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材料科学Materials Science

Superconducting phase diagram of multilayer square-planar nickelates

多层方平面镍酸盐的超导相图

▲ 作者：Grace A. Pan, Dan Ferenc Segedin, Sophia F. R. TenHuisen, Lopa Bhatt, Harrison LaBollita, Abigail Y. Jiang, et al.

▲链接：

https://www.science.org/doi/10.1126/science.adp4440

▲ 摘要： 方平面镍酸盐中超导性的发现，为探索高温超导的起源提供了一个丰富的材料平台。然而，实验研究在很大程度上局限于无限层结构的RNiO2（R为稀土元素）镍酸盐。

研究组构建了多层方平面Ndn+1NinO2n+2化合物的相图，并发现了维度n = 4至8的超导特征。随着n减小，超导各向异性因4f电子效应而演化，电子结构特征趋近于类铜酸盐行为。

磁涨落在超导区以及过掺杂的非超导区均持续存在。

超导区与化学掺杂的无限层镍酸盐区重叠，表明方平面镍酸盐在不同结构实现形式之间既存在共性，也存在差异。该工作为创建新型镍基超导体建立了多层模板。

▲ Abstract： The discovery of superconductivity in square-planar nickelates has offered a rich materials platform to explore the origins of high-temperature superconductivity. However, experimental investigations have largely been limited to the infinite-layer RNiO2 (R, rare earth) nickelates. We constructed a phase diagram of multilayer square-planar Ndn+1NinO2n+2 compounds and found signatures of superconductivity for dimensionality n = 4 to 8. Upon decreasing n, the superconducting anisotropy evolves owing to 4f electron effects, and electronic structure characteristics approach cuprate-like behavior. Magnetic fluctuations persist from within the superconducting regime and into the overdoped, nonsuperconducting regime. The superconducting regime overlaps with that of chemically doped infinite-layer nickelates, demonstrating underlying commonalities as well as differences across varying structural realizations of square-planar nickelates. Our work establishes this layered template for creating new nickel-based superconductors.

Nodeless superconducting gap and electron-boson coupling in (La,Pr,Sm)3Ni2O7 films

(La,Pr,Sm)3Ni2O7薄膜中的无节点超导能隙和电子—玻色子耦合

▲ 作者：Jianchang Shen, Guangdi Zhou, Yu Miao, Peng Li, Zhipeng Ou, Yaqi Chen, et al.

▲链接：

https://www.science.org/doi/10.1126/science.adw8329

▲ 摘要： 环境压力下Ruddlesden-Popper双层镍酸盐薄膜中超导性的发现，为直接研究超导态的电子能标及其配对机制提供了契机。

研究组通过开发一种超高真空低温样品淬火与传递技术，报道了对超导(La,Pr,Sm)3Ni2O7薄膜的角分辨光电子能谱测量结果。沿布里渊区对角线方向，观测到约 18

毫电子伏特的超导能隙，并伴有相干峰。该有限能隙遍布整个布里渊区，表明不存在能隙节点。

研究组在费米能级以下约 70 毫电子伏特的能量—动量色散中观测到一个扭结，表明存在电子—玻色子耦合。无节点超导能隙与电子—玻色子耦合的同时观测，为理解 Ruddlesden-Popper 双层镍酸盐中的配对对称性及其粘合机制提供了重要认识。

▲ Abstract： The discovery of superconductivity in Ruddlesden-Popper bilayer nickelate films under ambient pressure provides an opportunity to directly investigate electronic energy scales of the superconducting state and the pairing mechanism. We report angle-resolved photoemission spectroscopy measurements of superconducting (La,Pr,Sm)3Ni2O7 thin films by developing an ultrahigh-vacuum cryogenic sample quenching and transfer technique. A superconducting gap of ~18 milli – electron volts with coherence peaks is observed along the Brillouin zone diagonal. The finite gap persists across the entire Brillouin zone, revealing the absence of gap nodes. A kink is observed in the energy-momentum dispersion at ~70 milli – electron volts below the Fermi level, indicating an electron-boson coupling. The simultaneous observation of a nodeless superconducting gap and electron-boson coupling provides insight into the pairing symmetry and gluing mechanism in Ruddlesden-Popper bilayer nickelates.

化学Chemistry

Industrial-scale nanocrystalline Ni – Mo – MgO catalysts for hybrid reforming of waste to fuels

用于废弃物混合重整制燃料的工业级纳米晶 Ni-Mo-MgO催化剂

▲ 作者：Seok-Jin Kim, Raghu V. Maligal-Ganesh, Javeed Mahmood, Phil Woong Kang, Aadesh Harale, Abdulrahman S. AlSuhaibani, et al.

▲链接：

https://www.science.org/doi/10.1126/science.adp5208

▲ 摘要： 降低烃类和废弃物碳排放的策略，必须克服与催化剂耐久性和废弃物预分选相关的挑战。利用二氧化碳（CO2）重整低价值碳源，为将废物流转化为燃料和化学品提供了一条工业规模的途径。

研究组开发了一种单晶氧化镁镍钼合金纳米催化剂（NiMoCat），并将其制成适用于高压工业反应器的公斤级颗粒状。在加压CO2条件下，脂肪烃（甲烷、正丁烷）和芳烃（苯、甲苯）反应生成定量合成气，未发生甲烷化反应或生成丁二烯、多环芳烃等非预期氧化副产物。

放大制备的NiMoCat在长期运行中保持活性，并可实现两步法工艺：先将未经分选的废弃物气化，然后在真实烟气或CO2气流中进行混合重整。对沼气制二甲醚路线的详细生命周期分析表明，该策略可实现与现有燃料和化学品基础设施兼容的可扩展且可持续的CO2利用。

▲ Abstract： Strategies for lowering carbon emissions from hydrocarbons and waste must overcome the challenges related to catalyst durability and the presorting of waste. Reforming low-value carbon sources with

carbon dioxide (CO2) offers an industrial-scale pathway for recycling waste streams into fuels and chemicals. We developed a nickel-molybdenum alloy nanocatalyst on single-crystalline magnesium oxide (NiMoCat) in pellet form on a kilogram scale suitable for high-pressure industrial reactors. Aliphatic hydrocarbons (methane, n-butane) and aromatics (benzene, toluene) under pressurized CO2 yielded quantitative syngas without methanation or undesired oxidative by-products, such as butadiene or polyaromatics. Scaled-up NiMoCat maintains activity during long-term operation and enables a two-step process involving gasification of unsorted waste followed by hybrid reforming under realistic flue gas or CO2 flow. A detailed life-cycle analysis of biogas-to-dimethyl ether conversion showcases a scalable, sustainable CO2 utilization compatible with current fuel and chemical infrastructures.

Nano – electron volt Fourier-limited transition of a single surface-adsorbed molecule

单表面吸附分子的纳电子伏特傅里叶极限跃迁

▲ 作者：Masoud Mirzaei, Alexey Shkarin, Burak Gurlek, Johannes Zirkelbach, Ashley J. Shin, Irena Deperasi ń ska, et al.

▲链接：

https://www.science.org/doi/10.1126/science.aeg5014

▲摘要：高分辨率光谱学能够探测弱相互作用和细微现象。尽管这类测量在气相和晶体材料中已是常规操作，但对于表面吸附物种的研究尚未达到最终的光谱分辨率——即消除退相干、使跃迁线宽由激发态寿命决定的分辨率水平。

在这项工作中，研究组设计了一种表面制备与沉积方法，能够对有机晶体表面上的单个分子实现傅里叶极限电子跃迁的测量。通过在液氦温度下进行光谱学和超分辨显微成像，研究组揭示了吸附物种的光谱和空间特征。该结果为固态物理学研究奠定了基础，有望将埃级空间分辨率与高分辨率激光光谱学相结合。

▲ Abstract： High-resolution spectroscopy allows the probing of weak interactions and subtle phenomena. Although such measurements are routinely performed in the gas phase and in crystalline materials, studies of adsorbed species on surfaces have previously fallen short of the ultimate spectral resolution, where dephasing is eliminated and the transition linewidth is determined by the excited-state lifetime. In this work, we devise an approach to surface preparation and deposition that provides access to Fourier-limited electronic transitions in single molecules on the surface of an organic crystal. By performing spectroscopy and super-resolution microscopy at liquid helium temperature, we shed light on the spectral and spatial features of the adsorbed species. Our results pave the way for investigations in solid-state physics, where angstrom spatial resolution can be combined with high-resolution laser spectroscopy.

地球科学Earth Science

Impact heating and the hidden Hadean

撞击加热和隐伏的冥古宙

▲ 作者：Tim E. Johnson, Craig O’Neill, Simon Turner and Christopher L. Kirkland

▲链接：

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▲摘要：冥古宙（≥40.3亿年前）期间地壳的性质尚不确定。早期地球动力学的数值模型强调地幔温度的控制作用，尽管有实证表明冥古宙存在强烈的撞击通量，但这些模型通常仅考虑内部产生的热量。

利用该撞击通量的随机模型，研究组表明撞击产生的累积热量在整个冥古宙期间将远远超过内部产生的热量。冥古宙的地壳在数千米深度以下将广泛熔融，导致致密的富铁镁物质发生重力分异，并驱动地壳平均组成趋向于更加富硅化。

在全球范围内，撞击加热在39亿年后变得不再重要，地壳得以增厚。持久性大陆地壳大致出现在这一时期，很可能并非巧合。

▲ Abstract： The nature of Earth’s crust during the Hadean eon [≥4.03 billion years ago (Ga)] is uncertain. Numerical models of early Earth geodynamics emphasize the control of mantle temperature but generally consider only internally derived heat, despite empirical evidence for an intense Hadean impact flux. Using a stochastic model of that flux, we show that the time-integrated heat due to impacts would have dwarfed that produced internally throughout the Hadean. Earth’s Hadean crust would have been extensively molten at depths below a few kilometers, causing gravitational segregation of dense, iron- and magnesium-rich material and driving average crustal compositions to become increasingly silica rich. Globally, impact heating would have become much less important after 3.9 Ga, allowing the crust to thicken. That enduring continental crust appeared around this time is likely not a coincidence.

古植物学Paleobotany

Diversification of angiosperm reproductive strategies predated the end-Cretaceous extinction

被子植物繁殖策略的多样化早于白垩纪末期灭绝事件

▲ 作者：Jaemin Lee, Dori L. Contreras, James G. Saulsbury, Garland R. Upchurch and Cindy V. Looy

▲链接：

https://www.science.org/doi/10.1126/science.adw9457

▲摘要：被子植物的繁殖演化传统上被认为与白垩纪末期的生物危机及随后的生态重组密切相关。

研究组报道了新墨西哥州Jose Creek组晚坎潘期（7460万年前）一个热带森林中发现的多样且出人意料的大孢子（扩散单元）。近80种不同的孢子形态类型表明，该植物群在形态特化程度上有所增加，其孢子体积的平均值和变化范围异常之大，可与新生代记录相媲美。

这些发现表明，繁殖投入和特化的大幅增加发生在白垩纪末期灭绝事件之前。该结果表明，白垩纪被子植物已演化出多样的扩散策略，暗示着动物介导的传播以及密集的被子植物整合冠层建立时间远远早于此前的认识。

▲ Abstract： Angiosperm reproductive evolution is traditionally linked to the end-Cretaceous biotic crisis and subsequent ecological restructuring. Here, we report diverse and unexpectedly large diaspores (dispersal units) from an in situ late Campanian (74.6 million years ago) tropical forest from the Jose Creek Formation in New Mexico. Nearly 80 distinct diaspore morphotypes demonstrate that the flora had increased morphological specialization and an exceptionally large average and range of diaspore volume comparable to the Cenozoic records. These findings suggest that substantial increases in reproductive investment and specialization preceded the end-Cretaceous extinction. Our results indicate that Cretaceous angiosperms had already evolved diverse dispersal strategies, suggesting that animal-mediated dispersal and dense, angiosperm-integrated canopies were established far earlier than was previously recognized.

作者：未玖 来源：科学网微信公众号