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本期推荐报道 2022 年 3 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 3 月 Nature 论文

[1]Emergence of Fermi arcs due to magnetic splitting in an antiferromagnet

反铁磁体中的磁分裂产生费米弧

出版信息：Nature, 24 March 2022, VOL 603, ISSUE 7902

作者：Benjamin Schrunk, Yevhen Kushnirenko, Brinda Kuthanazhi, Junyeong Ahn, Lin-Lin Wang, Evan O'Leary, et al.

第一作者单位：These authors contributed equally: Benjamin Schrunk, Yevhen Kushnirenko

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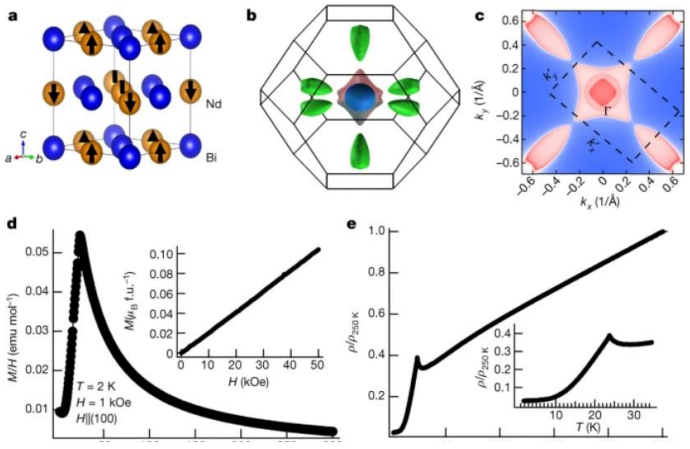
全文链接：https://www.nature.com/articles/s41586-022-04412-x

Abstract：The Fermi surface plays an important role in controlling the electronic, transport and thermodynamic properties of materials. As the Fermi surface consists of closed contours in the momentum space for well-defined energy bands, disconnected sections known as Fermi arcs can be signatures of unusual electronic states, such as a pseudogap. Another way to obtain Fermi arcs is to break either the time-reversal symmetry or the inversion symmetry of a three-dimensional Dirac semimetal, which results in formation of pairs of Weyl nodes that have opposite chirality, and their projections are connected by Fermi arcs at the bulk boundary. Here, we present experimental evidence that pairs of hole- and electron-like Fermi arcs emerge below the Neel temperature (TN) in the antiferromagnetic state of cubic NdBi due to a new magnetic splitting effect. The observed magnetic splitting is unusual, as it creates bands of opposing curvature, which change with temperature and follow the antiferromagnetic order parameter. This is different from previous theoretically considered and experimentally reported cases of magnetic splitting, such as traditional Zeeman and Rashba, in which the curvature of the bands is preserved. Therefore, our findings demonstrate a type of magnetic band splitting in the presence of a long-range antiferromagnetic order that is not readily explained by existing theoretical ideas.

摘要翻译：费米面在控制材料的电子、输运和热力学性质等方面起着重要作用。由于费米面由动量空间中定义明确的能带闭合轮廓组成，因此所谓费米弧的断开部分，可能是不寻常电子态的标志，例如赝隙。另一种获得费米弧的方法是打破三维狄拉克半金属的时间反演对称性或反演对称性，从而形成一对手性相反的韦尔节点，它们的投影通过体边界处的费米弧连接。研究组提供了实验证据，证明在立方 NdBi 的反铁磁状态中，由于一种新的磁分裂效应，在尼尔温度（TN）以下出现了成对的类空穴和类电子的费米弧。观察到的磁分裂很不寻常，因为它产生了相反曲率带，这些带随温度变化，并遵循反铁磁序参数。这不同于之前理论上考虑和实验上报道的磁分裂情况，如传统的塞曼和拉什巴，在这些情况中，带曲率得以保留。研究结果表明，在存在长程反铁磁序的情况下，出现了一种新型磁能带分裂，而现有理论观点无法解释。

文中插图：



[2]**Unbiasing fermionic quantum Monte Carlo with a quantum computer**

无偏的费米子量子蒙特卡罗与量子计算机

出版信息：Nature, 17 March 2022, Volume 603 Issue 7901

作者：William J. Huggins, Bryan A. O'Gorman, Nicholas C. Rubin, David R. Reichman, Ryan Babbush & Joonho Lee

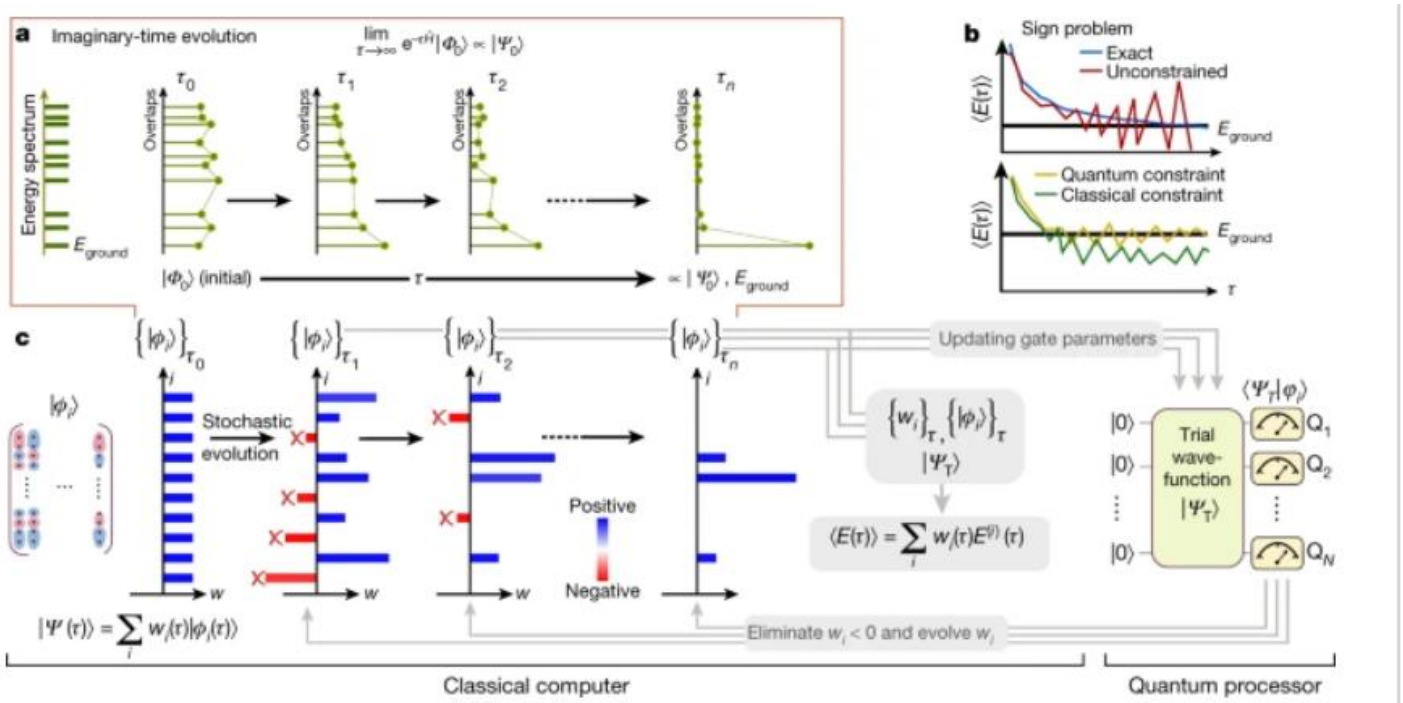
第一作者单位：Google Quantum AI, Mountain View, CA, USA

全文链接：https://www.nature.com/articles/s41586-021-04351-z

Abstract：Controlling the fermionic sign problem with constraints ensures the efficiency of QMC at the expense of potentially significant biases owing to the limited flexibility of classical computation. Here we propose an approach that combines constrained QMC with quantum computation to reduce such biases. We implement our scheme experimentally using up to 16 qubits to unbias constrained QMC calculations performed on chemical systems with as many as 120 orbitals. These experiments represent the largest chemistry simulations performed with the help of quantum computers, while achieving accuracy that is competitive with state-of-the-art classical methods without burdensome error mitigation. Compared with the popular variational quantum eigensolver, our hybrid quantum-classical computational model offers an alternative path towards achieving a practical quantum advantage for the electronic structure problem without demanding exceedingly accurate preparation and measurement of the ground-state wavefunction.

摘要翻译：用约束来控制费米符号问题保证了量子蒙特卡罗计算（QMC）的效率，但代价是由于经典计算的灵活性有限而可能存在显著的偏差。在此，我们提出了一种将 QMC 与量子计算相结合的方法来减少这种偏差。我们的方案在实验中实现了，我们使用了多达 16 个量子位来进行无偏约束 QMC 计算，这些计算是在多达 120 个轨道的化学系统上进行的。这些实验代表了在量子计算机的帮助下进行的最大的化学模拟，同时实现了与最先进的经典方法竞争的精度，而不需要负担的错误缓解。与流行的变分量子本征求解器相比，我们的量子-经典混合计算模型为电子结构问题提供了另一种实现实际量子优势的途径，而不需要非常精确的基态波函数的制备和测量。

文中插图：



[3]Wind dispersal of battery-free wireless devices

风扩散的无电池无线设备

出版信息：Nature, 17 March 2022, Volume 603 Issue 7901

作者：Vikram Iyer, Hans Gaensbauer, Thomas L. Daniel & Shyamnath Gollakota

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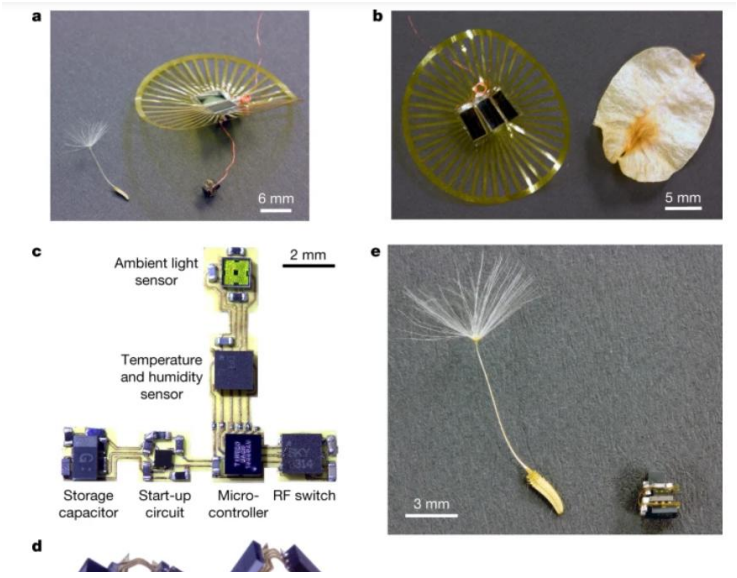
全文链接：https://www.nature.com/articles/s41586-021-04363-9

Abstract: Plants cover a large fraction of the Earth's land mass despite most species having limited to no mobility. To transport their propagules, many plants have evolved mechanisms to disperse their seeds using the wind. A dandelion seed, for example, has a bristly filament structure that decreases its terminal velocity and helps orient the seed as it wafts to the ground. Inspired by this, we demonstrate wind dispersal of battery-free wireless sensing devices. Our millimetre-scale devices weigh 30 milligrams and are designed on a flexible substrate using programmable, off-the-shelf parts to enable scalability and flexibility for various sensing and computing applications. The system is powered using lightweight solar cells and an energy harvesting circuit that is robust to low and variable light conditions, and has a backscatter communication link that enables data transmission. To achieve the wide-area dispersal and upright landing that is necessary for solar power harvesting, we developed dandelion-inspired, thin-film porous structures that achieve a terminal velocity of 0.87 ± 0.02 metres per second and aerodynamic stability with a probability of upright landing of over 95%. Our results in outdoor environments demonstrate that these devices can travel 50–100 metres in gentle to moderate breeze. Finally, in natural systems, variance in individual seed morphology causes some seeds to fall closer and others to travel farther. We adopt a similar approach and show how we can modulate the porosity and diameter of the structures to achieve dispersal variation across devices.

摘要翻译：植物覆盖了地球陆地的很大一部分，尽管大多数物种都不能运动。为了运输繁殖后代，许多植物进化出了利用风传播种子的机制。例如，蒲公英的种子有一种刚毛状的丝状结构，可以降低其末端速度，并在种子飘向地面时帮助其定位。受此启发，我们在此展示无电池无线的风扩散传感设备。我们的毫米级设备重量为 30 毫克，基于一个灵活的基板上，使用可编程的、现成的部件，为各种传感和计算应用提供可扩展性和灵活性。该系统使用轻型太阳能电池和能量收集电路供电，电路对低光照和可变光照条件非常稳定，并有一个反向散射通信链路，可以实现数据传输。为了实现太阳能收集所必需的大面积分散和垂直降落，我们开发了蒲公英启发的薄膜多孔结构，其终端速度为 0.87±0.02 米/秒，空气动力学稳定性，垂直降落的概率超过 95%。户外环境实验的结果表明，这些设备可以在轻柔到正常的微风中移动 50-100 米。最后，在自然系统中，个别种子形态的差异导致一些种子落得更近，而另一些则传播得更远。我们采用了类似的方法，并展示了我们如何调节结构的孔隙度和直径，以实现设备间的分散变化。

文中插图：



[4]**AGN as potential factories for eccentric black hole mergers**

偏心黑洞合并的潜在“工厂”

出版信息: Nature, 10 March 2022, VOL 603, ISSUE 7900

作者： J. Samsing, I. Bartos, D. J. D’Orazio, Z. Haiman, B. Kocsis, N. W. C. Leigh, B. Liu, M. E. Pessah & H. Tagawa

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全文链接：https://www.nature.com/articles/s41586-021-04333-1

Abstract： There is some weak evidence that the black hole merger named GW190521 had a non-zero eccentricity1,2. In addition, the masses of the component black holes exceeded the limit predicted by stellar evolution3. The large masses can be explained by successive mergers4,5, which may be efficient in gas disks surrounding active galactic nuclei, but it is difficult to maintain an eccentric orbit all the way to the merger, as basic physics would argue for circularization6. Here we show that active galactic nuclei disk environments can lead to an excess of eccentric mergers, if the interactions between single and binary black holes are frequent5 and occur with mutual inclinations of less than a few degrees. We further illustrate that this eccentric population has a different distribution of the inclination between the spin vectors of the black holes and their orbital angular momentum at merger7, referred to as the spin–orbit tilt, compared with the remaining circular mergers.

摘要翻译：有一些不太多的证据表明，一个叫作 GW190521 的黑洞合并具有非零偏心。此外，组成黑洞的质量超过了恒星演化预测的极限。这些巨大的质量可以用连续的合并来解释，这可能在活动星系核周围的气体盘中是有效的，但很难保持一个偏心轨道一直到合并，就像基础物理学认为的圆化一样。作者研究表明，如果单黑洞和双黑洞之间的相互作用经常发生，并且相互倾斜度不超过几度，活跃的星系核盘环境就能导致过量的偏心合并。研究进一步说明，与其他圆形合并相比，这个偏心群具有不同的黑洞自旋矢量和合并时轨道角动量之间的倾角分布，称为自旋轨道倾角。

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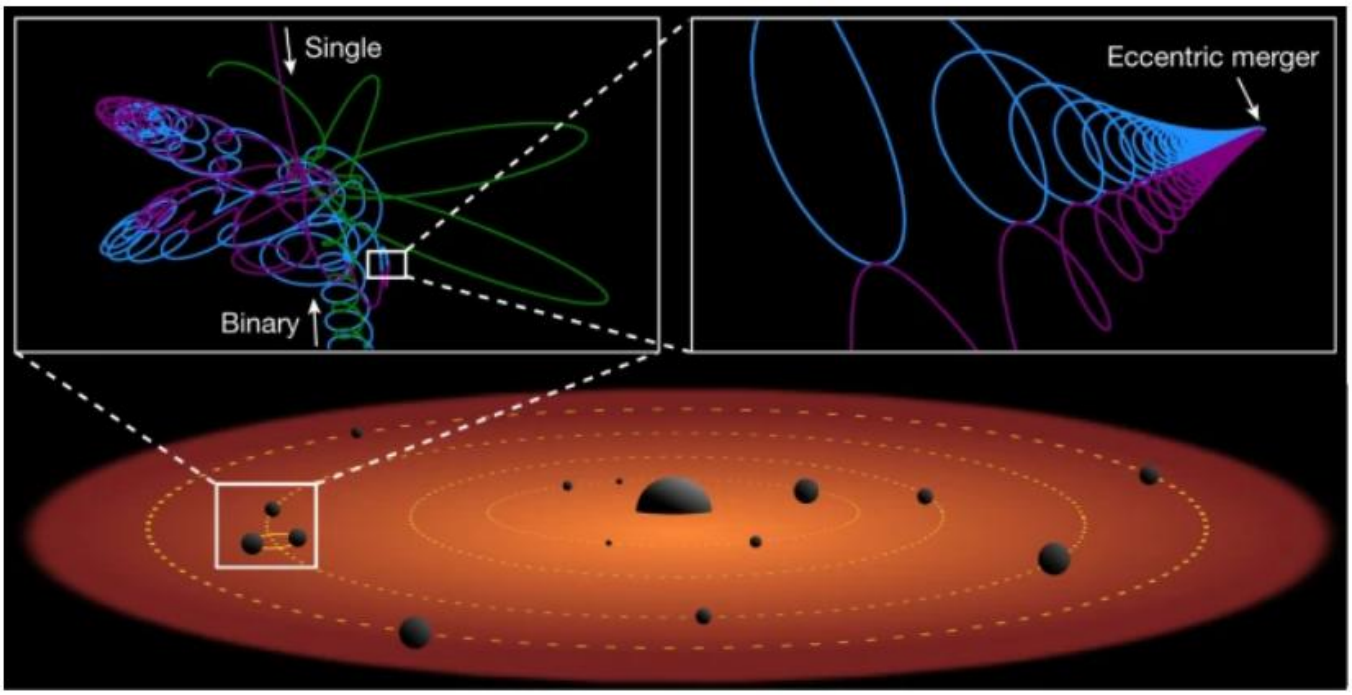

[5]**Ultra-narrow optical linewidths in rare-earth molecular crystals**

稀土分子晶体中的超窄光学线宽

出版信息：Nature, 10 March 2022, VOL 603, ISSUE 7900

作者：Diana Serrano, Senthil Kumar Kuppusamy, Benoît Heinrich, Olaf Fuhr, David Hunger, Mario Ruben & Philippe Goldner

第一作者单位：These authors contributed equally: Diana Serrano, Senthil Kumar Kuppusamy Chimie ParisTech, PSL University, CNRS, Institut de Recherche de Chimie Paris, Paris, France

全文链接：https://www.nature.com/articles/s41586-021-04316-2

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。

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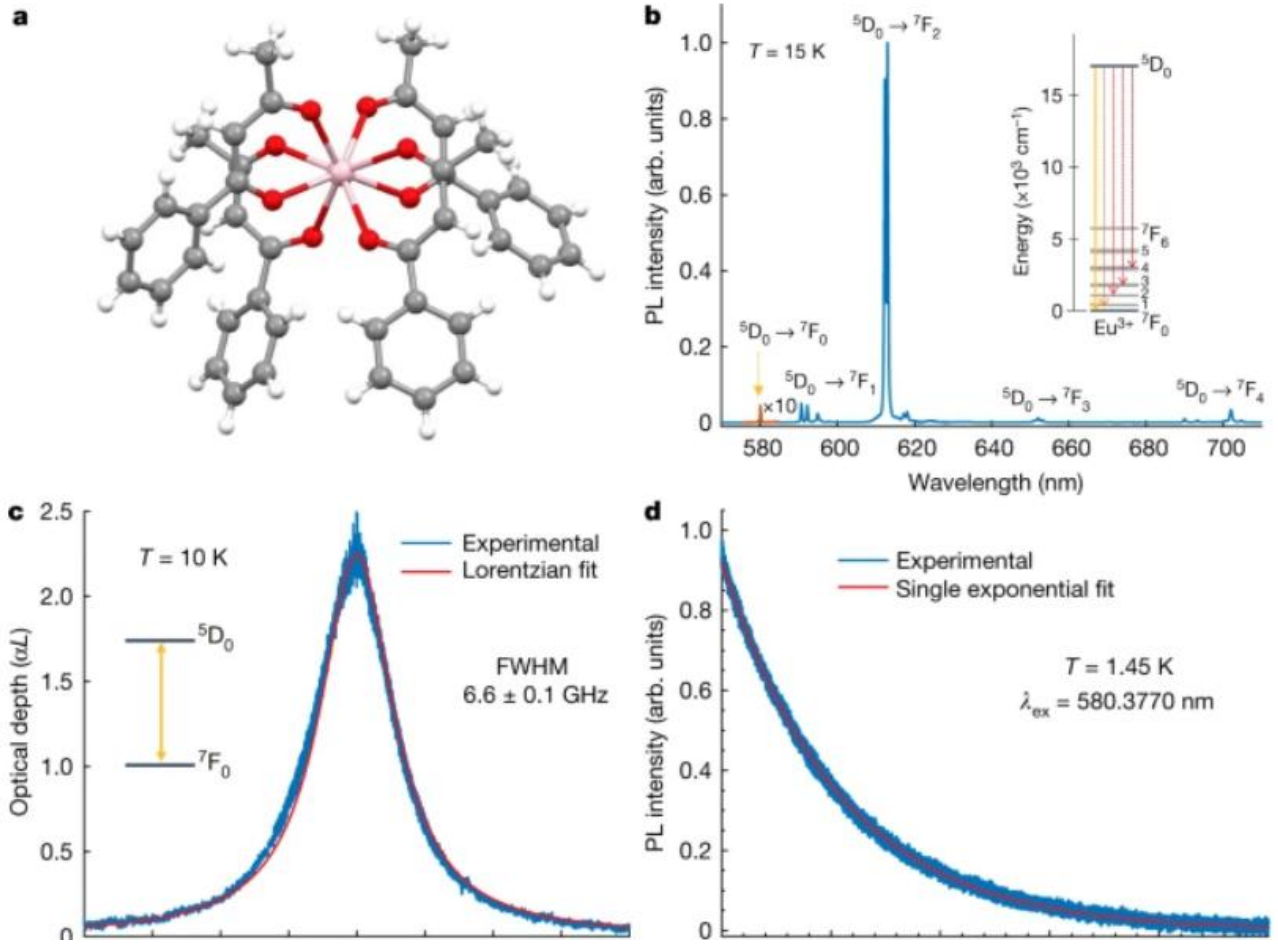

[6]**Structure of the moiré exciton captured by imaging its electron and hole**

电子和空穴成像捕获摩尔激子的结构

出版信息：Nature, 10 March 2022, VOL 603, ISSUE 7900

作者：Ouri Karni, Elyse Barré, , Julien Madéo, Felipe H. da Jornada, Tony F. Heinz & Keshav M. Dani, etc.

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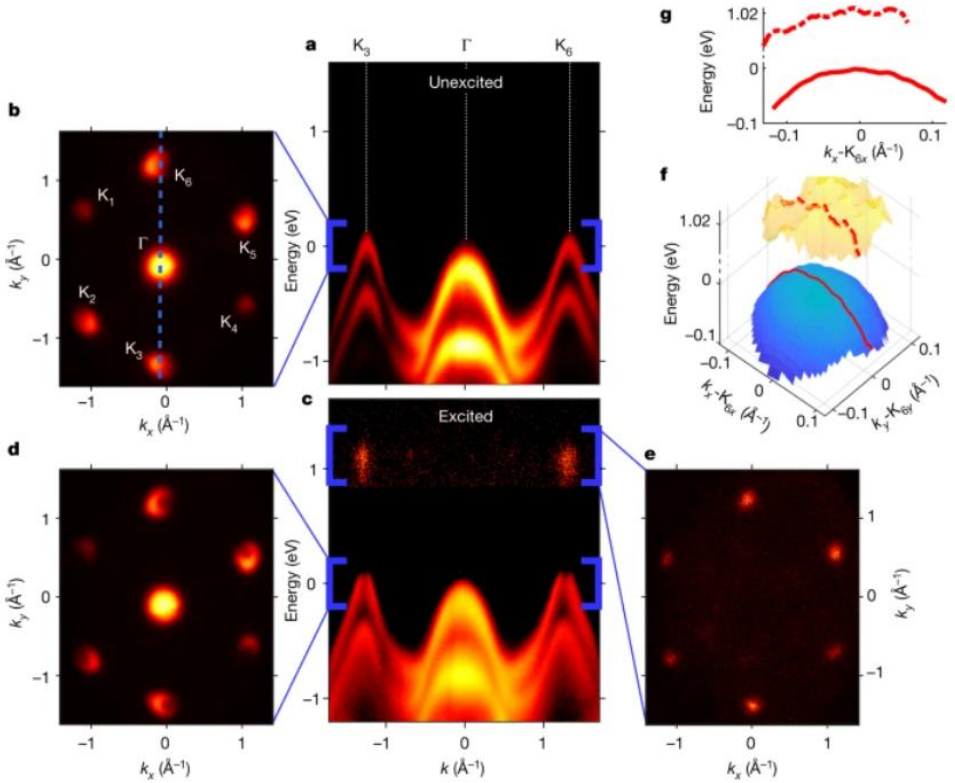
全文链接：https://www.nature.com/articles/s41586-021-04360-y

Abstract: Interlayer excitons (ILXs) — electron–hole pairs bound across two atomically thin layered semiconductors — have emerged as attractive platforms to study exciton condensation, single-photon emission and other quantum information applications. Yet, despite extensive optical spectroscopic investigations, critical information about their size, valley configuration and the influence of the moiré potential remains unknown. Here, in a WSe2/MoS2 heterostructure, we captured images of the time-resolved and momentum-resolved distribution of both of the particles that bind to form the ILX: the electron and the hole. We thereby obtain a direct measurement of both the ILX diameter of around 5.2 nm, comparable with the moiré-unit-cell length of 6.1 nm, and the localization of its centre of mass. Surprisingly, this large ILX is found pinned to a region of only 1.8 nm diameter within the moiré cell, smaller than the size of the exciton itself. This high degree of localization of the ILX is backed by Bethe–Salpeter equation calculations and demonstrates that the ILX can be localized within small moiré unit cells. Unlike large moiré cells, these are uniform over large regions, allowing the formation of extended arrays of localized excitations for quantum technology.

摘要翻译：层间激子（ILXs）——电子空穴对结合在两个原子薄层半导体上——已经成为研究激子凝聚、单光子发射和其他量子信息应用的有吸引力的平台。作者在 WSe2/MoS2 异质结构中，捕获了结合形成 ILX 的两种粒子的时间分辨和动量分辨分布的图像：电子和空穴。他们获得了 ILX 直径约 5.2 纳米的直接测量，以及其质量中心的定位。令人惊讶的是，这个大的 ILX 被发现固定在摩尔细胞内一个直径只有 1.8 纳米的区域，比激子本身的大小还小。这种 ILX 的高度定位得到了贝特-萨尔皮特方程计算的支持，并证明 ILX 可以定位在小的摩尔单元细胞内。与大型的摩尔细胞不同，这些细胞在大区域上是均匀的，这使得量子技术可以形成局部激发的扩展阵列。

文中插图:



[7]**Recovery time of a plasma-wakefield accelerator**

等离子体尾流场加速器的恢复时间

出版信息：Nature, 3 March 2022, VOL 603, ISSUE 7899

作者：R. D’Arcy, J. Chappell, J. Beinortaite, S. Diederichs, G. Boyle, B. Foster, et al.

第一作者单位：Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

全文链接：https://www.nature.com/articles/s41586-021-04348-8

Abstract：The interaction of intense particle bunches with plasma can give rise to plasma wakes capable of sustaining gigavolt-per-metre electric fields, which are orders of magnitude higher than provided by state-of-the-art radio-frequency technology. Plasma wakefields can, therefore, strongly accelerate charged particles and offer the opportunity to reach higher particle energies with smaller and hence more widely available accelerator facilities. However, the luminosity and brilliance demands of high-energy physics and photon science require particle bunches to be accelerated at repetition rates of thousands or even millions per second, which are orders of magnitude higher than demonstrated with plasma-wakefield technology. Here we investigate the upper limit on repetition rates of beam-driven plasma accelerators by measuring the time it takes for the plasma to recover to its initial state after perturbation by a wakefield. The many-nanosecond-level recovery time measured establishes the in-principle attainability of megahertz rates of acceleration in plasmas. The experimental signatures of the perturbation are well described by simulations of a temporally evolving parabolic ion channel, transferring energy from the collapsing wake to the surrounding media. This result establishes that plasma-wakefield modules could be developed as feasible high-repetition-rate energy boosters at current and future particle-physics and photon-science facilities.

摘要翻译：强粒子束与等离子体的相互作用可以产生能够维持每米千兆伏的电场等离子体尾流，这比最先进的射频技术提供的电场高出几个数量级。因此，等离子体尾流场可以强烈地加速带电粒子，并提供了用更小、更广泛使用的加速器设施达到更高粒子能量的机会。然而，高能物理和光子科学对光度和亮度的要求，需要粒子束以每秒数千甚至数百万次的重复率加速，这比等离子体尾流场技术所演示的要高几个数量级。研究组通过测量尾流场扰动后等离子体恢复到初始状态所需的时间，研究了束流驱动等离子体加速器的重复率上限。测量的多纳秒级恢复时间建立了等离子体中兆赫加速率的原理可达性。通过模拟一个时间演化的抛物线离子通道，将能量从坍塌的尾流转移到周围的介质中，研究组很好地描述了微扰的实验特征。研究结果表明，在当前和未来的粒子物理和光子科学设施中，等离子体尾流场模块有望开发为可行的高重复率能量推进器。

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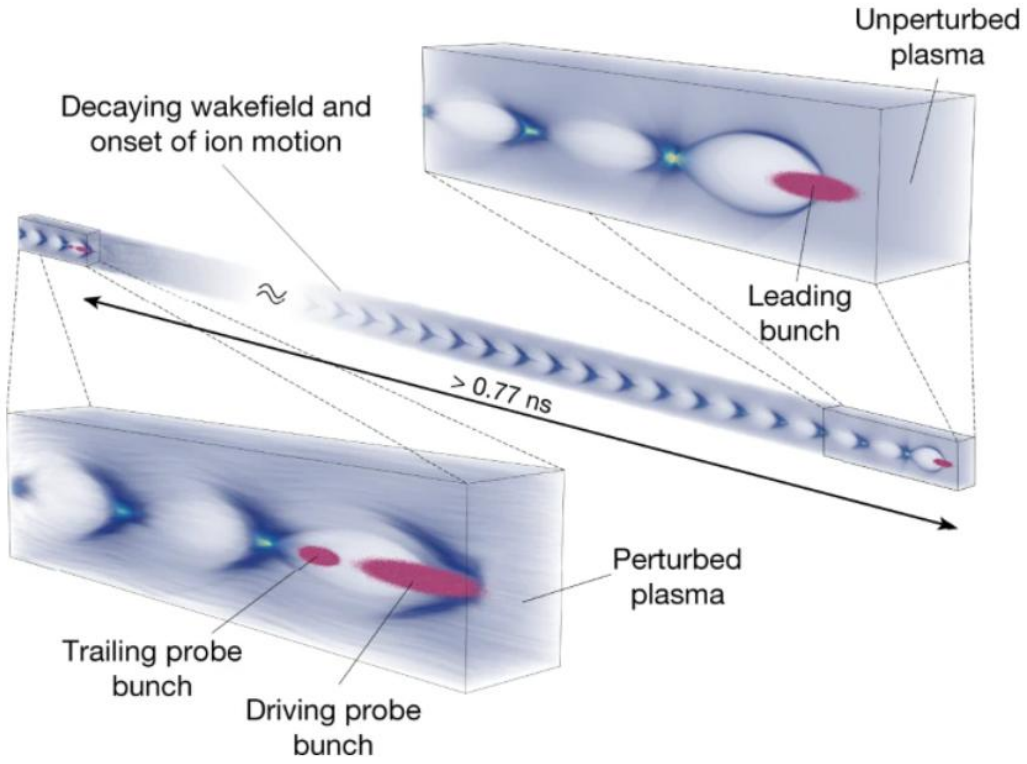

[1]**Compressibility and the equation of state of an optical quantum gas in a box**

盒子中光学量子气体的可压缩性和状态方程

出版信息：Science, 25 MAR 2022, VOLUME 375 ISSUE 6587

作者：ERIK BUSLEY, LEON ESPERT MIRANDA et al.

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全文链接：https://www.science.org/doi/10.1126/science.abm2543

Abstract：We demonstrate a measurement of the compressibility of a two-dimensional quantum gas of light in a box potential and obtain the equation of state for the optical medium. The experiment was carried out in a nanostructured dye-filled optical microcavity. We observed signatures of Bose-Einstein condensation at high phase-space densities in the finite-size system. Upon entering the quantum degenerate regime, the measured density response to an external force sharply increases, hinting at the peculiar prediction of an infinite compressibility of the deeply degenerate Bose gas.

摘要翻译：我们证明了二维光量子气体在位阱中可压缩性的测量，并得到了光学介质的状态方程。实验是在纳米结构的染料填充光学微腔中进行的。我们在有限尺寸的系统中观察到高相空间密度下玻色-爱因斯坦凝聚的特征。在进入量子简并区后，测量到的密度对外力的响应急剧增加，暗示了对深简并玻色气体具有无限压缩性的预测。

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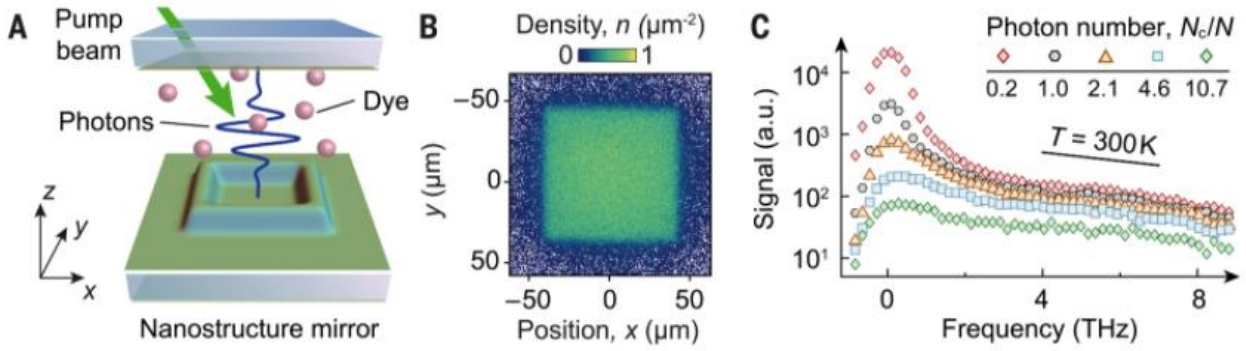

[2]**Relaxor ferroelectric polymer exhibits ultrahigh electromechanical coupling at low electric field**

弛豫铁电聚合物在低电场下表现出超高的机电耦合

出版信息：Science, 25 MAR 2022, VOLUME 375 ISSUE 6587

作者：XIN CHEN, HANCHENG QIN et al.

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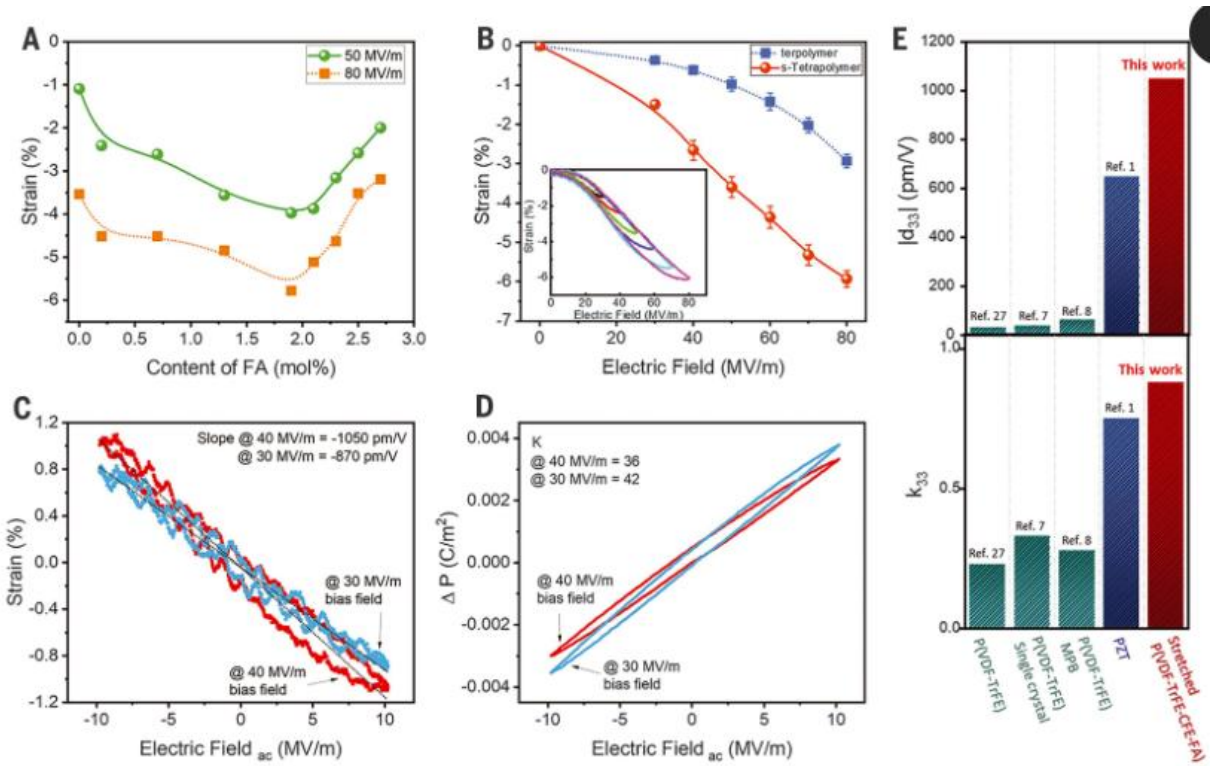
全文链接：https://www.science.org/doi/10.1126/science.abn0936

Abstract：Electromechanical (EM) coupling—the conversion of energy between electric and mechanical forms—in ferroelectrics has been used for a broad range of applications. Ferroelectric polymers have weak EM coupling that severely limits their usefulness for applications. We introduced a small amount of fluorinated alkyne (FA) monomers (<2 mol %) in relaxor ferroelectric poly(vinylidene fluoride-trifluoroethylene-chlorofluoroethylene) (PVDF-TrFE-CFE) terpolymer that markedly enhances the polarization change with strong EM coupling while suppressing other polarization changes that do not contribute to it. Under a low–dc bias field of 40 megavolts per meter, the relaxor tetrapolymer has an EM coupling factor (k33) of 88% and a piezoelectric coefficient (d33) >1000 picometers per volt. These values make this solution-processed polymer competitive with ceramic oxide piezoelectrics, with the potential for use in distinct applications.

摘要翻译：铁电体中的机电（EM）耦合——电能和机械形式之间的能量转换——已被广泛应用。铁电聚合物具有微弱的电磁耦合，这严重限制了它们的应用价值。我们在弛豫铁电聚（偏二氟乙烯-三氟乙烯-氯氟乙烯）（PVDF-TrFE-CFE）三元共聚物中引入了少量氟化炔烃（FA）单体（<2 mol %），显著提高了极化变化具有较强的电磁耦合而抑制其它极化变化。在 40 兆伏/米的低直流偏置电场下，弛豫四聚体的电磁耦合系数（k33）为 88%，压电系数（d33）>为 1000 皮米/伏。这些价值使得这种解决方案处理聚合物与陶瓷氧化物压电具有竞争优势，且有在不同的应用中使用的潜力。

文中插图：



[3]**Frequency-dependent polarization of repeating fast radio bursts—implications for their origin**

极化重复快速无线电脉冲

出版信息：Science，18 MAR 2022,VOLUME 375 ISSUE 6586

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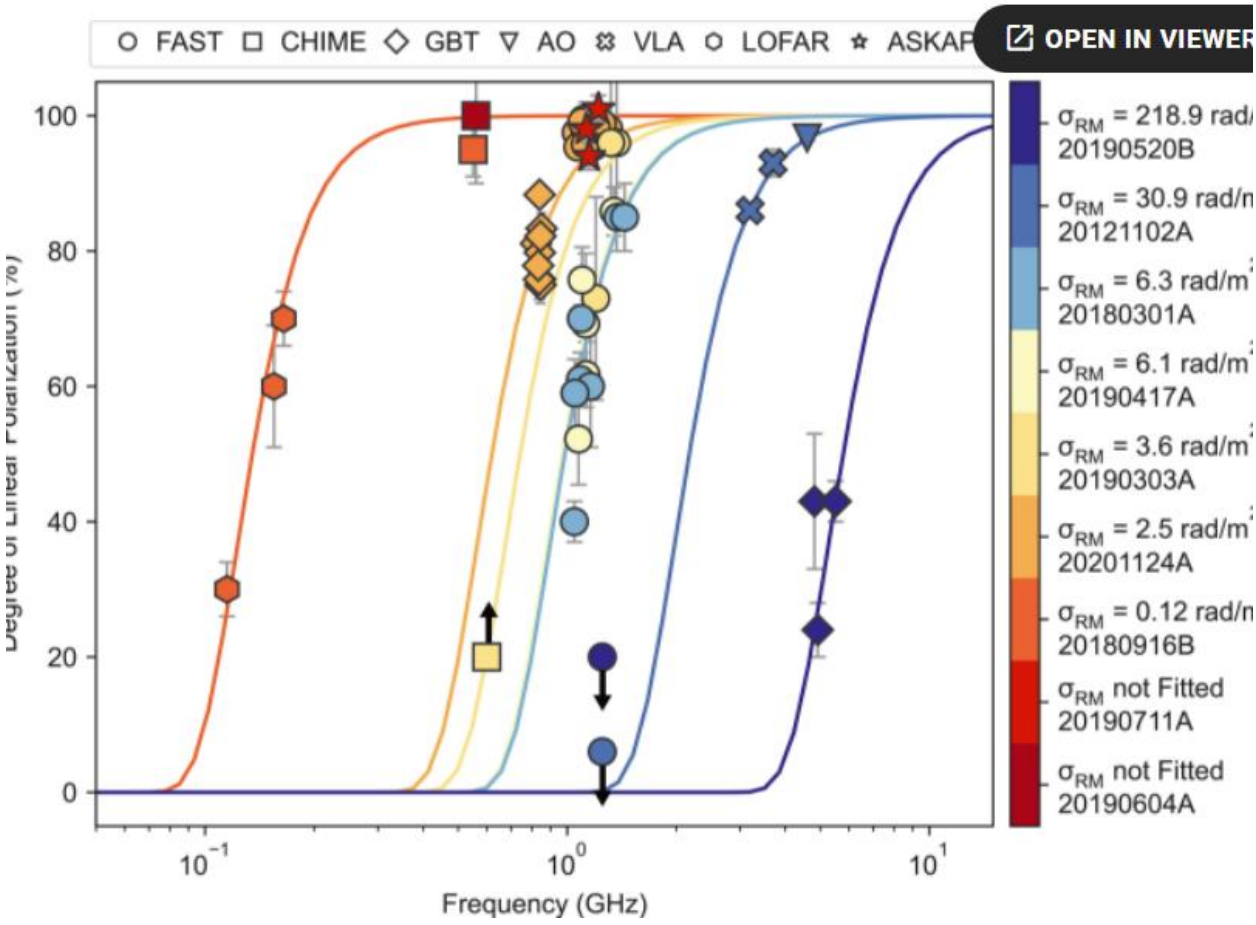
全文链接：https://www.science.org/doi/10.1126/science.abl7759

Abstract： Fast radio bursts (FRBs) are intense, millisecond flashes of radio emission from extragalactic sources of unknown origin. Most FRBs are seen only once, but others repeat at irregular intervals and thereforre can be followed. Feng et al. measured the polarization of five repeating FRBs (see the Perspective by Caleb). They found that each source is polarized at high frequencies but becomes depolarized below a threshold frequency that varies between sources. The authors found that all repeating FRBs are 100% polarized at the source, before the radio waves scatter off complex foreground structures such as supernova remnants. These results constrain theories of the repeating FRB emission mechanism.

摘要翻译：快速射电暴（FRBs）是一种强烈的、毫秒级的、来自未知来源的河外射电发射。大多数快速射电暴只出现一次，但其他快速射电暴以不规则的间隔重复出现，因此可被跟踪。作者测量了 5 个重复 FRB 的偏振。他们发现每个源在高频率下是极化的，但在阈值频率以下就会去极化，阈值频率在不同源之间是不同的。作者发现，在无线电波散射出复杂的前景结构（如超新星遗迹）之前，所有重复的 FRB 在源处都是 100%极化的。这些结果限制了重复 FRB 发射机理的理论。

文中插图：



[4]**Spectroscopy signatures of electron correlations in a trilayer graphene/hBN moiré superlattice**

三层石墨烯超晶格中电子关联的光谱特征

出版信息：Science, 18 MAR 2022,VOLUME 375 ISSUE 6586

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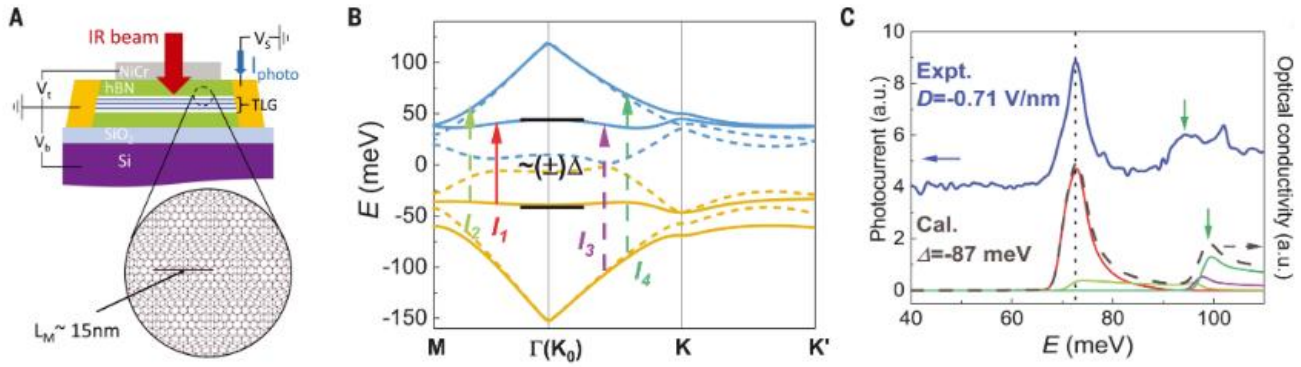
全文链接：https://www.science.org/doi/10.1126/science.abg3036

Abstract： Stacking graphene layers on top of each other in particular configurations can have a profound effect on the electronic properties of the resulting material. Spectroscopic methods can be used to study the band structure, but the addition of top layers to control the carrier density and improve sample properties makes such measurements tricky. Yang et al. overcame these challenges and used infrared spectroscopy in dual-gated trilayer graphene stacked in the so-called ABC configuration and encapsulated in hexagonal boron nitride. The researchers mapped out the band structure features created by the stacking and electron correlations and measured the parameters of the many-body model expected to describe this material. The method may be extended to study other related superlattices.

摘要翻译：石墨烯层在特定结构上相互叠加，会对材料的电子性能产生深远的影响。光谱方法可以用来研究能带结构，但添加顶层来控制载流子密度和改善样品性质使这种测量变得棘手。作者克服了这些挑战，并利用红外光谱技术，将双门控三层石墨烯堆叠在所谓的 ABC 结构中，并封装在六方氮化硼中。研究人员绘制出了由叠加和电子关联产生的能带结构特征，并测量了有望描述这种材料的多体模型的参数。该方法可推广到其他相关超晶格的研究。

文中插图：



[5]**Tracking the sliding of grain boundaries at the atomic scale**

在原子尺度上追踪晶界的滑动

出版信息：Science, 18 MAR 2022,VOLUME 375 ISSUE 6586

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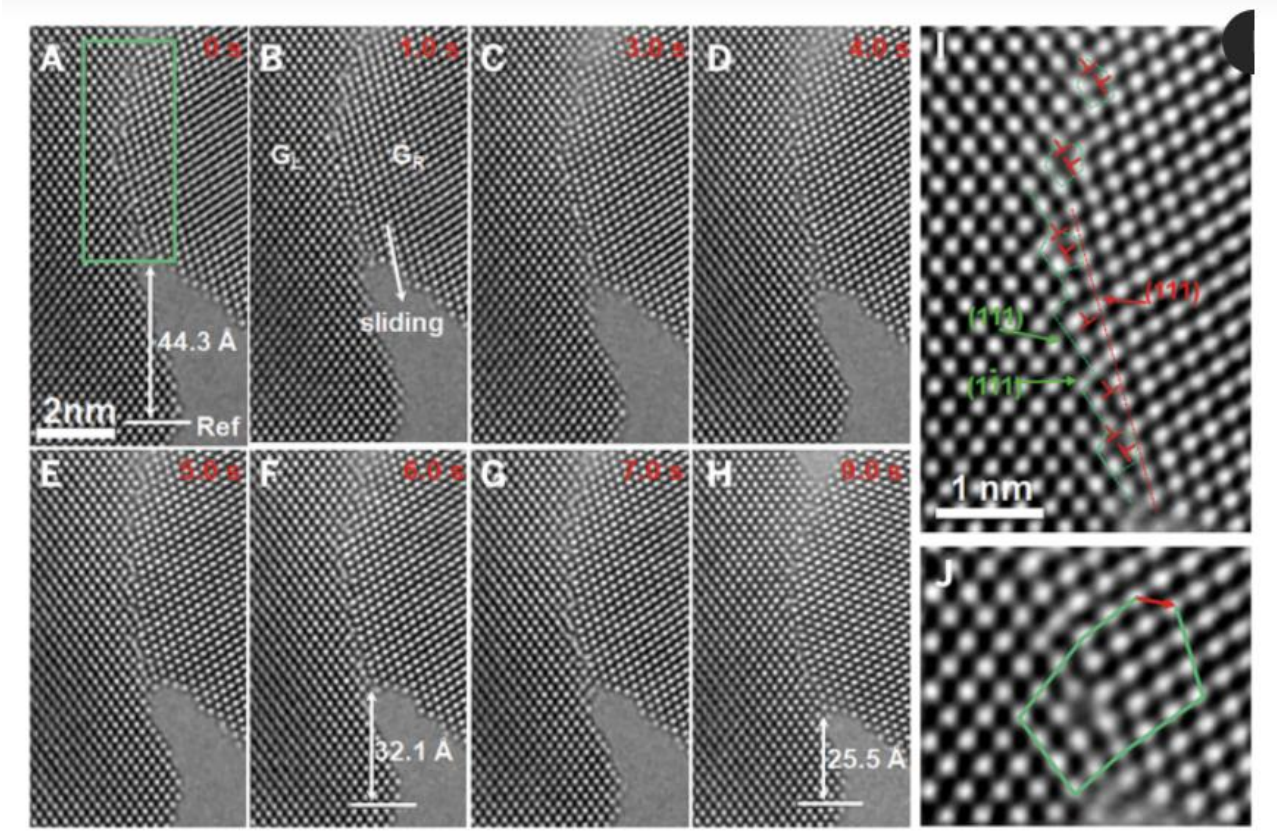
全文链接：https://www.science.org/doi/10.1126/science.abm2612

Abstract： The behavior of grain boundaries in metals during deformation is important because it can dictate the macroscopic behavior. Lihua et al. used aberration-corrected in situ electron microscopy observation of platinum grain boundaries during straining to detail how they evolve. The authors observed grain boundary sliding, which is a well-known and expected mechanism. However, the authors also observed a unexpected mechanism that involves the removal of lattice planes at the grain boundaries. Their observations show the importance of using very-high-resolution microscopy to understand the role of grain boundaries during deformation.

摘要翻译：金属在变形过程中晶界的行为是很重要的，它可以决定宏观行为。作者使用畸变校正的原位电子显微镜观察了应变过程中的铂晶界，详细描述它们是如何进化的。他们观察到晶界滑动，这是一个众所周知和预期的机制。然而，作者也观察到一个意想不到的机制，涉及到晶界晶格平面的移除。他们的观察表明了使用高分辨率显微镜来理解晶界在变形过程中的作用的重要性。

文中插图：



[6]**Frequency multiplication by collective nanoscale spin-wave dynamics**

集体纳米尺度自旋波动力学的倍频

出版信息：Science, 11 MAR 2022, VOL 375, ISSUE 6585

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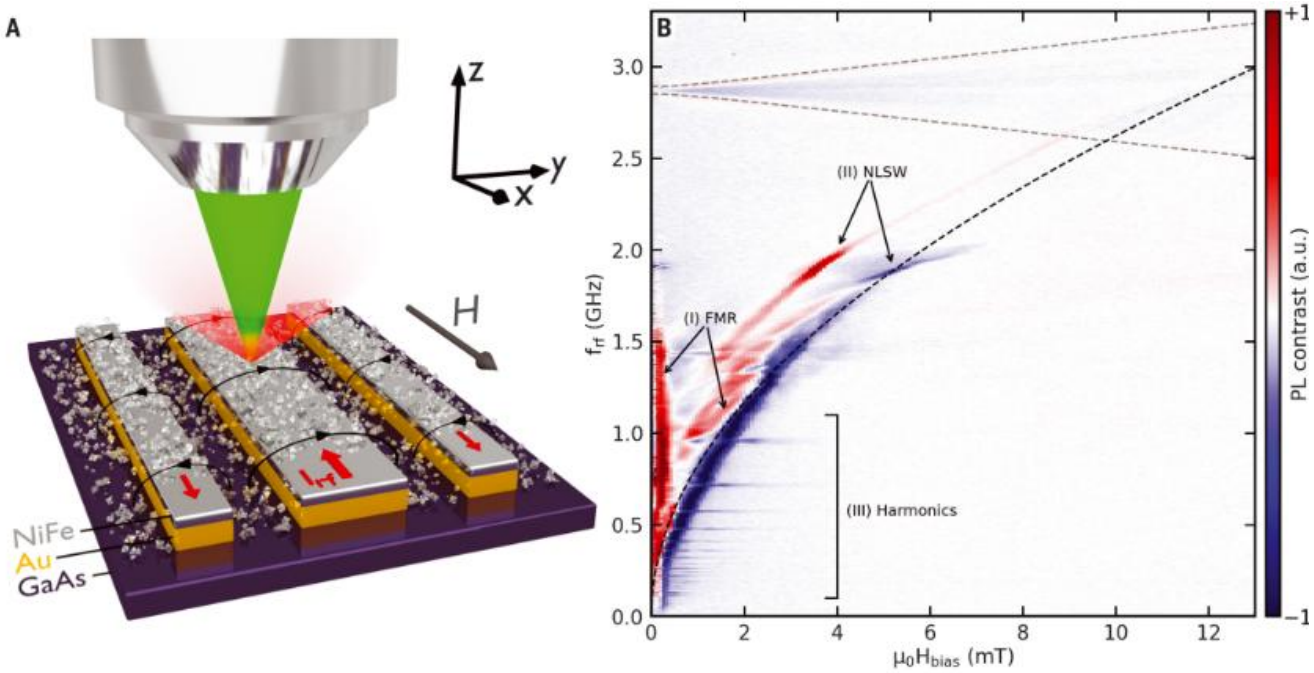
全文链接：https://www.science.org/doi/10.1126/science.abm6044

Abstract： Frequency multiplication is a process in modern electronics in which harmonics of the input frequency are generated in nonlinear electronic circuits. Devices based on the propagation and interaction of spin waves are a promising alternative to conventional electronics. The characteristic frequency of these excitations is in the gigahertz (GHz) range and devices are not readily interfaced with conventional electronics. Here, we locally probe the magnetic excitations in a soft magnetic material by optical methods and show that megahertz-range excitation frequencies cause switching effects on the micrometer scale, leading to phase-locked spin-wave emission in the GHz range. Indeed, the frequency multiplication process inside the magnetic medium covers six octaves and opens exciting perspectives for spintronic applications, such as all-magnetic mixers or on-chip GHz sources.

摘要翻译：倍频是现代电子学中输入频率的谐波在非线性电子电路中产生的过程。基于自旋波传播和相互作用的器件是一种很有前途的传统电子器件的替代品。这些激励的特征频率在千兆赫（GHz）范围内，设备不易与传统电子设备连接。研究组通过光学方法局部探测软磁材料中的磁激励，并表明兆赫范围的激励频率会在微米尺度上产生开关效应，从而在 GHz 范围内产生锁相自旋波发射。事实上，磁介质中的倍频过程覆盖了六个倍频程，这为自旋电子学应用开辟了光明的前景，例如全磁混频器或芯片上的 GHz 源。

文中插图：



[7]**A synthetic monopole source of Kalb-Ramond field in diamond**

金刚石中观察到 Kalb-Ramond 场张量磁单极子

出版信息：Science, 4 MAR 2022, VOL 375, ISSUE 6584

作 者： MO CHEN, CHANGHAO LI, GIANDOMENICO PALUMBO, YAN-QING ZHU , NATHAN GOLDMAN , AND PAOLA CAPPELLARO

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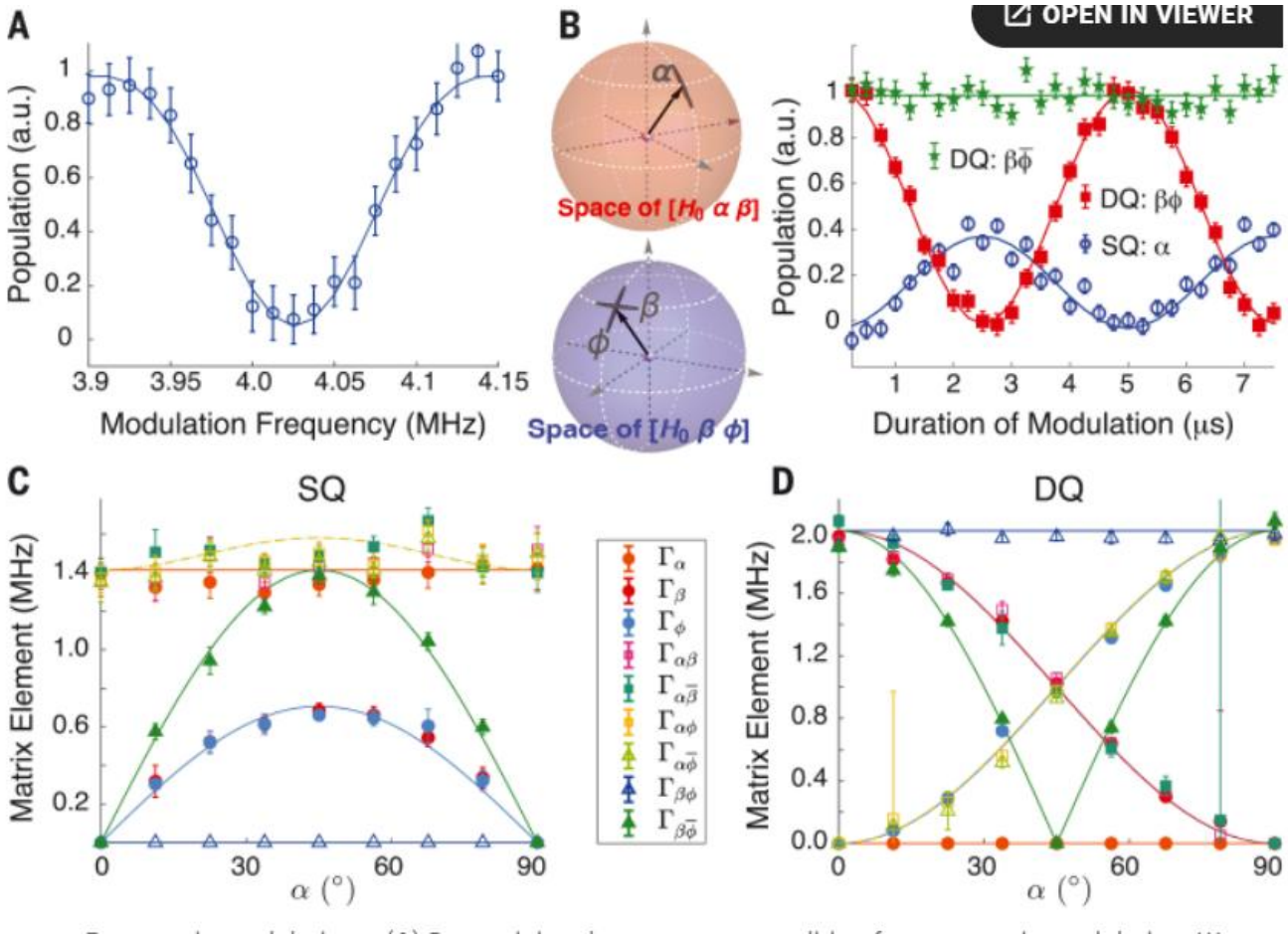
全文链接：https://www.science.org/doi/10.1126/science.abe6437

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：



[8]**Topological magnon band structure of emergent Landau levels in a skyrmion lattice**

斯格明子晶格的拓扑磁振子带结构

出版信息：Science, 4 MAR 2022, VOL 375, ISSUE 6584

作者：T. WEBER, D. M. FOBES, J. WAIZNERP. STEFFENS et al.

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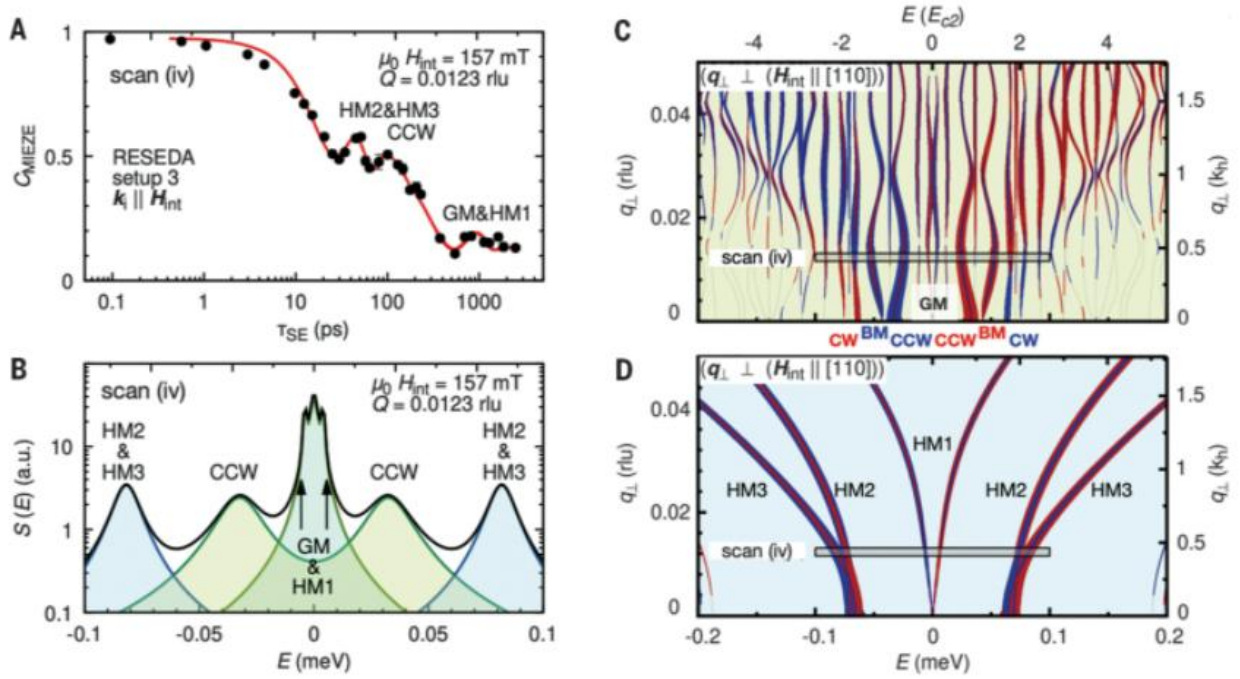
全文链接：https://www.science.org/doi/10.1126/science.abe4441

Abstract：The motion of a spin excitation across topologically nontrivial magnetic order exhibits a deflection that is analogous to the effect of the Lorentz force on an electrically charged particle in an orbital magnetic field. We used polarized inelastic neutron scattering to investigate the propagation of magnons (i.e., bosonic collective spin excitations) in a lattice of skyrmion tubes in manganese silicide. For wave vectors perpendicular to the skyrmion tubes, the magnon spectra are consistent with the formation of finely spaced emergent Landau levels that are characteristic of the fictitious magnetic field used to account for the nontrivial topological winding of the skyrmion lattice. This provides evidence of a topological magnon band structure in reciprocal space, which is borne out of the nontrivial real-space topology of a magnetic order.

摘要翻译：自旋激发在拓扑非平凡磁序上的运动显示出一种偏转，类似于洛伦兹力对轨道磁场中带电粒子的影响。我们使用极化非弹性中子散射来研究硅化锰材料中的斯格明子管晶格中磁振子（即玻色子集体自旋激发）的传播。对于垂直于斯格明子晶格的波矢，磁振子谱与精细间隔的出射朗道能级的形成一致，这是用来解释斯格明子晶格非琐细拓扑缠绕的虚拟磁场的特征。这证明了在倒易空间中存在拓扑磁振子能带结构，这是由磁序的非平凡实空间拓扑产生的。

文中插图：



[9]**Breakdown of topological protection by cavity vacuum fields in the integer quantum Hall effect**

整数量子霍尔效应中腔真空场对拓扑保护的破坏

出版信息：Science, 4 MAR 2022, VOL 375, ISSUE 6584

作者：FELICE APPUGLIESE, JOSEFINE ENKNER, GIAN LORENZO PARAVICINI-BAGLIANI et al.

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全文链接：https://www.science.org/doi/10.1126/science.abl5818

Abstract： The prospect of controlling the electronic properties of materials via the vacuum fields of cavity electromagnetic resonators is emerging as one of the frontiers of condensed matter physics. We found that the enhancement of vacuum field fluctuations in subwavelength split-ring resonators strongly affects one of the most paradigmatic quantum protectorates, the quantum Hall electron transport in high-mobility two-dimensional electron gases. The observed breakdown of the topological protection of the integer quantum Hall effect is interpreted in terms of a long-range cavity-mediated electron hopping where the anti-resonant terms of the light-matter coupling Hamiltonian develop into a finite resistivity induced by the vacuum fluctuations. Our experimental platform can be used for any two-dimensional material and provides a route to manipulate electron phases in matter by means of vacuum-field engineering.

摘要翻译：利用空腔电磁谐振器的真空场来控制材料的电子性质是凝聚态物理研究的前沿之一。我们发现，亚波长分裂环谐振腔中真空场涨落的增强极大影响了最典型的量子保护者之一，即高迁移率二维电子气体中的量子霍尔电子输运。用长空腔介导的电子跳变解释了观测到的整数量子霍尔效应拓扑保护失效，在此过程中，光物质耦合哈密顿量的反共振项在真空涨落诱导下发展为有限电阻率。我们的实验平台可用于任何二维材料，为利用真空场工程来操纵物质中的电子相提供了途径。

文中插图：