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物理学 8 月 Science 论文

[1]Observation of a continuous time crystal

连续时间晶体的首次观察

出版信息：Science, 5 AUG 2022, VOL 377, ISSUE 6606

作者：PHATTHAMON KONGKHAMBUT, JIM SKULTE, LUDWIG MATHEY, JAYSON G. COSME, ANDREAS HEMMERICH, AND HANS KESSLE

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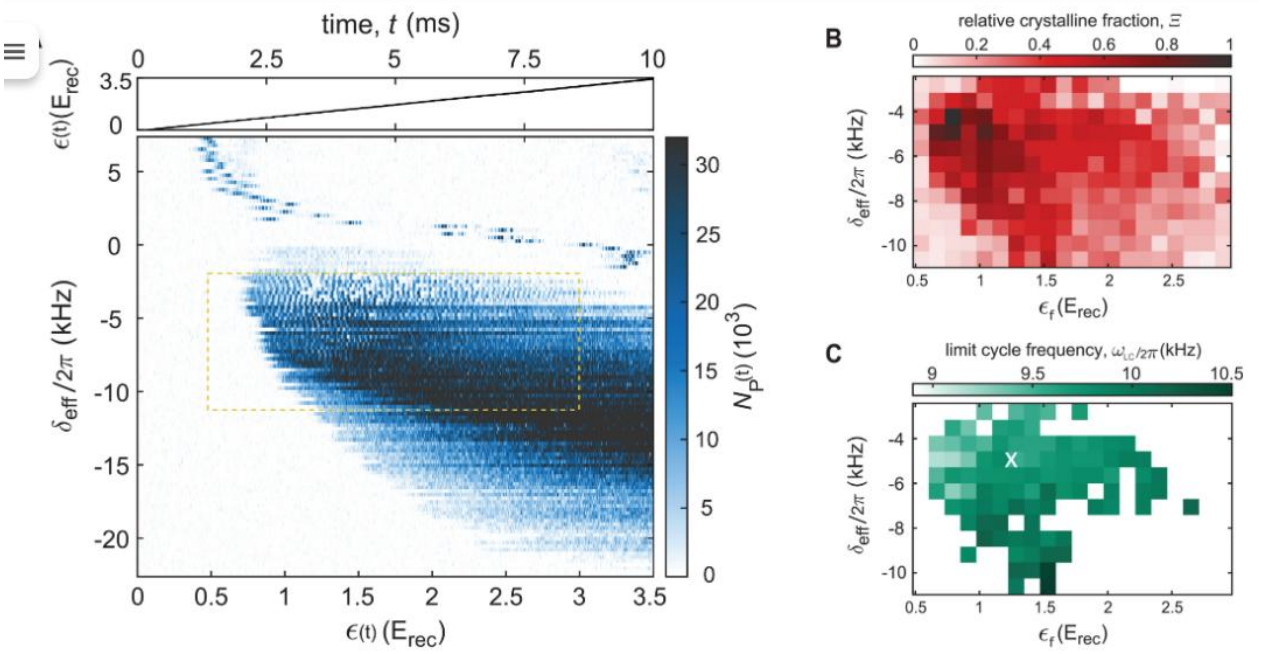
全文链接：https://www.science.org/doi/10.1126/science.abo3382

Abstract： Time crystals are classified as discrete or continuous depending on whether they spontaneously break discrete or continuous time translation symmetry. Although discrete time crystals have been extensively studied in periodically driven systems, the experimental realization of a continuous time crystal is still pending. We report the observation of a limit cycle phase in a continuously pumped dissipative atom-cavity system that is characterized by emergent oscillations in the intracavity photon number. The phase of the oscillation was found to be random for different realizations, and hence, this dynamical many-body state breaks continuous time translation symmetry spontaneously. Furthermore, the observed limit cycles are robust against temporal perturbations and therefore demonstrate the realization of a continuous time crystal.

摘要翻译：时间晶体分为离散时间晶体或连续时间晶体，这取决于其是否自发打破离散时间平移对称性或连续时间平移对称性。虽然离散时间晶体已在周期驱动系统中进行了广泛研究，但连续时间晶体的实验实现仍悬而未决。研究组报道了在连续泵浦的耗散原子腔系统中观察到一个极限循环相位，其特征是内腔光子数中的涌现振荡。振荡相位对于不同的实现是随机的，因此，这种动态多体状态自发打破了连续时间平移对称性。此外，观测到的极限循环对时间扰动具有鲁棒性，因此证明了连续时间晶体的实现。

文中插图：



[2]

Dynamics of active liquid interfaces

活性液体界面动力学

出版信息：Science, 12 AUG 2022, VOL 377, ISSUE 6607

作者：RAYMOND ADKINSITAMAR KOLVIN, ZHIHONG YOU, SVEN WITTHAUS, M. CRISTINA MARCHETTI AND ZVONIMIR DOGIC

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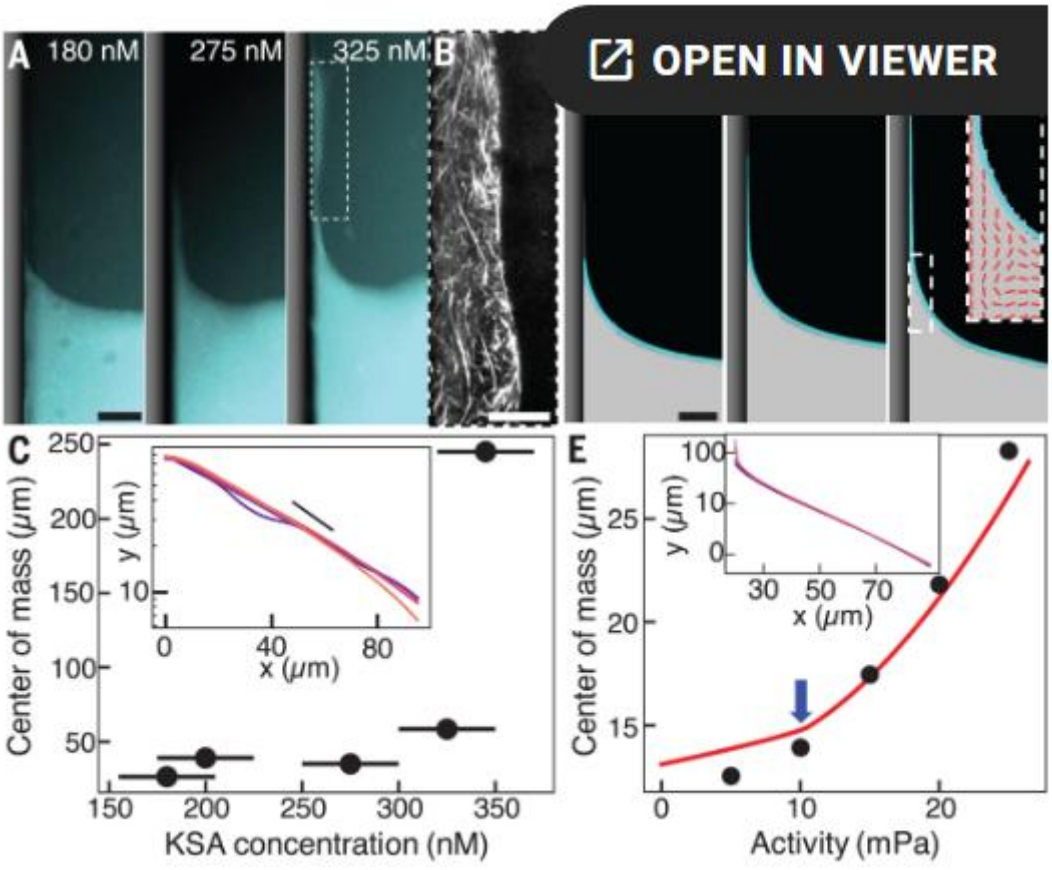
全文链接：https://www.science.org/doi/10.1126/science.abo5423

Abstract：Incompatible liquids such as oil and water will phase separate with low interfacial tension. Adkins et al. investigated the dynamics of a one-dimensional interface separating an active nematic phase with a passive isotropic phase. They found a rich behavior of fluctuating interfaces in which the phase-separating fluids could form active emulsions that did not coarsen and in which droplets formed spontaneously. Macroscopic interfaces can also displayed propagating waves with a characteristic wave number and speed. Furthermore, the activity of one of the fluids, in which the addition of energy drove the ordering of that fluid, was able to modify the wetting transitions. The authors also observed active wetting of a solid surface whereby active extensile stresses parallel to the surface drove the fluid to climb a solid wall against gravity.

摘要翻译：不相容的液体，如油和水，会以较低的界面张力相分离。作者研究了将主动向列相与被动各向同性相分离的一维界面的动力学。他们发现了波动界面的丰富行为，在这种界面中，相分离流体可以形成活性乳剂，而不会变浓，液滴会自发形成。宏观界面还可以显示具有特征波数和波速的波的传播。此外，其中一种流体的活动，其中能量的添加驱动了该流体的顺序，能够修改润湿转变。作者还观察到固体表面的主动润湿，即与表面平行的主动伸展应力驱动流体逆重力爬上固体壁。

文中插图：



[3]

Proton-coupled energy transfer in molecular triads

分子三联体中的质子耦合能量转移

出版信息：Science, 12 AUG 2022, VOL 377, ISSUE 6607

作者：BELINDA PETTERSSON RIMGARD, ZHEN TAO, GIOVANNY A. PARADA, LAURA F. COTTERSHARON HAMMES-SCHIFFER, JAMES M. MAYER, AND LEIF HAMMARSTROM

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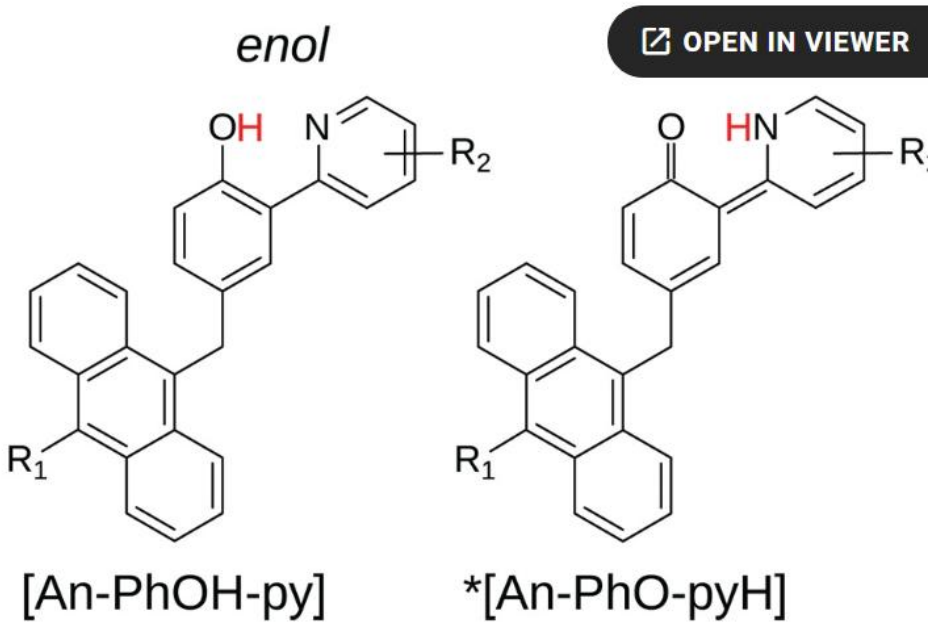
全文链接：https://www.nature.com/articles/s41586-022-04955-z

Abstract：Proton-coupled electron transfer (PCET) reactions have generated considerable interest because of their essential role in various energy conversion processes in biology. Pettersson Rimgard et al. report another type of mechanism denoted as proton-coupled energy transfer (PCEnT), in which proton transfer is coupled to electronic excitation energy transfer. PCEnT was experimentally detected when analyzing the excited state behavior for a series of anthracene-phenol-pyridine trimers in low-temperature conditions, where PCET is thermodynamically hindered. Theoretical calculations showed that the observed PCEnT is a non-adiabatic singlet-singlet energy transfer coupled to proton tunneling, which, unlike PCET, occurs with no charge transfer between donor and acceptor. PCEnT is potentially important for light-activated chemistry, photonic materials, and photobiology, but it has yet to be identified for natural systems.

摘要翻译：质子耦合电子转移（PCET）反应因其在生物学中各种能量转换过程中的重要作用而引起广泛关注。作者报告了另一种叫作质子耦合能量转移（PCEnT）的机制，其中质子转移与电子激发能量转移相耦合。在低温条件下，当 PCET 受到热力学阻碍时，作者通过实验检测了一系列蒽-酚-吡啶三聚体的激发态行为。理论计算表明，观察到的 PCEnT 是一个非绝热的单重态-单重态能量转移耦合到质子隧穿，不同于 PCET，它发生在施主和受主之间且没有电荷转移。PCEnT 在光激活化学、光子材料和光生物学方面具有潜在的重要意义，但在自然系统中尚未被确定。

文中插图：

	R_1	R_2
1	CN	4-Me
2	CN	4-OMe
3	CN	4-NMe_2
4	CN	4-CN
5	H	4-Me
6	H	H
7	H	4-CF_3
8	H	6-CF_3



[4]

Cavity-mediated electron-photon pairs

腔介导的电子-光子对

出版信息：Science, 12 AUG 2022, VOL 377, ISSUE 6607

作者：ARMIN FEIST, GUANHAO HUANG, GERMAINE AREND, YUJIA YANG, HUGO LOURENÇO-MARTINS, CLAUS ROPERS, etc.

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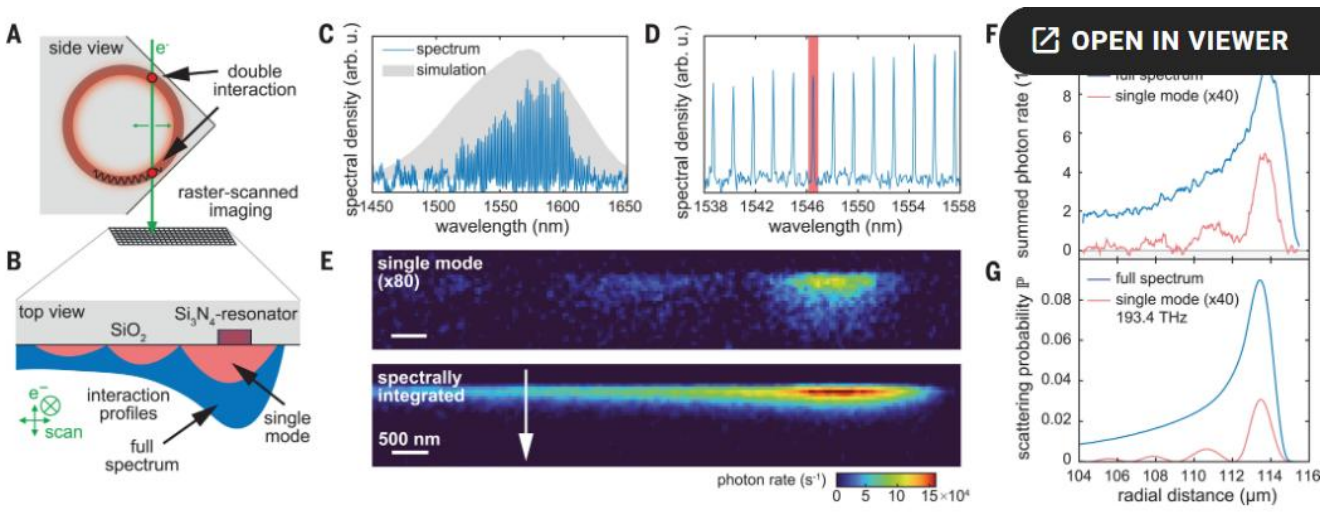
全文链接：https://www.science.org/doi/10.1126/science.abo5037

Abstract：The interaction of electron beams with cavities and resonant structures represents a universal scheme for generating electromagnetic radiation. Feist et al. fabricated structures with phase-matched interactions between free electrons and the vacuum cavity field of a photonic chip-based microresonator. As the electrons passed near the resonator, coupling between them and the vacuum field resulted in the spontaneous generation of photons within the cavity. Because the electron-photon pairs are correlated, they should be a useful source for the development of free-electron quantum optics providing enhanced imaging and sensing capabilities.

摘要翻译：电子束与空腔和共振结构的相互作用代表了产生电磁辐射的通用方案。Feist 等人在基于光子芯片的微谐振腔中制造了自由电子与真空腔场相匹配的相互作用结构。当电子通过谐振腔附近时，它们与真空场之间的耦合导致光子在腔内自发产生。由于电子-光子对是相关的，它们应该是自由电子量子光学发展的一个有用的来源，提供增强的成像和传感能力。

文中插图：



[5]

Tweezer-programmable 2D quantum walks in a Hubbard-regime lattice

在哈伯德区晶格中的镊子可编程二维量子行走

出版信息：Science, 12 AUG 2022, VOL 377, ISSUE 6608

作者：AARON W. YOUNG, WILLIAM J. ECKNER, NATHAN SCHINE et al.

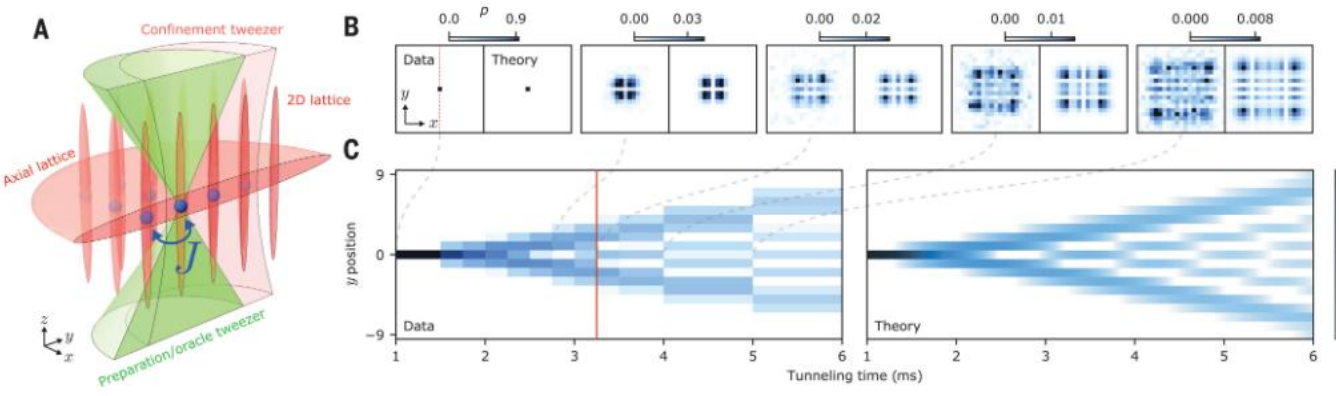
第一作者单位：

全文链接：https://www.science.org/doi/10.1126/science.abo0608

Abstract：Quantum walks provide a framework for designing quantum algorithms that is both intuitive and universal. To leverage the computational power of these walks, it is important to be able to programmably modify the graph a walker traverses while maintaining coherence. We do this by combining the fast, programmable control provided by optical tweezers with the scalable, homogeneous environment of an optical lattice. With these tools we study continuous-time quantum walks of single atoms on a square lattice and perform proof-of-principle demonstrations of spatial search with these walks. When scaled to more particles, the capabilities demonstrated can be extended to study a variety of problems in quantum information science, including performing more effective versions of spatial search using a larger graph with increased connectivity.

摘要翻译：量子行走为设计量子算法提供了一个既直观又通用的框架。为了利用这些量子行走的计算能力，能够以编程的方式修改行走产生的图像的同时保持一致性，就变得尤为重要。我们通过将光镊提供的快速、可编程控制与可伸缩、均匀的光学晶格环境相结合来实现这一点。利用这些工具，我们研究了单原子在正方形晶格上的连续时间量子行走，并利用这些行走执行空间搜索的原理证明演示。当扩展到更多的粒子时，展示的能力可以扩展到研究量子信息科学中的许多问题，包括使用更大的、连接增加的图像来执行更有效的空间检索。

文中插图：



[6]

Tunable light-induced dipole-dipole interaction between optically levitated nanoparticles

光学悬浮纳米粒子间的可调光致偶极-偶极相互作用

出版信息：Science, 26 AUG 2022, VOL 377, ISSUE 6609

作者：JAKOB RIESER, MARIO A. CIAMPINI, HENNING RUDOLPH, NIKOLAI KIESEL, KLAUS HORNBERGER, BENJAMIN A. STICKLER, ET AL.

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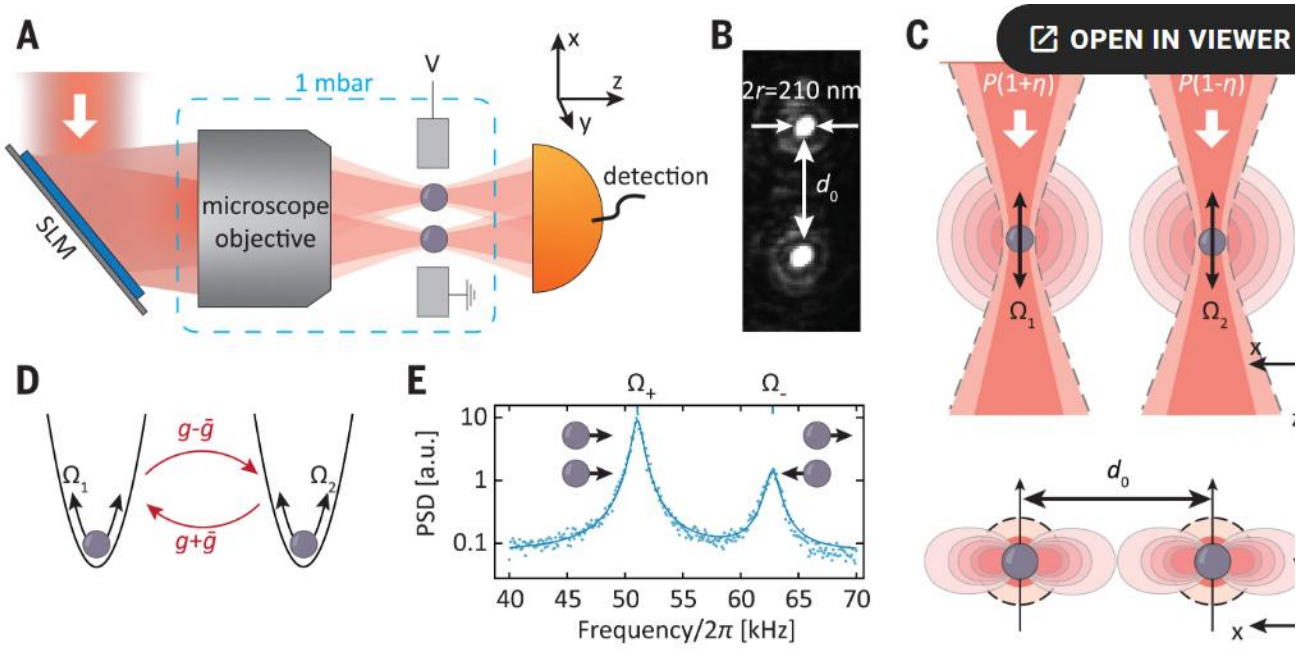
全文链接：https://www.science.org/doi/10.1126/science.abp9941

Abstract： Arrays of optically trapped nanoparticles have emerged as a platform for the study of complex nonequilibrium phenomena. Analogous to atomic many-body systems, one of the crucial ingredients is the ability to precisely control the interactions between particles. However, the optical interactions studied thus far only provide conservative optical binding forces of limited tunability. In this work, we exploit the phase coherence between the optical fields that drive the light-induced dipole-dipole interaction to couple two nanoparticles. In addition, we effectively switch off the optical interaction and observe electrostatic coupling between charged particles. Our results provide a route to developing fully programmable many-body systems of interacting nanoparticles with tunable nonreciprocal interactions, which are instrumental for exploring entanglement and topological phases in arrays of levitated nanoparticles.

摘要翻译：光学捕获纳米粒子阵列已成为研究复杂非平衡现象的平台。与原子多体系统类似，关键要素之一是精确控制粒子间相互作用的能力。然而，迄今为止研究的光学相互作用仅提供有限可调的保守光学结合力。在这项工作中，研究组利用了驱动光诱导偶极-偶极相互作用的光场间相位相干性来耦合两个纳米粒子。此外，他们还有效地关闭了光学相互作用，并观察到带电粒子之间的静电耦合。该研究结果为开发具有可调非互易相互作用的互动纳米粒子完全可编程多体系统提供了一条途径，这有助于探索悬浮纳米粒子阵列中的纠缠和拓扑相。

文中插图：



[7]

Resonant metasurfaces for generating complex quantum states

产生复杂量子态的共振超表面

出版信息：Science, 26 AUG 2022, VOL 377, ISSUE 6609

作者：TOMÁS SANTIAGO-CRUZ, SYLVAIN D. GENNARO, OLEG MITROFANOV, SADHVIKAS ADDAMANE, JOHN RENO, IGAL BRENER, ET AL.

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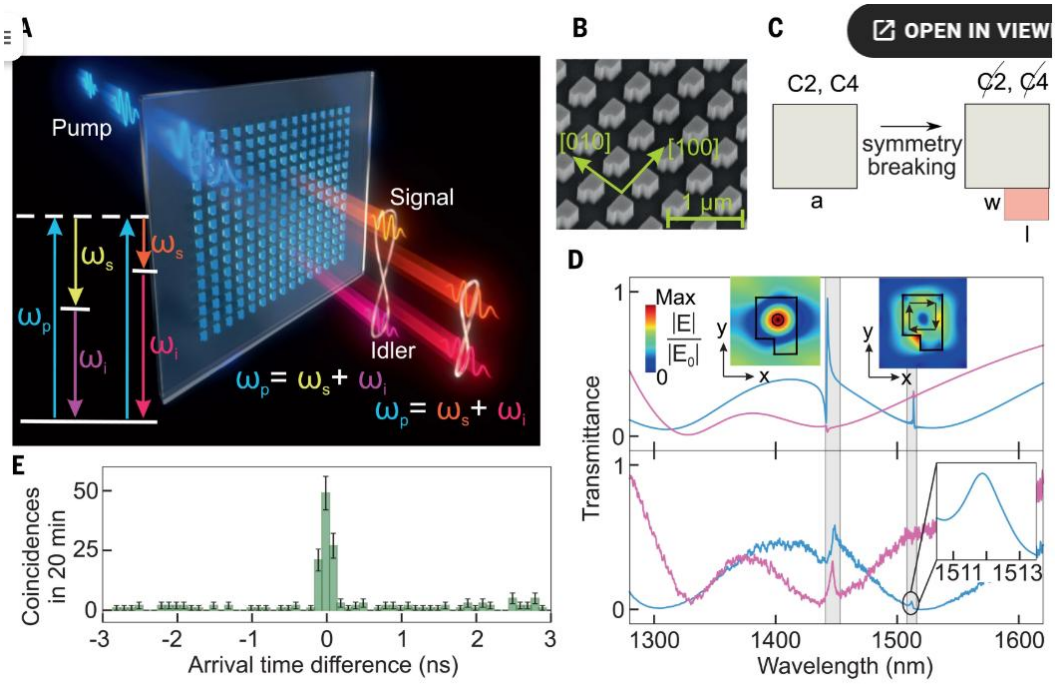
全文链接：https://www.science.org/doi/10.1126/science.abq8684

Abstract：Quantum state engineering, the cornerstone of quantum photonic technologies, mainly relies on spontaneous parametric downconversion and four-wave mixing, where one or two pump photons spontaneously decay into a photon pair. Both of these nonlinear effects require momentum conservation for the participating photons, which strongly limits the versatility of the resulting quantum states. Nonlinear metasurfaces have subwavelength thickness and allow the relaxation of this constraint; when combined with resonances, they greatly expand the possibilities of quantum state engineering. Here, we generated entangled photons via spontaneous parametric downconversion in semiconductor metasurfaces with high‐quality factor, quasi-bound state in the continuum resonances. By enhancing the quantum vacuum field, our metasurfaces boost the emission of nondegenerate entangled photons within multiple narrow resonance bands and over a wide spectral range. A single resonance or several resonances in the same sample, pumped at multiple wavelengths, can generate multifrequency quantum states, including cluster states. These features reveal metasurfaces as versatile sources of complex states for quantum information.

摘要翻译：量子态工程是量子光子技术的基石，主要依赖于自发参数下转换和四波混频，其中一个或两个泵浦光子自发衰减为光子对。这两种非线性效应都需要参与光子的动量守恒，这严重限制了所产生量子态的通用性。非线性超表面具有亚波长厚度，放宽了这种限制；当与共振结合时，非线性超表面极大地扩展了量子态工程的可能性。研究组在具有连续共振高质量因子、准束缚态的半导体超表面，通过自发参量下转换产生纠缠光子。通过增强量子真空场，该超表面在多个窄共振带和宽光谱范围内增强了非简并纠缠光子的发射。在多个波长下泵浦的同一样品中，单个共振或多个共振可以产生多频量子态，包括簇态。这些特征揭示了超表面可作为量子信息复杂状态的通用来源。

文中插图：



[8]

Massively degenerate coherent perfect absorber for arbitrary wavefronts

任意波前的大规模简并相干完美吸收体

出版信息：Science, 26 AUG 2022, VOL 377, ISSUE 6609

作者：YEVGENY SLOBODKIN, GIL WEINBERG, HELMUT HÖRNER, KEVIN PICHLER, STEFAN ROTTER AND ORI KATZ

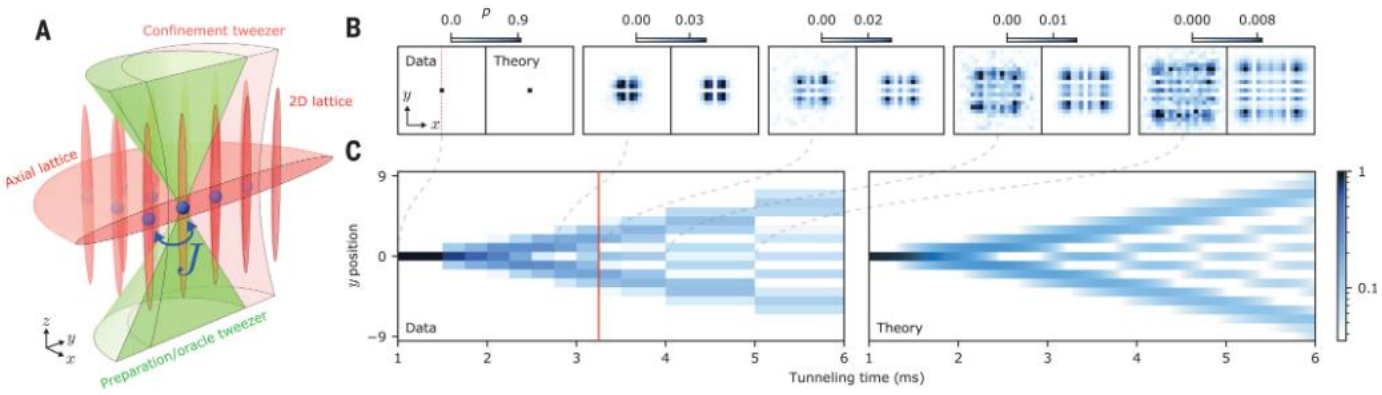
第一作者单位：Applied Physics Department, The Hebrew University of Jerusalem, Jerusalem 9190401, Israel.

全文链接：https://www.science.org/doi/10.1126/science.abq8103

Abstract：One of the key insights of non-Hermitian photonics is that well-established concepts such as the laser can be operated in reverse to realize a coherent perfect absorber (CPA). Although conceptually appealing, such CPAs are limited so far to a single, judiciously shaped wavefront or mode. Here, we demonstrate how this limitation can be overcome by time-reversing a degenerate cavity laser based on a unique cavity that self-images any incident light field onto itself. Placing a weak, critically coupled absorber into this cavity, any incoming wavefront, even a complex and dynamically varying speckle pattern, is absorbed with close to perfect efficiency in a massively parallel interference process. These characteristics open up interesting new possibilities for applications in light harvesting, energy delivery, light control, and imaging.

摘要翻译：非厄米光子学的一个关键见解是，诸如激光器之类的成熟概念可以反向操作以实现相干完美吸收体（CPA）。尽管在概念上很吸引人，但迄今为止，此类 CPA 仅限于单一的、形状合理的波前或模式。研究组演示了如何通过时间反转简并腔激光器来克服这一限制，该激光器基于一个独特的腔，它可以自我成像任何入射光场。将一个弱的、临界耦合的吸收体放置在该腔中，任何入射波前（即使是一个复杂的、动态变化的散斑图案）在大规模平行干涉过程中都以接近完美的效率被吸收。这些特性为光采集、能量传输、光控制和成像等领域的应用开辟了吸引人的新可能性。

文中插图：



物理学 8 月 Nature 论文

[1]Quantized current steps due to the a.c. coherent quantum phase-slip effect

由交流相干量子相滑移效应引起的量子化电流步长

出版信息：Nature, 4 AUG 2022, Volume 608，Issue 7921

作者：Rais S. Shaikhaidarov, Kyung Ho Kim, Jacob W. Dunstan, Ilya V. Antonov, Sven Linzen, Mario Ziegler, Dmitry S. Golubev, Vladimir N. Antonov, Evgeni V. Il'ichev & Oleg V. Astafiev

第一作者单位：Royal Holloway, University of London, Egham, UK

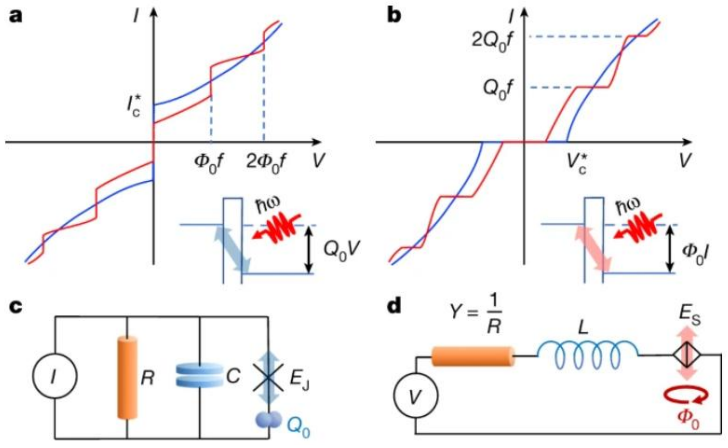
National Physical Laboratory, Teddington, UK

全文链接：https://www.nature.com/articles/s41586-022-04947-z

Abstract：The a.c. Josephson effect predicted in 1962 and observed experimentally in 1963 as quantized 'voltage steps' (the Shapiro steps) from photon-assisted tunnelling of Cooper pairs is among the most fundamental phenomena of quantum mechanics and is vital for metrological quantum voltage standards. The physically dual effect, the a.c. coherent quantum phase slip (CQPS), photon-assisted tunnelling of magnetic fluxes through a superconducting nanowire, is envisaged to reveal itself as quantized 'current steps. The basic physical significance of the a.c. CQPS is also complemented by practical importance in future current standards, a missing element for closing the quantum metrology triangle. In 2012, the CQPS was demonstrated as superposition of magnetic flux quanta in superconducting nanowires. However, the direct flat current steps in superconductors, the only unavailable basic effect of superconductivity to date, was unattainable due to lack of appropriate materials and challenges in circuit engineering. Here we report the direct observation of the dual Shapiro steps in a superconducting nanowire. The sharp steps are clear up to 26 GHz frequency with current values 8.3 nA and limited by the present set-up bandwidth. The current steps were theoretically predicted in small Josephson junctions 30 years ago. However, unavoidable broadening in Josephson junctions prevents their direct experimental observation. We solve this problem by placing a thin NbN nanowire in an inductive environment.

摘要翻译：1962 年预测并于 1963 年在实验中观测到的交流约瑟夫森效应是量子力学中最基本的现象之一，对计量量子电压标准至关重要。物理上的双重效应，交流相干量子相滑移（CQPS），通过超导纳米线的光子辅助磁通量隧穿，被设想为量子化的"电流步骤"。在未来的现行标准中，交流电 CQPS 的基本物理意义也得到了实际重要性的补充，这是实现闭合量子计量三角的一个缺失元素。2012 年，CQPS 被证明是超导纳米线中磁通量量子的叠加。然而，由于缺乏合适的材料和电路工程方面的挑战，超导的直流电平流步骤是迄今为止唯一无法实现的超导的基本效应。作者报告了在超导纳米线的双夏皮罗步骤的直接观察。相关的步骤清晰到 26 GHz 频率，电流值 8.3 nA，并受限于目前的设置带宽。目前的步骤是在 30 年前的小约瑟夫森连接理论上预测。然而，约瑟夫森结不可避免的增宽阻碍了他们的直接实验观察。作者通过在感应环境中放置一个薄的 NbN 纳米线来解决这个问题。

文中插图：



[2]

Non-Hermitian morphing of topological modes

拓扑模的非厄米变形

出版信息：Nature volume 608, pages50 – 55 (2022)

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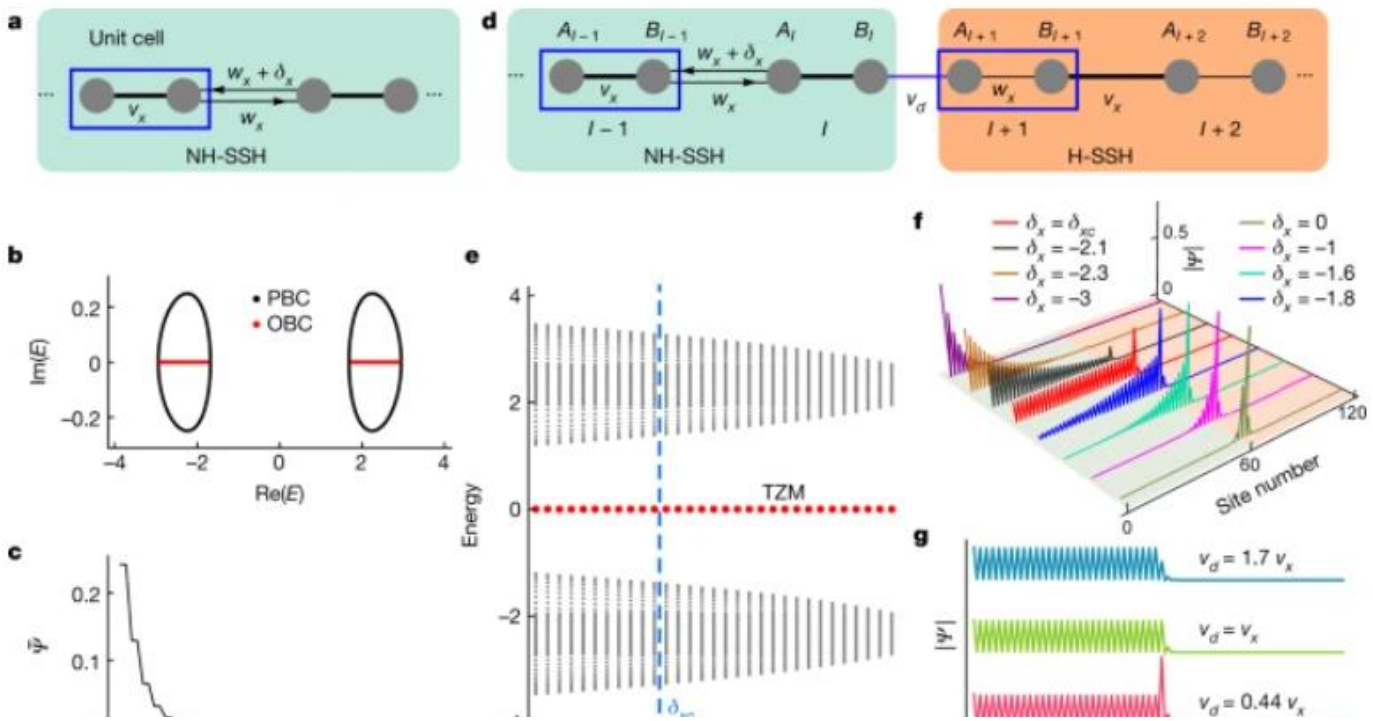
全文链接：https://www.nature.com/articles/s41586-022-04929-1

Abstract：Topological modes (TMs) are usually localized at defects or boundaries of a much larger topological lattice. Recent studies of non-Hermitian band theories unveiled the non-Hermitian skin effect (NHSE), by which the bulk states collapse to the boundary as skin modes. Here we explore the NHSE to reshape the wavefunctions of TMs by delocalizing them from the boundary. At a critical non-Hermitian parameter, the in-gap TMs even become completely extended in the entire bulk lattice, forming an ‘extended mode outside of a continuum’. These extended modes are still protected by bulk-band topology, making them robust against local disorders. The morphing of TM wavefunction is experimentally realized in active mechanical lattices in both one-dimensional and two-dimensional topological lattices, as well as in a higher-order topological lattice. Furthermore, by the judicious engineering of the non-Hermiticity distribution, the TMs can deform into a diversity of shapes. Our findings not only broaden and deepen the current understanding of the TMs and the NHSE but also open new grounds for topological applications.

摘要翻译：拓扑模态（TMs）通常局限于更大的拓扑晶格的缺陷或边界上。最近对非厄米能带理论的研究揭示了非厄米皮效应（NHSE），通过该效应，体态以皮模的形式向边界塌陷。作者探索了 NHSE，以重塑波函数的 TMs 的非局域从边界。在一个临界的非厄米参数下，间隙内 TM 甚至在整个体晶格中完全扩展，形成一个“连续体外的扩展模”。这些扩展模式仍然受到大频带拓扑的保护，使它们对局部混乱具有鲁棒性。实验实现了 TM 波函数在主动力学晶格中的变形，包括一维和二维拓扑晶格以及高阶拓扑晶格。此外，通过明智地设计非厄米分布，TMs 可以变形成各种形状。该发现不仅拓宽和深化了目前对 TMs 和 NHSE 的理解，而且为拓扑应用开辟了新的基础

文中插图：



[3]

Self-oscillating pump in a topological dissipative atom－cavity system

拓扑耗散原子-腔系统中的自振荡泵浦

出版信息：Nature, 18 August 2022, VOL 608, ISSUE 7923

作者：Davide Dreon, Alexander Baumg?rtner, Xiangliang Li, Simon Hertlein, Tilman Esslinger & Tobias Donner

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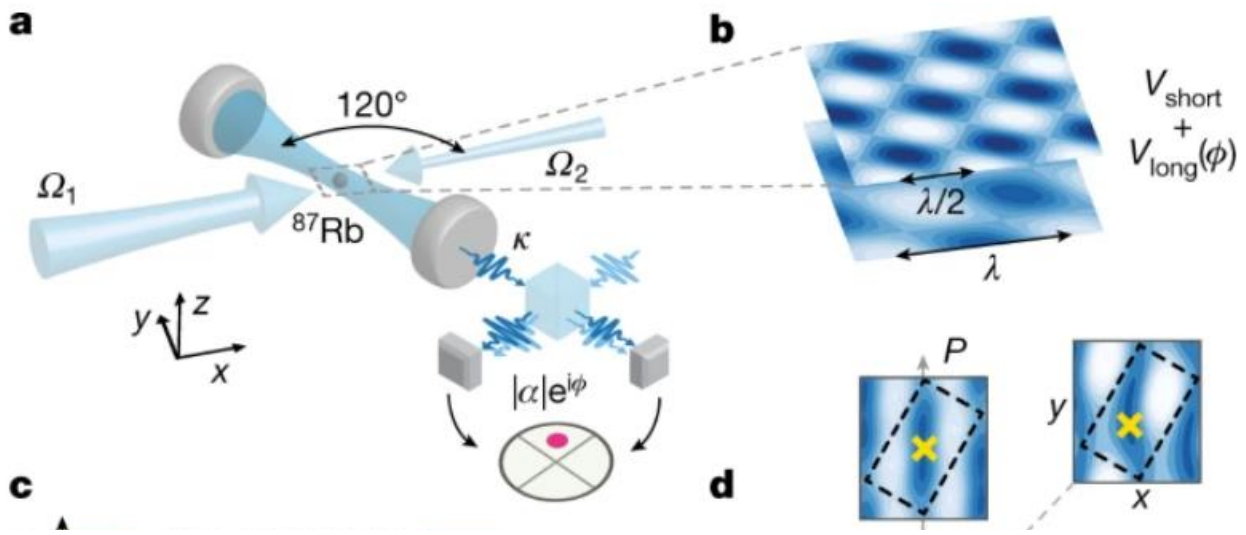
全文链接：https://www.nature.com/articles/s41586-022-04970-0

Abstract: Pumps are transport mechanisms in which direct currents result from a cyclic evolution of the potential. As Thouless showed, the pumping process can have topological origins, when considering the motion of quantum particles in spatially and temporally periodic potentials. However, the periodic evolution that drives these pumps has always been assumed to be imparted from outside, as has been the case in the experimental systems studied so far. Here we report on an emergent mechanism for pumping in a quantum gas coupled to an optical resonator, where we observe a particle current without applying a periodic drive. The pumping potential experienced by the atoms is formed by the self-consistent cavity field interfering with the static laser field driving the atoms. Owing to dissipation, the cavity field evolves between its two quadratures, each corresponding to a different centrosymmetric crystal configuration. This self-oscillation results in a time-periodic potential analogous to that describing the transport of electrons in topological tight-binding models, such as the paradigmatic Rice－Mele pump. In the experiment, we directly follow the evolution by measuring the phase winding of the cavity field with respect to the driving field and observing the atomic motion in situ. The observed mechanism combines the dynamics of topological and open systems, and features characteristics of continuous dissipative time crystals.

摘要翻译：泵浦是一种传输机制，其中直流电由电势的循环演变产生。如 Thouless 泵浦所示，当考虑量子粒子在时空周期势中的运动时，泵浦过程可能具有拓扑起源。然而，驱动这些泵浦的周期性演化一直被认为是从外部传递的，正如迄今为止研究的实验系统。研究组报道了一种泵浦耦合到光学谐振器的量子气体涌现机制，在不使用周期性驱动的情况下观察粒子电流。原子所经历的泵浦电势由自洽腔场干扰驱动原子的静态激光场形成。由于耗散，腔场在其两个正交之间演化，每个正交对应于不同的中心对称晶体构型。这种自振荡产生了一种时间周期势，类似于拓扑紧束缚模型中描述电子输运的势，如典型的 Rice-Mele 泵。在实验中，研究组通过测量腔场相对于驱动场的相位绕组并在原位观察原子运动，直接跟踪这一演化过程。观察到的机制结合了拓扑系统和开放系统的动力学，并具有连续耗散时间晶体的特征。

文中插图：



[4]

Formation of moiré interlayer excitons in space and time

莫尔层间激子的时空形成

出版信息：Nature, 18 August 2022, VOL 608, ISSUE 7923

作者：David Schmitt, Jan Philipp Bange, Wiebke Bennecke, AbdulAziz AlMutairi, Giuseppe Meneghini, Kenji Watanabe, et al.

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全文链接：https://www.nature.com/articles/s41586-022-04977-7

Abstract：Moiré superlattices in atomically thin van der Waals heterostructures hold great promise for extended control of electronic and valleytronic lifetimes, the confinement of excitons in artificial moiré lattices and the formation of exotic quantum phases. Such moiré-induced emergent phenomena are particularly strong for interlayer excitons, where the hole and the electron are localized in different layers of the heterostructure. To exploit the full potential of correlated moiré and exciton physics, a thorough understanding of the ultrafast interlayer exciton formation process and the real-space wavefunction confinement is indispensable. Here we show that femtosecond photoemission momentum microscopy provides quantitative access to these key properties of the moiré interlayer excitons. First, we elucidate that interlayer excitons are dominantly formed through femtosecond exciton – phonon scattering and subsequent charge transfer at the interlayer-hybridized Σ valleys. Second, we show that interlayer excitons exhibit a momentum fingerprint that is a direct hallmark of the superlattice moiré modification. Third, we reconstruct the wavefunction distribution of the electronic part of the exciton and compare the size with the real-space moiré superlattice. Our work provides direct access to interlayer exciton formation dynamics in space and time and reveals opportunities to study correlated moiré and exciton physics for the future realization of exotic quantum phases of matter.

摘要翻译：原子厚度范德华异质结构中的莫尔超晶格在延长控制电子和谷电子寿命、人工莫尔晶格中的激子约束以及奇异量子相形成方面具有巨大的前景。这种莫尔诱导的涌现现象对于层间激子尤其强烈，其中空穴和电子位于异质结构的不同层中。为了充分挖掘相关莫尔和激子物理的潜力，必须深入了解超快层间激子形成过程和实空间波函数约束。研究组通过飞秒光电发射动量显微镜提供了对莫尔层间激子这些关键属性的定量访问。首先，阐明了层间激子主要通过飞秒激子-声子散射和随后在层间杂化Σ谷处的电荷转移而形成；其次，证明了层间激子具有动量指纹，这是超晶格莫尔改性的直接标志；第三，重建了激子电子部分的波函数分布，并将其尺寸与实空间莫尔超晶格进行了比较。该研究工作提供了在时空上直接访问层间激子形成动力学的途径，并揭示了研究相关莫尔和激子物理的机会，以助力未来实现物质的奇异量子相。

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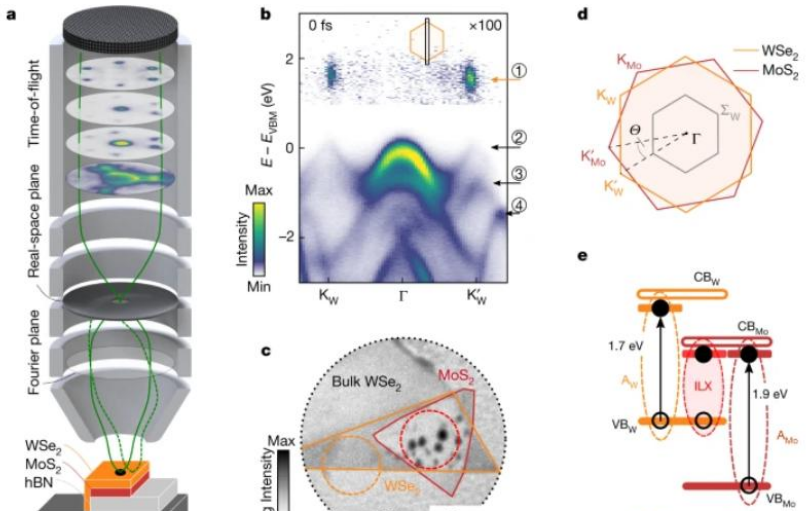

[5]

Efficient generation of entangled multiphoton graph states from a single atom

单原子多光子纠缠图态的有效生成

出版信息：Nature, 25 August 2022, VOL 608, ISSUE 7924

作者：Philip Thomas, Leonardo Ruscio, Olivier Morin & Gerhard Rempe

第一作者单位：Max-Planck-Institut für Quantenoptik, Garching, Germany

全文链接：https://www.nature.com/articles/s41586-022-04987-5

Abstract： The central technological appeal of quantum science resides in exploiting quantum effects, such as entanglement, for a variety of applications, including computing, communication and sensing. The overarching challenge in these fields is to address, control and protect systems of many qubits against decoherence. Against this backdrop, optical photons, naturally robust and easy to manipulate, represent ideal qubit carriers. However, the most successful technique so far for creating photonic entanglement is inherently probabilistic and, therefore, subject to severe scalability limitations. Here we report the implementation of a deterministic protocol for the creation of photonic entanglement with a single memory atom in a cavity. We interleave controlled single-photon emissions with tailored atomic qubit rotations to efficiently grow Greenberger – Horne – Zeilinger (GHZ) states of up to 14 photons and linear cluster states of up to 12 photons with a fidelity lower bounded by 76(6)% and 56(4)%, respectively. Thanks to a source-to-detection efficiency of 43.18(7)% per photon, we measure these large states about once every minute, which is orders of magnitude faster than in any previous experiment. In the future, this rate could be increased even further, the scheme could be extended to two atoms in a cavity or several sources could be quantum mechanically coupled, to generate higher-dimensional cluster states. Overcoming the limitations encountered by probabilistic schemes for photonic entanglement generation, our results may offer a way towards scalable measurement-based quantum computation and communication.

摘要翻译：量子科学的核心技术诉求在于利用量子效应，如纠缠，在计算、通信和传感等多种应用中发挥作用。在这些领域的首要挑战是解决、控制和保护系统的许多量子比特的退相干。在这种背景下，天生稳健且易于操作的光学光子代表了理想的量子比特载波。然而，迄今为止最成功的创造光子纠缠的技术是固有的概率，因此，受到严重的可扩展性的限制。作者报告了利用一个腔里单个存储原子形成光子纠缠的一个确定性协议。他们将可控的单光子发射与定制的原子量子比特旋转交织在一起，以保真度下界分别为 76(6)%和 56(4)%有效地增长多达 14 个光子的最大纠缠态（格林伯格-霍恩-齐林格态）和多达 12 个光子的线性簇态。由于每个光子的源-探测效率为 43.18(7)%，研究者大约每分钟测量一次这些态，这比以前的任何实验都快了几个数量级。未来，这一速率可能进一步提高，该方案可能扩展到一个腔中的两个原子或多个源的量子力学耦合，以产生高维簇态。克服了概率方案产生光子纠缠的局限性，该结果为可扩展的基于测量的量子计算和通信提供了一种潜在方法。

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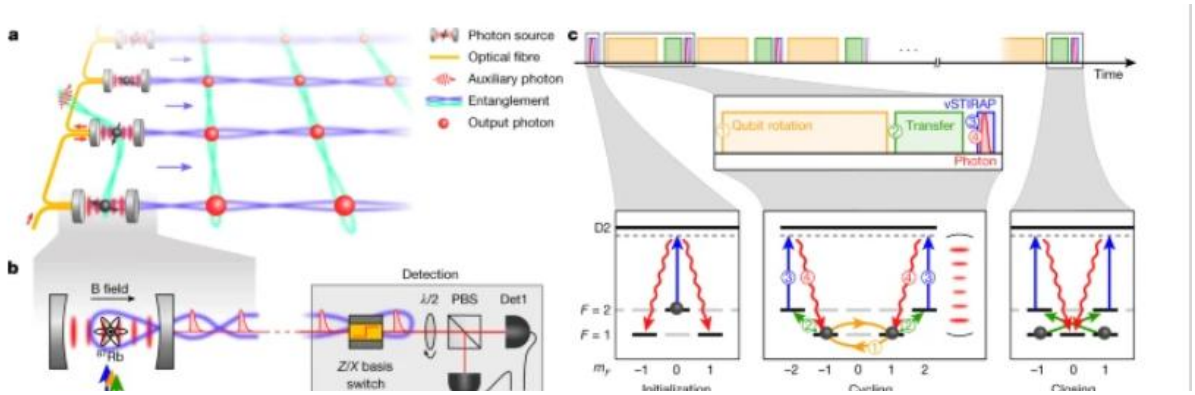

[6]

Quantum error correction with silicon spin qubits

用硅自旋量子位进行量子纠错

出版信息：Nature, 25 August 2022, VOL 608, ISSUE 7924

作者：Kenta Takeda, Akito Noiri, Takashi Nakajima, Takashi Kobayashi & Seigo Tarucha

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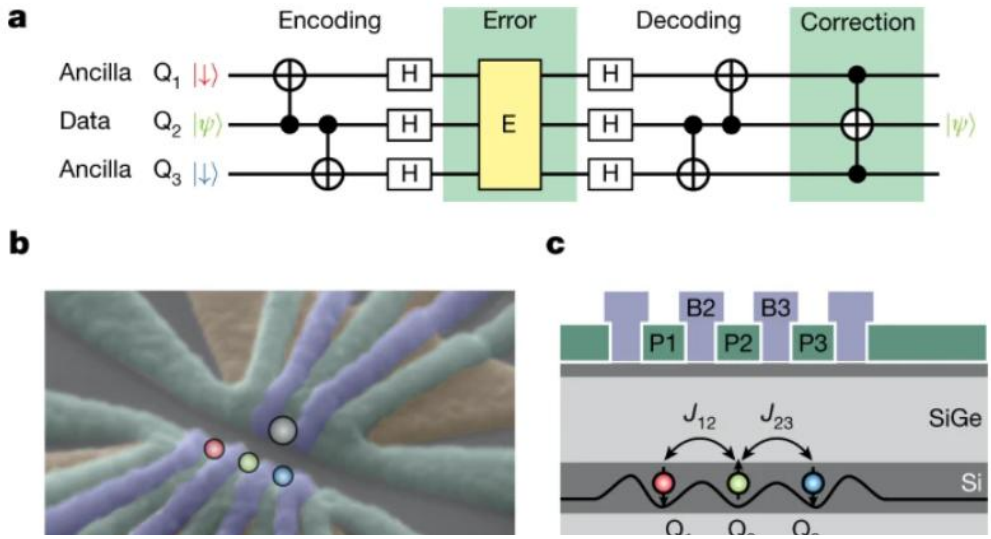
全文链接：https://www.nature.com/articles/s41586-022-04986-6

Abstract：Future large-scale quantum computers will rely on quantum error correction (QEC) to protect the fragile quantum information during computation. Among the possible candidate platforms for realizing quantum computing devices, the compatibility with mature nanofabrication technologies of silicon-based spin qubits offers promise to overcome the challenges in scaling up device sizes from the prototypes of today to large-scale computers. Recent advances in silicon-based qubits have enabled the implementations of high-quality one-qubit and two-qubit systems. However, the demonstration of QEC, which requires three or more coupled qubits, and involves a three-qubit gate or measurement-based feedback, remains an open challenge. Here we demonstrate a three-qubit phase-correcting code in silicon, in which an encoded three-qubit state is protected against any phase-flip error on one of the three qubits. The correction to this encoded state is performed by a three-qubit conditional rotation, which we implement by an efficient single-step resonantly driven iToffoli gate. As expected, the error correction mitigates the errors owing to one-qubit phase-flip, as well as the intrinsic dephasing mainly owing to quasi-static phase noise. These results show successful implementation of QEC and the potential of a silicon-based platform for large-scale quantum computing.

摘要翻译：未来的大规模量子计算机将依靠量子纠错（QEC）来保护计算过程中脆弱的量子信息。在可能实现量子计算设备的候选平台中，硅基自旋量子比特与成熟的纳米制造技术的兼容性，为克服从今天的原型到大规模计算机的设备尺寸放大的挑战提供了希望。硅基量子比特的最新进展已经实现了高质量的 1 量子比特和 2 量子比特系统。然而，QEC 的演示需要三个或更多耦合量子比特，并涉及三个量子比特门或基于测量的反馈，这仍然是一个开放的挑战。作者演示了一种硅中的三量子位相位校正码，其中一个被编码的三量子位状态被保护，以防止三个量子位中的任何一个的相位翻转错误。对这个编码状态的校正是通过一个三量子位的条件旋转来完成的，研究者通过一个高效的单步共振驱动 iToffoli 门来实现。如预期的那样，误差修正减小了由单量子比特相位翻转引起的误差，以及由准静态相位噪声引起的本征失相。这些结果表明 QEC 的成功实现以及硅基大规模量子计算平台的潜力。

文中插图：



[7]

Kardar–Parisi–Zhang universality in a one-dimensional polariton condensate

一维极化子凝聚的 KPZ 普适性

出版信息：Nature, 25 August 2022, VOL 608, ISSUE 7924

作者：Quentin Fontaine, Davide Squizzato, Florent Baboux, Ivan Amelio, Aristide Lemaître, Martina Morassi, Isabelle Sagnes, Luc Le Gratiet, Abdelmounaim Harouri, Michiel Wouters, Iacopo Carusotto, Alberto Amo, Maxime Richard, Anna Minguzzi, Léonie Canet, Sylvain Ravets & Jacqueline Bloch

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全文链接：https://www.nature.com/articles/s41586-022-05001-8

Abstract： Revealing universal behaviours is a hallmark of statistical physics. Phenomena such as the stochastic growth of crystalline surfaces and of interfaces in bacterial colonies, and spin transport in quantum magnets all belong to the same universality class, despite the great plurality of physical mechanisms they involve at the microscopic level. More specifically, in all these systems, space – time correlations show power-law scalings characterized by universal critical exponents. This universality stems from a common underlying effective dynamics governed by the nonlinear stochastic Kardar – Parisi – Zhang (KPZ) equation. Recent theoretical works have suggested that this dynamics also emerges in the phase of out-of-equilibrium systems showing macroscopic spontaneous coherence. Here we experimentally demonstrate that the evolution of the phase in a driven-dissipative one-dimensional polariton condensate falls in the KPZ universality class. Our demonstration relies on a direct measurement of KPZ space – time scaling laws, combined with a theoretical analysis that reveals other key signatures of this universality class. Our results highlight fundamental physical differences between out-of-equilibrium condensates and their equilibrium counterparts, and open a paradigm for exploring universal behaviours in driven open quantum systems.

摘要翻译：揭示普遍行为是统计物理学的一个重要特征。晶体表面和细菌菌落界面的随机生长和量子磁体的自旋输运等现象都属于同一普世性类别，尽管它们在微观层面上涉及到大量的物理机制。更具体地说，在所有这些系统中，时空相关性显示出幂律尺度，其特征是普遍的临界指数。这种普适性源于由非线性随机 Kardar – Parisi – Zhang（KPZ）方程所控制的一个共同的潜在有效动力学。最近的理论工作表明，这种动力学也出现在显示宏观自发相干的非平衡系统的阶段。作者通过实验证明了驱动耗散一维极化激子凝聚态的相位演化落在 KPZ 普适类中。作者表示，他们的论证依赖于 KPZ 时空尺度定律的直接测量，并结合揭示这个普适性类的其他关键特征的理论分析。其结果突出了非平衡凝聚体及其平衡对等体之间的基本物理差异，并为探索驱动开放量子系统中的普遍行为打开了一个范式。

文中插图：