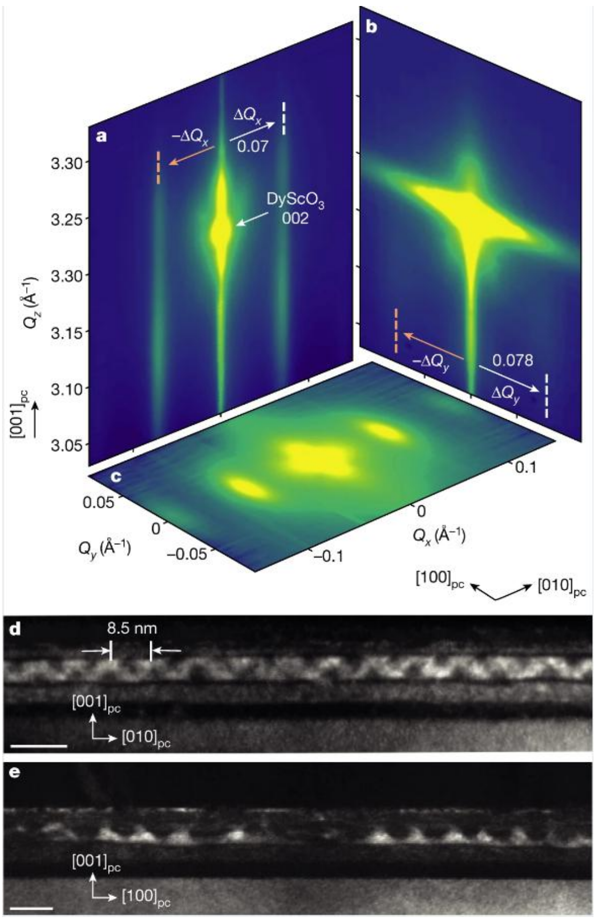
第一作者单位：Department of Physics, University of Warwick, Coventry, UK

全文链接：https://www.nature.com/articles/s41586-021-04260-1

Abstract： Ferroics, especially ferromagnets, can form complex topological spin structures such as vortices and skyrmions when subjected to particular electrical and mechanical boundary conditions. Simple vortex-like, electric-dipole-based topological structures have been observed in dedicated ferroelectric systems, especially ferroelectric – insulator superlattices such as PbTiO3/SrTiO3, which was later shown to be a model system owing to its high depolarizing field. To date, the electric dipole equivalent of ordered magnetic spin lattices driven by the Dzyaloshinskii – Moriya interaction (DMi) has not been experimentally observed. Here we examine a domain structure in a single PbTiO3 epitaxial layer sandwiched between SrRuO3 electrodes. We observe periodic clockwise and anticlockwise ferroelectric vortices that are modulated by a second ordering along their toroidal core. The resulting topology, supported by calculations, is a labyrinth-like pattern with two orthogonal periodic modulations that form an incommensurate polar crystal that provides a ferroelectric analogue to the recently discovered incommensurate spin crystals in ferromagnetic materials. These findings further blur the border between emergent ferromagnetic and ferroelectric topologies, clearing the way for experimental realization of further electric counterparts of magnetic DMi-driven phases.

摘要翻译：铁性材料，尤其是铁磁体，在特定的电和力学边界条件下，可形成复杂的拓扑自旋结构，如旋涡和斯格明子。在专用铁电系统中，尤其是在 PbTiO3/SrTiO3 等铁电-绝缘体超晶格中，人们已观察到简单的涡状电偶极子拓扑结构，但后来由于其高去极化场，被证明是一个模型系统。迄今为止，还没有实验观察到由 Dzyaloshinskii – Moriya 相互作用（DMi）驱动的有序磁自旋晶格的等效电偶极。研究组探讨了夹在 SrRuO3 电极间的单一 PbTiO3 外延层的畴结构。他们观察到周期性的顺时针和逆时针铁电旋涡，沿其环形核心受到二阶调制。计算结果支持的拓扑结构是具有两个正交周期调制的迷宫状图案，形成了一个不相称的极性晶体，其铁电性类似于最近在铁磁材料中发现的不相称自旋晶体。这些发现进一步模糊了突现铁磁和铁电拓扑之间的边界，为未来磁 DMi 驱动相的电对应物的实验实现扫清了道路。

文中插图：



[8]**Search for magnetic monopoles produced via the Schwinger mechanism**

寻找通过施温格机制产生的磁单极子

出版信息：Nature, 3 February 2022, Volume 602 Issue 7895

作者：B. Acharya, J. Alexandre, P. Benes, B. Bergmann et al.

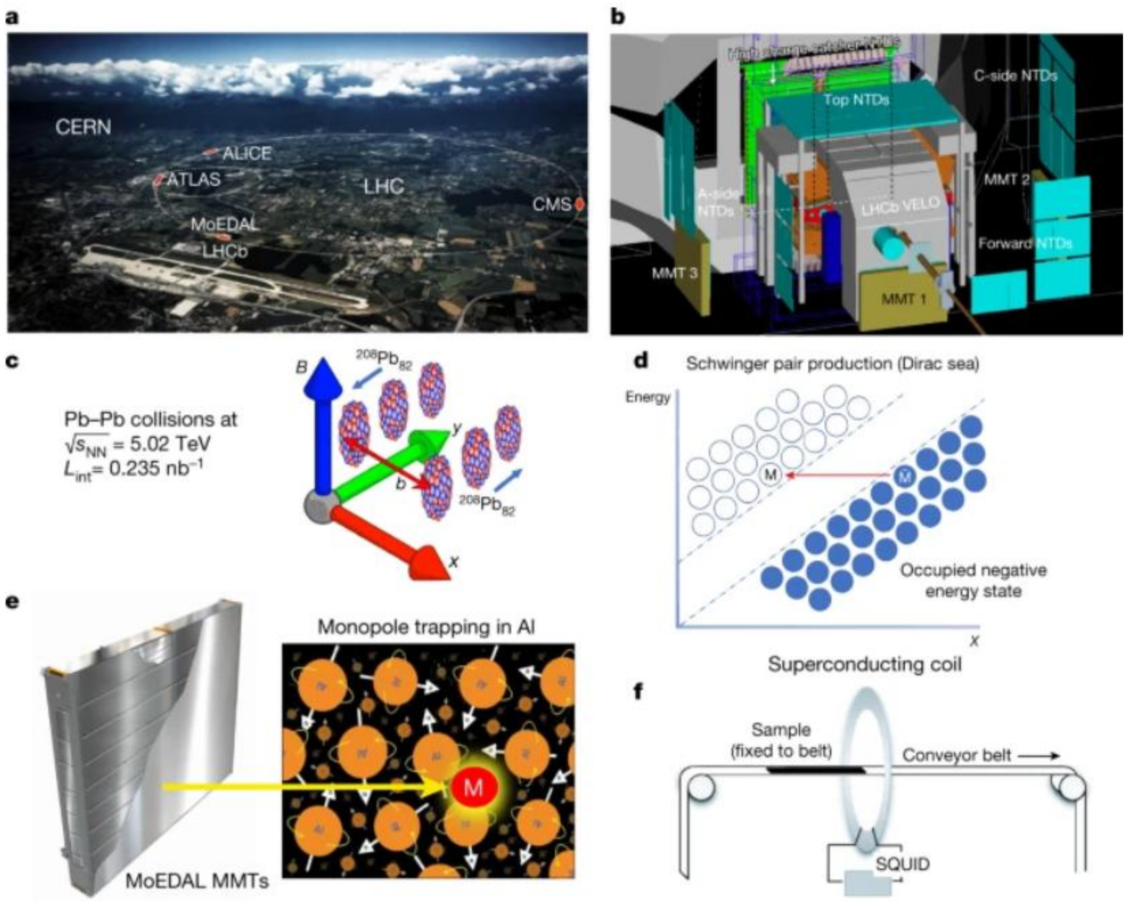
第一作者单位：Theoretical Particle Physics & Cosmology Group, Physics Department, King’s College London, London, UK

全文链接：https://www.nature.com/articles/s41586-021-04298-1

Abstract: Here we present a search for magnetic monopole production by the Schwinger mechanism in Pb–Pb heavy ion collisions at the Large Hadron Collider, producing the strongest known magnetic fields in the current Universe. It was conducted by the MoEDAL experiment, whose trapping detectors were exposed to 0.235 per nanobarn, or approximately 1.8 × 109, of Pb–Pb collisions with 5.02-teraelectronvolt center-of-mass energy per collision in November 2018. A superconducting quantum interference device (SQUID) magnetometer scanned the trapping detectors of MoEDAL for the presence of magnetic charge, which would induce a persistent current in the SQUID. Magnetic monopoles with integer Dirac charges of 1, 2 and 3 and masses up to 75 gigaelectronvolts per speed of light squared were excluded by the analysis at the 95% confidence level. This provides a lower mass limit for finite-size magnetic monopoles from a collider search and greatly extends previous mass bounds.

摘要翻译：在此，我们展示了在大型强子对撞机 Pb-Pb 重离子碰撞中，施温格机制产生磁单极子的研究，这产生了目前的宇宙中已知最强的磁场。这是由 MoEDAL 实验进行的，该实验的捕获探测器在 2018 年 11 月暴露在每纳米库内 0.235 个 Pb-Pb 碰撞中，或约 1.8 × 109 个 Pb-Pb 碰撞中，每次碰撞的质心能量为 5.02 兆兆电子伏。超导量子干涉装置（SQUID）磁强计扫描 MoEDAL 的捕获探测器以寻找磁荷的存在，磁荷会在 SQUID 中诱导持续电流。磁荷基本单位为 1、2 和 3 个基本单位的轻于每光速平方 75 吉电子伏的单极子的存在被排除在 95%置信水平的分析之外。这提供了一个较低的质量限制，有限大小的磁单极子从对撞机搜索，并大大扩展了以前的质量界限。

文中插图：



[9]**Domain-wall dynamics in Bose–Einstein condensates with synthetic gauge fields**

合成规范场中玻色-爱因斯坦凝聚的畴壁动力学

出版信息：Nature, 3 February 2022, Volume 602 Issue 7895

作者：Kai-Xuan Yao, Zhendong Zhang & Cheng Chin

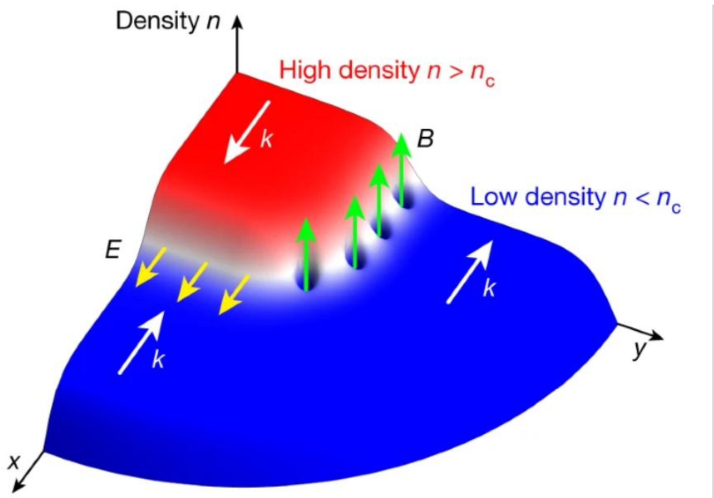
第一作者单位：James Franck Institute, University of Chicago, Chicago, IL, USA

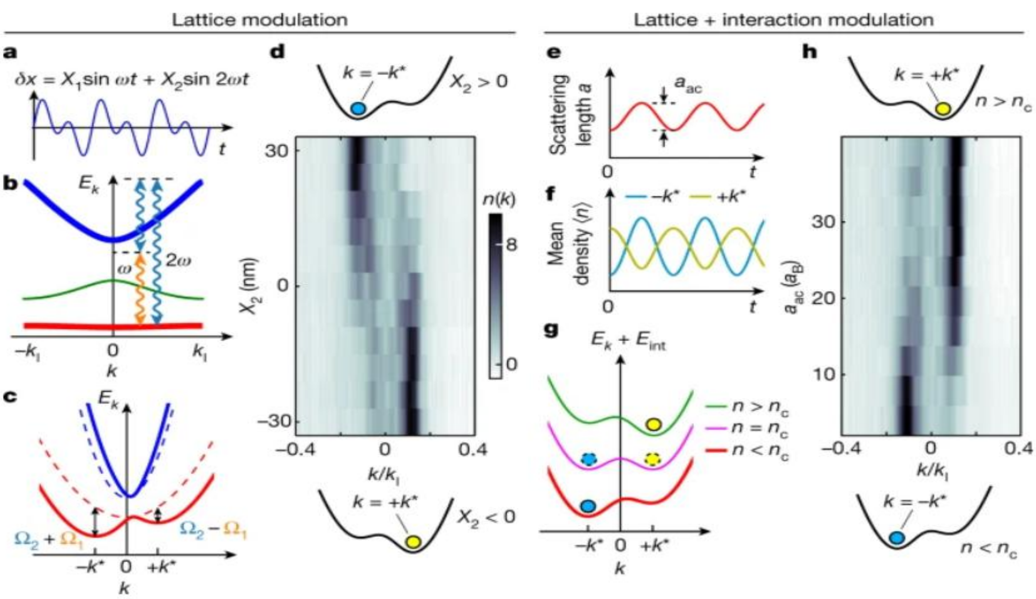
全文链接：https://www.nature.com/articles/s41586-021-04250-3

Abstract： Here we demonstrate deterministic formation of domain walls in a stable Bose–Einstein condensate with a gauge field that is determined by the atomic density. The density-dependent gauge field is created by simultaneous modulations of an optical lattice potential and interatomic interactions, and results in domains of atoms condensed into two different momenta. Modelling the domain walls as elementary excitations, we find that the domain walls respond to synthetic electric field with a charge-to-mass ratio larger than and opposite to that of the bare atoms. Our work offers promising prospects to simulate the dynamics and interactions of previously undescribed excitations in quantum systems with dynamical gauge fields.

摘要翻译：在此，我们证明了在稳定的玻色-爱因斯坦凝聚与由原子密度决定的规范场中，畴壁的确定性形成。密度相关规范场是由光学晶格势和原子间相互作用的同时调制产生的，并导致原子域凝聚成两个不同的动量。将畴壁建模为基本激发，我们发现畴壁响应于电荷质量比大于或相反于裸原子的合成电场。我们的工作对用动态规范场模拟量子系统中先前未描述的激发的动力学和相互作用进行了有前途的展望。

文中插图：





[10]**Polarized phonons carry angular momentum in ultrafast demagnetization**

圆极化声子在超快退磁中具有角动量

出版信息：Nature, 3 February 2022, Volume 602 Issue 7895

作者：S. R. Tauchert, M. Volkov, D. Ehberger, D. Kazenwadel et al.

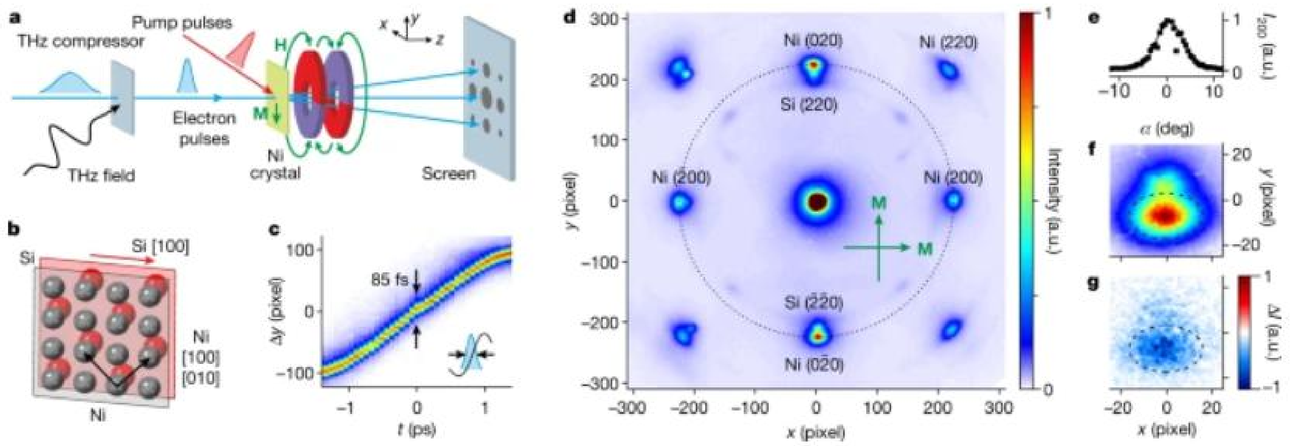
第一作者单位：Universität Konstanz, Fachbereich Physik, Konstanz, Germany

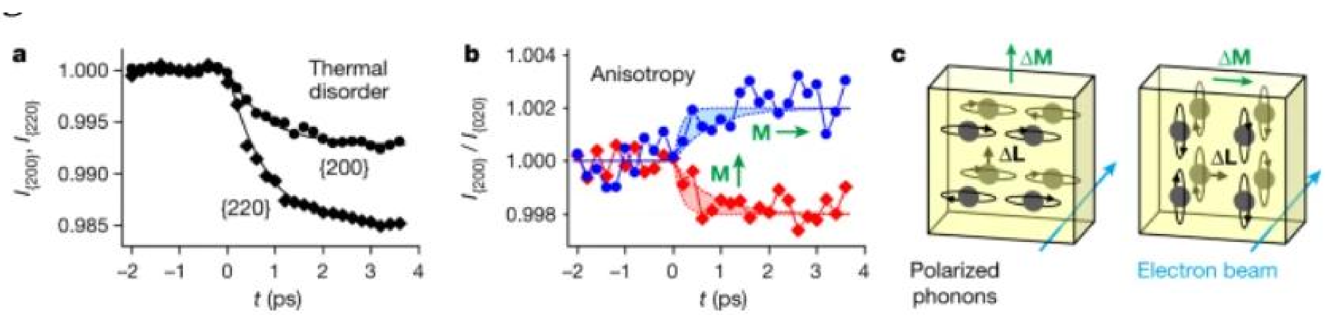
全文链接：https://www.nature.com/articles/s41586-021-04306-4

Abstract： Here we use ultrafast electron diffraction to reveal in nickel an almost instantaneous, long-lasting, non-equilibrium population of anisotropic high-frequency phonons that appear within 150 – 750 fs. The anisotropy plane is perpendicular to the direction of the initial magnetization and the atomic oscillation amplitude is 2 pm. We explain these observations by means of circularly polarized phonons that quickly absorb the angular momentum of the spin system before macroscopic sample rotation. The time that is needed for demagnetization is related to the time it takes to accelerate the atoms. These results provide an atomistic picture of the Einstein – de Haas effect and signify the general importance of polarized phonons for non-equilibrium dynamics and phase transitions.

摘要翻译：在这里，我们使用超快电子衍射揭示了镍中几乎瞬时的、持久的、各向异性高频声子的非平衡分布，出现在 150-750 fs。各向异性平面垂直于初始磁化方向，原子振荡振幅为 2pm。我们认为这是在材料旋转之前迅速吸收角动量的自旋系统的圆极化声子造成的。退磁所需的时间与原子加速所需的时间有关。这些结果提供了爱因斯坦-德哈斯效应的原子图象，表明了圆极化声子在非平衡动力学和相变中的一般重要性。

文中插图：





物理学 2 月 Science 论文

[1]**Second sound attenuation near quantum criticality**

量子临界附近的二次声衰减米颗粒超晶格组装的宏观材料

出版信息：Science, 4 FEB 2022, VOL 375, ISSUE 6580

作者：XI LI, XIANG LUO, SHUAI WANG, KE XIEXIANG-PEI LIUHUI HU, YU-AO CHEN, XING-CAN YAO, JIAN-WEI PAN

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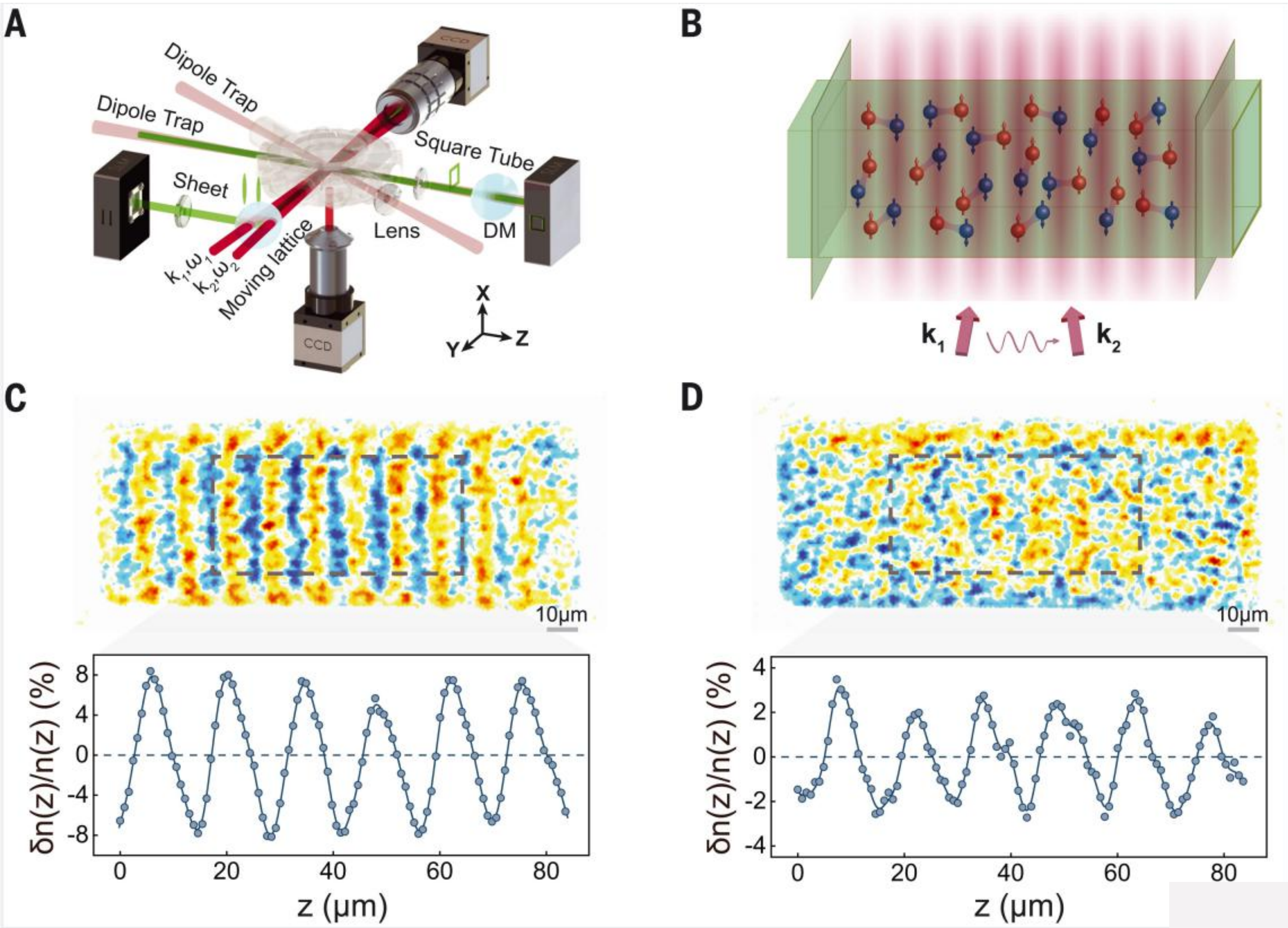
国内相关报道：http://news.ustc.edu.cn/info/1055/78322.htm

全文链接：https://www.science.org/doi/10.1126/science.abi4480

Abstract： Heat usually propagates diffusively, but it can also under certain circumstances propagate like a wave, much as sound does. This phenomenon, called second sound, has been observed in superfluids, including helium and ultracold atomic gases. However, measuring the attenuation of second sound remains tricky. Li et al. accomplished this feat by creating a uniform ultracold gas of strongly interacting fermionic lithium atoms with a very large Fermi energy. Placing the gas in an external periodic potential and measuring the response, the researchers extracted the coefficients characterizing second sound attenuation.

摘要翻译： 热通常是扩散传播的，但在某些情况下它也可以像波一样传播，就像声音一样。这种现象被称为二次声，已在包括氦和超冷原子气体的超流体中被观察到。然而，测量二次声的衰减仍然很棘手。潘建伟等通过创造一种均匀的超冷气体来完成这一壮举，这种气体由强相互作用的费米锂原子组成，具有非常大的费米能量。将气体置于一个外部周期电位中并测量其响应，研究人员提取出表征二次声衰减的系数。

文中插图：



[2]**Induced giant piezoelectricity in centrosymmetric oxides**

Bernal 双层石墨烯的同位旋磁性和自旋极化超导性

出版信息：Science, 11 FEB 2022, VOL 375, ISSUE 6581

作者：D.-S. PARK, M. HADADL. M. RIEMER, R. IGNATANS et al.

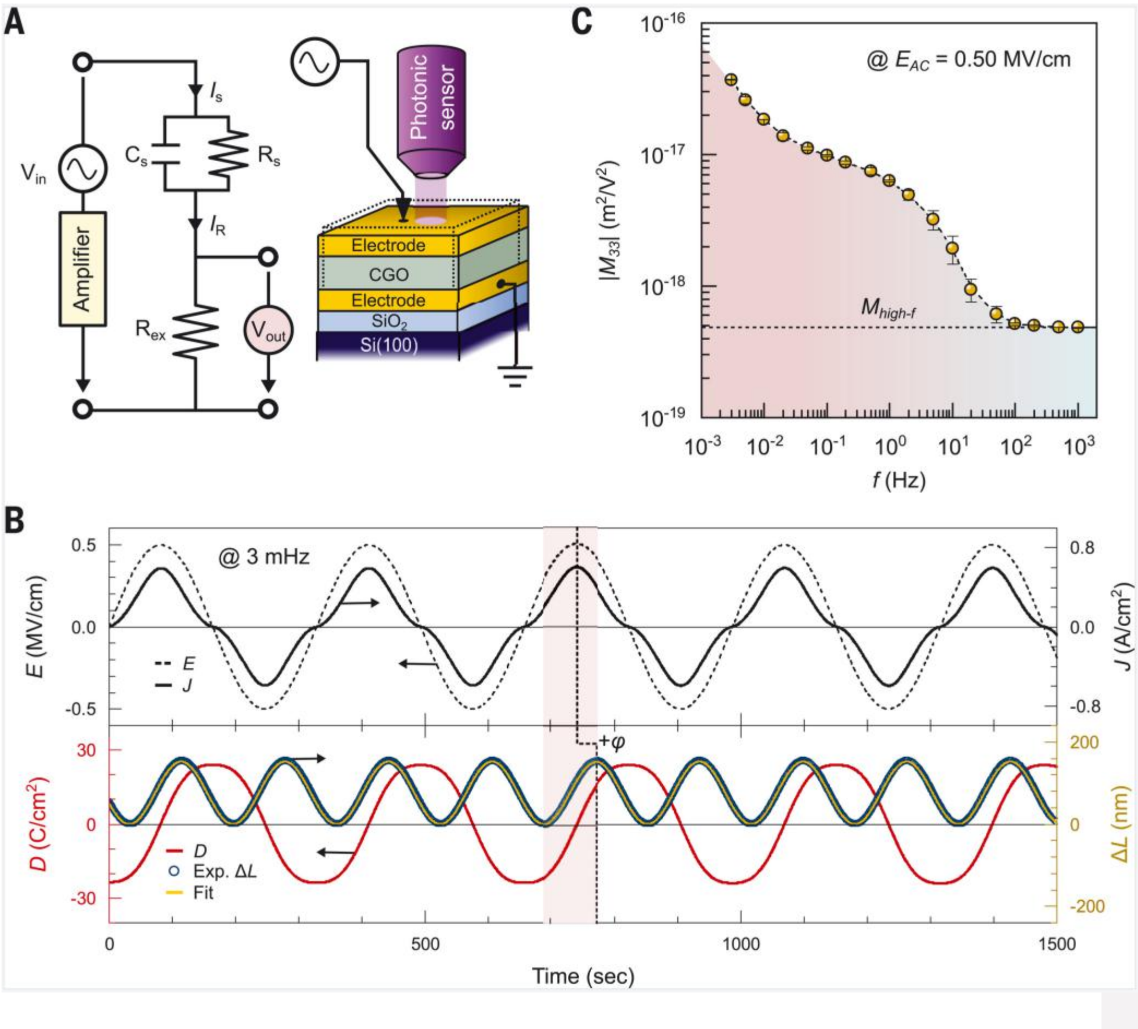
第一作者单位：Group for Ferroelectrics and Functional Oxides, SwissFederal Institute of Technology–EPFL, 1015 Lausanne,Switzerland

全文链接：https://www.science.org/doi/10.1126/science.abm7497

Abstract：Piezoelectrics are materials that linearly deform in response to an applied electric field. As a fundamental prerequisite, piezoelectric materials must have a noncentrosymmetric crystal structure. For more than a century, this has remained a major obstacle for finding piezoelectric materials. We circumvented this limitation by breaking the crystallographic symmetry and inducing large and sustainable piezoelectric effects in centrosymmetric materials by the electric field – induced rearrangement of oxygen vacancies. Our results show the generation of extraordinarily large piezoelectric responses [with piezoelectric strain coefficients(d33) of ~200,000 picometers per volt at millihertz frequencies] in cubic fluorite gadolinium-doped CeO2−x films, which are two orders of magnitude larger than the responses observed in the presently best-known lead-based piezoelectric relaxor – ferroelectric oxide at kilohertz frequencies. These findings provide opportunities to design piezoelectric materials from environmentally friendly centrosymmetric ones.

摘要翻译：压电材料是在外加电场作用下线性变形的材料。压电材料必须具有非中心对称的晶体结构，这是压电材料的基本前提。而这一直是一个多世纪以来寻找压电材料的主要障碍。我们打破了晶体对称性，并通过电场诱导氧空位的重排，在中心对称材料中产生大而持久的压电效应，从而克服了这一限制。我们的结果显示，这一方式在立方萤石钆掺杂 CeO2−x 薄膜中产生巨大的压电响应（在毫赫兹频率下，压电应变系数(d33)为~20 万皮米/伏特），这比目前最著名的铅基压电弛豫铁电氧化物在千赫兹频率上观察到的响应大两个数量级。这些发现为设计环境友好型中心对称压电材料提供了机会。

文中插图：



[3]**Isospin magnetism and spin-polarized superconductivity in Bernal bilayer graphene**

混合卤化物钙钛矿 LED 配体设计的带隙稳定性

出版信息：Science, 18 FEBRUARY 2022, VOL 375, ISSUE 6582

作者：HAOXIN ZHOU, LUDWIG HOLLEIS, YU SAITO, LIAM COHEN, WILLIAM HUYNH, CAITLIN L. PATTERSON, ET AL.

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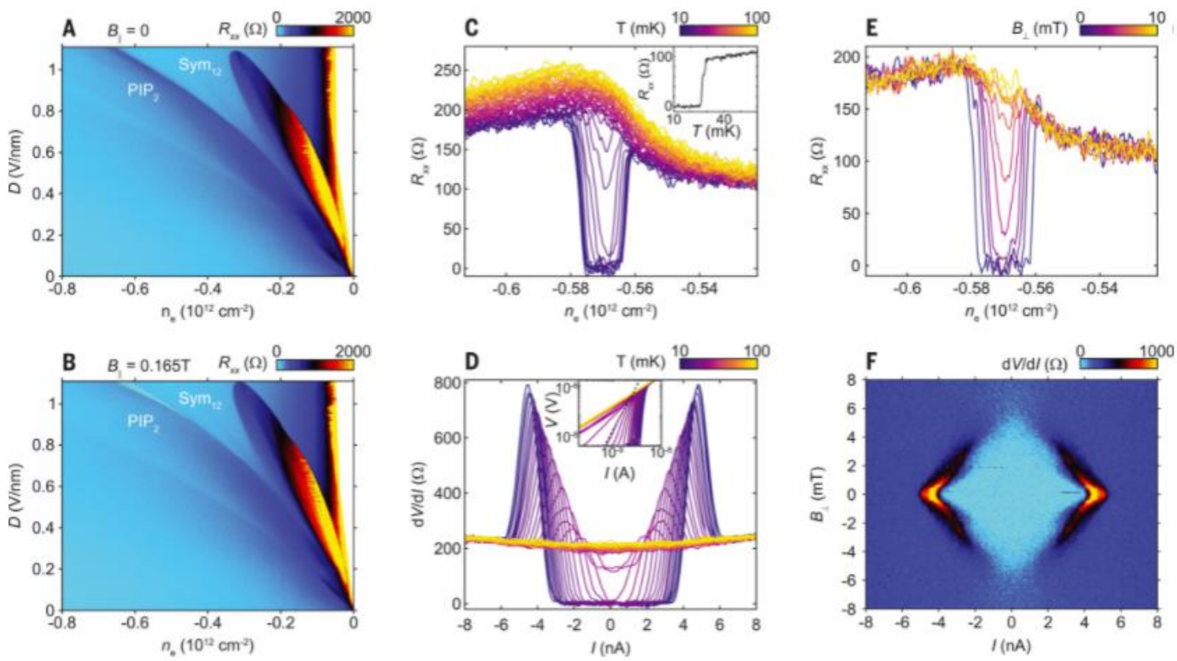
全文链接：https://www.science.org/doi/10.1126/science.abm8386

Abstract： In conventional superconductors, Cooper pairing occurs between electrons of opposite spin. We observe spin-polarized superconductivity in Bernal bilayer graphene when doped to a saddle-point van Hove singularity generated by a large applied perpendicular electric field. We observe a cascade of electrostatic gate-tuned transitions between electronic phases distinguished by their polarization within the isospin space defined by the combination of the spin and momentum-space valley degrees of freedom. Although all of these phases are metallic at zero magnetic field, we observe a transition to a superconducting state at finite magnetic field B ‖ ≈ 150 milliteslas applied parallel to the two-dimensional sheet. Superconductivity occurs near a symmetry-breaking transition and exists exclusively above the B ‖ limit expected of a paramagnetic superconductor with the observed transition critical temperature TC ≈ 30 millikelvins, consistent with a spin-triplet order parameter.

摘要翻译：在传统超导体中，库珀配对发生在自旋相反的电子之间。研究组观察了当掺杂到由大垂直电场产生的鞍点范霍夫奇点时，Bernal 双层石墨烯的自旋极化超导性。他们观察到电子相位之间的静电栅极调谐跃迁级联，以同位旋空间中的极化为特征，同位旋空间由自旋和动量空间谷自由度组合定义。虽然所有这些相在零磁场下都是金属的，但研究组观察到在有限磁场 B‖≈150 mT 平行施加于二维薄片上时，会发生向超导状态的转变。超导性发生在对称破缺转变附近，仅存在于顺磁超导体预期的 B‖极限之上，观测到的转变临界温度 TC≈30 mK，与自旋三重态序参数一致。

文中插图：



[4]**A framework for scintillation in nanophotonics**

纳米光子学的闪烁

出版信息：SCIENCE, 25 FEB 2022, volume 375, ISSUE 6583

作 者： CHARLES ROQUES-CARMES, NICHOLAS RIVERA, ALI GHORASHISTEVEN E. KOOI, YANG, ZIN LINJUSTIN BEROZ, AVIRAM MASSUDA, JAMISON SLOAN, etc.

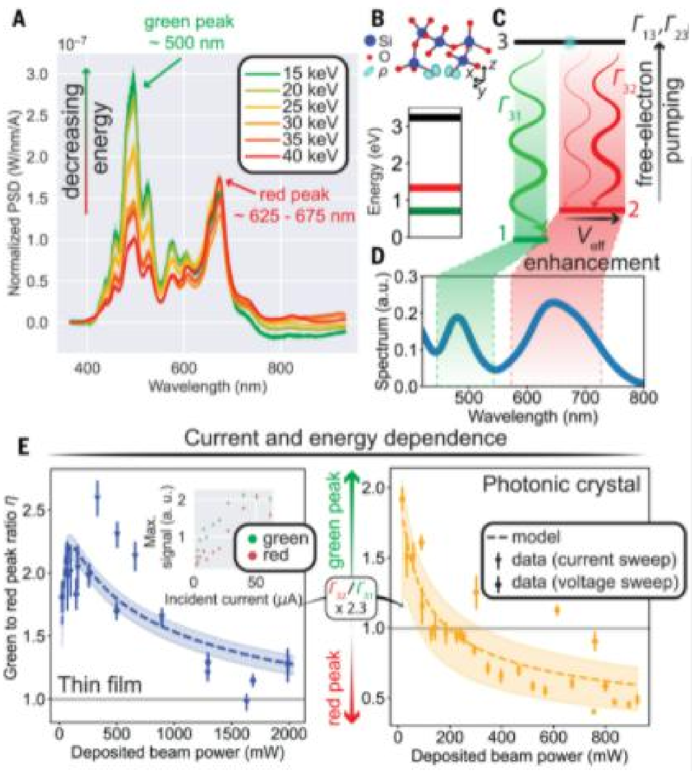
第一作者单位：Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA.

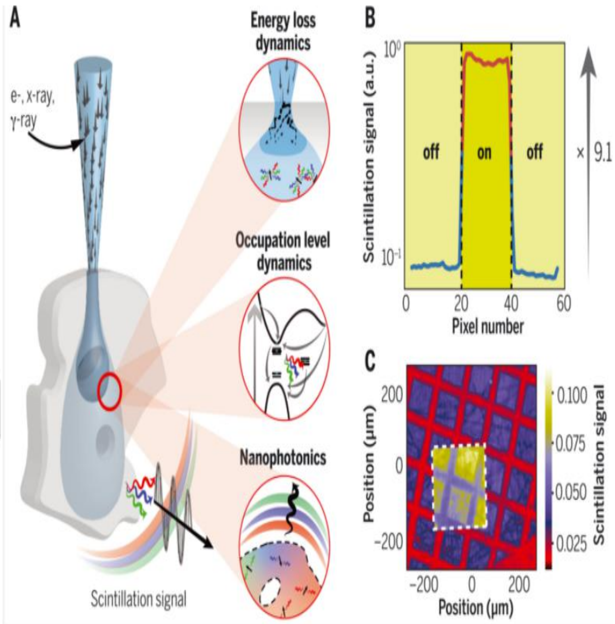
全文链接：https://www.science.org/doi/10.1126/science.abm9293

Abstract： When a high-energy particle collides with a material, the energy is transferred to atoms in the material, and light can be emitted. This scintillation process is used in many detector applications ranging from medical imaging to high-energy particle physics. Roques-Carmes et al. integrated scintillating materials with nanophotonic structures to enhance and control their light emission (see the Perspective by Yu and Fan). The authors show how nanophotonic structures enable the ability to shape the spectral, angular, and polarization characteristics of scintillation. This approach should enable the development of brighter, faster, and higher-resolution scintillators.

摘要翻译：当高能粒子与物质碰撞时，能量被转移到物质中的原子上，就会发光。这种闪烁过程被用于从医学成像到高能粒子物理的许多探测器应用。作者将闪烁材料与纳米光子结构集成在一起，以增强和控制其发光。他们展示了如何使纳米光子结构形成闪烁的光谱、角和偏振特性。这种方法将有助于开发出更亮、更快和更高分辨率的闪烁体。

文中插图：





[5]**Highly stretchable van der Waals thin films for adaptable and breathable electronic membranes**

高拉伸范德瓦尔薄膜可用作适应性强的电子膜

出版信息：**SCIENCE, 25 FEB 2022, volume 375, ISSUE 6583**

作者：ZHUOCHENG YAN, DONG XUZHAO, YANG LIN, PEIQI WANG, BOCHENG CAO, HUAYING REN, CHENGZHANG WAN, LAIYUAN WANG, XIANGFENG DUAN

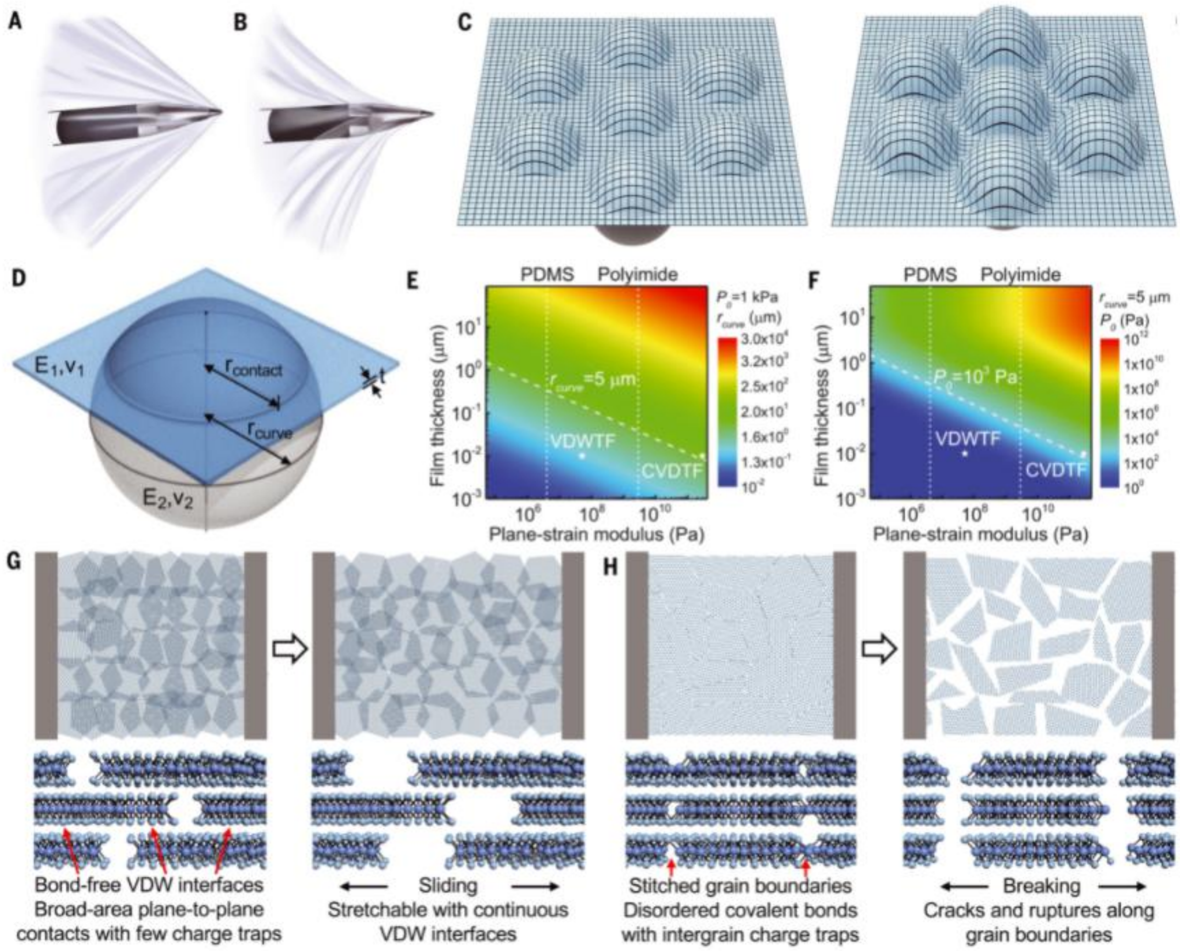
第一作者单位：Department of Chemistry and Biochemistry, University of California, Los Angeles, CA 90095, USA.

全文链接：https://www.science.org/doi/10.1126/science.abl8941

Abstract：Rigid materials become more flexible when cast as thin sheets, but they will still bump and buckle when subjected to in-plane rotation or twisting motions and thus cannot conformally cover a curved and mobile surface. Yan et al. formed roughly 10-nanometer-thick freestanding sheets by spin coating films containing flakes of semiconducting materials. The flakes attract each other through bond-free van der Waals interfaces to enable mechanical stretchability and malleability as well as permeability and breathability. These properties make them suitable for bioelectronic membranes that can monitor and amplify a range of electrophysiological signals, including demonstrations of electrocardiography and electroencephalography.

摘要翻译：刚性材料在浇铸成薄板时具有更强的柔韧性，但在受到面内旋转或扭转运动时仍会发生碰撞和屈曲，从而不能贴合地覆盖弯曲和可移动的表面。作者通过旋转涂覆含有半导体材料薄片的薄膜，形成了大约 10 纳米厚的独立薄片。薄片通过无键范德瓦尔界面相互吸引，以实现机械拉伸、延展性以及透气性。这些特性使它们适用于可监测和放大一系列电生理信号的生物电子膜，比如进行心电图和脑电图演示的生物电子膜。

文中插图：



[6]**Black hole spin–orbit misalignment in the x-ray binary MAXI J1820+070**

X 射线双星中的黑洞自旋轨道错位

出版信息：SCIENCE, 25 FEB 2022, volume 375, ISSUE 6583

作 者： JURI POUTANEN, ALEXANDRA VELEDINA, ANDREI V. BERDYUGIN, SVETLANA V. BERDYUGINA, HELEN JERMAKPETER G. JONKER, JARI J. E. KAJAVA, ILIA A. KOSENKOV, VADIM KRAVTSOV, SERGEY S. TSYGANKOV

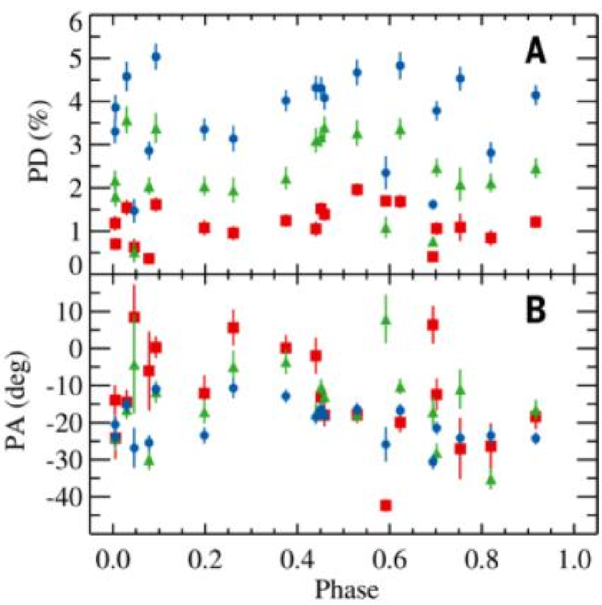
第一作者单位：Department of Physics and Astronomy, FI-20014 University of Turku, Finland.

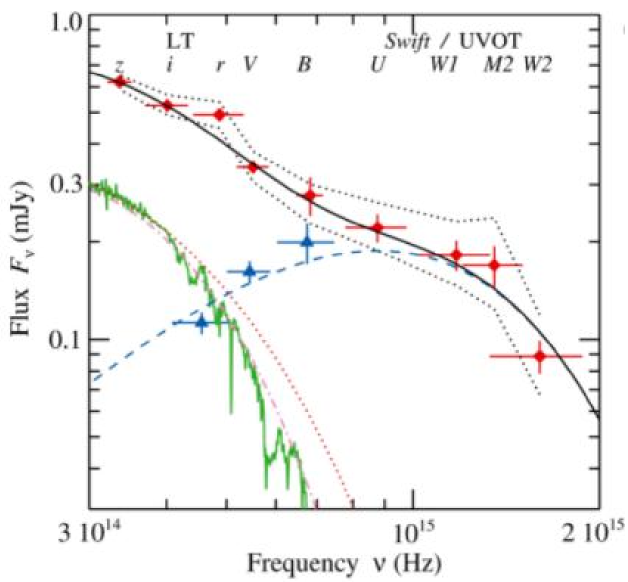
全文链接：https://www.science.org/doi/10.1126/science.abl4679

Abstract：The observational signatures of black holes in x-ray binary systems depend on their masses, spins, accretion rate, and the misalignment angle between the black hole spin and the orbital angular momentum. We present optical polarimetric observations of the black hole x-ray binary MAXI J1820+070, from which we constrain the position angle of the binary orbital. Combining this with previous determinations of the relativistic jet orientation, which traces the black hole spin, and the inclination of the orbit, we determine a lower limit of 40° on the spin-orbit misalignment angle. The misalignment must originate from either the binary evolution or black hole formation stages. If other x-ray binaries have similarly large misalignments, these would bias measurements of black hole masses and spins from x-ray observations.

摘要翻译：X 射线双星系统中黑洞的观测特征取决于它们的质量、自旋、吸积速率以及黑洞自旋和轨道角动量之间的不对位角。本文介绍了 X 射线双星 MAXI J1820+070 中黑洞的光学偏振观测，并对其轨道位置角进行了约束。结合之前对黑洞自旋的相对论喷流方向和轨道倾角的测定，作者确定了自旋-轨道偏差角的下限为 40°。这种不一致一定是由双星演化或黑洞形成阶段引起的。如果其他的 X 射线双星也有类似的大偏差，这将使 X 射线观测中黑洞质量和自旋的测量产生偏差。

文中插图：





[7]**Topological modes in a laser cavity through exceptional state transfer**

在激光腔中实现拓扑模式

出版信息：SCIENCE, 25 FEB 2022, volume 375, ISSUE 6583

作者：A. SCHUMER, Y. G. N. LIU, XJ. LESHINL. DINGY. ALAHMADI, A. U. HASSANH. NASARIS. ROTTER, D. N. CHRISTODOULIDES, M. KHAJAVIKHAN

第一作者单位：Ming Hsieh Department of Electrical and Computer Engineering, University of Southern California, Los Angeles, CA 90089, USA.

全文链接：https://www.science.org/doi/10.1126/science.abl6571

Abstract：Laser cavities are typically simple structures in the sense that the pump light oscillates between the cavity walls symmetrically, ideally with a single resonant output mode. More complex cavity designs exploiting materials exhibiting gain and loss can be realized that result in an exceptional point at which the output mode can effectively be tuned. Schumer et al. designed a cavity in which the pump light encircles the exceptional point as it propagates back and forth within the cavity. The result is a laser capable of simultaneously emitting in two different, but topologically linked, transverse profiles, each from a different facet of the cavity. The approach provides flexibility in designing topologically robust laser cavities.

摘要翻译：激光腔是典型的简单结构，泵浦光在腔壁之间对称振荡，理想情况下是单共振输出模式。

利用显示增益和损耗的材料可以实现更复杂的腔体设计，从而导致输出模式可以有效调谐的异常点。作者设计了一种腔体，当泵浦光在腔体内来回传播时，它围绕着特殊点。其结果是一种激光能够同时发射两种不同的，但在拓扑上相连的横向轮廓，每一种轮廓都来自腔体的不同侧面。该方法为设计拓扑稳健的激光腔提供了灵活性。

文中插图：