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本期推荐报道 2022 年 9月 Nature 、Science 期刊上材料科学领域的部分最新论文。

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[1]Promotion of superconductivity in magic-angle graphene multilayers

磁角石墨烯多层膜中超导性的提升

出版信息： Science, 30 SEP 2022, VOL 377, ISSUE 6614

作者： YIRAN ZHANG, ROBERT POLSKI, CYPRIAN LEWANDOWSKI et al.

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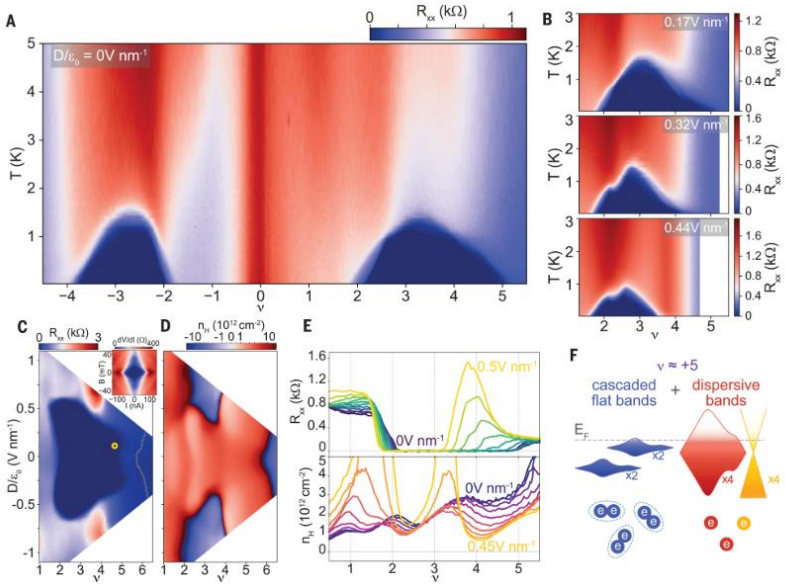
全文链接： https://www.science.org/doi/10. 1126/science.abn8585

Abstract： Graphene moiré superlattices show an abundance of correlated insulating, topological, and superconducting phases. Whereas the origins of strong correlations and nontrivial topology can be directly linked to flat bands, the nature of superconductivity remains enigmatic. We demonstrate that magic-angle devices made of twisted tri-, quadri-, and pentalayer graphene placed on monolayer tungsten diselenide exhibit flavor polarization and superconductivity. We also observe insulating states in the tril- and quadrilayer arising at finite electric displacement fields. As the number of layers increases, superconductivity emerges over an enhanced filling-factor range, and in the pentalayer it extends well beyond the filling of four electrons per moiré unit cell. Our results highlight the role of the interplay between flat and more dispersive bands in extending superconducting regions in graphene moiré superlattices.

摘要翻译： 石墨烯摩尔超晶格显示出丰富的相关绝缘、拓扑和超导相。尽管强相关性和非平凡拓扑的起源可以直接与平坦带联系起来，但超导性的特质仍然是个谜团。我们证明了，将扭曲三层、四层和五层石墨烯置于单层二烯化钨上的后产生的魔角装置表现出极化和超 导性。我们还观察到三层和四层石墨烯在有限电位移场下产生了绝缘态。随着层数的增加，超导性在一个增强的填充因子范围内出现，在五层石墨烯中，它扩展到每个摩尔的 4 个电子的填充。我们的结果突出了扁平带和更分散带之间的相互作用在石墨烯摩尔超晶格中延伸超导区域的角色。

文中插图：



9 月 Nature 论文

[1]

Aligned macrocycle pores in ultrathin films for accurate molecular sieving

超薄膜中定向大环孔的精确分子筛分

出版信息：Nature, 1 September 2022, Volume 609 Issue 7925

作者：Zhiwei Jiang, Ruijiao Dong, Austin M. Evans et al.

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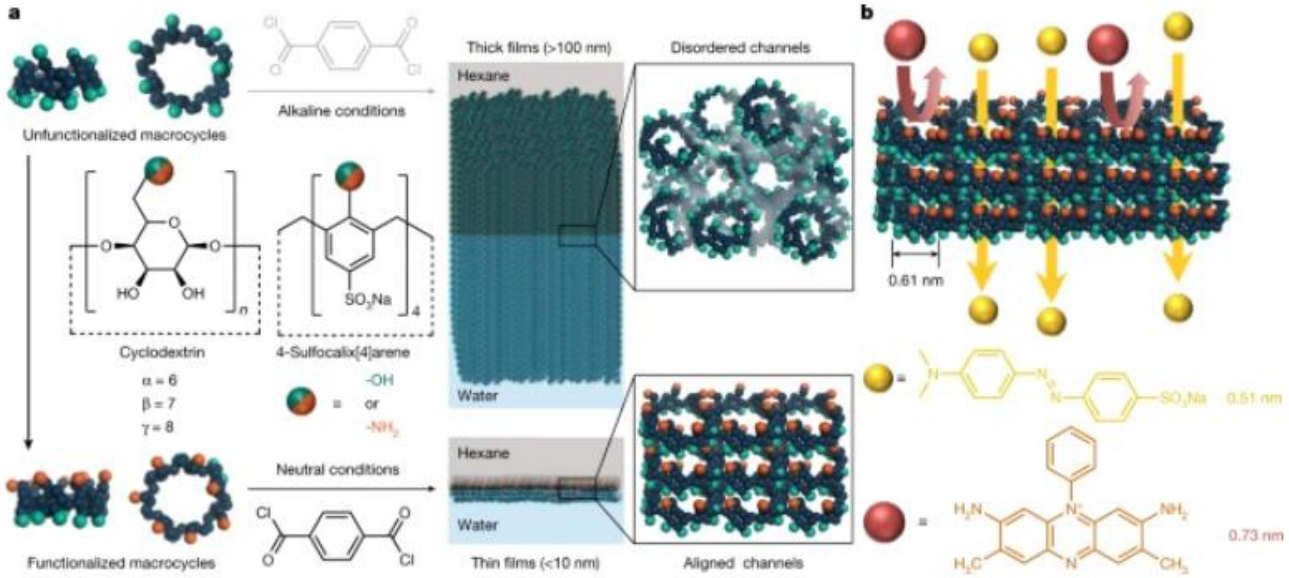
全文链接：https://www.nature.com/articles/s41586-022-05032- 1

Abstract：Here, we synthesized selectively functionalized macrocycles with differentiated reactivities that preferentially aligned to create well-defined pores across an ultrathin nanofilm. The ordered structure was enhanced by reducing the nanofilm thickness down to several nanometres. This orientated architecture enabled direct visualization of subnanometre macrocycle pores in the nanofilm surfaces, with the size tailored to ångström precision by varying the macrocycle identity. Aligned macrocycle membranes provided twice the methanol permeance and higher selectivity compared to disordered counterparts. Used in high-value separations, exemplified here by enriching cannabidiol oil, they achieved one order of magnitude faster ethanol transport and threefold higher enrichment than commercial state-of-the-art membranes. This approach offers a feasible strategy for creating subnanometre channels in polymer membranes, and demonstrates their potential for accurate molecular separations.

摘要翻译：在此，我们合成了选择性功能化的大环，它具有分化的反应性，优先排列，在超薄纳米膜上能形成良好的孔。通过将纳米膜厚度降低到几纳米，这种有序结构得到了增强。这种定向结构使纳米膜表面亚纳米级大周期孔隙的直接可视化成为可能，通过改变大周期特性，尺寸可 精确到埃。与无序的大环膜相比，定向的大环膜具有两倍的甲醇渗透性和更高的选择性。在高值分离中使用，例如富集大麻二酚油，它们实现了一个数量级的乙醇传输和比商业先进的膜高三倍 的富集。这种方法为在聚合物膜中创建亚纳米通道提供了一种可行的策略，并证明了其在精确分子分离方面的潜力。

文中插图：



[2]

Heterodimensional superlattice with in-plane anomalous Hall effect

具有面内大反常霍尔效应的异维超晶格

出版信息：Nature, 1 September 2022, Volume 609 Issue 7925

作者：Jiadong Zhou, Wenjie Zhang, Yung-Chang Lin et al.

第一作者单位：Centre for Quantum Physics, Key Laboratory of Advanced Optoelectronic Quantum Architecture and Measurement (MOE), School of Physics, Beijing Institute of Technology, Beijing, China

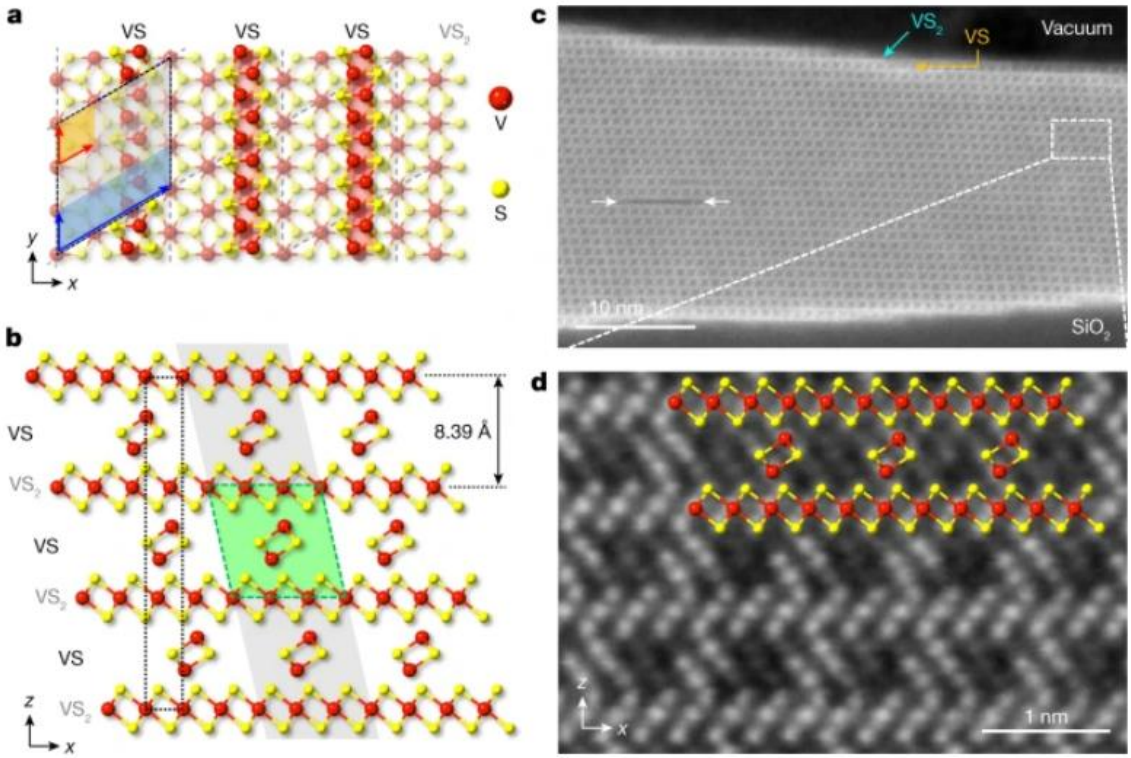
全文链接：https://www.nature.com/articles/s41586-022-05031-2

Abstract：

Here we report an intrinsic heterodimensional superlattice consisting of alternating layers of two-dimensional vanadium disulfide (VS2) and a one-dimensional vanadium sulfide (VS) chain array, deposited directly by chemical vapour deposition. This unique superlattice features an unconventional 1T stacking with a monoclinic unit cell of VS2/VS layers identified by scanning transmission electron microscopy. An unexpected Hall effect, persisting up to 380 kelvin, is observed when the magnetic field is in-plane, a condition under which the Hall effect usually vanishes. The observation of this effect is supported by theoretical calculations, and can be attributed to an unconventional anomalous Hall effect owing to an out-of-plane Berry curvature induced by an in-plane magnetic field, which is related to the one-dimensional VS chain. Our work expands the conventional understanding of superlattices and will stimulate the synthesis of more extraordinary superstructures.

摘要翻译：在此，我们报告了一种直接通过化学气相沉积沉积的、由二维二硫化钒（VS2）和一维硫化钒（VS）链相互交叉排列组成的本征异维超晶格。这种独特的超晶格具有非常规的 1T 叠加，通过扫描透射电子显微镜识别出二硫化钒/硫化钒层的单斜单元细胞。当磁场在平面上时，可以观察到一个意想不到的霍尔效应，其持续时间可达 380 开尔文，在这种情况下， 霍尔效应通常会消失。这一效应的观测得到了理论计算的支持，可以归因于与一维硫化钒链有关的、由面内磁场诱导的面外贝 里曲率引起的非常规反常霍尔效应。我们的工作扩展了对超晶格的传统理解，并将促进更多超结构的合成。

文中插图：



[3]

Exciton-coupled coherent magnons in a 2D semiconductor

二维半导体中激子耦合相干磁子

出版信息： Nature, 8 September 2022, VOL 609, ISSUE 7926

作者： Youn Jue Bae, Jue Wang, Allen Scheie, Junwen Xu, Daniel G. Chica, Geoffrey M. Diederich, et al.

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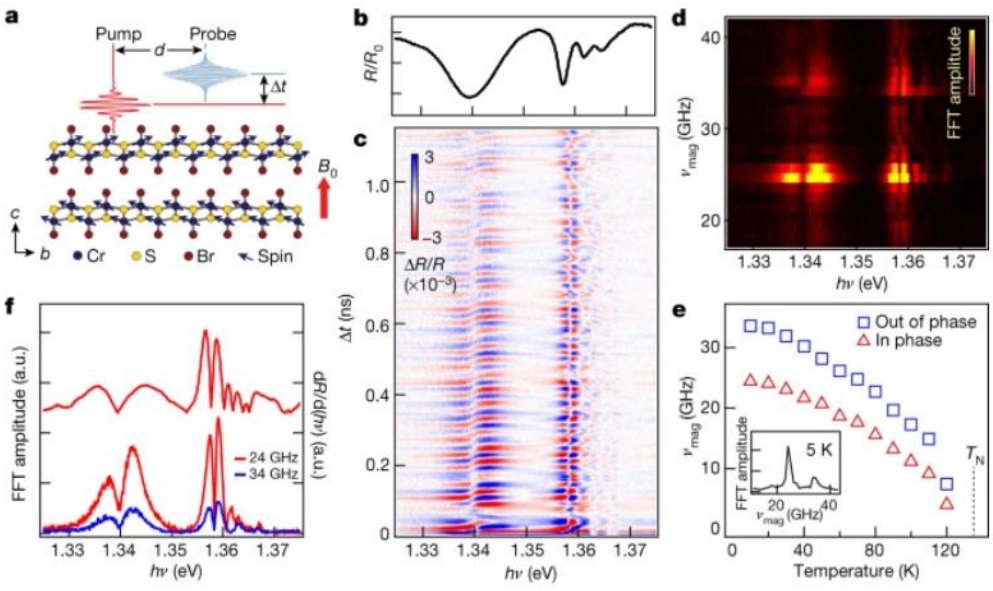
全文链接： https://www.nature.com/articles/s41586-022-05024- 1

Abstract： The recent discoveries of two-dimensional (2D) magnets and their stacking into van der Waals structures have expanded the horizon of 2D phenomena. One exciting application is to exploit coherent magnons as energy-efficient information carriers in spintronics and magnonics or as interconnects in hybrid quantum systems. A particular opportunity arises when a 2D magnet is also a semiconductor, as reported recently for CrSBr and NiPS3 that feature both tightly bound excitons with a large oscillator strength and potentially long-lived coherent magnons owing to the bandgap and spatial confinement. Although magnons and excitons are energetically mismatched by orders of magnitude, their coupling can lead to efficient optical access to spin information. Here we report strong magnon–exciton coupling in the 2D A-type antiferromagnetic semiconductor CrSBr. Coherent magnons launched by above-gap excitation modulate the exciton energies. Time-resolved exciton sensing reveals magnons that can coherently travel beyond seven micrometres, with a coherence time of above five nanoseconds. We observe these exciton-coupled coherent magnons in both even and odd numbers of layers, with and without compensated magnetization, down to the bilayer limit. Given the versatility of van der Waals heterostructures, these coherent 2D magnons may be a basis for optically accessible spintronics, magnonics and quantum interconnects.

摘要翻译： 最近发现的二维（2D）磁体及其堆叠为范德华结构扩大了2D 现象的范围。一个令人振奋的应用是利用相干磁子作为自旋电子学和磁子学中能效信息载体或作为混合量子系统中的互连。当 2D 磁体同时也是半导体时，就会出现一个特殊机会，如最近报道的 CrSBr 和 NiPS3，其特征是具有大振荡器强度的紧密束缚激子和由于带隙和空间约束而潜在的长寿命相干磁子。虽然磁子和激子在能量上失 配了几个数量级，但二者耦合可导致对自旋信息的有效光学存取。研究组报道了2D A 型反铁磁半导体CrSBr 中的强磁子-激子耦合。通过上述间隙激发发射的相干磁子调 制激子能量。时间分辨激子传感显示磁子可以相干移动超过 7 微米，相干时间超过 5 纳秒。研究组在偶数层和奇数层中观察到这些激子-耦合相干磁子(无论是否有补偿磁化），直至双层极限。考虑到范德华异质结构的多功能性，这些相干 2D 磁子可能是光学可存取的自旋电子学、磁子学和量子互连的基础。

文中插图：



[4]

Anomalous slip in body-centred cubic metals

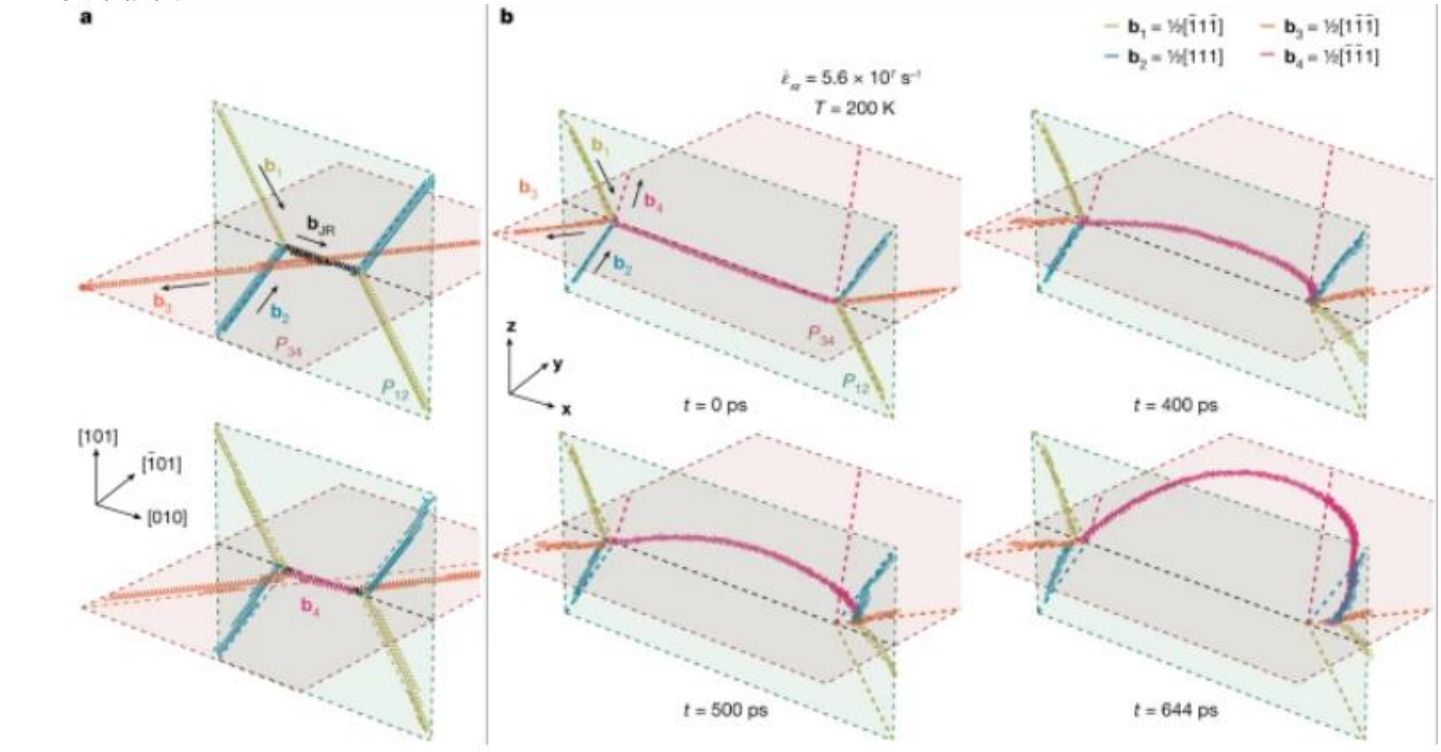
体心立方金属的异常滑移

出版信息：Nature, 29 September 2022, VOL 609, ISSUE 7929
作者：Daniel Caillard, Baptiste Bienvenu & Emmanuel Clouet
第一作者单位：CEMES-CNRS, Toulouse, France
全文链接：https://www.nature.com/articles/s41586-022-05087-0

Abstract：Crystal strength and plastic flow are controlled by the motion and interaction of dislocations, the line defects carrying atomic shear increments. Whereas, in most crystals, deformation develops in the crystallographic planes in which the glide force acting on dislocations is maximum, plasticity in body-centred cubic metals is more complex. Slip systems in which the resolved shear stress is not the highest can dominate at low temperature, leading to anomalous slip. Using in situ tensile tests in a transmission electron microscope we show that anomalous slip arises from the high mobility of multi-junctions, that is, junctions between more than two dislocations, which glide at a velocity several orders of magnitude larger than single dislocations. These multi-junctions result from the interaction of a simple binary junction with a gliding dislocation. Although elasticity theory predicts that these binary junctions should be unstable in crystals with a weak elastic anisotropy such as tungsten, both experiments and atomistic simulations reveal that such junctions can be created under dynamic conditions, in agreement with the existence of anomalous slip in almost all body-centred cubic metals, including tungsten.

摘要翻译：晶体强度和塑性流动受位错的运动和相互作用控制，这种线缺陷携带原子剪切增量。然而，在大多数晶体中，变形发生在最大滑移位错晶面上，而体心立方金属的塑性则更为复杂。在低温条件下，解析剪应力最高的滑移系统不占主导地位，导致异常滑移。利用透射电子显微镜的原位拉伸试验，研究组发现异常滑移由多结（即两个以上位错之间的结）的高迁移率引起，其滑移速度比单个位错大几个数量级。这些多结是简单二元结与滑移位错相互作用的结果。尽管弹性理论预测这些二元结在弱弹性各向异性晶体中（如钨）很可能不稳定，但实验和原子模拟都表 明该类结可以在动态条件下产生，这与几乎所有体心立方金属（包括钨）中存在的异常滑移一致。

文中插图



[5]

Tracking single adatoms in liquid in a transmission electron microscope

用透射电子显微镜追踪液体中的单吸附原子

出版信息： Nature, 29 September 2022, VOL 609, ISSUE 7929

作者： Nick Clark, Daniel J. Kelly, Mingwei Zhou, Yi-Chao Zou, Chang Woo Myung, David G. Hopkinson, et al

第一作者单位： Department of Materials, University of Manchester, Manchester, UK

National Graphene Institute, University of Manchester, Manchester, UK

全文链接： https://www.nature.com/articles/s41586-022-05130-0

Abstract： Single atoms or ions on surfaces affect processes from nucleation to electrochemical reactions and heterogeneous catalysis. Transmission electron microscopy is a leading approach for visualizing single atoms on a variety of substrates. It conventionally requires high vacuum conditions, but has been developed for in situ imaging in liquid and gaseous environments with a combined spatial and temporal resolution that is unmatched by any other method—notwithstanding concerns about electron-beam effects on samples. When imaging in liquid using commercial technologies, electron scattering in the windows enclosing the sample and in the liquid generally limits the achievable resolution to a few nanometres. Graphene liquid cells, on the other hand, have enabled atomic-resolution imaging of metal nanoparticles in liquids. Here we show that a double graphene liquid cell, consisting of a central molybdenum disulfide monolayer separated by hexagonal boron nitride spacers from the two enclosing graphene windows, makes it possible to monitor, with atomic resolution, the dynamics of platinum adatoms on the monolayer in an aqueous salt solution. By imaging more than 70,000 single adatom adsorption sites, we compare the site preference and dynamic motion of the adatoms in both a fully hydrated and a vacuum state. We find a modified adsorption site distribution and higher diffusivities for the adatoms in the liquid phase compared with those in vacuum. This approach paves the way for in situ liquid-phase imaging of chemical processes with single-atom precision.

摘要翻译： 材料表面上的单个原子或离子影响着从成核到电化学反应和多相催化的过程。透射电子显微镜是观察各种基底上单个原子的主要方法，通常需要高真空条件，但已开发出在液体和气体环境中的原位成像，具有空间和时间的综合分辨率，这是其他任何方法都无法比拟的——尽管需要考虑电子束对样品的影响。当使用商业技术在液体中成像时，封闭样品的窗口和液体中的电子散射通常将可达到的分辨率限制在几纳米。另一方面，石墨烯液体电池已实现对液体中金属纳米颗粒进行原子分辨率成像。研究组展示了一种双石墨烯液体电池，由一个中心二硫化钼单分子层组成，通过六方氮化硼间隔层与两个封闭的石墨烯窗口隔开，从而能够以原子分辨率监测水盐溶液中单分子层上铂吸附原子的动力学。通过对超过 7 万个单吸附原子吸附位点进行成像，研究组比较了吸附原子在完全水合状态和真空状态下的位置偏好和动态运动。他们发现与真空中相比，吸附原子在液相中的吸附位点分布有所改变，扩散系数更高。这种方法为单原子精度化学过程的原位液相成像铺平了道路。

文中插图：