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本期推荐报道 2022 年 7 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 7 月 Science 论文

[1] Thermalization dynamics of a gauge theory on a quantum simulator

在量子模拟器上展示规范场论的热动力学

出版信息：SCIENCE,14 Jul 2022,Vol 377, Issue 6603

作者：Zhao-Yu Zhou, Guo-Xian Su, Jad C. Halimeh , Robert Ott , Hui Sun, Philipp Hauke, Bing Yang, Zhen-Sheng Yuan , Jürgen Berges, Jian-Wei Pan

第一作者单位：Hefei National Research Center for Physical Sciences at the Microscale and School of Physical Sciences, University of Science and Technology of China, Hefei 230026, China.

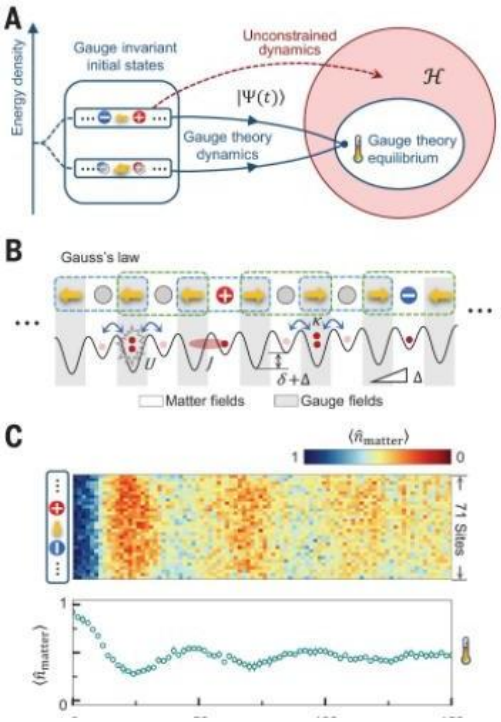
全文链接：

https://www.science.org/doi/10.1126/science.abl6277

Abstract：Gauge theories form the foundation of modern physics, with applications ranging from elementary particle physics and early-universe cosmology to condensed matter systems. We perform quantum simulations of the unitary dynamics of a U(1) symmetric gauge field theory and demonstrate emergent irreversible behavior. The highly constrained gauge theory dynamics are encoded in a one-dimensional Bose-Hubbard simulator, which couples fermionic matter fields through dynamical gauge fields. We investigated global quantum quenches and the equilibration to a steady state well approximated by a thermal ensemble. Our work may enable the investigation of elusive phenomena, such as Schwinger pair production and string breaking, and paves the way for simulating more complex, higher-dimensional gauge theories on quantum synthetic matter devices.

导读：规范场论成为了现代物理学的基础，应用范围涉及基本粒子物理学、早期宇宙学、以及凝聚态物质系统等。本研究实现了U(1)对称规范场论幺正动力学的量子模拟，在模拟过程中出现了不可逆的行为，同时还观测到了量子全局淬灭和通过热系综平衡至稳定态的过程。该成果为在量子合成物质器件中模拟更加复杂、更高维度的规范场论开辟新道路。

文中插图：



[2]

Visualizing Eigen/Zundel cations and their interconversion in monolayer water on metal surfaces

金属表面单层水中Eigen/Zundel 阳离子及其相互转换的直接成像

出版信息：SCIENCE,14 Jul 2022,Vol 377, Issue 6603

作者：Ye Tian, Jiani Hong, Duanyun Cao, Sifan You, Yizhi Song, Bowei Cheng , Zhichang Wang, et al.

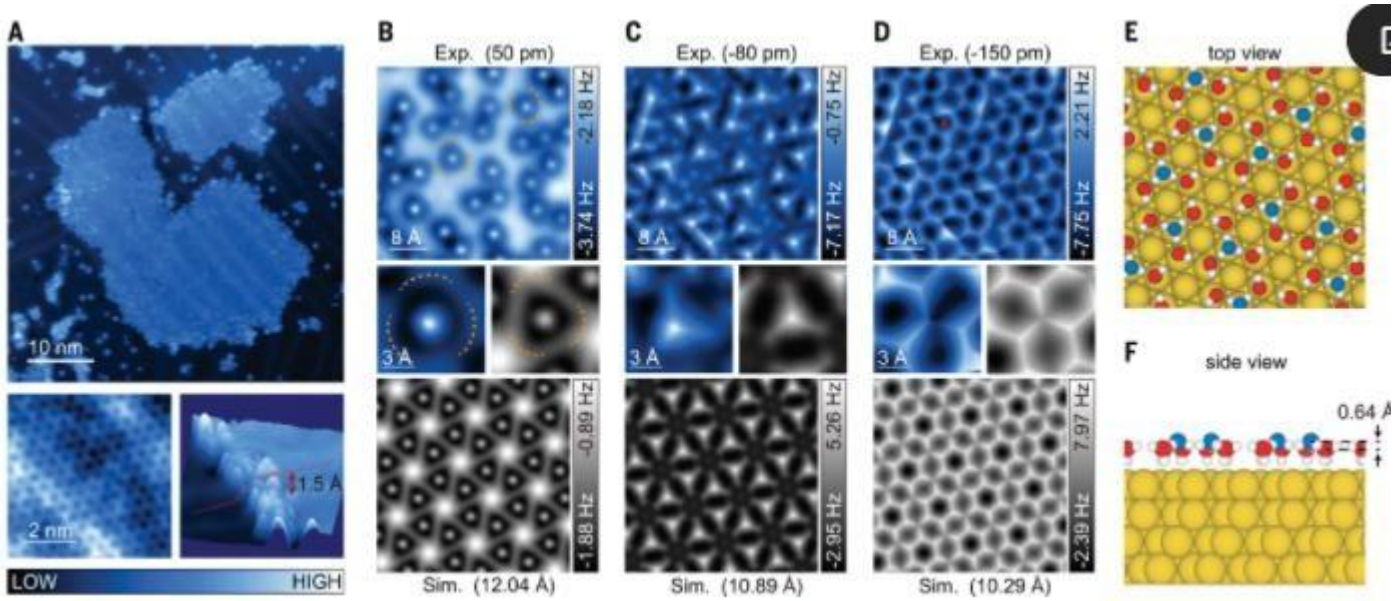
第一作者单位：International Center for Quantum Materials, School of Physics, Peking University, Beijing 100871, China.

全文链接：https://www.science.org/doi/10.1126/science.abo0823

Abstract： The nature of hydrated proton on solid surfaces is of vital importance in electrochemistry, proton channels, and hydrogen fuel cells but remains unclear because of the lack of atomic-scale characterization. We directly visualized Eigen- and Zundel-type hydrated protons within the hydrogen bonding water network on Au(111) and Pt(111) surfaces, using cryogenic qPlus-based atomic force microscopy under ultrahigh vacuum. We found that the Eigen cations self-assembled into monolayer structures with local order, and the Zundel cations formed long-range ordered structures stabilized by nuclear quantum effects. Two Eigen cations could combine into one Zundel cation accompanied with a simultaneous proton transfer to the surface. Moreover, we revealed that the Zundel configuration was preferred over the Eigen on Pt(111), and such a preference was absent on Au(111).

摘要翻译：固体表面上水合质子的属性对电化学、质子通道和氢燃料电池至关重要，但目前仍缺乏原子尺度下的表征。本研究使用低温 qPlus 原子力显微镜直接观察到 Au(111) 和 Pt(111) 表面上氢键水网络中的Eigen 型和 Zundel 型水合质子，发现 Eigen 阳离子自组装成具有局部有序的单层结构，而 Zundel 阳离子形成通过核量子效应稳定的长程有序结构。

文中插图：



[3]
Spacecraft sample collection and subsurface excavation of asteroid (101955) Bennu

小行星（101955）Bennu 样本采集和行星表面下挖掘

出版信息：SCIENCE，7 Jul 2022， Vol 377, Issue ， 6603， pp. 285-291
DOI: 10.1126/science.abm1018

作者：D. S. Lauretta, C. D. Adam, A. J. Allen , R.-L. Ballouz, O. S. Barnouin, et al.
第一作者单位： Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA.

全文链接：https://www.science.org/doi/10.1126/science.abm1018

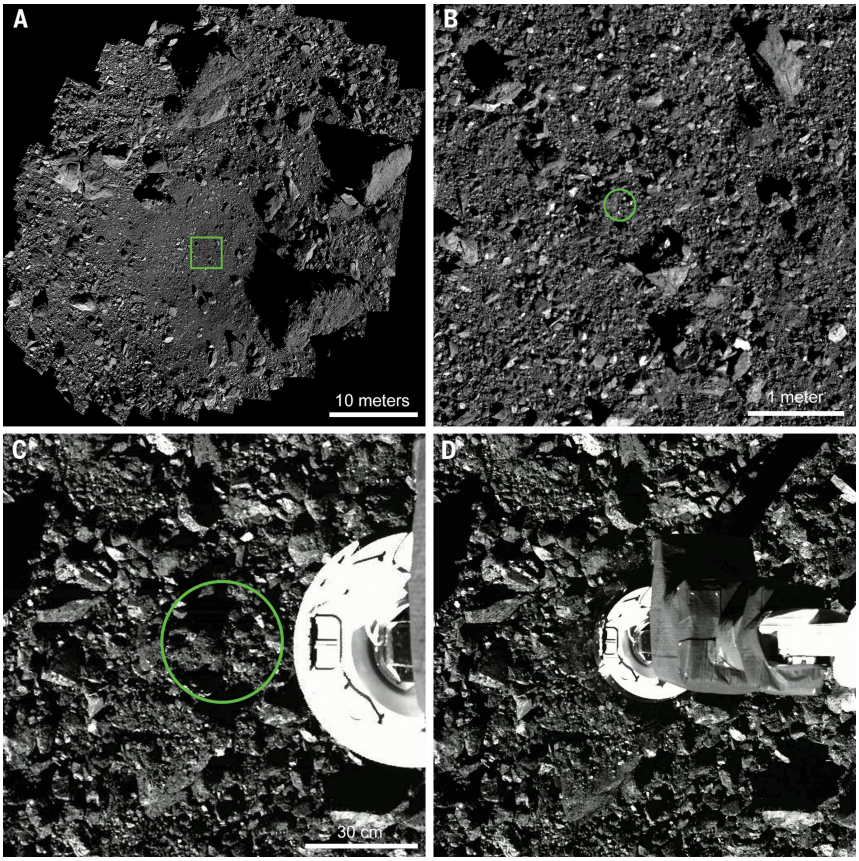
Abstract:

Carbonaceous asteroids, such as (101955) Bennu, preserve material from the early Solar System, including volatile compounds and organic molecules. We report spacecraft imaging and spectral data collected during and after retrieval of a sample from Bennu's surface. The sampling event mobilized rocks and dust into a debris plume, excavating a 9-meter-long elliptical crater. This exposed material is darker, spectrally redder, and more abundant in fine particulates than the original surface. The bulk density of the displaced subsurface material was 500 to 700 kilograms per cubic meter, which is about half that of the whole asteroid. Particulates that landed on instrument optics spectrally resemble aqueously altered carbonaceous meteorites. The spacecraft stored 250 ± 101 grams of material, which will be delivered to Earth in 2023.

导读：

太空探测器在小行星（101955）Bennu 上收集的约 250 克物质将于 2023 年送返地球。本研究汇报了采样过程中与结束后得到的影像及光谱数据。作为碳质小行星，Bennu 保留了包括挥发性化合物和有机分子在内的太阳系早期物质。此次采样任务在Bennu 上制造了长达 9 米的椭圆形坑洞，暴露了其表面下颜色更深红、富含更多细颗粒且密度低于整体小行星的岩石尘土。

文中插图：



物理学

7 月 Nature 论文

[1] Evaporation of microwave-shielded polar molecules to quantum degeneracy

微波屏蔽的极性分子通过蒸发实现量子简并

出版信息：Nature, 607, pages677–681 (2022)，27 July 2022

作者：Andreas Schindewolf, Roman Bause, Xing-Yan Chen, Marcel Duda, Tijs Karman, Immanuel Bloch & Xin-Yu Luo

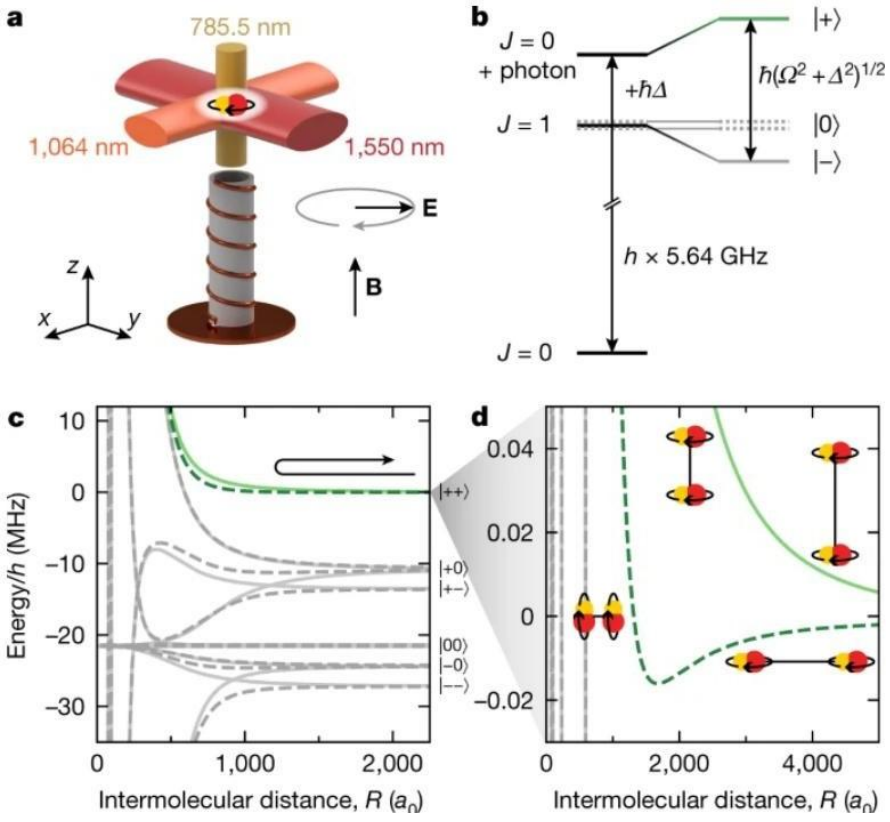
第一作者单位：Max-Planck-Institut für Quantenoptik, Garching, Germany

全文链接：https://www.nature.com/articles/s41586-022-04900-0

Abstract：Ultracold polar molecules offer strong electric dipole moments and rich internal structure, which makes them ideal building blocks to explore exotic quantum matter1,2,3,4,5,6,7,8,9, implement quantum information schemes10,11,12 and test the fundamental symmetries of nature13. Realizing their full potential requires cooling interacting molecular gases deeply into the quantum-degenerate regime. However, the intrinsically unstable collisions between molecules at short range have so far prevented direct cooling through elastic collisions to quantum degeneracy in three dimensions. Here we demonstrate evaporative cooling of a three-dimensional gas of fermionic sodium–potassium molecules to well below the Fermi temperature using microwave shielding. The molecules are protected from reaching short range with a repulsive barrier engineered by coupling rotational states with a blue-detuned circularly polarized microwave. The microwave dressing induces strong tunable dipolar interactions between the molecules, leading to high elastic collision rates that can exceed the inelastic ones by at least a factor of 460. This large elastic-to-inelastic collision ratio allows us to cool the molecular gas to 21 nanokelvin, corresponding to 0.36 times the Fermi temperature. Such cold and dense samples of polar molecules open the path to the exploration of many-body phenomena with strong dipolar interactions.

导读：超冷极性分子提供超强电偶极矩以及丰富的内部结构，成为探索奇异量子物质的理想体系。本研究使用微波屏蔽技术，将三维钠-钾费米分子气体蒸发冷却至费米温度之下。微波敷料可诱导分子间强烈的可调谐偶极相互作用，导致的高弹性碰撞率超过非弹性碰撞率的 460 倍。这一巨大的弹性-非弹性碰撞比使得将分子气体降温至 210nK 成为可能。该结果为探索具有强偶极相互作用的多体现象提供新思路。

文中插图：



[2] Experimental quantum key distribution certified by Bell's theorem

贝尔定理证明实验条件下的量子密钥分发

出版信息： Nature, 607, pages682–686 (2022)，27 Jul 2022

作者： D. P. Nadlinger, P. Drmota, B. C. Nichol, G. Araneda, D. Main, R. Srinivas, D. M. Lucas, C. J. Ballance, K. Ivanov, E. Y.-Z. Tan, P. Sekatski, R. L. Urbanke, R. Renner, N. Sangouar

第一作者单位： Clarendon Laboratory, Department of Physics, University of Oxford, Oxford, UK

全文链接： https://www.nature.com/articles/s41586-022-04941-5

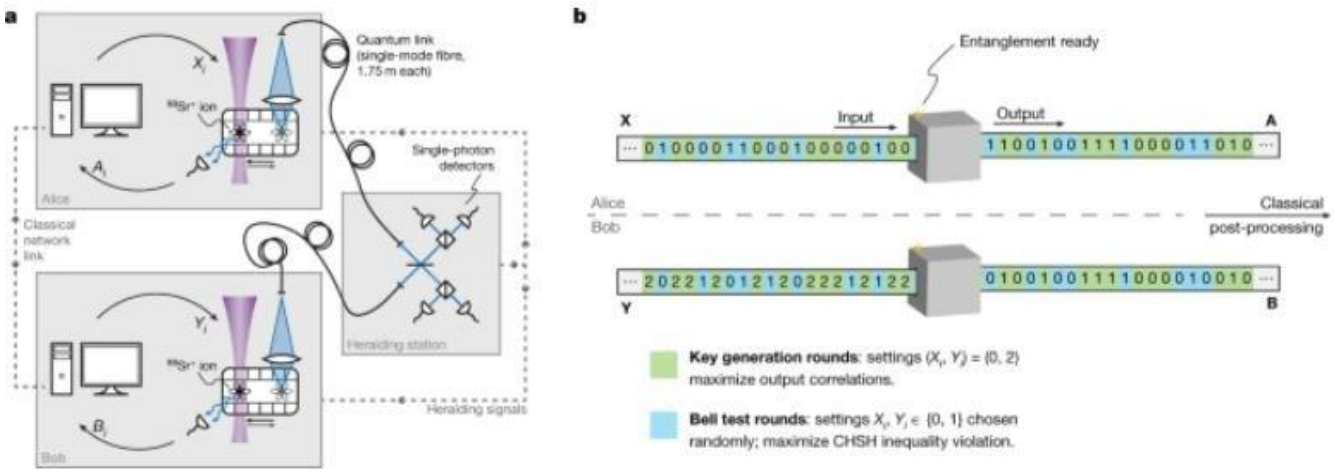
Abstract：

Cryptographic key exchange protocols traditionally rely on computational conjectures such as the hardness of prime factorization1 to provide security against eavesdropping attacks. Remarkably, quantum key distribution protocols such as the Bennett–Brassard scheme2 provide information-theoretic security against such attacks, a much stronger form of security unreachable by classical means. However, quantum protocols realized so far are subject to a new class of attacks exploiting a mismatch between the quantum states or measurements implemented and their theoretical modelling, as demonstrated in numerous experiments3,4,5,6. Here we present the experimental realization of a complete quantum key distribution protocol immune to these vulnerabilities, following Ekert's pioneering proposal7 to use entanglement to bound an adversary's information from Bell's theorem8. By combining theoretical developments with an improved optical fibre link generating entanglement between two trapped-ion qubits, we obtain 95,628 key bits with device-independent security9,10,11,12 from 1.5 million Bell pairs created during eight hours of run time. We take steps to ensure that information on the measurement results is inaccessible to an eavesdropper. These measurements are performed without space-like separation. Our result shows that provably secure cryptography under general assumptions is possible with real-world devices, and paves the way for further quantum information applications based on the device-independence principle.

导读：

量子密钥分发提供信息理论安全，势必传统方法更强大的安全形式。本研究在实验条件下实现完整的量子密钥分发协议，利用纠缠绑定来自贝尔定理的对方信息。结合理论研发与光纤连接生成量子比特纠缠，研究人员通过 8 小时运行创造的 150 万个贝尔对中获得 95628 个密钥比特，具有设备无关安全性。该结果为进一步扩展量子信息应用开辟新途径。

文中插图：



[3]

A device-independent quantum key distribution system for distant users

面向远程用户的设备无关量子密钥分发系统

出版信息：Nature，607, pages687–691，(2022)，27 Jul 2022

作者：Wei Zhang, Tim van Leent, Kai Redeker, Robert Garthoff, René Schwonnek, Florian Fertig, Sebastian Eppelt, Wenjamin Rosenfeld, Valerio Scarani, Charles C.-W. Lim & Harald Weinfurter

第一作者单位：Fakultät für Physik, Ludwig-Maximilians-Universität, München, Germany Munich Center for Quantum Science and Technology (MCQST), München, Germany

全文链接：https://www.nature.com/articles/s41586-022-04891-y

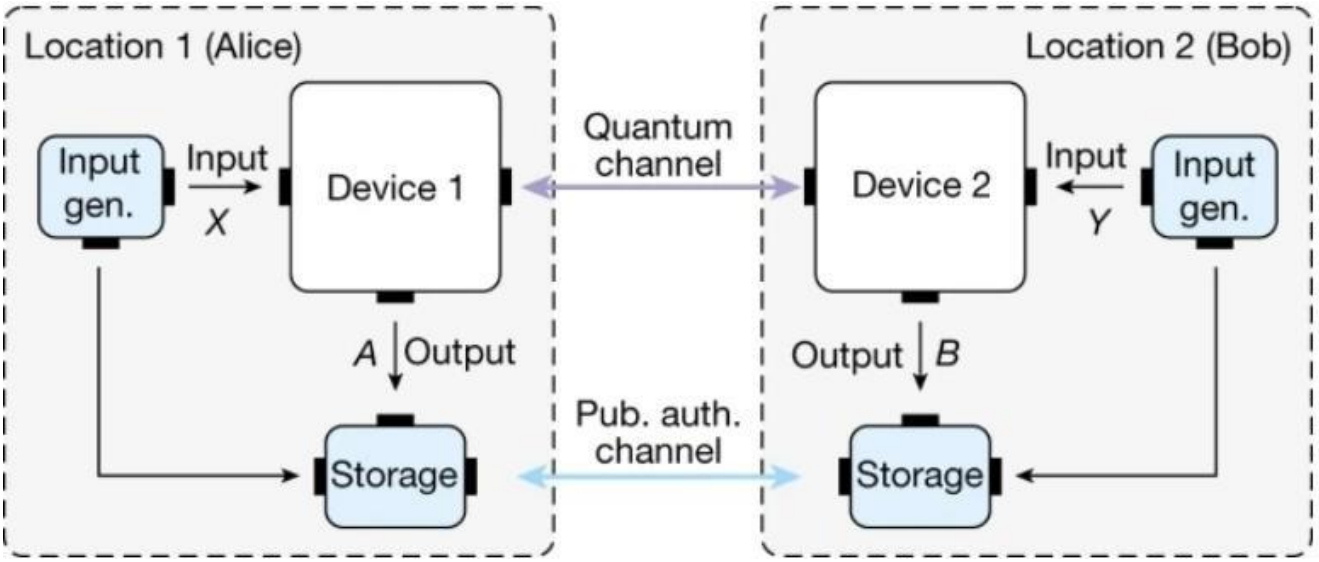
Abstract：

Device-independent quantum key distribution (DIQKD) enables the generation of secret keys over an untrusted channel using uncharacterized and potentially untrusted devices1,2,3,4,5,6,7,8,9. The proper and secure functioning of the devices can be certified by a statistical test using a Bell inequality10,11,12. This test originates from the foundations of quantum physics and also ensures robustness against implementation loopholes13, thereby leaving only the integrity of the users' locations to be guaranteed by other means. The realization of DIQKD, however, is extremely challenging—mainly because it is difficult to establish high-quality entangled states between two remote locations with high detection efficiency. Here we present an experimental system that enables for DIQKD between two distant users. The experiment is based on the generation and analysis of event-ready entanglement between two independently trapped single rubidium atoms located in buildings 400 metre apart14. By achieving an entanglement fidelity of $F \geq 0.892(23)$ and implementing a DIQKD protocol with random key basis15, we observe a significant violation of a Bell inequality of $S = 2.578(75)$—above the classical limit of 2—and a quantum bit error rate of only 0.078(9). For the protocol, this results in a secret key rate of 0.07 bits per entanglement generation event in the asymptotic limit, and thus demonstrates the system's capability to generate secret keys. Our results of secure key exchange with potentially untrusted devices pave the way to the ultimate form of quantum secure communications in future quantum networks.

导读：

设备无关量子密钥分发（DIQKD）可使用未表征可能还不受信任的设备在未受信任的通道内生成密钥。本研究展示一套可实现两个远程用户之间 DIQKD 的实验系统，实验产生并分析了分别位于相聚 400 米的楼房内两个独立俘获的单个铷原子之间的事件既定纠缠。最终在渐近极限的每次纠缠生成事件中实现 0.07 比特的密钥率， 表明系统有能力生成密钥。而这种能与可能未受信任设备交换密钥的行为为开拓量子安全通信开辟新途径。

文中插图：



[4]

Magnetic memory and spontaneous vortices in a van der Waals superconductor

范德华超导体中的磁记忆和自发涡旋

出版信息：Nature，607, pages692–696 (2022)，27 July 2022

作者：Eylon Persky, Anders V. Bjørlig, Irena Feldman, Avior Almoalem, Ehud Altman, Erez Berg, Itamar Kimchi, Jonathan Ruhman, Amit Kanigel & Beena Kalisky

第一作者单位：Department of Physics, Bar Ilan University, Ramat Gan, Israel

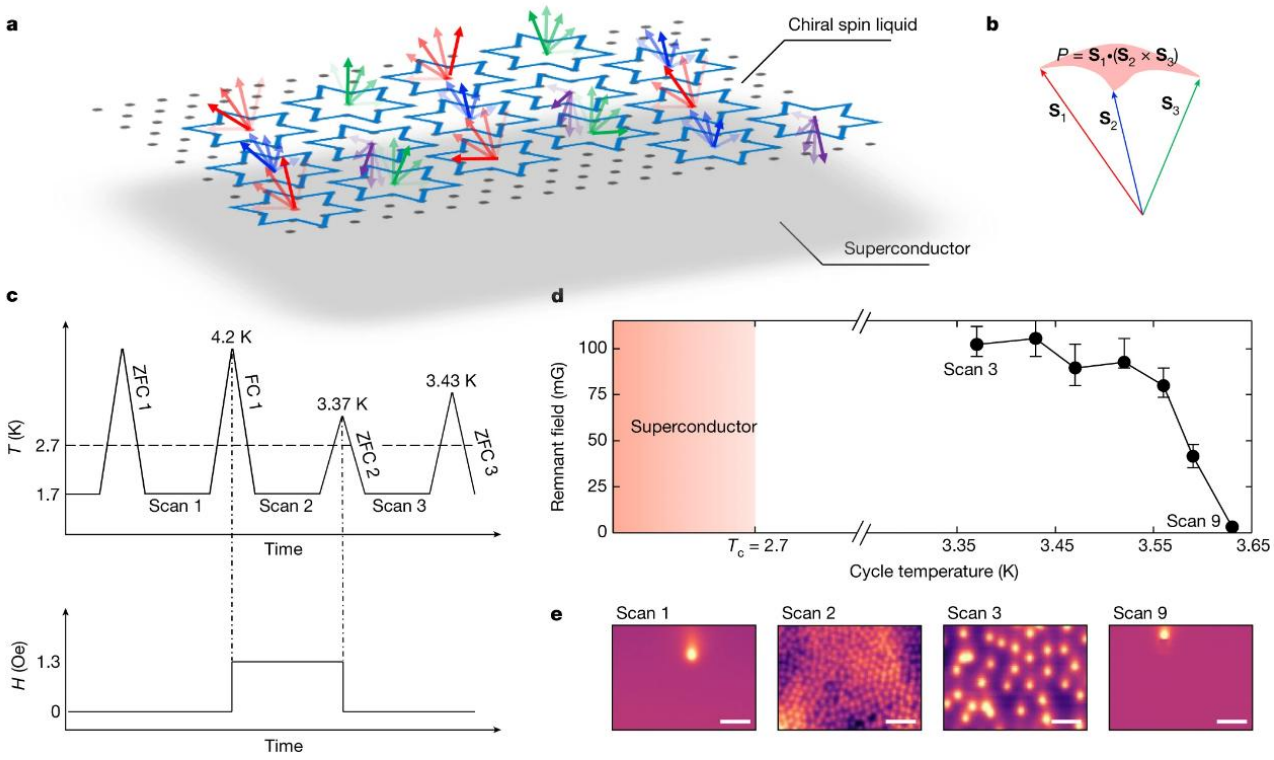
Bar Ilan Institute of Nanotechnology and Advanced Materials, Bar Ilan University, Ramat Gan, Israel

全文链接：https://www.nature.com/articles/s41586-022-04855-2

Abstract： Doped Mott insulators exhibit some of the most intriguing quantum phases of matter, including quantum spin liquids, unconventional superconductors and non-Fermi liquid metals1,2,3. Such phases often arise when itinerant electrons are close to a Mott insulating state, and thus experience strong spatial correlations. Proximity between different layers of van der Waals heterostructures naturally realizes a platform for experimentally studying the relationship between localized, correlated electrons and itinerant electrons. Here we explore this relationship by studying the magnetic landscape of tantalum disulfide 4Hb-TaS2, which realizes an alternating stacking of a candidate spin liquid and a superconductor4. We report on a spontaneous vortex phase whose vortex density can be trained in the normal state. We show that time-reversal symmetry is broken in the normal state, indicating the presence of a magnetic phase independent of the superconductor. Notably, this phase does not generate ferromagnetic signals that are detectable using conventional techniques. We use scanning superconducting quantum interference device microscopy to show that it is incompatible with ferromagnetic ordering. The discovery of this unusual magnetic phase illustrates how combining superconductivity with a strongly correlated system can lead to unexpected physics.

导读：掺杂莫特绝缘体表现出了一些有趣的物质量子相态，包括量子自旋液体，非常规超导体与非费米液体金属。本文通过分析二硫化钽 4Hb-TaS2 的磁场景观图研究了局域关联电子与巡游电子之间关系，并观测到自发涡旋的出现，其涡旋密度可在正常态中得到修正。此外还在正常态中观测到其时间反演对称性被破坏，说明存在独立于超导体的磁相位。该结果表明将超导性与强相关系统结合会产生意想不到的物理学现象。

文中插图：



[5]

Exceptional-point-based accelerometers with enhanced signal-to-noise ratio

信噪比增强的异常点加速计

出版信息：Nature volume 607, pages697–702 (2022)，27 JUl 2022,

作者：Rodion Kononchuk, Jizhe Cai, Fred Ellis, Ramathasan Thevamaran & Tsampikos Kottos

第一作者单位： Wave Transport in Complex Systems Lab, Department of Physics, Wesleyan University, Middletown, CT, USA

全文链接：https://www.nature.com/articles/s41586-022-04904-w

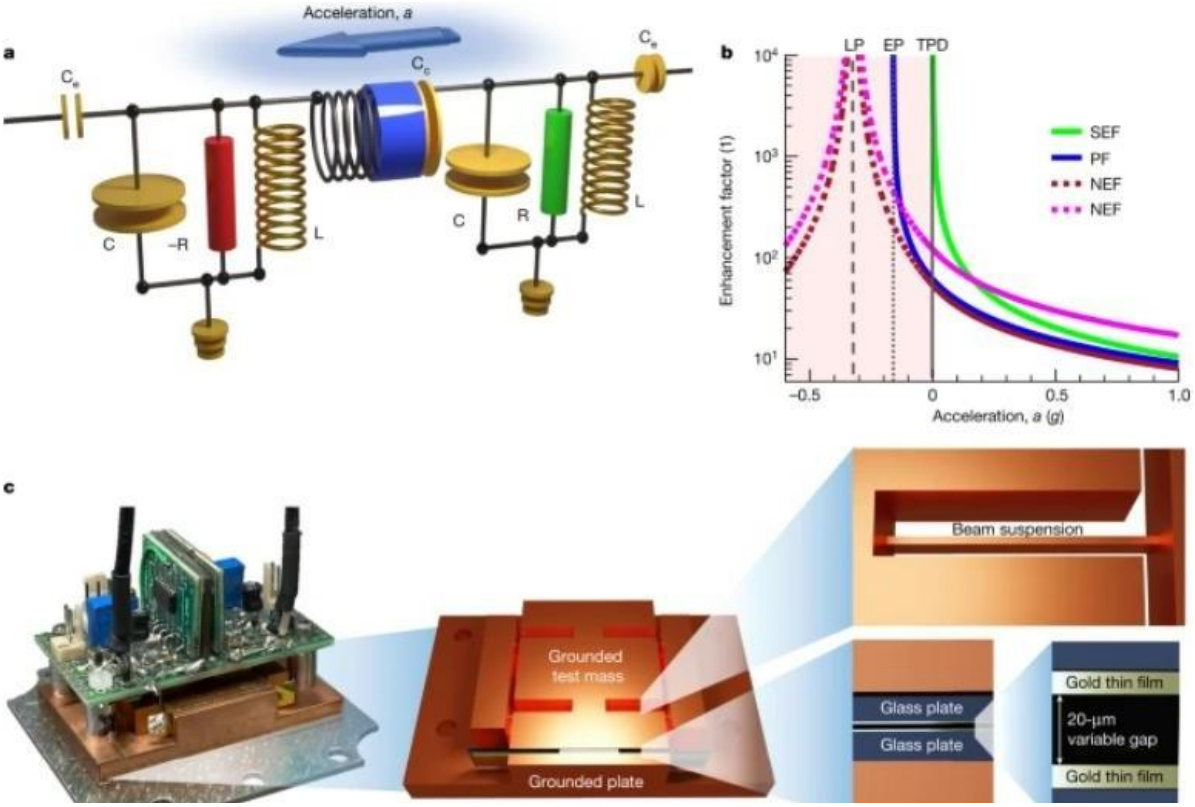
Abstract：

Exceptional points (EP) are non-Hermitian degeneracies where eigenvalues and their corresponding eigenvectors coalesce1,2,3,4. Recently, EPs have attracted attention as a means to enhance the responsivity of sensors, through the abrupt resonant detuning occurring in their proximity5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20. In many cases, however, the EP implementation is accompanied by noise enhancement, leading to the degradation of the sensor’ s performance15,16,17,18,19,20. The excess noise can be of fundamental nature (owing to the eigenbasis collapse) or of technical nature associated with the amplification mechanisms utilized for the realization of EPs. Here we show, using an EP-based parity‐ time symmetric21,22 electromechanical accelerometer, that the enhanced technical noise can be surpassed by the enhanced responsivity to applied accelerations. The noise owing to eigenbasis collapse is mitigated by exploiting the detuning from a transmission peak degeneracy (TPD) — which forms when the sensor is weakly coupled to transmission lines — as a measure of the sensitivity. These TPDs occur at a frequency and control parameters for which the biorthogonal eigenbasis is still complete and are distinct from the EPs of the parity‐ time symmetric sensor. Our device shows a threefold signal-to-noise-ratio enhancement compared with configurations for which the system operates away from the TPD.

导读：

近年来，非厄米简并的异常点（EP）有潜力成为增强传感器响应性的手段。本研究使用基于 EP 的宇称时间对称电子机械加速计，通过增强对加速的响应性来抑制同样增强的机械噪声。该设备的信噪比相较于远离传输峰简并度（TPD）运行的系统配置增强了三倍。

文中插图：



[6]

Dynamical topological phase realized in a trapped-ion quantum simulator

制造出有两个时间维度的量子比特

出版信息：Nature, 607, pages463–467 (2022)，20 Jul 2022

作者：Philipp T. Dumitrescu, Justin G. Bohnet, John P. Gaebler, Aaron Hankin, David Hayes, Ajesh Kumar, Brian Neyenhuis, Romain Vasseur & Andrew C. Potter

第一作者单位：Center for Computational Quantum Physics, Flatiron Institute, New York, NY, USA

全文链接：https://www.nature.com/articles/s41586-022-04853-4

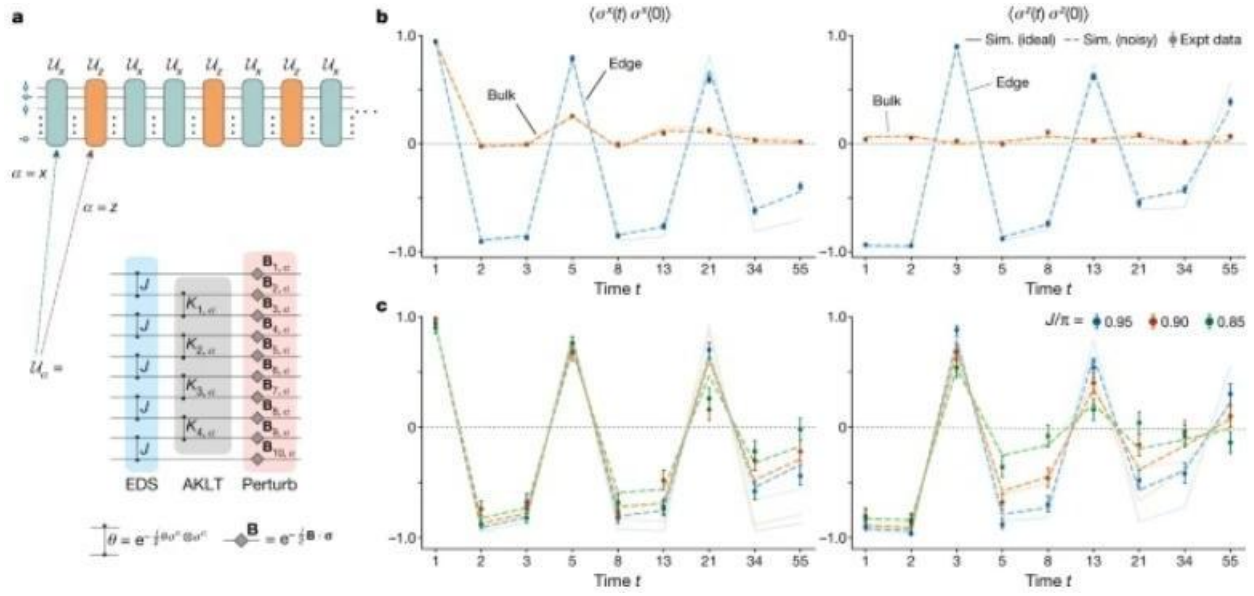
Abstract：

Nascent platforms for programmable quantum simulation offer unprecedented access to new regimes of far-from-equilibrium quantum many-body dynamics in almost isolated systems. Here achieving precise control over quantum many-body entanglement is an essential task for quantum sensing and computation. Extensive theoretical work indicates that these capabilities can enable dynamical phases and critical phenomena that show topologically robust methods to create, protect and manipulate quantum entanglement that self-correct against large classes of errors. However, so far, experimental realizations have been confined to classical (non-entangled) symmetry-breaking orders1,2,3,4,5. In this work, we demonstrate an emergent dynamical symmetry-protected topological phase6, in a quasiperiodically driven array of ten 171Yb+ hyperfine qubits in Quantinuum ’ s System Model H1 trapped-ion quantum processor7. This phase shows edge qubits that are dynamically protected from control errors, cross-talk and stray fields. Crucially, this edge protection relies purely on emergent dynamical symmetries that are absolutely stable to generic coherent perturbations. This property is special to quasiperiodically driven systems: as we demonstrate, the analogous edge states of a periodically driven qubit array are vulnerable to symmetry-breaking errors and quickly decohere. Our work paves the way for implementation of more complex dynamical topological orders8,9 that would enable error-resilient manipulation of quantum information.

导读：

量子比特很容易被环境影响，使量子计算机产生误差。具有对称性的量子比特能更好地抵抗扰动。本研究用特定激光脉冲序列照射在量子计算机内的原子上，即激发 10 个拍成一列的镱离子，并观察其两端的量子比特变化，结果发现在有序重复的激光脉冲下，量子态保持了 1.5 秒，而在基于斐波那契数列的激光脉冲下，量子态保持了 5.5 秒。该结果为长期量子信息存储带来新希望。

文中插图：



[7] Digital quantum simulation of Floquet symmetry-protected topological phases

Floquet 对称保护拓扑相的数字量子模拟

出版信息：Nature, 607, pages468–473 (2022)，20 Jul 2022

作者：Xu Zhang, Wenjie Jiang, Jinfeng Deng, Ke Wang, Jiachen Chen, Pengfei Zhang, Wenhui Ren, Hang Dong, Shibo Xu, Yu Gao, Feitong Jin, Xuhao Zhu, Qiujiang Guo, Hekang Li, Chao Song, Alexey V. Gorshkov, Thomas Iadecola, Fangli Liu, Zhe-Xuan Gong, Zhen Wang, Dong-Ling Deng & H. Wang

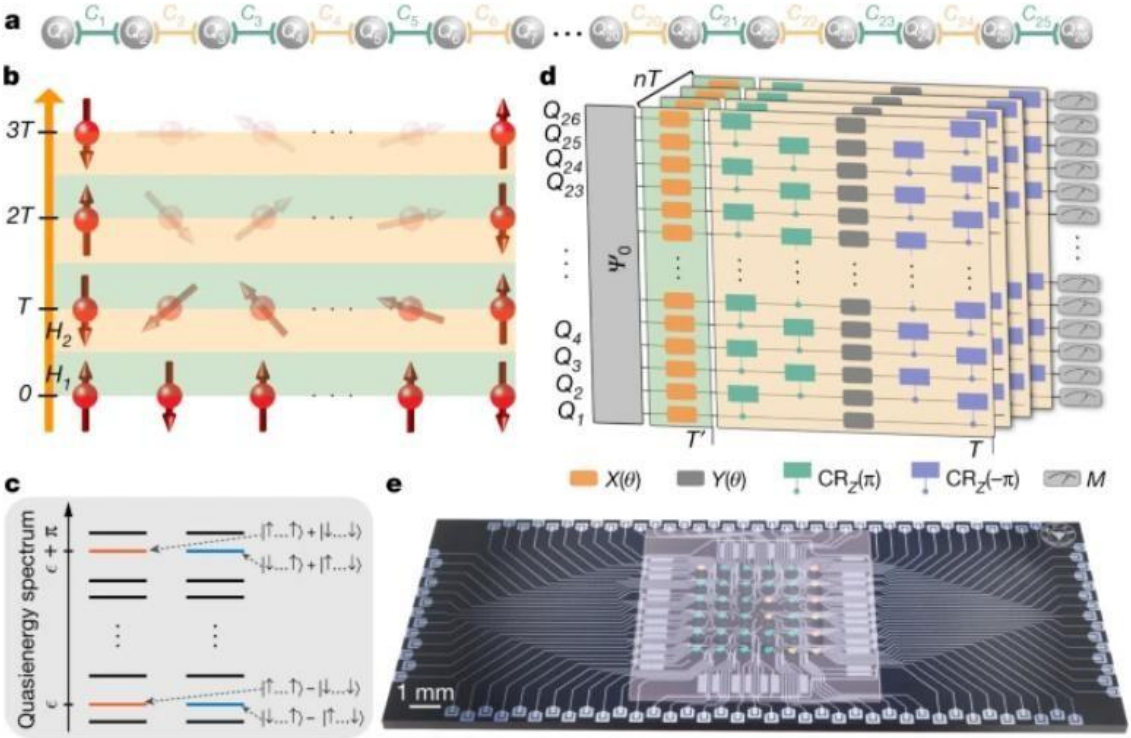
第一作者单位：Department of Physics, ZJU-Hangzhou Global Scientific and Technological Innovation Center, Interdisciplinary Center for Quantum Information, and Zhejiang Province Key Laboratory of Quantum Technology and Device, Zhejiang University, Hangzhou, China

全文链接：https://www.nature.com/articles/s41586-022-04854-3

Abstract：Quantum many-body systems away from equilibrium host a rich variety of exotic phenomena that are forbidden by equilibrium thermodynamics. A prominent example is that of discrete time crystals1,2,3,4,5,6,7,8, in which time-translational symmetry is spontaneously broken in periodically driven systems. Pioneering experiments have observed signatures of time crystalline phases with trapped ions9,10, solid-state spin systems11,12,13,14,15, ultracold atoms16,17 and superconducting qubits18,19,20. Here we report the observation of a distinct type of non-equilibrium state of matter, Floquet symmetry-protected topological phases, which are implemented through digital quantum simulation with an array of programmable superconducting qubits. We observe robust long-lived temporal correlations and subharmonic temporal response for the edge spins over up to 40 driving cycles using a circuit of depth exceeding 240 and acting on 26 qubits. We demonstrate that the subharmonic response is independent of the initial state, and experimentally map out a phase boundary between the Floquet symmetry-protected topological and thermal phases. Our results establish a versatile digital simulation approach to exploring exotic non-equilibrium phases of matter with current noisy intermediate-scale quantum processors21.

导读：远离平衡态的量子多体系统拥有丰富的奇异量子现象，目前的开创性实验已经观测到各种时间晶体相的特征。本研究报告观测到物质非平衡态的一个独特类型：Floauet 对称保护拓扑相。研究人员使用数字量子模拟结合可编程的超导量子比特阵列，最终在多达 40 个驱动周期内观察到边缘自旋的稳健长寿命时间相关性和次谐波时间响应。该结果为探索物质的奇异非平衡相提供通用的数字模拟方案。

文中插图：



[8]

Nuclear moments of indium isotopes reveal abrupt change at magic number 82

铟同位素核矩揭示幻数 82 处的突然变化

出版信息：Nature volume 607, pages260–265 (2022)，13 July 2022

作者：A. R. Vernon, R. F. Garcia Ruiz, T. Miyagi, C. L. Binnersley, J. Billowes, M. L. Bissell, J. Bonnard, T. E. Cocolios, J. Dobaczewski, G. J. Farooq-Smith, K. T. Flanagan, G. Georgiev, W. Gins, R. P. de Groote, R. Heinke, J. D. Holt, J. Hustings, Á. Koszorús, D. Leimbach, K. M. Lynch, G. Neyens, S. R. Stroberg, S. G. Wilkins, X. F. Yang & D. T. Yordanov

第一作者单位：A School of Physics and Astronomy, The University of Manchester, Manchester, UK Massachusetts Institute of Technology, Cambridge, MA, USA

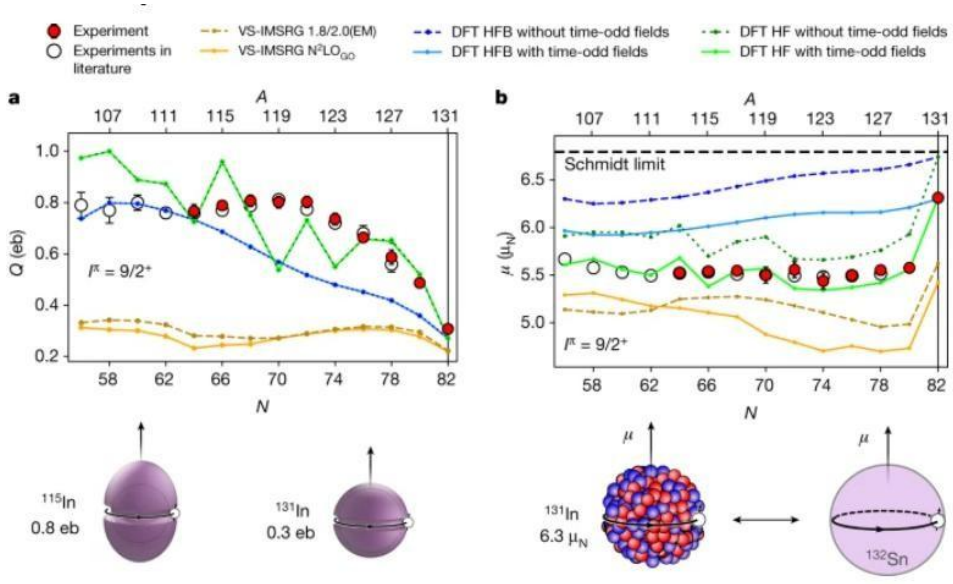
Instituut voor Kern- en Stralingsfysica, KU Leuven, Leuven, Belgium

全文链接：https://www.nature.com/articles/s41586-022-04818-7

Abstract：In spite of the high-density and strongly correlated nature of the atomic nucleus, experimental and theoretical evidence suggests that around particular ‘ magic ’ numbers of nucleons, nuclear properties are governed by a single unpaired nucleon1,2. A microscopic understanding of the extent of this behaviour and its evolution in neutron-rich nuclei remains an open question in nuclear physics3,4,5. The indium isotopes are considered a textbook example of this phenomenon6, in which the constancy of their electromagnetic properties indicated that a single unpaired proton hole can provide the identity of a complex many-nucleon system6,7. Here we present precision laser spectroscopy measurements performed to investigate the validity of this simple single-particle picture. Observation of an abrupt change in the dipole moment at N = 82 indicates that, whereas the single-particle picture indeed dominates at neutron magic number N = 82 (refs. 2,8), it does not for previously studied isotopes. To investigate the microscopic origin of these observations, our work provides a combined effort with developments in two complementary nuclear many-body methods: ab initio valence-space in-medium similarity renormalization group and density functional theory (DFT). We find that the inclusion of time-symmetry-breaking mean fields is essential for a correct description of nuclear magnetic properties, which were previously poorly constrained. These experimental and theoretical findings are key to understanding how seemingly simple single-particle phenomena naturally emerge from complex interactions among protons and neutrons.

导读：实验与理论证据表明，围绕核子的特定“幻数”，原子核特性受到单个未成对的核子调控。本研究通过激光谱的精准测量，研究了铟同位素简单的单粒子图景的有效性。在幻数为 82 时观测到偶极矩的突然变化。该研究将两套相互补充的原子核多体方法结合，发现纳入时间对称破缺平均场是正确描述原子核磁特性的关键。这些发现为理解自然涌现自质子-中子复杂相互作用的简单的单粒子现象提供新思路。

文中插图：



[9]

Optical observation of single spins in silicon

硅中单自旋的光学观察

出版信息：Nature，volume 607, pages266–270 (2022)，13 JUl 2022

作者：Daniel B. Higginbottom, Alexander T. K. Kurkjian, Camille Chartrand, Moein Kazemi, Nicholas A. Brunelle, Evan R. MacQuarrie, James R. Klein, Nicholas R. Lee-Hone, Jakub Stacho, Myles Ruether, Camille Bowness, Laurent Bergeron, Adam DeAbreu, Stephen R. Harrigan, Joshua Kanaganayagam, Danica W. Marsden, Timothy S. Richards, Leea A. Stott, Sjoerd Roorda, Kevin J. Morse, Michael L. W. Thewalt & Stephanie Simmons

第一作者单位：These authors contributed equally: D. B. Higginbottom, A. T. K. Kurkjian

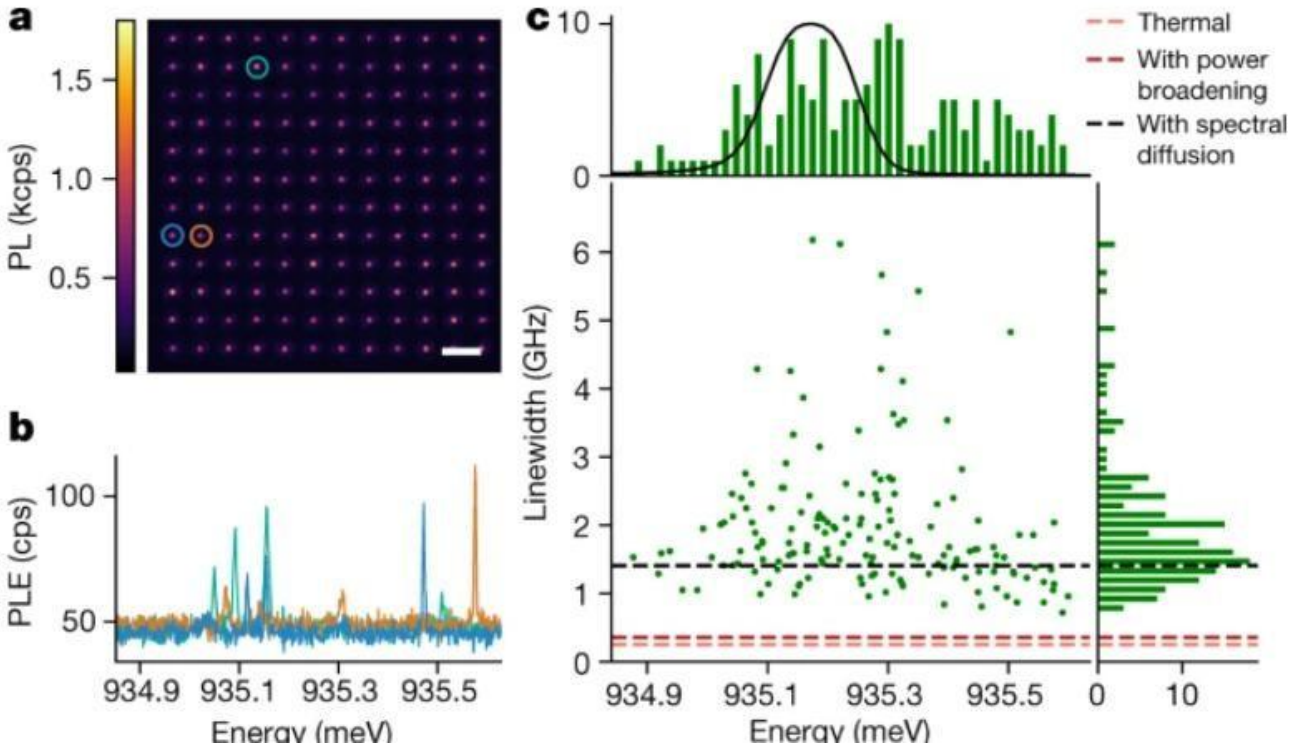
Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada

全文链接：https://www.nature.com/articles/s41586-022-04821-y

Abstract： The global quantum internet will require long-lived, telecommunications-band photon – matter interfaces manufactured at scale1. Preliminary quantum networks based on photon – matter interfaces that meet a subset of these demands are encouraging efforts to identify new high-performance alternatives2. Silicon is an ideal host for commercial-scale solid-state quantum technologies. It is already an advanced platform within the global integrated photonics and microelectronics industries, as well as host to record-setting long-lived spin qubits3. Despite the overwhelming potential of the silicon quantum platform, the optical detection of individually addressable photon – spin interfaces in silicon has remained elusive. In this work, we integrate individually addressable 'T centre' photon – spin qubits in silicon photonic structures and characterize their spin-dependent telecommunications-band optical transitions. These results unlock immediate opportunities to construct silicon-integrated, telecommunications-band quantum information networks.

导读：虽然硅量子平台应用潜力巨大，但硅中单个可寻址的光子-自旋界面的光学检测仍待阐释。本研究在硅光子结构中集成了单个可寻址 T 中心光子-自旋量子比特，表征了其自旋依赖的电信波段光学跃迁。该结果为构建硅集成的电信波段量子信息网络开辟新途径。

文中插图：



[10]

Measuring the knot of non-Hermitian degeneracies and non-commuting braids

测量非厄米简并和非对易辫形成的结

出版信息：Nature volume 607, pages271–275 (2022)， 13 Jul 2022

作 者： Yogesh S. S. Patil, Judith Höller, Parker A. Henry, Chitres Guria, Yiming Zhang, Luyao Jiang, Nenad Kralj, Nicholas Read & Jack G. E. Harris

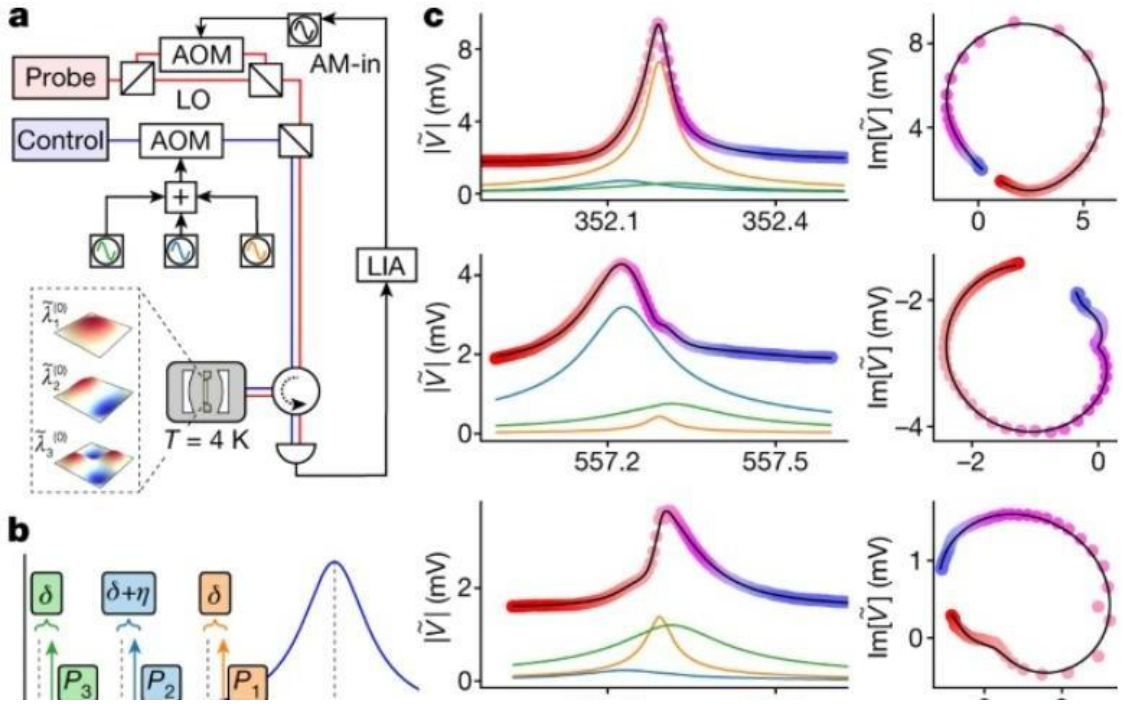
第一作者单位：Department of Physics, Yale University, New Haven, CT, USA

全文链接：https://www.nature.com/articles/s41586-022-04796-w

Abstract： Any system of coupled oscillators may be characterized by its spectrum of resonance frequencies (or eigenfrequencies), which can be tuned by varying the system’s parameters. The relationship between control parameters and the eigenfrequency spectrum is central to a range of applications1,2,3. However, fundamental aspects of this relationship remain poorly understood. For example, if the controls are varied along a path that returns to its starting point (that is, around a ‘loop’), the system’s spectrum must return to itself. In systems that are Hermitian (that is, lossless and reciprocal), this process is trivial and each resonance frequency returns to its original value. However, in non-Hermitian systems, where the eigenfrequencies are complex, the spectrum may return to itself in a topologically non-trivial manner, a phenomenon known as spectral flow. The spectral flow is determined by how the control loop encircles degeneracies, and this relationship is well understood for N=2 (where N is the number of oscillators in the system)4,5. Here we extend this description to arbitrary N. We show that control loops generically produce braids of eigenfrequencies, and for N>2 these braids form a non-Abelian group that reflects the non-trivial geometry of the space of degeneracies. We demonstrate these features experimentally for N=3 using a cavity optomechanical system.

导读：耦合振荡器系统可以通过其共振频率（或者特征频率）频谱来表征，并可通过改变系统参数来调谐。然而对参数调控与特征频率之间的关系仍知之甚少。本研究表明调控环路一般会产生特征频率辫，当N>2 时，这些辫形成非阿贝尔群，反映出简并空间的非平庸几何学。随后在实验条件下使用空腔光机系统展示了N=3 时的这些特征。

文中插图：



[11]

Elastocaloric determination of the phase diagram of Sr2RuO4

Sr2RuO4 相图的弹热测定

出版信息：Science, 13 Jul 2022

作者：You-Sheng Li, Markus Garst, Jörg Schmalian, Sayak Ghosh, Naoki Kikugawa, Dmitry A. Sokolov, Clifford W. Hicks, Fabian Jerzembeck, Matthias S. Ikeda, Zhenhai Hu, B. J. Ramshaw, et al.

第一作者单位： Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

全文链接：https://www.nature.com/articles/s41586-022-04820-z

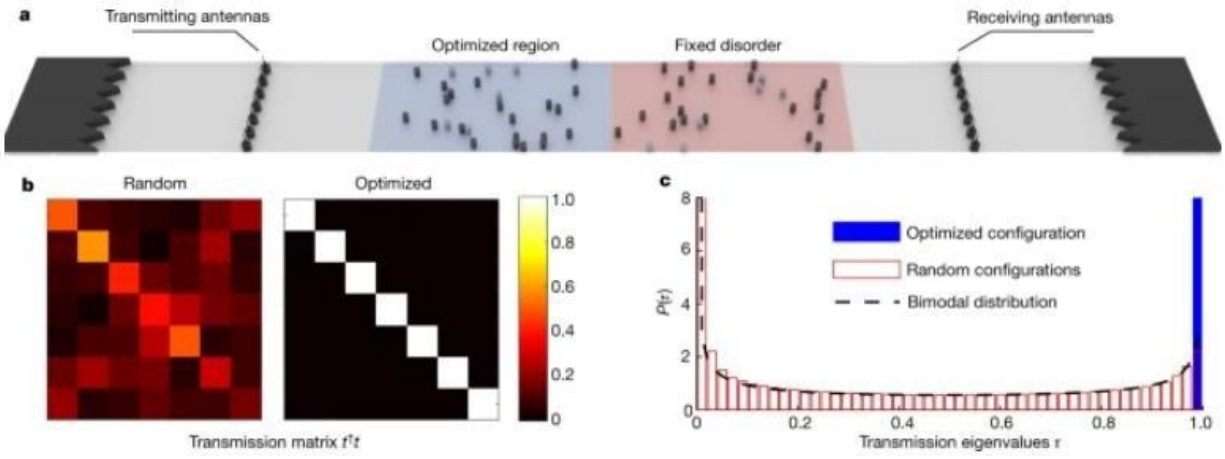
Abstract：

One of the main developments in unconventional superconductivity in the past two decades has been the discovery that most unconventional superconductors form phase diagrams that also contain other strongly correlated states. Many systems of interest are therefore close to more than one instability, and tuning between the resultant ordered phases is the subject of intense research1. In recent years, uniaxial pressure applied using piezoelectric-based devices has been shown to be a particularly versatile new method of tuning2,3, leading to experiments that have advanced our understanding of the fascinating unconventional superconductor Sr2RuO4 (refs. 4,5,6,7,8,9). Here we map out its phase diagram using high-precision measurements of the elastocaloric effect in what we believe to be the first such study including both the normal and the superconducting states. We observe a strong entropy quench on entering the superconducting state, in excellent agreement with a model calculation for pairing at the Van Hove point, and obtain a quantitative estimate of the entropy change associated with entry to a magnetic state that is observed in proximity to the superconductivity. The phase diagram is intriguing both for its similarity to those seen in other families of unconventional superconductors and for extra features unique, so far, to Sr2RuO4.

导读：

大部分非常规超导体形成的相图中也包含其他强相关态。本研究使用弹热效应的高精测量， 绘制出非常规超导体 Sr2RuO4 的相图。并观测到在进入超导态时出现强烈的熵淬灭，定量评估了与进入磁性态相关的熵变化值。该相图为研究其他非常规超导体家族及其特征提供新思路。

文中插图：



[12]

A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery

希格斯玻色子发现十年后 ATLAS 实验绘制的粒子相互作用详细图谱

出版信息：Nature volume 607, pages52–59 (2022)， 04 Jul 2022

作者：The ATLAS Collaboration

全文链接：https://www.nature.com/articles/s41586-022-04893-w

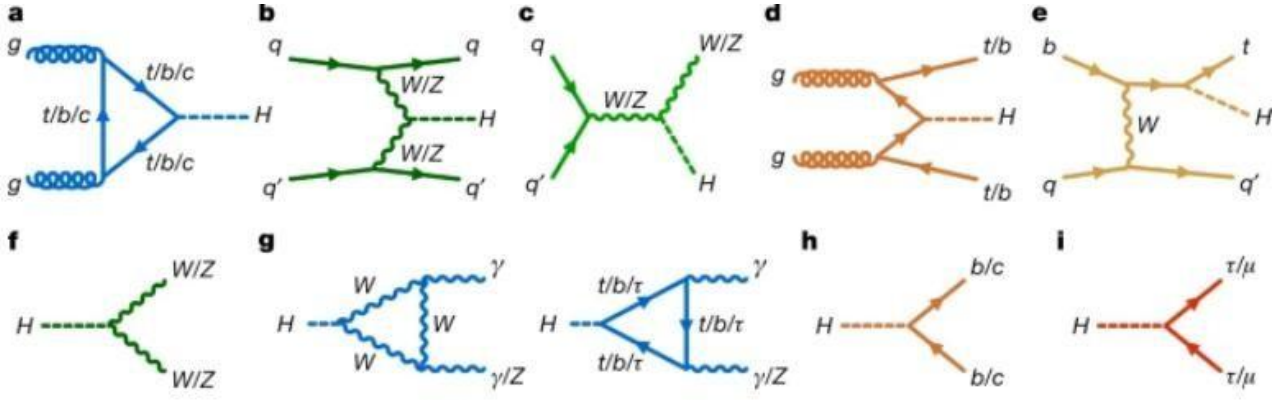
Abstract：

The standard model of particle physics1,2,3,4 describes the known fundamental particles and forces that make up our Universe, with the exception of gravity. One of the central features of the standard model is a field that permeates all of space and interacts with fundamental particles5,6,7,8,9. The quantum excitation of this field, known as the Higgs field, manifests itself as the Higgs boson, the only fundamental particle with no spin. In 2012, a particle with properties consistent with the Higgs boson of the standard model was observed by the ATLAS and CMS experiments at the Large Hadron Collider at CERN10,11. Since then, more than 30 times as many Higgs bosons have been recorded by the ATLAS experiment, enabling much more precise measurements and new tests of the theory. Here, on the basis of this larger dataset, we combine an unprecedented number of production and decay processes of the Higgs boson to scrutinize its interactions with elementary particles. Interactions with gluons, photons, and W and Z bosons — the carriers of the strong, electromagnetic and weak forces—are studied in detail. Interactions with three third-generation matter particles (bottom (b) and top (t) quarks, and tau leptons (τ)) are well measured and indications of interactions with a second-generation particle (muons, μ) are emerging. These tests reveal that the Higgs boson discovered ten years ago is remarkably consistent with the predictions of the theory and provide stringent constraints on many models of new phenomena beyond the standard model.

导读：

2012 年欧洲核子研究中心的 ATLAS 和 CMS 实验观测到符合希格斯玻色子特征的粒子存在，之后越来越多的希格斯玻色子被观测到，有助于精确测量并完善标准模型及相关理论。本研究在基于大数据的基础上结合希格斯玻色子的生成和衰退过程，细致分析了其与基本粒子（包括胶子、光子、W 和Z 玻色子）的相互作用过程，。该结果证实发现的希格斯玻色子与理论预测的一直，并为标准模型之外的新物理现象模型提供的严格的约束。

文中插图：



[13]

A portrait of the Higgs boson by the CMS experiment ten years after the discovery

希格斯玻色子发现十年后 CMS 实验的粒子肖像

出版信息：Nature volume 607, pages60–68 (2022)， 04 Jul 2022

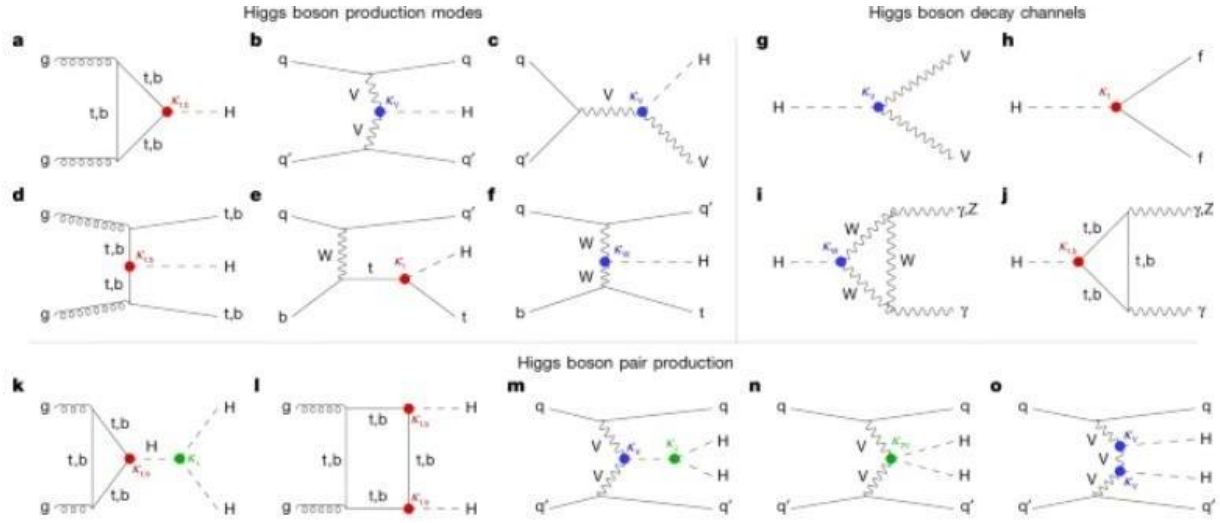
作者：The CMS Collaboration

全文链接：https://www.nature.com/articles/s41586-022-04892-x

Abstract： In July 2012, the ATLAS and CMS collaborations at the CERN Large Hadron Collider announced the observation of a Higgs boson at a mass of around 125 gigaelectronvolts. Ten years later, and with the data corresponding to the production of a 30-times larger number of Higgs bosons, we have learnt much more about the properties of the Higgs boson. The CMS experiment has observed the Higgs boson in numerous fermionic and bosonic decay channels, established its spin‐parity quantum numbers, determined its mass and measured its production cross-sections in various modes. Here the CMS Collaboration reports the most up-to-date combination of results on the properties of the Higgs boson, including the most stringent limit on the cross-section for the production of a pair of Higgs bosons, on the basis of data from proton‐proton collisions at a centre-of-mass energy of 13 teraelectronvolts. Within the uncertainties, all these observations are compatible with the predictions of the standard model of elementary particle physics. Much evidence points to the fact that the standard model is a low-energy approximation of a more comprehensive theory. Several of the standard model issues originate in the sector of Higgs boson physics. An order of magnitude larger number of Higgs bosons, expected to be examined over the next 15 years, will help deepen our understanding of this crucial sector.

导读：本研究报告了希格斯玻色子的最新特征分析数据，其中结合了包括以质心能量为 13TeV 的质子-质子碰撞数据为基础，生成具有最严格限制横截面的希格斯玻色子对。所有观测结果符合基本粒子物理学标准模型的预测，大量证据指出标准模型是更全面理论的低能近似。深入研究更多数量的希格斯玻色子有助于加深我们对这一关键领域的理解。

文中插图：



[14]

Entangling single atoms over 33 km telecom fibre

跨越 33 千米电信光线的单原子纠缠

出版信息：Nature volume 607, pages69–73 (2022), 06 Jul 2022

作者：Tim van Leent, Matthias Bock, Florian Fertig, Robert Garthoff, Sebastian Eppelt, Yiru Zhou, Pooja Malik, Matthias Seubert, Tobias Bauer, Wenjamin Rosenfeld, Wei Zhang, Christoph Becher & Harald Weinfurter

第一作者单位：Faculty of Physics, Ludwig-Maximilians-University of Munich, Munich, Germany

Munich Center for Quantum Science and Technology, Munich, Germany

全文链接：https://www.nature.com/articles/s41586-022-04764-4

Abstract：

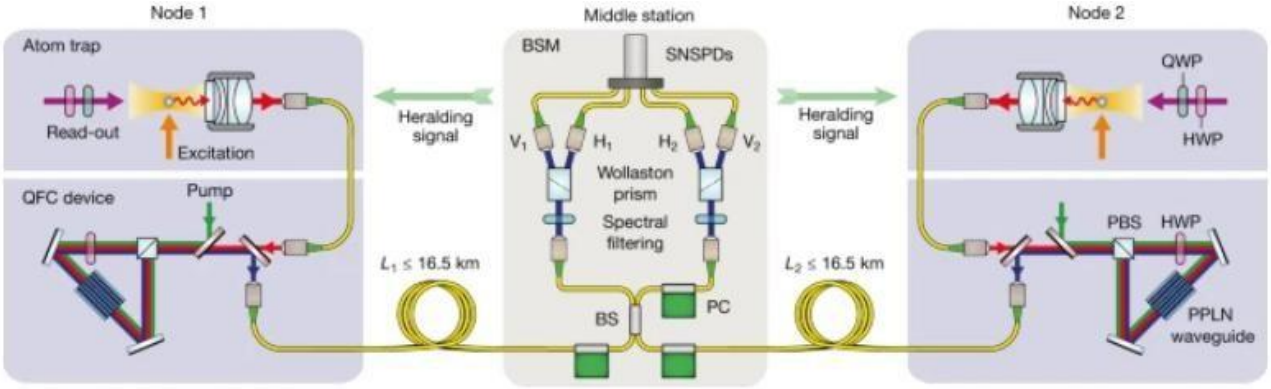
Quantum networks promise to provide the infrastructure for many disruptive applications, such as efficient long-distance quantum communication and distributed quantum computing1,2. Central to these networks is the ability to distribute entanglement between distant nodes using photonic channels. Initially developed for quantum teleportation3,4 and loophole-free tests of Bell’ s inequality5,6, recently, entanglement distribution has also been achieved over telecom fibres and analysed retrospectively7,8. Yet, to fully use entanglement over long-distance quantum network links it is mandatory to know it is available at the nodes before the entangled state decays. Here we demonstrate heralded entanglement between two independently trapped single rubidium atoms generated over fibre links with a length up to 33 km. For this, we generate atom

– photon entanglement in two nodes located in buildings 400 m line-of-sight apart and to overcome high-attenuation losses in the fibres convert the photons to telecom wavelength using polarization-preserving quantum frequency conversion9. The long fibres guide the photons to a Bell-state measurement setup in which a successful photonic projection measurement heralds the entanglement of the atoms10. Our results show the feasibility of entanglement distribution over telecom fibre links useful, for example, for device-independent quantum key distribution11,12,13 and quantum repeater protocols. The presented work represents an important step towards the realization of large-scale quantum network links.

导读：

量子网络为包括有效远距离量子通信和分布式量子计算在内的众多应用提供基础设施。本研究在 33 千米的光纤链路上展示两个独立被俘获的单个铷原子之间的纠缠。研究人员在视距为 400 米的建筑物内设置两个节点，在其中生成原子-光子纠缠，并且克服了光纤中的高衰减损耗。长光纤将光子引导至贝尔态测量装置中，其中成功的光子投影测量预示着原子的纠缠。该结果向实现大规模量子网络连接迈进一步。

文中插图：



[15]

Turbulent cold flows gave birth to the first quasars

湍急冷流孕育首批类星体

出版信息：Nature volume 607, pages48–51 (2022), 06 Jul 2022

作者：M. A. Latif, D. J. Whalen, S. Khochfar, N. P. Herrington & T. E. Woods .

第一作者单位：Physics Department, College of Science, United Arab Emirates University, Al-Ain, UAE

全文链接：https://www.nature.com/articles/s41586-022-04813-y

Abstract：How quasars powered by supermassive black holes formed less than a billion years after the Big Bang is still one of the outstanding problems in astrophysics, 20 years after their discovery1,2,3,4. Cosmological simulations suggest that rare cold flows converging on primordial haloes in low-shear, environments could have created these quasars if they were 104 – 105 solar masses at birth, but could not resolve their formation5,6,7,8. Semi-analytical studies of the progenitor halo of a primordial quasar found that it favours the formation of such seeds, but could not verify if one actually appeared9. Here we show that a halo at the rare convergence of strong, cold accretion flows creates massive black holes seeds without the need for ultraviolet backgrounds, supersonic streaming motions or even atomic cooling. Cold flows drive violent, supersonic turbulence in the halo, which prevents star formation until it reaches a mass that triggers sudden, tcatastrophic baryon collapse that forms 31,000 and 40,000 solar-mass stars. This simple, robust process ensures that haloes capable of forming quasars by a redshift of z > 6 produce massive seeds. The first quasars were thus ra natural consequence of structure formation in cold dark matter cosmologies, and not exotic, finely tuned fenvironments as previously thought10,11,12,13,14.

导读：宇宙早期的湍急冷流孕育了首批类星体。本研究指出，首批类星体在充满冷暗物质的宇宙中自然形成。位于强大冷流交汇处的晕圈可在没有紫外背景、超音速流动和原子冷却的基础下产生大质量黑洞种子，冷流的存在能让拥有 31000 到 40000 太阳质量的恒星在剧烈的重子坍缩下形成。这一研究揭开了天体物理领域 20 年来悬而未决的类星体诞生之谜。

文中插图：