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前言

2017年，超导国家重点实验室在尖端设备研制、科学研究、人才引进和培养，科研环境营造、以及国际国内交流与合作方面,继续取得新的进展。

在尖端科研设备建设方面，由财政部和科学院组织的“深紫外固态激光源前沿装备研制（二期）”项目《基于深紫外激光的大动量极低温角分辨光电子能谱仪研制》顺利进行，该项目已经完成了系统组装，进入最后的测试和验收阶段。经过多年的努力和积累，超导国家重点实验室已经建立和完善的角分辨光电子能谱、中子散射、扫描隧道显微镜、核磁共振、高压强磁场极低温综合极端条件、红外光谱等一系列高端实验研究手段以及先进的材料制备和表征技术，为超导和相关量子材料的研究奠定了坚实的基础。

2017年，超导国家重点实验室在铜氧化物高温超导体、铁基超导体以及其它非常规超导体和量子材料的探索和研究中，继续取得重要进展。发现新的133型Cr系非常规超导体KCr_3As_3和其它一些新超导体。成功地采用水热法外延生长出超导临界温度Tc达42.4K的(Li,Fe)OHFeSe薄膜，并发现其具有极高的上临界场。采用组合法成功制备出Tc可在<2K到15K之间连续调控的单一组分FeSe薄膜。采用激光角分辨光电子能谱，精确测量了铜氧化物高温超导体Bi2212的超导能隙结构，并研究了其在赝能隙转变区域能带的重组行为。利用核磁共振，发现Bi2201在重欠掺杂区取代反铁磁有序态的是长程电荷密度波有序态。通过对大量铁基母体和掺杂样品的向列相涨落性质的研究，发现反铁磁有序磁矩反比于向列居里常数，建立了一个统一的铁基超导体相图。在新型反铁磁材料$Ca_{0.73}La_{0.27}FeAs_2$中，发现了反铁磁-超导转变双临界点。此外，在拓扑材料$ZrTe_5$, $HfTe_5$和WTe_2, 高熵合金材料和量子自旋液体体系的研究中，也都取得重要结果。

在人才引进培养和获奖方面，黄元和吴云博士加入实验室并获得“物理所百人计划”支持。周兴江研究员负责的“铜基和铁基高温超导机理研究团队”入选为科技部“创新人才推进计划重点领域创新团队”。一批研究生获得科学院和物理所等各项奖励：本年度有14名研究生被授予博士学位、3名被授予硕士学位。

2017年，超导国家重点实验室继续保持一个“公开、公正、公平、和谐”的科研环境，重视开展国际国内学术交流与合作，努力创造一个活跃的学术氛围。2017年实验室开展了多次内部学术交流会、《超导基础理论和实验技术》讲座和超导实验室学术报告。2017年10月，成功主办了第七届超导前沿国际会议：非传统超导体的光谱学研究。超导实验室将主办2018年8月19-24日在北京召开的第12届超导材料和机理国际会议(M2S-2018)，为此成立了组织委员会，已开展了大量的筹备工作。

超导国家重点实验室的发展和这些成绩的取得，是全体师生共同努力的结果，也离不开学术委员会委员和国内外同仁和朋友的帮助和指导，离不开财政部、科技部、科学院、基金委、物理所等部门的领导和支持，在此表示衷心的感谢。我们将继续努力，再接再厉，争取取得更大成绩。

赵忠贤
超导国家重点实验室学术委员会主任

周兴江
超导国家重点实验室主任
2017年 12月

PREFACE

In 2017, the National Lab for Superconductivity (NLSC) continues to make progresses in various aspects including development of sharp experimental tools, scientific research, talent training and recruitment, and international and domestic scientific exchange and collaborations.

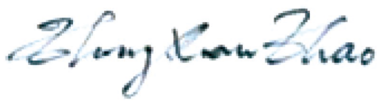
In building scientific infrastructure, NLSC has successfully developed a series of VUV laser-based photoemission systems, including spin- and angle-resolved photoemission system, photon-energy-tunable angle-resolved photoemission system, and angle-resolved photoemission system based on time-of-flight electron energy analyzer.The new laser-ARPES system with large momentum and ultralow temperature (below 1 K) is in the final stage of testing and commissioning. The "Bamboo" thermal neutron triple-axis spectrometer in China Advanced Research Reactor (CARR) has been successfully commissioned. So far, NLSC has established a number of advanced experimental tools, including angle-resolved photoemission spectroscopy (ARPES), neutron scattering, scanning tunneling microscopy (STM), nuclear magnetic resonance (NMR), combined extreme conditions for high pressure, low temperature and high magnetic field, optical spectroscopy that have laid a solid foundation for the superconductivity research.

2017 marks a fruitful year for NLSC in studying high temperature cuprate superconductors, the iron-based superconductors, and other quantum materials. Several new superconductors are discovered, including a new Cr-based KCr_3As_3superconductor. Epitaxially-grown superconducting (Li,Fe)OHFeSe films have been successfully fabricated with high Tc at 42.4 K and high upper critical field. Single crystal FeSe films with Tc continuously varying between <2K and 15K have been made on one substrate by combinatorial approach. Superconducting gap of Bi2212 was precisely measured by laser-ARPES with super-high resolution and the band evolution across the pseudogap temperature was investigated. NMR on Bi2202 finds that in the heavily underdoped region the long-range antiferromagnetic order is replaced by long-range CDW with doping. Through studies on various parent and doped Fe-based compounds, a unified phase diagram was established for the iron-based superconductors. Bi-critical point of antiferromagnetism-superconductivity transition was identified in a new $Ca_{0.73}La_{0.27}FeAs_2$material.Important results are also obtained on studying topological materials like $ZrTe_5$, $HfTe_5$ and WTe_2, high-entropy alloy superconductors, quantum spin liquid systems and so on.

In 2017, Dr. Yuan HUANG and Yu WUjoined NLSC awarded with the Institute of Physics "Hundred Talents Program". The team of "High Temperature Superconductivity Mechanism of the Cu- and Fe-Based Superconductors" led by Prof. XingjiangZHOU was selected into the Innovation Team of the Ministry of Science and Technology of China. A number of graduate students got prizes and awards from the CAS and IOP. In 2017, 14graduate students got Ph. D degree and 3 got Master degree.

In 2017, NLSC has continued to maintain an open, justified, fair and harmonious scientific environment, paid attention to scientific exchange and collaboration, and strived to create an active research atmosphere. We held a number of lab internal workshops, lectures on Basic Knowledge and Experimental Techniques Related to Superconductivity, and seminars. InOctober of 2017, we successfully organized the International Symposium on Frontier of Superconductivity Research (VII): Optical Spectroscopy on Unconventional Superconductors. NLSC will host the 12^{th} International Conference on Materials and Mechanisms of Superconductivity and High Temperature Superconductors (M2S-2018) and the local organizers did a lot of work in 2017 to prepare for the Conference.

We thank all members in NLSC, both staff members and students, for the great efforts they have made in 2017. We are also grateful to the members of our Lab Academic committee, and colleagues and friends worldwide, for their continuous help and suggestions. These achievements are not possible without the financial support from the Ministry of Commerce, the Ministry of Science and Technology, Chinese Academy of Sciences, National Natural Science Foundation of China, and the Institute of Physics. We will keep on doing our best to achieve more progress in the future.



Zhongxian Zhao
Chairman of Academic Committee
National Lab for Superconductivity

Xingjiang Zhou
Director,
National Lab for Superconductivity
December, 2017

实验室概况

超导国家重点实验室

超导电性是指材料在临界温度之下电阻完全消失的一种宏观量子现象。超导电性的研究一直是凝聚态物理的重要课题，对基础理论创新和应用技术发展两方面都有着重要的意义。自1911年荷兰物理学家Onnes发现超导电性以来，已经有5次诺贝尔物理学奖授予和超导相关的研究。1986年铜氧化物高温超导体的发现，掀起了全球超导研究的热潮，中科院物理研究所的科学家在液氮温区高温超导体的发现中做出了杰出的贡献。1987年国家计委批准在物理所筹建国家超导实验室，1991年4月通过验收并正式列入国家重点实验室系列，面向国内外开放。现任实验室主任为周兴江研究员, 学术委员会主任为中科院院士赵忠贤研究员。

超导国家重点实验室是我国超导研究的重要基地，也是国际国内超导研究学术合作与交流的重要窗口。实验室承担着中国科学院、科技部和自然科学基金会等部门多个重大研究项目。目前在实验条件、研究水准、人才引进和培养等各个层面得到显著提高，已经发展成为具有一定规模和综合实力并具有国际影响力的实验室。实验室建立和完善的系列真空紫外激光角分辨/自旋分辨光电子能谱、中子散射、扫描隧道显微镜、核磁共振、高压强磁场极低温综合极端条件、红外光谱等一系列高端实验研究手段，在超导和相关量子材料研究中发挥了重要作用。2008年新型铁基高温超导体的发现，掀起了高温超导研究的另一波高潮，超导国家重点实验室在新型铁基超导材料的发现以及相关的物性研究中，做出了举世瞩目的贡献。

研究方向：

超导国家重点实验室的研究大致分为新超导材料探索、超导电性机理研究、超导材料物性研究和超导薄膜物理与器件等四个方向。目前共设有八个课题组：

（1）基于高通量组合薄膜技术的新超导体探索和物理研究；
（2）介观尺度超导体中的量子现象的研究；
（3）探索高温超导体及相关的机理研究；
（4）超导薄膜材料和器件的物理及应用；
（5）超导材料和其它量子材料的光电子能谱研究；
（6）利用中子散射研究强关联电子体系；
（7）新奇超导体功能与机制的核磁共振研究；
（8）新型量子功能材料的探索研究。

此外，超导实验室还包括国家超导技术联合研究开发中心，超导技术应用中心和公共实验服务平台。

实验室设备：

实验室拥有种类齐全先进完备的材料制备和分析测试设备。材料制备：各种类型烧结炉和单晶生长设备，包括光学浮区单晶炉，熔融电解法单晶生长炉，温度梯度法单晶生长炉等。十多台磁控溅射、脉冲激光沉积镀膜设备，超高真空电子束蒸发设备，激光分子束外延组合薄膜生长设备，可以生长铜氧化物高温超导体、新型铁基超导体以及各种常规超导体薄膜。样品表征：原子力显微镜、劳厄衍射仪、高功率可变温X射线衍射仪，以及辅助设备离子束刻蚀机、紫外曝光机等。输运和磁性测量：多台SQUID和PPMS 测量系统和磁性测量系统。还有针对超导材料物性和超导机理研究而研发的核磁共振谱仪，低温强磁场扫描隧道谱仪，高压低温联合实验测量系统，热中子三轴谱仪，以及一系列真空紫外激光光电子能谱仪等尖端实验设备。

人才队伍：

实验室现有研究技术人员43人，其中有中国科学院院士1人，正高级职称人员15人，副高级职称人员18人。超导国家重点实验室非常重视人才引进、培养和队伍建设，拥有一支优秀的、结构合理的研究队伍。人员中有2人入选中组部“千人计划”，2人获国家杰出青年科学基金，5人入选中科院“百人计划”，1人入选“青年千人计划”。20多年来，由超导国家重点实验室培养的优秀科技人员，遍及世界各地的重要科研机构。目前共有在读研究生98名。

获得成果：

超导国家重点实验室成立二十余年来，经过实验室所有成员的勤奋努力，实验室在铜氧化物高温超导体、铁基超导体以及其它新型超导体的发现和研究中都做出了国际瞩目的成果，在设备的自主创新研发中也取得了丰硕成果。获得了国际和国家许多表彰和奖励。如国家自然科学一、二等奖、何梁何利奖、中国科学院杰出科技成就奖、中国科学院自然科学奖、求是杰出科技成就集体奖、周光召杰出青年基础科学奖，卢嘉锡青年人才奖、中国物理学会胡刚复奖、全球华人物理和天文学会亚洲杰出成就奖，国际超导领域重要的Bernd T. Matthias奖，发展中国家科学院TWAS物理奖等。超导国家重点实验室团队获2014年度“全国工人先锋号”荣誉称号。

发展目标和远景计划：

超导国家重点实验室将进一步加强人才培养和引进，注重高端实验设备的自主研发，加强实验室内部学术交流与合作以及和谐科研环境的建设，并与国际、国内相关研究团队建立起广泛的交流与合作。力争在新超导材料探索、非常规超导机理研究、以及超导相关的器件和应用研究中取得重要的原创性成果和突破。通过实验室全体师生的共同努力，希望把超导国家重点实验室建设成为国际上一流的超导研究重要基地。

Introduction

National Laboratory for Superconductivity

The establishment of the National Laboratory for Superconductivity (NLSC) at the Institute of Physics, Chinese Academy of Sciences (CAS) was formally approved by the State Commission of Development & Planning (SCDP) in 1987. The preparations were started in 1988, and in April of 1991, the Laboratory was finally established, accepted and listed as a State Key Laboratory, which has been officially open to both domestic and foreign researchers. The director of the Laboratory is Professor XingJiang Zhou and the chair of the Academic Committee is Professor Zhongxian Zhao.

As the national premier base for superconductivity research, NLSC is now conducting many important research projects supported by the Chinese Academy of Sciences, the Ministry of Science and Technology and the National Natural Science Foundation of China (NSFC). With substantial improvements in experimental facilities, research standards and in recruiting and training talents, NLSC is attaining considerable scale, integrated capacity, and worldwide influence. For many years, the National Lab for Superconductivity has carried out world-class research on exploration of novel superconductors, high-quality single crystal growth, vortex dynamics, physics and mechanism of superconductivity. In 1987, the team led by Prof. Zhongxian Zhao discovered independently Ba-Y-Cu-O superconductor with a superconducting transition temperature above the liquid Nitrogen. By the end of 2006, the world's first VUV (Vacuum Ultra-Violet) laser-based angle-resolved photoelectron spectrometer with ultra-high energy resolution, based on our own knowledge property rights and core techniques, was successfully developed in NLSC and delivered important results for the research of superconductivity. During the new upsurge of research in superconductivity triggered by the discovery of iron-based superconductors in 2008, scientists in NLSC have again drawn worldwide attention by their remarkable contributions on exploring new iron based materials with higher Tc and studying the related physical properties of iron based superconductors. In the last few years, the NLSC has established a number of advanced scientific instruments, including angle-resolved photoemission spectroscopy, neutron scattering, scanning tunneling microscopy, nuclear magnetic resonance, optical spectroscopy, and combined extreme conditions with high pressure, ultra-low temperature and high magnetic field that have laid a solid foundation for the superconductivity study.

The NLSC has already established 9 research divisions which focus on:
(I) Exploration of new superconductors and novel superconductivity on high-throughput combinatorial thin films;
(II) Research on the quantum phenomena in mesoscopic superconductors;
(III) Exploration of New Superconductors and Corresponding Mechanisms;
(IV) Physics and applications of superconducting thin films and devices;
(V) Photoemission Spectroscopy Study on Superconductors and Other Quantum Materials;
(VI) Neutron scattering study on strongly correlated electrons systems;
(VII) Study of tunneling spectroscopy and low-temperature physics in superconductors;
(VIII) Nuclear magnetic resonance study on novel superconductivity;
(IX) Novel Superconductors and Related Functional Materials.
Currently, it includes almost all the aspects in the research for the superconductivity.

In addition to core research projects, NLSC also attaches high importance to the recruiting and training of talents as well as team construction. Now, it has an excellent and structure-optimized group composed of 16 professors including 1 CAS academician, 2 member of the national “One-Thousand-Talents Scheme”, 5 members of the “CAS’ One-Hundred-TalentsScheme”, 2 grantees of the “National Outstanding Youth Foundation” and 1 “Youth One Thousand Talented People”. Moreover, a batch of young researchers and graduate students, who are full of innovative ideas and strong motivations, are now working at the forefront, thus filling the lab with energy and vitality.

The NLSC has also become a national base for academic exchange and collaborations among domestic and foreign scholars. It successfully organized the fifth International Conference for Superconductivity Materials & Related Mechanisms(1997), the International Conference on the Mechanism of High Temperature Superconductivity(2001), the series of Beijing Forum of the Mechanism of High Temperature Superconductivity from 2002, the Series of International Symposium on Frontier of Superconductivity Research(2011, 2012, 2013 and 2014), China/US Joint Workshop on Novel Superconductors (2010, 2011 and 2013) and so on. Both training and academic cooperation protocols have been established with many countries and regions.

The NLSC is now further devoted to refining research projects, optimizing personnel structure, recruiting new talents, developing unique state of art experimental facilities as well as initiating innovative research. At the same time, NLSC is effectively developing surefooted long-term collaborations with various internationally renowned scientific institutions across the nation and around the world. NLSC is dedicated to being a world class lab and preparing formore momentous scientific breakthroughs henceforth.

①	②
③	④
⑤	⑥
⑦	

① 2011 实验室超导大会集体照；2011 Annual Meeting of the Lab

② 2012 实验室超导大会集体照；2012 Annual Meeting of the Lab

③ 2013 实验室超导大会集体照；2013 Annual Meeting of the Lab

④ 2014实验室超导大会集体照；2014 Annual Meeting of the Lab

⑤ 2015实验室超导大会集体照；2015 Annual Meeting of the Lab

⑥ 2016实验室超导大会集体照；2016 Annual Meeting of the Lab

行政机构和管理
Organization & Administration

实验室主任	实验室副主任	行政秘书
周兴江 研究员	金魁 研究员	王凌倩
Director	Deputy Director	Secretary:
Prof. Xingjiang Zhou	Prof. Kui Jin	Ms. Lingqian Wang

历届主任
Successive Directors

第一届主任【1991—2000】	赵忠贤 研究员（院士）Prof. Zhongxian Zhao
第二届主任【2000—2009】	闻海虎 研究员 Prof. Haihu Wen

超导国家重点实验室第五届学术委员会（2018.1~2022.12）

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副主任：		
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顾问:		
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李方华	院士	中科院物理所
苏肇冰	院士	中科院理论所
杨国桢	院士	中科院物理所
于 渌	院士	中科院物理所
张殿琳	院士	中科院物理所
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朱道本	院士	中科院化学所
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张裕恒	院士	中国科技大学
何豫生	研究员	中科院物理所
金 铎	研究员	中科院物理所
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李 源	教授	北京大学
卢仲毅	教授	中国人民大学
李世燕	教授	复旦大学
吕 力	研究员	中科院物理所
雒建林	研究员	中科物理所
贾金峰	教授	上海交通大学
马琰铭	教授	吉林大学
马衍伟	研究员	中科院电工研究所
邱祥冈	研究员	中科院物理所
孙力玲	研究员	中科院物理所
田明亮	研究员	合肥强场实验室
闻海虎	研究员	南京大学
王浩华	教授	浙江大学
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王强华	教授	南京大学
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基于高通量组合薄膜技术的新超导体探索和物理研究
Exploration of new superconductors and novel superconductivity on high-throughput combinatorial thin films

SC03
课题组长：邱祥冈研究员/ Group Leader: Prof. Xianggang Qiu
介观尺度超导体中宏观量子现象的研究
Study on the macroscopic quantum phenomena in mesoscopic superconductors

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Exploring new unconventional superconductor and its mechanism

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超导材料和其它量子材料的光电子能谱研究
Photoemission Spectroscopy Study on Superconductors and Other Quantum Materials

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利用中子散射研究关联电子体系
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新奇超导体功能与机制的核磁共振研究
NMR study on superconductivity

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新型量子功能材料的探索研究
Novel Superconductors and Related Functional Materials

SC02 基于高通量组合薄膜技术的新超导体探索和物理研究

Exploration of new superconductors and novel superconductivity on high–throughput combinatorial thin films

组长/Leader:
金魁 Kui Jin
组员/ Group Members:
朱北沂 Beiyi Zhu　许波 Bo Xu　袁洁 Jie Yuan

Selected Scientific Results

1. 我们首次成功制备出Tc可在<2K到15K之间连续调控的单一组分FeSe薄膜，发现电子型载流子浓度对FeSe薄膜的超导电性起主导的影响作用。在单一组分 FeSe 薄膜研究工作的基础上，我们成功制备出具有梯度Tc分布的高质量FeSe组合薄膜，实现了在同一个样品上获得由不超导到Tc=12K的连续分布，并发现超导转变温度与晶格常数c、RRR均存在一个正相关的依赖关系。以前基于1500多个样品制备与表征耗时三年的工作，现在通过高通量的方法我们可以在同一个样品上实现，而且实验周期只需要一周就能完成。

We successfully prepared a series of single-component FeSe/CaF2 films with tunable Tc from < 2 K to 14 K, and the Tc strongly depends on the density of electron carriers. In order to figure out the origin of such tunable supercondutivity, FeSe thin films with a gradient Tc were fabricated by a combinatorial approach. This single-chip material library covers the Tc from 0 to ~12 K, and the superconducting transition temperature is positively correlated with the out-of-plane lattice parameter and the ration of room temperature resistance to residual resistance (RRR).The success in obtaining combinatorial FeSe thin films thereby provides an opportunity to explore the origin of superconductivity in FeSe films.

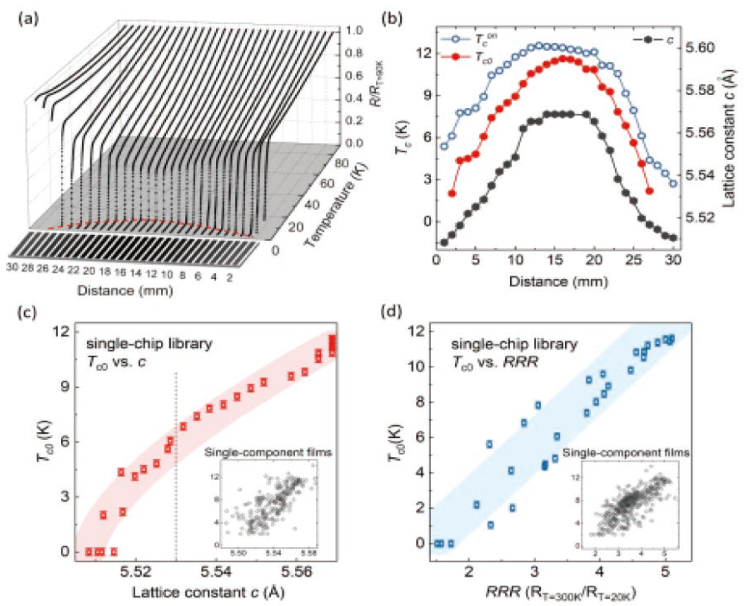

图1：(a)组合薄膜样品不同区域的 R-T 曲线；(b)组合薄膜样品不同区域的 Tcon、Tc0 和晶格常数c；(c)、(d)组合薄膜样品不同区域 Tc0 与晶格常数 c,剩余电阻率的对应关系，图中插图则为单一组分薄膜样品的数据。

(a)Temperature dependence of the resistance for all FeSe samples;(b)Position dependence of Tcon, Tc0 and the c-axis lattice constant;(c) c-axis lattice constant dependence of Tc;(d)RRR dependence of Tc0.

2. 对于T'结构的电子型铜氧化物，其母体是反铁磁绝缘体。无论采用什么方法合成电子型铜氧化物超导样品,低氧压环境退火必不可少。这使得在制备Ce掺杂超导样品的时候会引入两个变量：Ce和O。为了系统地研究氧含量变化和Ce掺杂对电子型铜氧化物超导电性的影响，我们采用高分子辅助沉积法制备出系列不同Tc的母体$Pr_2CuO_{4\pm\delta}$超导薄膜，并利用combi-LMBE系统在一片$SrTiO_3$ (STO)衬底上制备出梯度组份超导薄膜$La_{2-x}Ce_xCuO_{4\pm\delta}$（x=0.1-0.19）。随后，我们利用点接触方法测量了系列不同Tc的$Pr_2CuO_{4\pm\delta}$单晶薄膜隧道谱，在所有样品中均观察到明显的零偏压异常现象。该现象在电子型铜氧化物中被称为正常态能隙。这个现象可以被Altshuler-Aronov-Lee理论很好的解释，从而证实电子型铜氧化物中正常态能隙起源于无序诱导的电子-电子关联。另外，$La_{2-x}Ce_xCuO_{4\pm\delta}$组合薄膜的相关物性正在进一步的研究中。

For the T' - type cuprates, parent compounds are antiferromagnetic insulators. Regardless the methods we take for preparing various electron-doped cuprates, annealing process in a low-oxygen environment is indispensable for achieving superconductivity. Thus the preparation process of the Ce-doped samples will introduce two variables : Ce and O. Moreover, in order to systematically investigate the influence from oxygen- and cerium- doped respectively on superconductivity, a series of superconducting $Pr_2CuO_{4\pm\delta}$ films with different superconducting transition temperatures were prepared by polymer-assisted deposition method. Then we performed a tunneling study on these single-crystalline parent-cuprate thin films. The zero-bias anomaly in the differential conductance, well-reported in the normal state of $R_{2-x}Ce_xCuO_4$ (R = Pr, Nd, La) and named as normal-state gap (NSG), is observed in these Ce-free samples. The origination of NSG can be understood in the framework of the Altshuler-Aronov-Lee theory, where the disorder-induced electron-electron interactions suppress the density of states. In addition, we fabricated combinatorial $La_{2-x}Ce_xCuO_{4\pm\delta}$(x=0.1–0.19) thin films on one $SrTiO_3$ (STO) substrate by combi-LMBE, related research on the combi-film of $La_{2-x}Ce_xCuO_{4\pm\delta}$ is ongoing, on which we expect a detailed study on such as the quantum criticality.

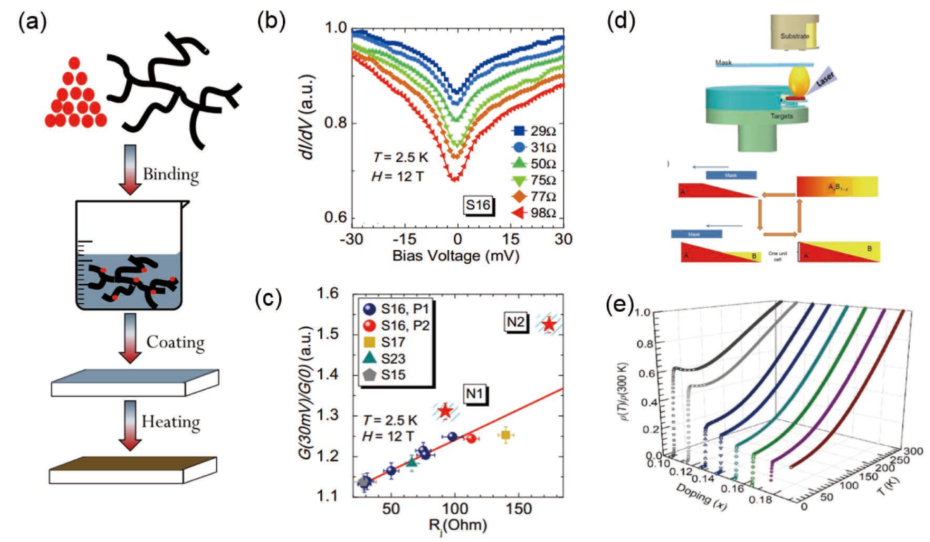

图2：电子型铜氧化物超导体的制备以及物性研究。(a)高分子辅助沉积法的示意图；(b-c) $Pr_2CuO_{4\pm\delta}$薄膜正常态能隙起源；(d-e)组合薄膜制备原理及$La_{2-x}Ce_xCuO_{4\pm\delta}$组合薄膜电阻随温度的变化曲线。

Preparation of electron-doped cuprates and study of their physical properties. (a)The schematic diagram of polymer assisted deposition method；(b-c) The origin of normal-state gap in Pr2CuO4±δ films；(d-e) The schematic diagram of the combi-film preparation and the resistivity versus temperature curves of La2–xCexCuO4±δ combi-film.

3. 作为目前为止唯一发现的尖晶石氧化物超导体，$LiTi_2O_4$ (LTO)最高Tc可达13K。前期，通过在（001）取向LTO样品的电输运和隧道谱研究，我们给出了第一幅LTO的电子态相图，揭示了其正常态复杂的自旋轨道相互作用不可忽略。进一步，我们研究了不同取向LTO的隧道谱，首次揭示出该体系存在明显的各向异性电声耦合，结合DFT计算和STEM实验，我们认为其来源于氧空位增强的Jahn-Teller畸变。最近，通过调节生长过程中的氧压，我们成功获得了从$LiTi_2O_{4-\delta}$到$Li_4Ti_5O_{12}$的一系列薄膜，样品的电阻经历了从超导到绝缘的转变。这个转变包含了两个过程，即氧空位的填充和$Li_4Ti_5O_{12}$相的生成。更进一步，我们研究了不同氧压下生长的样品的磁阻行为。随着氧压的增加，磁阻从正到负的转变温度(Tch)显示出非单调行为，即先降低后升高。我们认为Tch的降低归因于轨道相关态的抑制，而非均匀的相分离区域会产生正磁阻，从而导致Tch和氧压出现相反的关系。

As the only known spinel oxide superconductor, the superconducting transition temperature of $LiTi_2O_4$ can be as high as 13 K. Previously, we disclosed the first phase diagram in this system by electrical transport and tunneling spectra measurements, where the interactions between spin and orbit cannot be ignored. Further, we studied the tunneling spectra on [001]-, [110]-, and [111]-oriented $LiTi_2O_4$ thin films. For the first time, a prominent anisotropic electron-phonon coupling is observed in this system. Combined with DFT calculation and STEM measurements, we argue that the anisotropy stems from oxygen vacancies enhanced Jahn-Teller distortions. Recently, we successfully achieved a series of thin films from $LiTi_2O_{4-\delta}$ to $Li_4Ti_5O_{12}$, resistance of which undergoes a transition from superconductor to insulator by adjusting oxygen pressure. There are two processes happened during the evolution, i.e. the filling of oxygen vacancies and the forming of $Li_4Ti_5O_{12}$. Furthermore, we studied the magnetoresistance of the samples deposited under various oxygen pressure. With the increase of oxygen pressure, the transition temperature (Tch) of magnetoresistance from positive to negative shows a nonmonotonic behavior, i.e. first decrease and then increase. We suggest that the decrease of Tch can be attributed to the suppressing of orbital-related state, and the inhomogeneous phase separated regions contribute to the positive MR and thereby lead to the reverse relation between Tch and oxygen pressure.

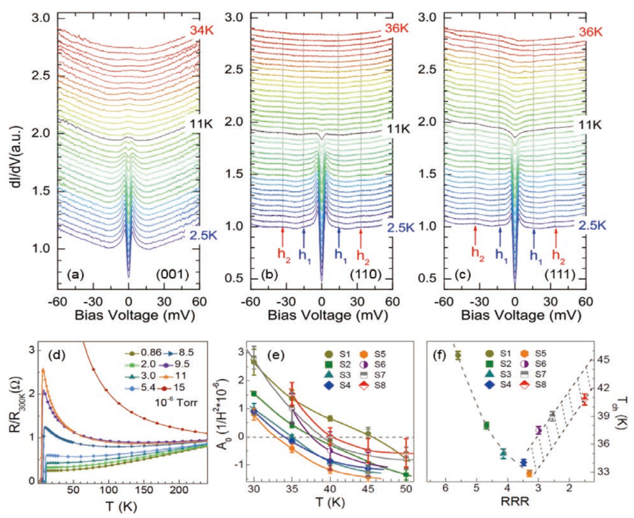

图3：尖晶石氧化物超导体$LiTi_2O_4$薄膜电输运和隧道谱研究。(a-c)不同取向$LiTi_2O_4$ 薄膜温度依赖的隧道谱；(d-f)氧压调控下的$LiTi_2O_{4-\delta}$薄膜的异常电输运行为。

The electrical transport and tunneling spectra study of spinel oxide superconductor $LiTi_2O_4$ thin film (a-c) Temperature dependence of tunneling spectra for spinel superconductor $LiTi_2O_4$ thin films grown on [001]-, [110]-, and [111]-oriented $MgAl_2O_4$ substrates. (d-f) The oxygen pressure dependence of the resistance property for spinel superconductor $LiTi_2O_{4-\delta}$ thin films.

4. 组合激光分子束外延-扫描隧道显微镜原位生长表征系统是由我组与技术部郇庆研究组合作自主研发的设备。该系统集成了高通量薄膜制备技术与连续电子态表征技术，可实现样品的快速制备与快速表征。过去两年内我们完成了系统的设计、装配。今年对系统进行了初步调试，现极限真空可达$4.9*10^{-10}$ Torr，极限低温可达4.58 K，低温持续时间达48小时且温度漂移在15 mK以内，已在室温大气环境下获得石墨表面清晰的原子分辨，各项指标均已达到设计要求。预计未来几个月内在该系统上可开展初步实验。

Our combi LMBE-STM system integrates the combi-film preparation and continuous electronic state characterization technique, enabling high-throughput sample preparation and fast characterization of electronic states. We finished the design and the assembly in past two years and made a preliminary debugging this year. Now the vacuum of the system is better than $5*10^{-10}$ Torr and can be cooled down to 4.58 K with $\Delta T < 15$ mK. The holding time of liquid He layer is up to 48 hours. We have successfully obtained a clear atomic resolution in graphite surface. So far, all the parameters satisfy the requirements. The preliminary experiments are expected in the next few months.

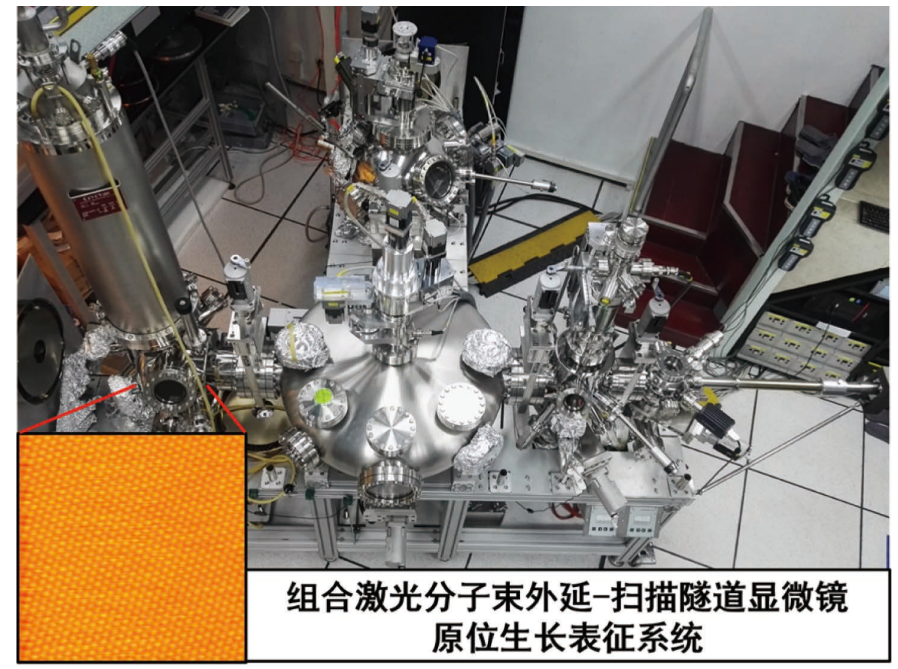

图4: 组合激光分子束外延-扫描隧道显微镜原位生长表征系统

Combi LMBE-STM system

SC02组成员合影

SC03

介观尺度超导体中宏观量子现象的研究

Study on the macroscopic quantum phenomena in mesoscopic superconductors

组长/Leader:
邱祥冈 Xianggang Qiu
组员/ Group Members:
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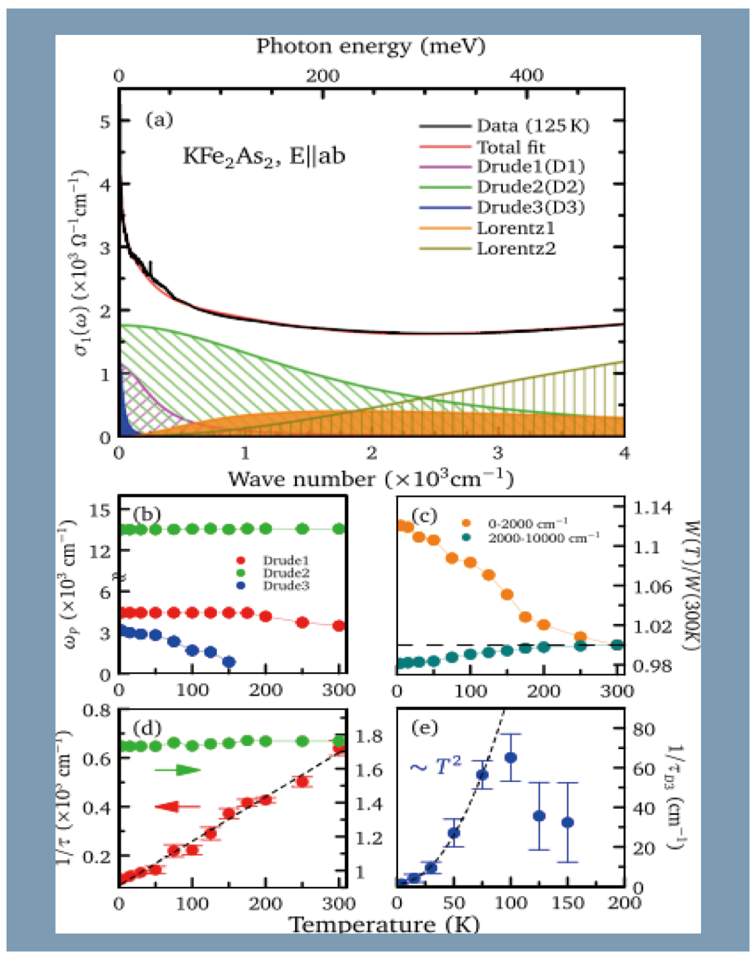
Selected Scientific Results

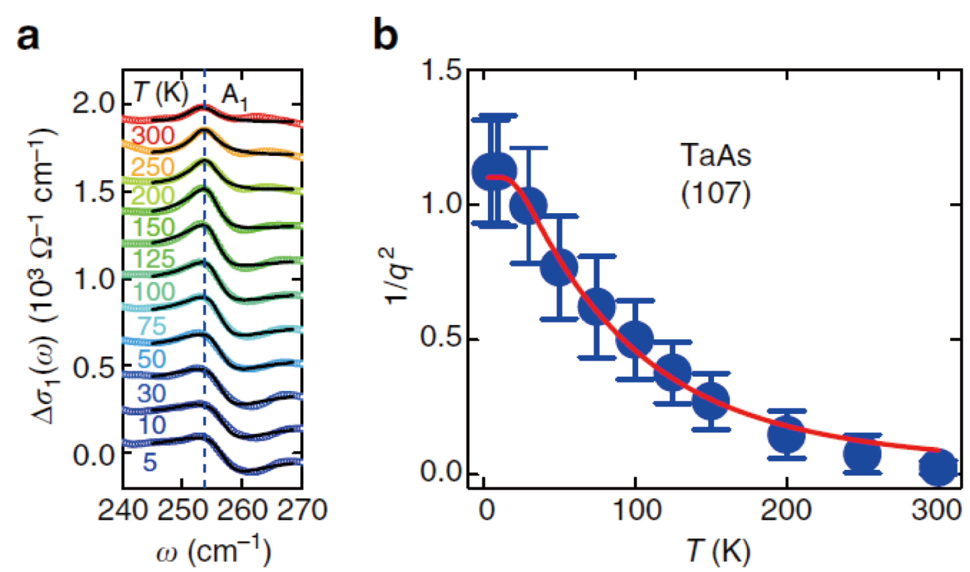
1. 利用红外光谱学手段研究了空穴过掺杂材料KFe_2As_2在155K附近发生相干非相干转变前后的电荷动力学行为。进入低温相干态之后，我们在光电导谱中发现了一个新形成的Drude响应，其在75K以下表现为明显的费米液体行为与输运结果一致。谱重分析表明新形成的Drude响应源于中红外谱重的退局域化。结合第一性原理计算，我们发现KFe2As2中的相干非相干转变源于dxy轨道退局域化导致的近藤屏蔽，而非轨道选择性Mott相变。

The ab-plane optical properties of KFe_2As_2 single crystals have been measured over a wide temperature and frequency range. Below 155 K, where this material undergoes an incoherent-coherent crossover, a new coherent response emerges in the optical conductivity. A spectral weight analysis suggests that this feature originates from high-energy bound states. Below 75 K the scattering rate for this feature is quadratic in temperature, indicating a Fermi-liquid response. Theoretical calculations suggest this crossover is dominated by the dxy orbital. Our results indicate Kondo-type screening is the likely mechanism for the incoherent-coherent crossover in hole-overdoped KFe_2As_2.



2. 最近，伴随着外尔半金属体系在TaAs家族被理论预言并首次被实验证实，外尔半金属材料独特的拓扑特性以及其新奇的量子效应受到了广泛的关注和研究。这类材料具有表面态费米弧，手性反常导致的负磁阻特性，反常的量子霍尔效应,以及极高的电子迁移率，在低能耗电子器件，量子计算等领域具有潜在的应用价值。在本工作中，我们通过红外光谱手段研究了外尔半金属TaAs的电子和声子性质,首次发现了外尔费米子和声子之间存在的很强的耦合作用，而且这种耦合作用可以被温度有效的调控。此研究不仅揭示了外尔费米子和声子之间的耦合机制，也为研究外尔半金属的新奇量子特性提供了新的有效途径。

TaAs has recently been realized to host the Weyl semimetal (WSM) state, which exhibits fascinating quantum phenomena as evidenced in many recent experiments. In this present study, we reveal explicit evidence for strong coupling between an infrared-active phonon and electronic transitions near the Weyl points through the observation of a Fano resonance in the Weyl semimetal TaAs. The resulting asymmetry in the phonon line shape, conspicuous at low temperatures, diminishes continuously with increasing temperature. This behavior originates from the suppression of electronic transitions near the Weyl points due to the decreasing occupation of electronic states below the Fermi level with increasing temperature, as well as Pauli blocking caused by thermally excited electrons above Fermi level. Our findings not only elucidate the mechanism governing the tunable Fano resonance but also open a route for exploring exotic physical phenomena through phonon properties in Weyl semimetals.



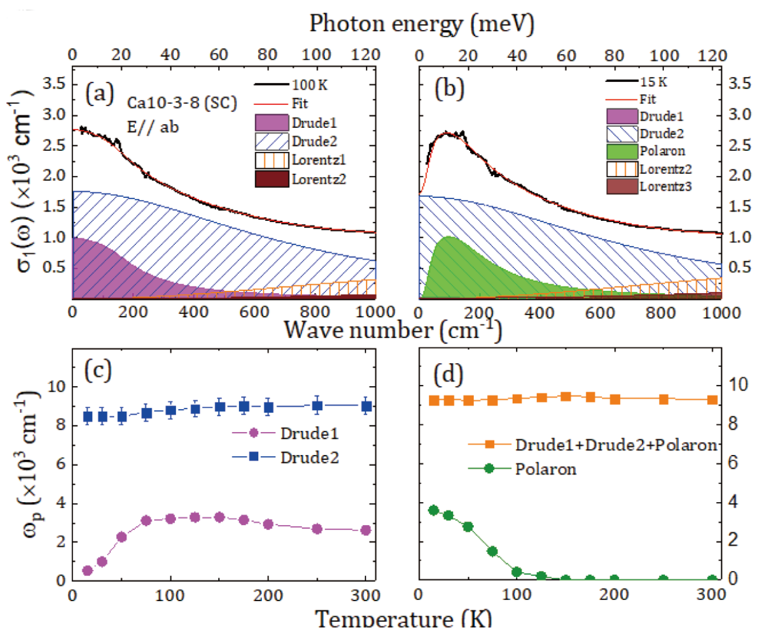
声子谱的Fano线型拟合以及Fano参数$1/q^2$的温度依赖关系。

Fano lineshape fits to the phonon spectra and the temperature dependence of the Fano parameter $1/q^2$

3. 在铁基超导材料$(CaFe_{1-x}Pt_xAs)_{10}Pt_3As_8$的相图中，在进入超导和反铁磁有序前有一个半导体态，类似于铜基超导材料中的赝能隙态。研究这一行为的起源将有助于我们进一步理解超导材料中的配对机理。因此我们合成了$(CaFe_{1-}$

$_{x}$Pt$_{x}$A$_{s}$)$_{10}$Pt$_{3}$As$_{8}$ 材料的母体以及最佳掺杂的样品并测量了其光学性质。通过分析计算得出的光电导谱，我们发现，半导体行为源于低频谱重的消失并与反铁磁涨落有关。此外，我们通过研究该类材料的声子动力学发现，在最佳掺杂材料中，磁涨落会增强电声子耦合，并导致声子陷俘电子行程大极化子。进入超导态后，我们发现极化子峰坍塌进入超流相。我们的发现表明在反铁磁涨落的激发下，增强的电声子涨落对超导配对有着促进作用。

In the phase diagram of $Ca_{10}(Pt_3As_8)(Fe_{1-x}Pt_xAs)_{10}$, above the superconducting (SC) and antiferromagnetic (AFM) dome, there exists a semiconducting like behavior, which mimics the pseudogap cuprates. Investigating the origin for the semiconducting like behavior would provide us important clue for the pairing mechanism. In this work, we have synthesized the parent compound and the optimal doped $Ca_{10}(Pt_3As_8)(Fe_{1-x}Pt_xAs)_{10}$, and measured their optical properties, respectively. From their optical conductivity, we found that the diminishing of the low-energy spectral weight in the normal state, corresponding to the semiconducting-like behavior, is related to the AFM fluctuation. On the other hand, we' ve realized the magnetic-enhanced electron-phonon coupling and that the far-infrared absorption peak in the optimal doped sample could be well described by the large polaron model, indicating the formation of large polaron in the semiconducting dome. Intriguingly, we notice that the polaron peak collapsed into the superfluid below Tc~12K. Thus, we propose that the magnetism induced polaron also participate in the unconventional pairing. Our study would provide a clue for pairing mechanism in unconventional high-Tc superconductors.



4. 利用红外光谱学手段研究了massless狄拉克半金属材料$CaMnSb_2$的光电导谱。由于多带体系，我们用最少的Drude模型拟合了低频光电导谱，发现等离子频率随着温度几乎不变，这与发现的0-1500 Drude谱重守恒对应的非常好。在对高频谱重的研究当中我们也发现了高频谱重向低频的转移，这可能与Mn离子的洪特耦合相关。结合第一性原理计算的能带图和线性光电导的发现，我们证明了该材料的狄拉克半金属性质。

The ab-plane optical properties of $CaMnSb_2$ single crystals have been measured over a wide temperature and frequency range. Since the multiband systems, we use the least 2 Drude modes to fit the low-frequency optical conductivity and find the plasma frequency almost constant, which corresponds to the constant spectral weight during 0 to 1500. The transfer of the high-frequency optical weight is attributed to the Mn2+ strong Hund coupling。 Based on the first principle calculation, we find the linear-dependent optical conductivity, and confirm the CaMnSb2 as Dirac semimetal.

SC03组成员合影

SC04 探索高温超导体及相关的机理研究

Exploring new unconventional superconductor and its mechanism

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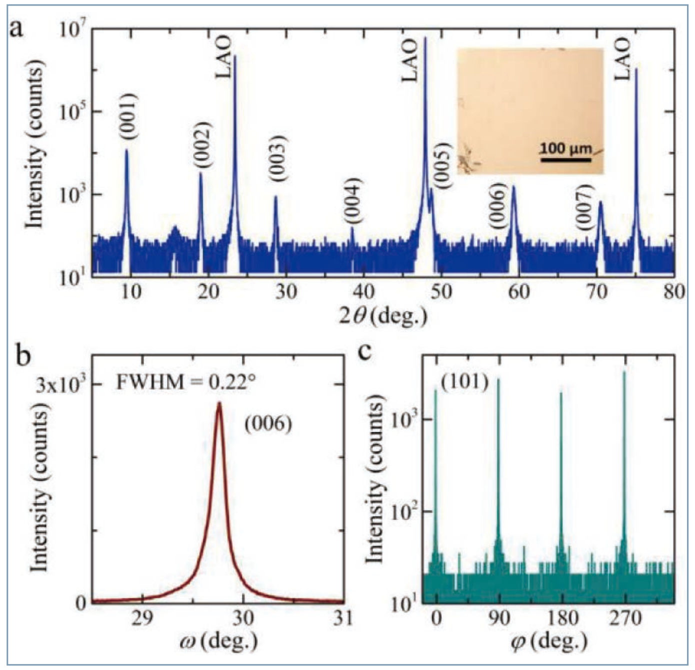
Selected Scientific Results

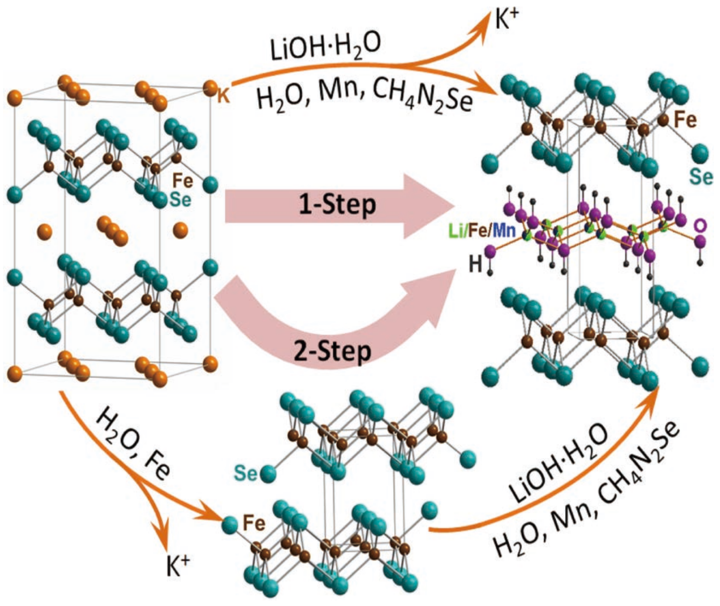
1. 首次成功水热外延出零电阻为42.4K的(Li,Fe)OHFeSe薄膜。 估算上临界场分别为79.5 T（c方向）和443 T（ab面）。20 K时的临界电流密度高达0.5 MA/cm2。高质量、高临界参数(Li,Fe)OHFeSe超导单晶薄膜的成功生长，一方面为铁硒基高温超导电性的机理研究提供了重要研究对象，另一方面，有望为高温超导在高性能电子器件、大型科研装置等方面的应用开发提供关键信息。相关研究成果发表于【Chinese Physics Letter 34, 077404 (2017) (Express Letter)】。



We have obtained superconducting (Li,Fe)OHFeSe film by a hydrothermal epitaxial growth. The film exhibits high superconducting critical parameters, including the bulk transition temperature of 42.4 K, the large critical current density of over 0.5MA/cm2 and the upper critical field of 79.5 T (c-direction)and 443 T (ab plane. Our results indicate that the (Li,Fe)OHFeSe film is promising for superconductivity applicationsin in high-performance electronic devices and large scientific facilities.

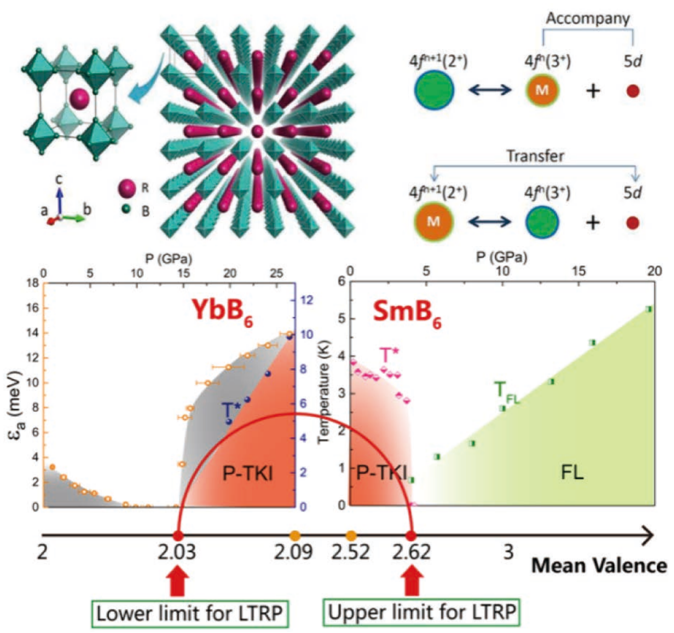
2. 应用我们发展的离子交换（1-step）与离子释放/引入法（2-step），首次在(Li,Fe)OHFeSe单晶中实现Mn的引入。发现超导转变温度未受明显影响，而空穴载流子的贡献有所增强，说明Mn掺杂所致的体系中空穴带的演变很可能与高温超导电性无直接关联。我们的离子交换与离子释放/引入法可以提供一种有效的3d电子引入手段，有助于深入研究多带体系中空穴带和电子带的特征及其与高温超导电性的相互关系。阶段性结果发表于CPB 26, 057402 (2017)。

We succeded in introducing Mn into (Li,Fe)OHFeSe superconducting crystals by two hydrothermal routes, ion exchange and ion release/introduction. Magnetic susceptibility and electrical transport measurements reveal that Mn doping influences little on the superconducting transition. But the hole carriers contribution is obviously modified, hence the hole band might have no direct relationship with the superconductivity. Our present hydrothermal methods provide an efficient way for elements substitution/doping into (Li,Fe)OHFeSe superconductors, which will promote the in-depth investigations on the role of multiple electron and hole bands and their interplay with the high-temperature superconductivity.



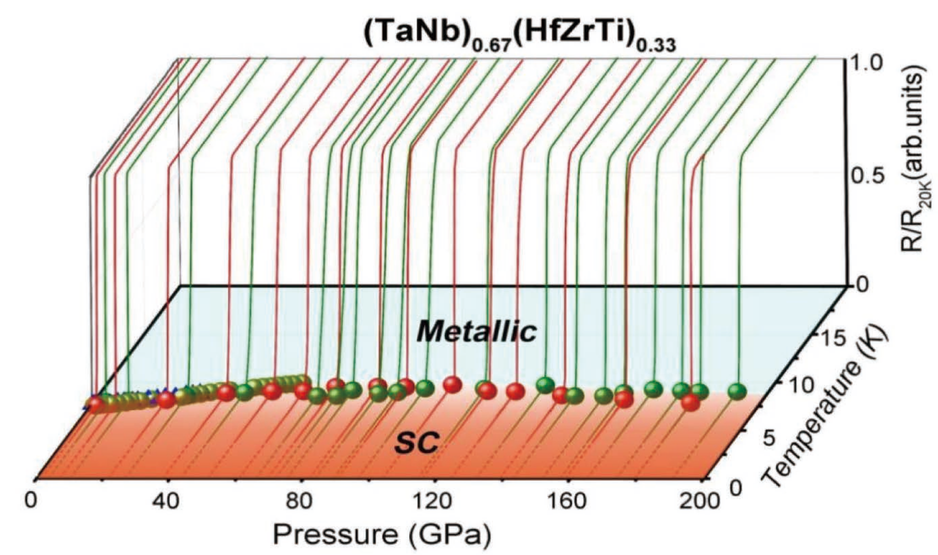
3. SmB6中“伴随型价态涨落”基态概念的提出：SmB6 是上世纪60年代就开始研究的经典近藤（Kondo）稀土硼化合物， 其令人困惑的低温电阻平台一直是强关联物理领域研究的一个重要问题。 近年随着奇异的低温量子振荡和与体绝缘态共存的金属表面态在SmB_6中的发现，使其重新成为研究热点。我们提出了SmB6在低温下呈现出的一系列奇异性的低温现象均源自其Sm离子中f电子独特的构型与其所处的具有“负膨胀”特性的B_6框架结构在不同温度下相互作用导致的特殊的价态变化， 使其基态处于一种不稳定的“伴随型”价态涨落， 既由f电子构型所决定的磁性Sm离子数量与传导电子的数量在涨落中同时增加或减少，这与常见的其它磁性离子价态变化中的情况完全不同。在稀土六硼化物中，只有SmB_6和YbB_6具有这种特殊的价态涨落形式。这一新观点以 ”Puzzle maker in SmB_6: accompany type of valence fluctuation state” 为题作为Key issue review文章发表在【Reports on Progress in Physics 80，112501, 2017】上。

In recent years, studying the Kondo insulator SmB6, a strongly correlated electron material that has been puzzling the community for decades, has again become an attractive topic due to the discovery of its unusual metallic surface state coexisting with the bulk insulating state. Many efforts have been made to understand the microphysics in SmB6, but some puzzles that have been hotly debated and argued have not been solved. In this article, based on the latest progress made in our high-pressure studies on SmB6 and the accumulating results reported by other groups, we propose a notion named the ‘accompany-type valence fluctuation state’, which possibly coexists with the bulk Kondo insulating ground state of SmB6. We expect that this notion could be taken as a common starting point for understanding in a unified way most of the low-temperature phenomena observed by different experimental investigations on SmB6, thus promoting the deciphering of the puzzles. We also expect that this notion could attract rigorous theoretical interpretation and further experimental investigation, or stimulate better thinking on the physics in SmB6.



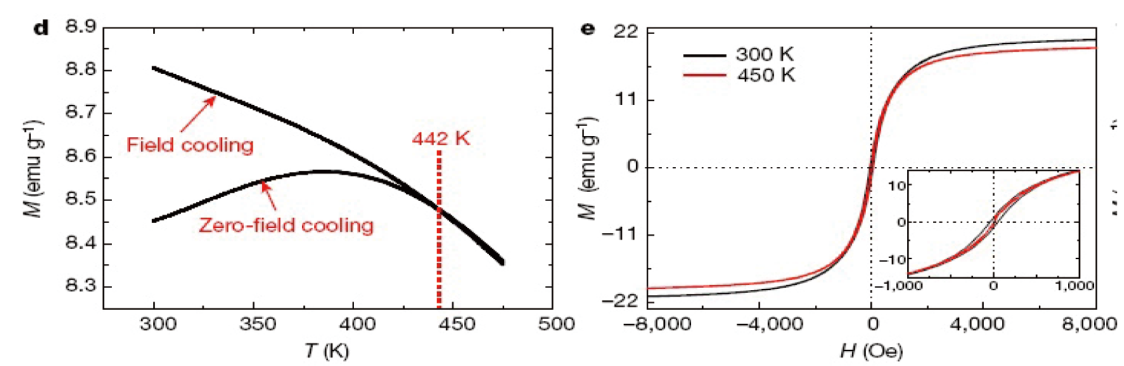
4. 高熵合金在超高压力下超导电性稳定性的发现：高熵合金的概念是基于20世纪90年对代大块非晶合金的研究的背景下提出的。高熵合金通常由五种以上等原子比或近等原子比的元素组成，并且每种元素在晶格点阵上呈无规则的分布构成具有简单晶体结构的固溶体，其在热力学上表现为混合熵高于熔化熵。我们对高质量高熵合金(TaNb)0.67(HfZrTi)0.33样品的超导电性进行了系统的原位超高压研究。发现该合金在压力下具有令人惊奇的稳定零电阻的超导电性：在高达190.6 GPa 的压力范围内能保持其电阻-温度曲线的超导转变陡峭和清晰的零电阻行为（见图），而且，在该如此大的压力范围内其超导转变温度变化很小。在上海光源完成的高压同步辐射XRD实验结果表明在 96GPa下，样品晶体结构稳定，没有结构相变发生，尽管其体积被压缩了~28 %。该项研究揭示了这种高熵合金超导体在超高压产生的大变形量下仍能很好的保持其常压相所具有的超导电性。该发现不仅丰富了人们对超导实验现象的了解，同时也对超导理论方面完整的理解超导机制提出了新的挑战。该项研究结果发表在美国科学院院刊【PNAS 114， 13144，2017,】上。Nature对该项成果在其 Research Highlight 栏目以题为“Super-squeezing can’t crush this superconductor’s powers”做了报道。

We report the observation of extraordinarily robust zero-resistance superconductivity in the pressurized (TaNb)0.67(HfZrTi)0.33 high-entropy alloy-a material with a body-centered-cubic crystal structure made from five randomly distributed transition-metal elements. The transition to superconductivity (TC) increases from an initial temperature of 7.7 K at ambient pressure to 10 K at ~60 GPa, and then slowly decreases to 9 K by 190.6 GPa, a pressure that falls within that of the outer core of the earth. We infer that the continuous existence of the zero-resistance superconductivity from 1 atm up to such a high pressure requires a special combination of electronic and mechanical characteristics. This high-entropy alloy superconductor thus may have a bright future for applications under extreme conditions, and also poses a challenge for understanding the underlying quantum physics.



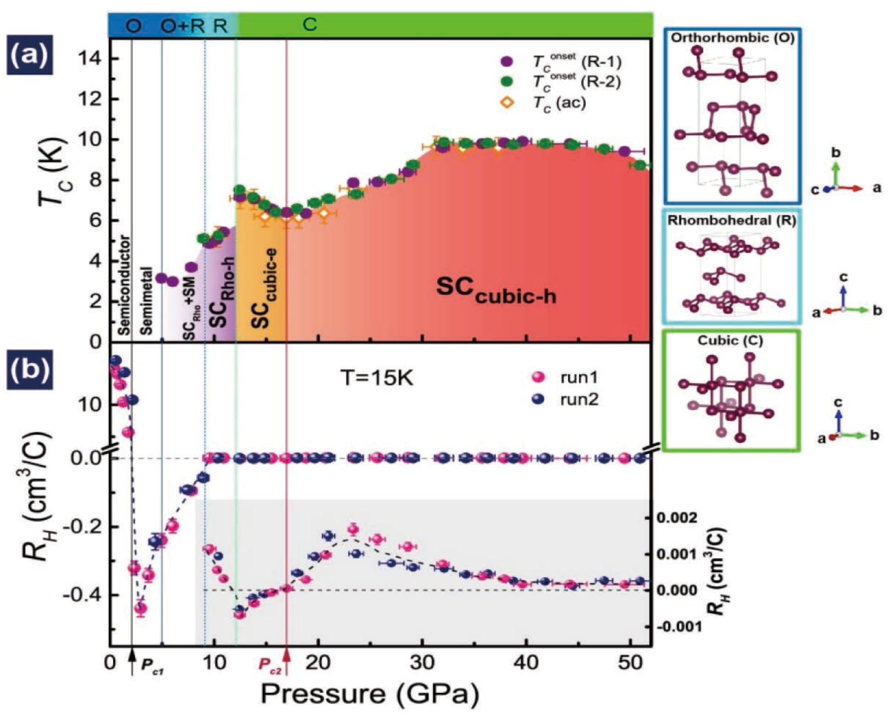
5. 与武汉理工大学张清杰教授、赵文俞教授及武汉大学石兢教授等合作，研究了热电材料中软磁纳米颗粒的高温磁性质。我们观测到的纳米颗粒的铁磁-超顺磁转变等实验结果对合作者们理解高温下热电材料中热电磁相互作用机制起到了重要作用。相关合作成果发表于Nature549, 247 (2017)。

We studied the magnetic properties of nanoparticles of a soft magnetic materials embedded in a thermoelectric matrix. A ferromagentism to superparamagnetism transition is observed around 442K. This work is conducted under the collaboration with Prof. Qingjie Zhuang and Prof. Wenyu Zhao at Wuhan University of Technology and Prof. Jing Shi at Wuhan Univesity.



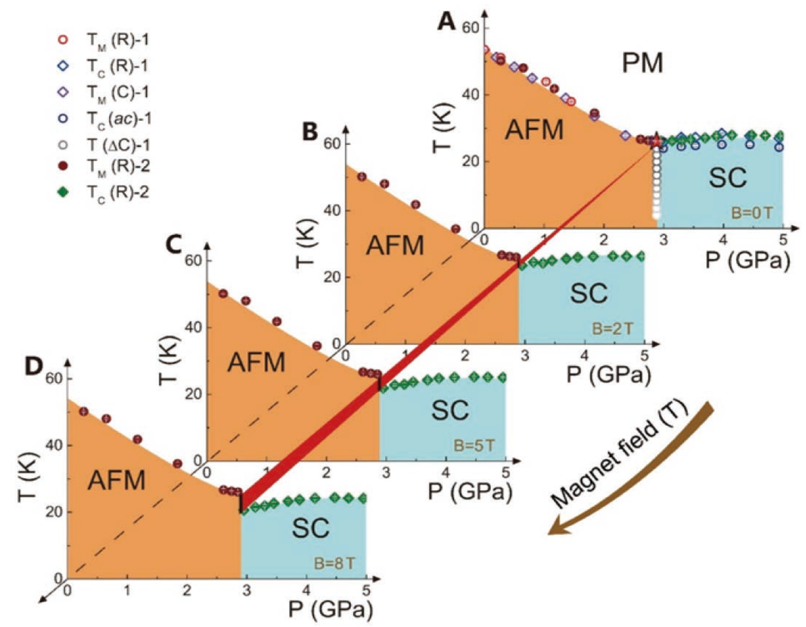
6. 空穴载流子在压致黑磷超导相中的重要作用：首次对黑磷单晶开展了超高压力的原位Hall测量，并建立了超导转变温度与Hall系数及结构相变的关系。研究发现，压力可导致黑磷产生两个Lifshtz相变： 一个发生在正交半导体相中， 另一个发生在立方超导相中。通过结构、Hall系数与超导转变温度的综合分析，发现空穴载流子对超导转变及提高Tc起到了重要作用。澄清了长期以来人们对单一立方相中Tc随压力的变化呈V型的困惑。【PRB 96(2017)224513】

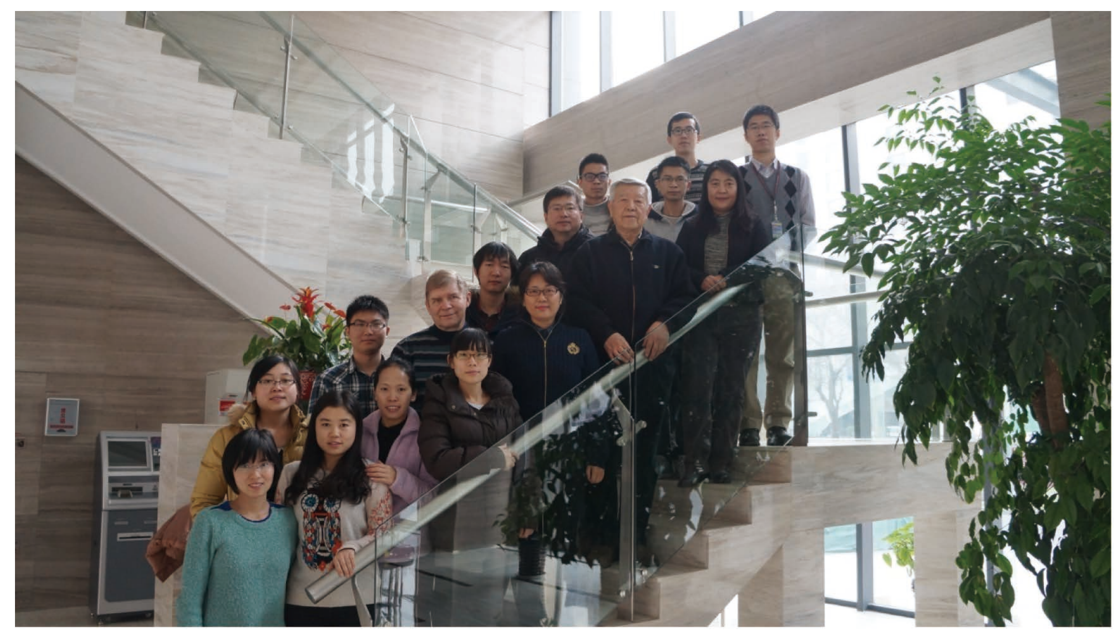
We report the in situ high-pressure (up to ~50-GPa) Hall-effect measurements on single-crystal black phosphorus. We find a strong correlation between the sign of the Hall coefficient, an indicator of the dominant carrier type, and the superconducting transition temperature (TC). Importantly, we find a change from electrondominant to hole-dominant carriers in the simple cubic phase of phosphorus at a pressure of~17.2GPa, providing an explanation for the puzzling valley it displays in its superconducting TC vs pressure phase diagram. Our results reveal that hole carriers play an important role in developing superconductivity in elemental phosphorus and the valley in TC at 18.8 GPa is associated with a Lifshitz transition.



7. 铁基合金中反铁磁-超导转变双临界点的发现：在对新型反铁磁材料Ca0.73La0.27FeAs2的研究中，通过一系列高压协同测量我们首次发现在反铁磁和超导相变临界压力和临界温度处存在双临界点，并观察到了压力诱导的反铁磁与超导之间的一级相变。实验结果表明，随着压力的增加，材料的反铁磁转变温度逐渐被抑制，在临界压力下，反铁磁转变温度突然消失，同时超导转变突然出现，并且超导转变起始温度与反铁磁转变消失的温度基本相同。这是首次在高温超导体中发现这种具有双临界点的反铁磁-超导转变相图， 为高温超导体机理的深入研究提供了新的实验结果。该项研究成果发表在 【Science Bulletin 62(2017)857】上。

One of the most strikingly universal features of the high-temperature superconductors is that the superconducting phase emerges in the close proximity of the antiferromagnetic phase, and the interplay between these two phases poses a long-standing challenge. It is commonly believed that, as the antiferromagnetic transition temperature is continuously suppressed to zero, there appears a quantum critical point, around which the existence of antiferromagnetic fluctuation is responsible for the development of the superconductivity. In contrast to this scenario, we report the observation of a bi-critical point identified at 2.88 GPa and 26.02 K in the pressurized high-quality single crystal Ca0.73La0.27FeAs2 by complementary in-situ high pressure measurements. At the critical pressure, we find that the antiferromagnetism suddenly disappears and superconductivity simultaneously emerges at almost the same temperature, and that the external magnetic field suppresses the superconducting transition temperature but hardly affects the antiferromagnetic transition temperature.





SC04课题组合影

SC05 超导薄膜材料和器件的物理及应用

Physics and applications of superconducting thin films and devices

组长/Leader:
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组员/ Group Members:
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李国强Guoqiang Li

Selected Scientific Results

1. 开展了四通道及五通道超导滤波器接收前端的研制工作，并已交付用户使用。超导接收前端提升了信号接收设备的灵敏度和抗干扰能力。

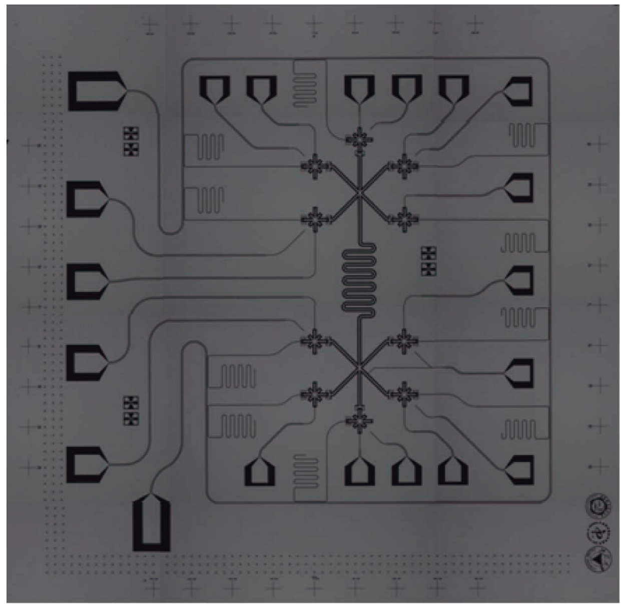
Developed the four channels and five channels HTS filters receiving front-end subsystems, which have been adopted by the users. The HTS subsystems improve the sensitivity to signals and the resistance to disturbance of the receivers.

2. 开展了针对气象雷达、4G移动通信的超导接收前端的研制和测试工作。

Developed and tested the HTS filters receiving front-end subsystems for meteorological radar and 4G mobile communication.

3. 课题组和浙江大学、中国科大上海研究院相关课题组合作继续开展超导量子比特器件和超导量子电路研究，制备了多种设计的多比特器件。并合作开展了多方面的量子实验，包括：利用超导量子比特进行量子热力学的模拟研究、超导量子比特和腔耦合系统的真空ATS效应、10比特器件上10个超导量子比特之间的纠缠，以及连续变量的几何相。

In close collaboration with other research groups of the Zhejing University and the University of Science and Technology of China, we have prepared Xmon type multi-qubit devices with different designs.Using these devices, a number of quantum experiments were carried out including the simulation of quantum thermodynamics, vacuum induced ATS effects, demonstration of quantum entanglement of 10 superconducting qubits,and the observation of a continuous-variable geometric phase .



4. 制备并研究了超导阶跃阻抗型共面波导谐振腔。观察到在极低温度和单光子功率下的本征品质因子与常规均匀谐振腔相当,显示了在提高超导量子电路集成度方面的前景。

We have fabricated high-quality superconducting stepped-impedance coplanar wave guide resonator devices. The measured intrinsic Q value of these devices is comparable to that of uniformed-impedance resonators, showing its potential in increasing the integration density superconducting quantum circuits.

SC07 超导材料和其它量子材料的光电子能谱研究

Photoemission Spectroscopy Study on Superconductors and Other Quantum Materials

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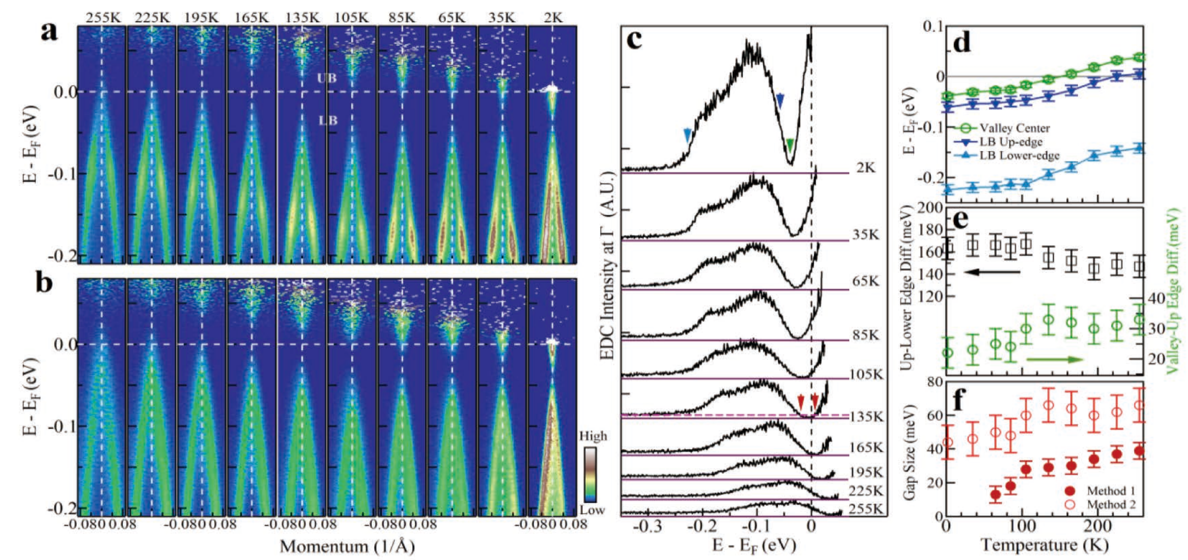
俞理 Li Yu　王庆艳 Qingyan Wang　黄元 Yuan Huang

Selected Scientific Results

1. ZrTe5中温度诱导Lifshitz相变的电子结构证据及其拓扑本质.自上世纪70年代以来，过渡金属碲化物ZrTe5和HfTe5在电阻温度曲线上有一个宽峰，并且在宽峰温度的上下，载流子类型发生改变，这一奇异的输运性质被发现以来。很多研究组对其做了研究，试图解释其输运性质的起源，但目前依然存在争议。最近，理论预言单层的ZrTe5是大能隙的量子自旋霍尔材料，在体能隙中，具有拓扑保护的边缘态。块材ZrTe5可能处于强弱拓扑态的边界上，随着层间距的减小，ZrTe5由弱拓扑绝缘体转变为强拓扑绝缘体。可能在温度对材料层间距的影响下，就可以实现上述的拓扑相变。ZrTe5的理论预言报道后，引起了大量的关于ZrTe5的实验研究，但对其拓扑本质仍然没有定论。所有以上问题的研究，离不开对ZrTe5电子结构的直接观测和系统的变温研究。我们利用高分辨的角分辨光电子能谱技术，系统研究了ZrTe5的电子结构及其随温度的演化情况。首次得到了包含ZrTe5导带和价带的电子结构，观测到了温度诱导的Lifshitz相变，可以直接解释ZrTe5的输运性质。并对ZrTe5的拓扑本质做了详细讨论，认为ZrTe5是弱拓扑绝缘体，随着温度的降低，有向强拓扑绝缘体转变的趋势。这项工作首次观测到了包含ZrTe5导带和价带的电子结构；实验得到的温度诱导Lifshitz相变现象可以直接解释ZrTe5的输运性质；全面讨论了ZrTe5的拓扑本质，认为ZrTe5从高温到低温是弱拓扑绝缘体，有向强拓扑绝缘体转变的趋势。为以后的相关研究提供了强有力的证据。【Yan Zhang et al., Nat. Commun. 8, 15512 (2017)】

The transition metal pentatellurides like ZrTe5 and HfTe5 have attracted considerable interest since the last 70s because they exhibit unusual transport properties characterized by a strong resistivity peak2,3 accompanied by a sign reversal of the Hall coefficient and thermopower across the peak temperature4–6. The origin of such transport property anomalies has been a subject of a long-time debate but remains unclear. It was predicted that single-layer ZrTe5 is a two-dimensional topological insulator with a large bulk bandgap, while bulk ZrTe5 may host a possibility of realizing a temperature-driven topological phase transition between the weak and strong topological insulators.Direct investigation on the electronic structure of ZrTe5 is highly desired in understanding the electronic origin of the transport property anomaly, and in uncovering the exact nature of the topological state in ZrTe5.For the first time, we find that the electronic property of ZrTe5 is dominated by two branches of bands with nearly linear dispersion, a valence band and a conduction band, at the Brillouin zone center. The temperature-induced Lifshitz transition provide a natural understanding on the underlying origin of the resistivity anomaly in ZrTe5. ZrTe5 is a weak topological insulator. With decreasing temperature, there is a tendency of the transition from a weak topological insulator to a strong topological insulator. Giving strong evidence of the further study on ZrTe5 and HfTe5.



2. 可能的拓扑绝缘体HfTe5中温度诱导的Lifshitz相变

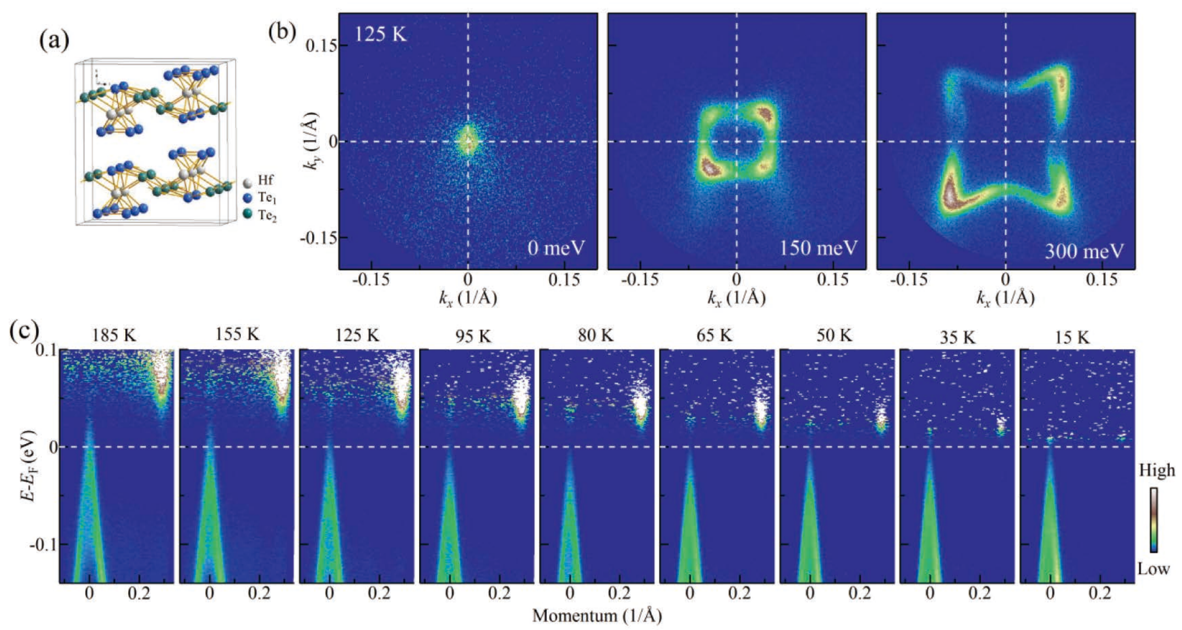
HfTe5与ZrTe5一样，具有奇异的输运性质，近期理论预言，单层的ZrTe5和HfTe5是大能隙大量子自旋霍尔材料，对应的块材可能处在强弱拓扑绝缘体的边界上。此后，大量关于ZrTe5的实验研究被报道，对于此类材料的拓扑本质仍存在争论。HfTe5与ZrTe5具有相似的晶格结构与物理性质，对其电子机构进行深入的研究，有利于澄清此类材料的有关争论。以上问题的研究，离不开对HfTe5电子结构的直接观测和系统的变温研究。

我们利用高分辨的角分辨光电子能谱技术，系统研究了HfTe5的电子结构及其随温度的演化情况。首次得到了HfTe5的电子结构，观测到了温度诱导的Lifshitz相变，可以直接解释HfTe5的输运性质。将ZrTe5和HfTe5的电子结构数据做了详细的比较，从电子机构随温度演化的角度，给出了两种材料输运性质的不同。认为HfTe5与ZrTe5一样，在常温到15K时是弱拓扑绝缘体，随着温度的降低，有向强拓扑绝缘体转变的趋势，相变点可能在更低的温度.这项工作首次报道了HfTe5的电子结构；实验得到的温度诱导Lifshitz相变现象可以直接解释HfTe5的输运性质；通过详细比较HfTe5与ZrTe5的实验数据，从电子机构随温度演化的角度，给出了两种材料输运性质的不同。同时讨论了HfTe5的拓扑本质，认为HfTe5从室温到15K是弱拓扑绝缘体，有向强拓扑绝缘体转变的趋势。为以后相关研究提供了有力的证据。【Yan Zhang et al., Sci. Bull. 62, 950-956 (2017)】

Temperature-induced Lifshitz transition in topological insulator candidate HfTe5

Very recently, the transition metal pentatellurides, HfTe5 or ZrTe5, have ignited renewed interest as a candidate of a novel topological material. The single-layer HfTe5 and ZrTe5 are predicted to be two-dimensional large band gap topological insulators, a topological phase transition is expected in bulk materials that can be driven even by temperature. In exploring the topological nature and addressing the origin of the transport anomaly in ZrTe5, many recent experiments conclude its topological nature. Up to now, a unified understanding of the topological nature in ZrTe5 and HfTe5 is still lacking. The electronic structure study of HfTe5 is highly anticipated.

We report the first electronic structure study on HfTe5 by ARPES measurements. Regarding the overall electronic structure and its temperature evolution, we find that HfTe5 behaves quite similarly to that of ZrTe5. Our results indicate a temperature-induced Lifshitz transition in HfTe5. It provides a natural understanding on the transport anomaly at ~65 K. The quantitative difference of transport properties between HfTe5 and ZrTe5 are reflected in the subtle difference of their electronic structures. We have carried out high resolution ARPES measurements on HfTe5. We discovered strong electronic evidence of a temperature-induced Lifshitz transition in HfTe5. Like ZrTe5, with decreasing temperature, HfTe5 undergoes an electronic state transition from a p-type-semimetal to a semiconductor, and finally to an n-type-semimetal. It provides a natural explanation on the long-standing puzzle about the origin of the transport anomalies in HfTe5 and ZrTe5. Our observations are consistent with that HfTe5 is a weak topological insulator and is located at the phase boundary between weak and strong topological insulators at very low temperature.



3. PLD方法生长的超导的多层FeSe薄膜的电子结构和向列相转变

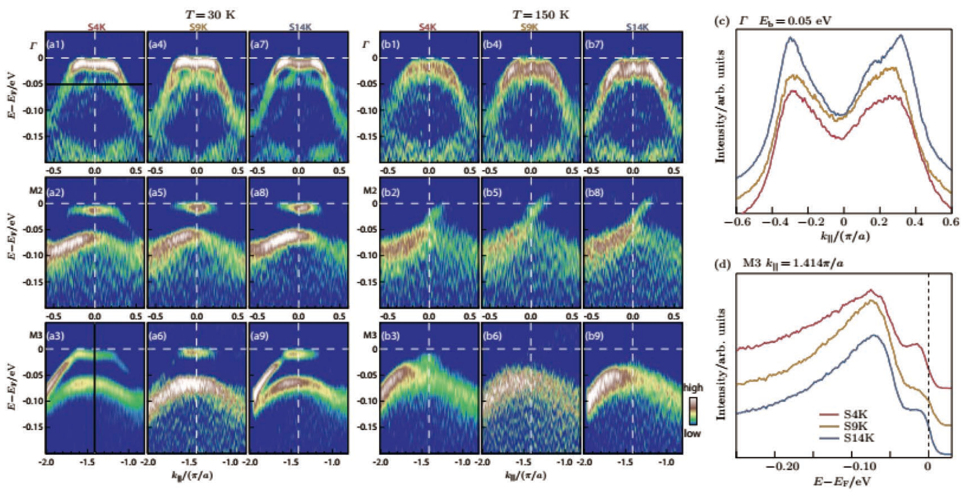
FeSe块材在常压下具有8K的超导转变温度，而加压后Tc可提高至38K。然而，具有相同结构的单层FeSe/STO却具有高达65K的超导转变温度。十几层厚度以上的FeSe/STO薄膜被认为与块材FeSe具有相同的性质，但实际上两层及以上的FeSe/STO薄膜是不超导的，甚至50层厚的薄膜也不超导。因此，FeSe块材和薄膜之间的相同点和不同点为理解相关超导机理提供了重要信息。近来，脉冲激光沉积方法被应用于FeSe薄膜的生长，在CaF2衬底上生长出了超导转变温度为5K~15K的一系列FeSe薄膜。这些薄膜的超导电性可以随着制备条件的微调而改变，导致FeSe/CaF2薄膜从不超导到不同转变温度的超导，甚至最高能达到Tc=15K，这明显高于块材FeSe的超导转变温度。

我们通过ARPES实验对PLD方法生长的FeSe/CaF2多层单晶薄膜的电子结构进行了比较全面的探测和比较，清晰地观测到了超导转变温度分别为4K、9K和14K的三种样品的费米面和能带结构。总的来说，他们具有相似的电子结构。通过蒸钾进行电子掺杂可以抑制向列相转变，并使样品由N相变为S相，伴随着布里渊区角落形成电子型费米面。PLD生长的多层FeSe薄膜与FeSe块材以及MBE生长的多层FeSe薄膜很相似。我们对PLD生长的FeSe/CaF2薄膜的ARPES结果建立了一个块材FeSe与MBE生长的FeSe/STO薄膜之间的连接，将为理解这些系统中高温超导电性的起源提供重要信息。【Bing Shen et al., Chinese Physics B, Vol.26 No.7:077402(2017)】

Electronic structure and nematic phase transition in superconducting multi-layer FeSe films grown by pulsed laser deposition method

Bulk FeSe has a superconducting transition temperature of ~ 8 K at ambient pressure; its Tc can be significantly enhanced up to 38 K under high pressure or up to 48 K by the gating method. Single-layer FeSe films grown on SrTiO3 substrate by molecular beam epitaxy (MBE) method show signatures of superconductivity up to 65 K. Multiple-layer FeSe/SrTiO3 films are thought to approach bulk materials when they are thick enough. However, FeSe/SrTiO3 films made by MBE method are not superconducting when their thickness is two or more layers, even above 50 layers. Study on the origin of the similarity and difference between the bulk FeSe and FeSe/SrTiO3 films by MBE method may provide important information to understand their underlying superconductivity mechanism.

Recently, pulsed laser deposition (PLD) method was developed to grow FeSe films on CaF2 substrate. Their superconductivity can be tuned by slightly varying the preparation conditions, resulting in FeSe/CaF2 films from nonsuperconducting to superconducting with different Tcs, even up to 15 K that is obviously higher than that of bulk FeSe.We have carried out comprehensive ARPES investigations on the electronic structure of single crystal multiple-layer FeSe films grown on CaF2 substrate by pulsed laser deposition method. Fermi surface, band structure, and their temperature dependence for three kinds of samples with different superconducting transition temperatures of 4 K, 9 K,and 14 K are measured. Overall, they share similar electronic structure but sample-dependent difference is identified. Electron doping by potassium deposition can suppress the nematic phase transition, and transform their electronic structure from the N phase to the S phase with electron-like Fermi surface around the Brillouin zone corners. The overall electronic structure of our PLD-grown multiplelayer FeSe films is similar to that of bulk FeSe and MBEgrown multiple-layer FeSe films. Our ARPES results on the PLD-grown FeSe/CaF2 films also establish a link between bulk FeSe single crystal and MBE-grown FeSe/SrTiO3 films and will provide important information to understand the origin of high temperature superconductivity in these systems.

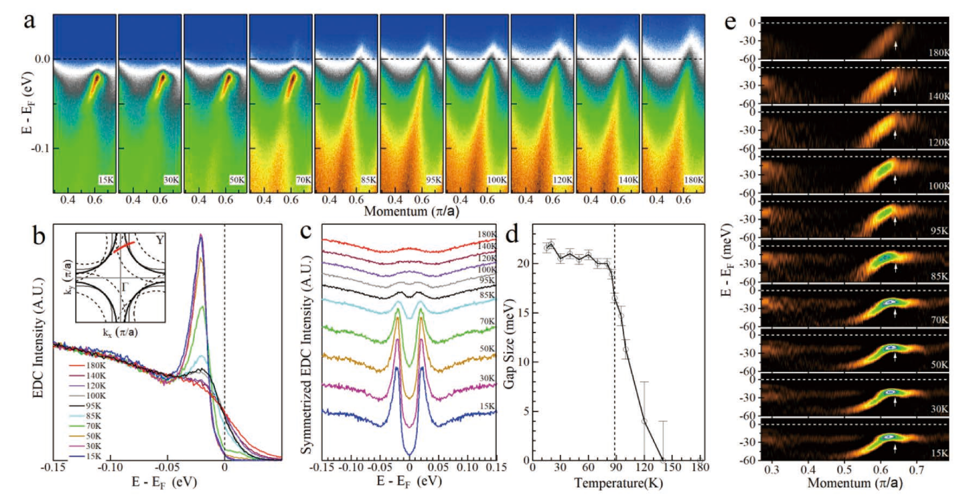


4. Bi2212超导态和赝能隙态的能隙和能带结构的温度演化行为。我们对最佳掺杂的Bi2212样品进行了精确的超导能隙随动量空间变化的研究，我们发现，最佳掺杂的Bi2212样品不能用单一的d波配对的形式拟合其在整个动量空间的分布。除了在反节点区域出现严重偏离d波配对形式的超导能隙，在靠近节点区还出现了小于d波配对形式，其偏离程度大于实验误差，所以我们引入含有高次项的d波配对形式，也即考虑次近邻电子-电子相互作用。我们发现，其与实验数据吻合很好。所以我们认为，在Bi2212中存在的超导能隙，并不符合单一的d波配对形式，而应该考虑含有高次项的d波配对。

我们同时还研究了Bi2212在反节点处能带结构随温度变化的关系，我们发现，反节点处在穿越Tc时，能隙并没有关闭，而是在更高温度140K左右，能隙才关闭，这与之前文献报道相符合，说明赝能隙的存在。超导能隙是电子-空穴对称化的能隙，也即在角分辨光电子能谱中，我们看到费米动量和由于能隙打开造成的能带翻转位置应该一致。然而之前对于Bi2201的观测中发现，T*之上的费米动量位置与Tc之下能带翻转位置有很大偏差，这说明从赝能隙态进入超导态发生了相变。然而在我们对Bi2212反节点处的观测发现，随着温度升高，费米动量和能带翻转的位置一致，没有出现Bi2201中能带重整化现象，说明在Bi2201中发生的现象，对于铜氧化物而言，并不是一个普适的现象。同时我们发现，在Bi2212反节点的能带结构中，其能带底部随着温度升高向深能级移动，这也与之前在Bi2201中观测到的有所不同。这些对我们理解赝能隙的本质，解释超导能隙与赝能隙关系，提供了丰富的信息。【Xun Sun et al., Chin. Phys.Lett. 35 017401 (2018)】

Temperature Evolution of Energy Gap and Band Structure in the Superconducting and Pseudogap States of Bi2Sr2CaCu2O8+δ Superconductor Revealed by Laser-Based Angle-Resolved Photoemission Spectroscopy

We have carried out detailed momentum-dependent and temperature-dependent measurements on Bi2Sr2CaCu2O8+δ(Bi2212) superconductor by super-high resolution laser-based angle-resolved photoemission spectroscopy. The precise determination of the superconducting gap for the nearly optimally-doped Bi2212 (Tc = 91 K) at low temperature indicates that its momentum-dependence deviates from the standard d-wave form (cos(2Φ)); it can be well fitted by including a high-order term (cos(6Φ)) that is related to the next nearest-neighbor interactions. We find that the band structure near the antinodal region smoothly evolves across the pseudogap temperature without a signature of band reorganization. This is distinct from that found in Bi2Sr2CuO6+δ superconductor suggesting that the band reorganization across the pseudogap temperature is not a universal behavior in cuprate superconductors. We also find the bottom of band structure around antinode shifts to high binding energy with increasing the temperature, which is different from Bi2201. These results provide new insights in understanding the nature of the superconducting gap and pseudogap in high temperature cuprate superconductors.The origin of the pseudogap in cuprate superconductors, whether it represents a phase transition or a crossover across T*, needs to be further investigated.



SC07组成员合影

SC08 利用中子散射研究关联电子体系

Neutron scattering on the correlated electron systems

组长/Leader:
李世亮 Shiliang Li
组员/ Group Members:
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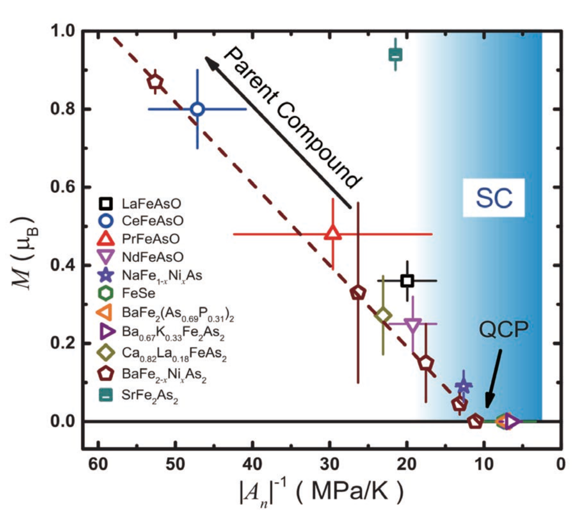
Selected Scientific Results

1. 我们通过测量单轴压力下的电阻行为，对大量铁基样品母体和和掺杂样品的向列相涨落性质进行了详细研究，发现反铁磁有序磁矩反比于向列居里常数。这暗示铁基超导体的磁基态可以通过调节向列涨落的强度获得。由此可以建立一个统一的铁基超导体相图，其中超导诞生于某一假设理想母体，该母体具有很大的有序磁矩及较弱的向列涨落。

We systematically studied the nematic fluctuations in many parent compounds and their doped samples by measuring the elastoresistivity under uniaxial pressure. They found that the ordered antiferromagnetic moment is inversely proportional to the nematic Curie constant, suggesting that the magnetic ground states can be tuned by the amplitude of nematic fluctuations. Accordingly, they provide the unified phase diagram for iron-based superconductors, where superconductivity emerges from a hypothetical parent compound with large ordered moment and weak nematic fluctuations.



SC08组成员合影

SC09 新奇超导体功能与机制的核磁共振研究

NMR study on superconductivity

组长/Leader:
郑国庆Guoqing Zheng
组员/ Group Members:
李政Zheng Li
杨杰Jie Yang

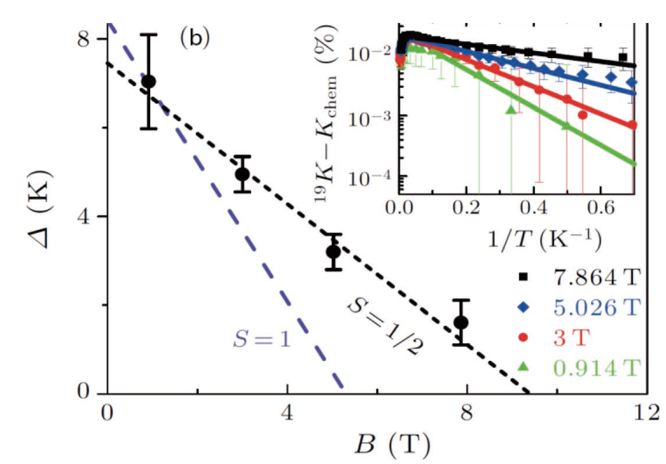
Selected Scientific Results

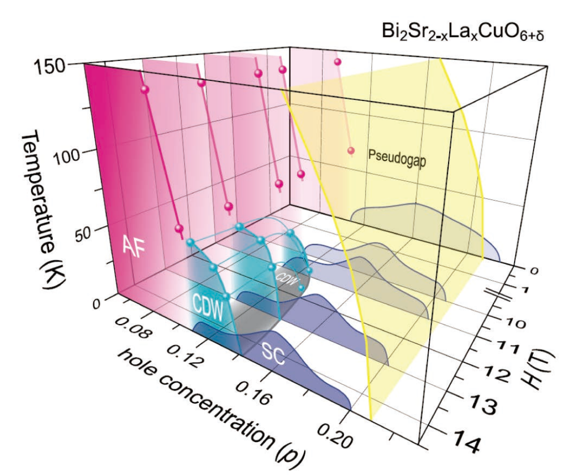
1. 通过^{19}F的NMR测量，确定了$Cu_3Zn(OH)_6FBr$中有能隙的1/2自旋的自旋子激发，这是Z2类型（即Toric code） 拓扑序的量子自旋液体的确定性信号。该工作是在具体材料中观察到 Z2拓扑序量子自旋液体的第一个确定性例子。

Our ^{19}F NMR data reveals a gapped spin-liquid ground state for $Cu_3Zn(OH)_6FBr$. Most importantly, we provide experimental evidence for spin-1/2 quantum number for spin excitations, i.e. spinons.

2. 在对高温超导体Bi2Sr2-xLaxCuO6的核磁共振研究中发现，在超导出现的低掺杂浓度范围内，取代反铁磁有序态的是长程电荷密度波有序态，电荷密度波有序态的临界温度是反铁磁临界温度的延伸，随着掺杂浓度的增加而减小，最终在掺杂浓度0.14附近消失。并且，它与赝能隙温度成正比。这一新发现揭示了电荷在产生超导中的重要作用，为研究高温超导机制提供了崭新的视角。

By ^{63}Cu-nuclear magnetic resonance, we report the discovery of CDW induced by an in-plane field, setting in above the dome in single-layered $Bi_2Sr_{2-x}LaxCuO_6$.The onset temperature TCDW takes over the antiferromagnetic order temperature TN beyond a critical doping level at which superconductivity starts to emerge,and scales with the pseudogap temperature T*. These results provide important insights into the relationship between spin order, CDW and the pseudogap, and their connections to high-temperature superconductivity.





SC10 新型量子功能材料的探索研究

Novel Superconductors and Related Functional Materials

组长/Leader:
陈根富Genfu Chen

组员/ Group Members:
任治安 Zhian Ren
单磊 Lei Shan
薛面起 Mianqi Xue
张帅 Shuai Zhang

Selected Scientific Results

1. 在新超导材料探索方面：发现首个133型Cr系非常规超导体KCr_3As_3，空气中稳定，Tc ~ 5 K。

2. 发现112型新铁砷化合物$EuFeAs_2$，是第一个112 型的铁基母体，通过Eu位掺La实现超导，Tc ~ 11 K。

3. 发现Co_2P型的ScRuSi 超导体，Tc ~ 3.1 K。

4. 发现Ir系的$BaIr_2As_2$ 超导体， Tc ~ 2.8 K。

5. 通过Th、F共掺杂方法把铁基SmFeAsO的超导Tc提高到58.6K，为铁基块材最高Tc。

6. 在三重简并费米子拓扑半金属材料WC上实现点接触诱导超导。

国际合作与学术交流

出访情况

序号	出访人员	职务	出访时间	出访地点
1	邱祥冈	研究员	2017.07.08-2017.08.07	比利时 鲁汶大学
2	邱祥冈	研究员	2017.07.22-2017.07.29	瑞士 PSI、法国 ESPCI大学
3	邱祥冈	研究员	2017.12.08-2017.12.12	日本 东京大学
4	周兴江	研究员	2017.01.15-2017.01.21	美国 劳伦斯伯克利国家实验室
5	周兴江	研究员	2017.07.23-2017.08.13	美国 斯坦福大学
6	马肖燕	副主任工程师	2017.05.02-2017.05.12	英国 ISIS散裂中子源
7	马肖燕	副主任工程师	2017.09.27-2017.10.03	英国 ISIS散裂中子源
8	李世亮	研究员	2017.05.20-2017.05.29	德国 FRM-II中子源
9	罗会仟	副研究员	2017.02.11-2017.02.22	日本 质子加速器研究机构
10	罗会仟	副研究员	2017.05.02-2017.05.12	英国 ISIS散裂中子源
11	罗会仟	副研究员	2017.09.19-2017.10.11	瑞士 保罗谢勒研究所
12	罗会仟	副研究员	2017.09.27-2017.10.03	英国 ISIS散裂中子源
13	罗会仟	副研究员	2017.11.18-2017.11.28	日本 质子加速器研究机构
14	罗会仟	副研究员	2017.12.12-2017.12.25	澳大利亚 布拉格研究所
15	罗会仟	副研究员	2017.01.18-2017.01.23	法国 劳厄-朗之万研究所
16	谢 涛	学生	2017.02.11-2017.02.22	日本 质子加速器研究机构
17	毛慧灿	学生	2017.01.18-2017.01.23	法国 劳厄-朗之万研究所
18	谢 涛	学生	2017.02.11-2017.02.22	日本 质子加速器研究机构
19	张汶良	学生	2017.02.12-2017.02.20	德国 FRM-II中子源
20	刘璐玉	学生	2017.03.18-2017.03.26	美国 国家标准局
21	谷延红	学生	2017.03.15-2017.03.20	澳大利亚 ANSTO
22	谢 涛	学生	2017.03.26-2017.04.07	德国 FRM-II中子源

出访情况

序号	出访人员	职务	出访时间	出访地点
23	魏 源	学生	2017.05.21-2017.05.28	德国 MLZ
24	魏 源	学生	2017.05.30-2017.06.09	德国 FRM-II中子源
25	毛慧灿	学生	2017.06.05-2017.06.16	澳大利亚 核科学技术组织
26	刘曌玉	学生	2017.06.11-2017.06.22	美国 国家标准局
27	魏 源	学生	2017.06.21-2017.06.29	日本 质子加速器研究机构
28	刘曌玉	学生	2017.07.05-2017.07.18	瑞士 保罗谢勒研究所
29	谢 涛	学生	2017.07.05-2017.07.15	澳大利亚 ANSTO
30	龚冬良	学生	2017.09.28-2017.09.10	瑞士 保罗谢勒研究所
31	谢 涛	学生	2017.09.20-2017.10.04	瑞士 保罗谢勒研究所
32	魏 源	学生	2017.09.28-2017.09.10	瑞士 保罗谢勒研究所
33	谢 涛	学生	2017.09.28-2017.09.10	瑞士 保罗谢勒研究所
34	刘曌玉	学生	2017.09.25-2017.10.07	德国 FRM-II中子源
35	张汶良	学生	2017.09.25-2017.10.07	德国 MLZ
36	毛慧灿	学生	2017.09.25-2017.10.04	德国 FRM-II中子源
37	毛慧灿	学生	2017.10.09-2017.10.20	澳大利亚 核科学技术组织
38	谷延红	学生	2017.10.15-2017.10.25	澳大利亚 核科学技术组织
39	谢 涛	学生	2017.11.18-2017.11.28	日本 质子加速器研究机构
40	谢 涛	学生	2017.12.14-2017.12.22	日本 质子加速器研究机构
41	谷延红	学生	2017.12.13-2017.12.26	澳大利亚 核科学技术组织
42	杨 润	学生	2016.10.21-2017.10.01	美国 布鲁克海文国家实验室

来访情况

序号	来访人员	职务	来访时间
1	Yosef Yeshuru	Professor	2017.09.05-2017.09.12
2	Tsuyoshi Tamegai	Professor	2017.11.05-2017.11.08
3	Joris Van De Vondel	Professor	2017.12.03-2017.12.09
4	Alejandro Silhanek	Professor	2017.12.03-2017.12.09
5	Meir Lewkowicz	Professor	2017.11.26-2017.12.07
6	Valerii Vinokur	Professor	2017.11.26-2017.12.02
7	Aviad Frydman	Professor	2017.11.15-2017.11.22
8	Rustem Khasanov	Senior Scientisit	2017.10.05-2017.10.09
9	Robert J. Cava	Professor	2017.06.09-2017.06.21
10	William Joel Nellis	Professor	2017.08.16-2017.08.25
11	Robert J. Cava	Professor	2017.11.06-2017.11.09
12	Kim Duck Young	Professor	2017.12.04-2017.12.04
13	Vladimir Sidorov	Professor	2017.12.01-2015.02.28
14	Devashibhai Adroja	Senior Scientist	2017.06.10-2017.06.20
15	Rafael Fernandes	Associate Professor	2017.10.08-2017.10.13
16	Ming Yi	Postdoctor	2017.07.17-2017.07.21
17	Victor Kornev	professor	2017.11.02-2017.11.11

国际会议

序号	姓名	会议名称	时间	报告题目	地点
1	金 魁	Tenth International Conference on Vortex Matter in Nanostructured Superconductors	2017.09.09-2017.09.14	Recent progress on the spinel oxide superconductor	罗德，希腊
2	袁 洁	Tenth International Conference on Vortex Matter in Nanostructured Superconductors	2017.09.09-2017.09.14	Mapping a Complete Phase Diagram of High-Tc Cuprates Via a High-throughput Method	罗德，希腊
3	朱北沂	The NCNST-BINA Workshop on Nanoscience and Nanotechnology	2017.05.07-2017.05.11	Vortex dynamics in nanostructured superconductors	拉马特甘 以色列
4	朱北沂	Tenth International Conference on Vortex Matter in Nanostructured Superconductors	2017.09.09-2017.09.14	Vortex Ratchet Effects in Asymmetric Superconducting Systems	罗德，希腊
5	何 格	APS March Meeting	2017.03.13-2017.03.17	Observation of anisotropic electronic correlations in the spinel oxide superconductor	新奥尔良 美国
6	邱祥冈	Quantum Nanophotonics Meeting	2017.02.25-2017.03.04	Subwavelength optics in superconducting metamaterials	韦斯卡 西班牙
7	邱祥冈	International Conference On Strongly Correlated Electron Systems Meeting	2017.07.16-2017.07.22	Optical study on the antiferromagnetic ordered state in electron-overdoped Ca0.77Nd0.23FeAs2	布拉格，捷克
8	邱祥冈	International Conference On Low Temperature Physics Meeting	2017.08.08-2017.08.17	Optical study on the anomalous phonon behavior in superconducting CaKFe4As4	哥德堡，瑞典
9	邱祥冈	Vortex In Nanostructured Superconductors Meeting	2017.09.08-2017.09.15	Parity effect of superconductivity in mesoscopic superconductors	罗德，希腊
10	邱祥冈	The 30th International Symposium On Superconductivity Meeting	2017.12.12-2017.12.16	Anomalous phonon behavior in CaKFe4As4	东京，日本

国际会议

序号	姓名	会议名称	时间	报告题目	地点
11	董晓莉	APS March meeting	2017.03.13-2017.03.17	Strong electronic two-dimensionality and close relationship between spin nematicity and superconductivity in soft-chemistry synthesized (Li,Fe) OHFeSe and FeSe single crystals	新奥尔良 美国
12	董晓莉	The 15th International Conference on Advanced Materials	2017.08.27-2017.09.01	Soft-chemistry synthesized superconducting single crystals and films of (Li,Fe) OHFeSe and FeSe	京都，日本
13	孙力玲	Sino-German Meeting Emergent Correlated Materials	2017.02.26-2017.03.03	Discovery of bi-critical point between AFM and superconducting phases in a Fe-based compound	柏林，德国
14	孙力玲	APS March meeting	2017.03.21-2017.03.24	Quantum phase transition and destruction of Kondo effect in pressurized in rare earth hexaborides	新奥尔良 美国
15	孙力玲	The 9th Joint Meeting of Chinese Physicists Worldwide: International Conference on Physics & Education "New opportunities in Physics" (OCPA9)	2017.07.17-2017.07.20	Superconductivity and carrier type in pressurized black phosphrous	北京，中国
16	孙力玲	5th Annual Basic Energy Science-Chinese Academy of Science (BES-CAS) Collaboration Workshop on Superconductivity from July 27 to 28, 2017	2017.07.27-2017.07.28	Progress in pressure-induced superconductivity	伯克利 美国

国际会议

序号	姓名	会议名称	时间	报告题目	地点
17	王 哲	APS MarchMeeting 2017	2017.03.13-2017.03.17	(Poster)-Correlation between superconductivity and bond angle of CrAs chain in non-centrosymmetric compounds A2Cr3As3 (A = K, Rb)	新奥尔良 美国
18	孙 亮	2017 International Microwave Symposium (IMS2017)	2017.06.04-2017.06.09	Developments in China for the design and application of high temperature superconducting (HTS) filters	夏威夷，美国
19	孙 亮	13th European Conference on Applied Superconductivity (EUCAS2017)	2017.09.17-2017.09.21	1. On the nature of unusual microwave response of thin FeSe1-xTex film near critical temperature 2. Recently developed microwave devices based on High-Tc superconducting films	日内瓦，瑞士
20	周兴江	APS March Meeting	2017.03.13-2017.03.17	Quantitative Determination of the Pairing Interactions for High Temperature Superconductivity in Cuprates	新奥尔兰 美国
21	周兴江	International Workshop on Strong Correlations and Angle-Resolved Photoemission Spectroscopy (CORPES 17)	2017.07.02-2017.07.07	Laser ARPES on High Temperature Superconductors and Topological Materials	广岛，日本
22	周兴江	The BES-CAS 5th Annual Workshop on Unconventional Superconductivity	2017.06.26-2017.06.28	Laser ARPES on Unconventional Superconductors	加尼福尼亚，美国
23	周兴江	International Research School and Workshop on Electronic Crystals (ECRYS 2017)	2017.08.27-2017.09.02	State-of-the-Art Laser ARPES on High Temperature Superconductors and Topological Materials	卡尔吉斯 法国

国际会议

序号	姓名	会议名称	时间	报告题目	地点
24	周兴江	Workshop on Fundamental Enduring Problems in Quantum Condensed Matter	2017.12.07-2017.12.09	Laser ARPES on High Temperature Superconductors --Key Electronic Ingredients and Pairing Mechanism	加尼福尼亚 美国
25	刘国东	APS March meeting	2017.03.12-2017.03.19	High-resolution angle-resolved photoemission study of electronic structure and charge-density wave formation in HoTe3.	新奥尔良 美国
26	赵 林	the 9th meeting Study of Matter at Extreme Conditions(SMEC2017)	2017.04.01-2017.04.09	Electronic Evidence of Temperature-Induced Lifshitz Transition and Topological Nature in ZrTe5	佛罗里达 美国
27	吕守鹏	APS March Meeting	2017.03.13-2017.03.17	Electronic Structure of ZrTe3 from Angle-Resolved Photoemission Spectroscopy	新奥尔良 美国
28	李世亮	International Conference on Advanced Materials 2017	2017.08.27-2017.09.01	Nematic order and its fluctuations in iron-based superconductors	京都，日本
29	马肖燕	International Conference on Neutron Scattering 2017	2017.07.08-2017.07.15	SPICE on the 'Bamboo' thermal triple-axis spectrometer	大田，韩国
30	罗会仟	APS March Meeting	2017.03.13-2017.03.17	Itinerant spin excitations and superconductivity in BaFe2-xNixAs2	新奥尔良 美国
31	罗会仟	International Conference on Neutron Scattering 2017	2017.07.08-2017.07.15	Electron doping effects on the spin spectroscopy of BaFe2-xNixAs2	大田，韩国

国际会议

序号	姓名	会议名称	时间	报告题目	地点
32	张汶良	March Meeting	2017.03.12-2017.03.18	Effect of Nematic Order on the Low-Energy Spin Fluctuations in Detwinned BaFe1.935Ni0.065As2	新奥尔良 美国
33	刘曌玉	APS March Meeting 2017	2017.03.13-2017.03.17	Nematic Quantum Critical Fluctuations in BaFe2-xNixAs2	新奥尔良 美国
34	郑国庆	The 37rd REIMEI Workshop on Frontiers of Correlated Quantum Matters and Spintronics	2017.01.13-2017.01.17	Spin-triplet superconducting state in doped topological insulator CuxBi2Se3 and unconventional superconductivity in Rb2Cr3As3	水户，日本
35	郑国庆	International School on Topological Science and Topological Matters	2017.02.13-2017.02.18	Spin-rotation symmetry breaking and triplet superconducting state in the doped topological insulator CuxBi2Se3	京都，日本
36	郑国庆	March Meeting	2017.03.13-2017.03.17	Spin-rotation symmetry breaking and triplet superconducting state in CuxBi2Se3	新奥尔良 美国
37	郑国庆	International Conference on Topological Materials Science 2017	2017.06.09-2017.06.13	Topological superconducting state in CuxBi2Se3 revealed by NMR	东京，日本
38	郑国庆	Quest for topological superconductivity	2017.07.04-2017.07.21	International workshop on Topological States and Phase Transitions in Strongly Correlated Systems	北京，中国

国内会议

序号	姓名	会议名称	时间	报告题目	地点
1	金　魁	第三届凝聚态物理会议	2017.06.25-2017.06.27	Recent progress on the spinel oxide superconductor	上海
2	袁　洁	第十四届全国超导学术研讨会	2017.08.20-2017.08.23	组合薄膜技术在超导体研究中的应用	天津
3	袁　洁	第十六届全国青年材料科学技术研讨会	2017.10.14-2017.10.15	高通量实验技术在超导研究中的应用进展	天津
4	董晓莉	第三届凝聚态物理会议	2017.06.24-2017.06.27	Tuning superconductivity in FeSe-based single crystals and films	上海
5	董晓莉	第十四届全国超导会议	2017.08.20-2017.08.24	Superconducting (Li,Fe) OHFeSe Film of High Quality and High Critical Parameters	天津
6	董晓莉	2017年度中国物理学会秋季会议	2017.09.08-2017.09.10	Single Crystals and Films of FeSe-based Superconductors for Basic Research & Possible Applications	成都
7	孙力玲	第15届高温超导北京论坛	2017.04.11-2017.04.14	空穴载流子在超导中的作用	烟台

国内会议

序号	姓名	会议名称	时间	报告题目	地点
8	孙力玲	2017年强磁场下前沿科学问题学术讨论会	2017.06.3-2017.06.05	自旋液体材料的高压研究	合肥
9	孙力玲	第三届凝聚态物理会议	2017.06.24-2017.06.27	黑磷单晶的高压输运研究	上海
10	孙力玲	第四届重费米子论坛	2017.11.17-2017.11.20	Ce-113 中的高压研究进展	江油
11	郑东宁	第十四届全国超导学术研讨会	2017.08.20-2017.08.24	高温超导弱电应用简介	天津
12	金贻荣	第十四届全国超导学术研讨会	2017.08.20-2017.08.24	用于超导量子比特的阶跃阻抗式谐振腔的研究	天津
13	郭学仪	第十四届全国超导学术研讨会	2017.08.20-2017.08.24	Xmon量子比特中的ATS效应研究和State Tomography测量	天津
14	李贺康	第十四届全国超导学术研讨会	2017.08.20-2017.08.24	超导Xmon量子比特的制备工艺研究	天津
15	郑东宁	2017新材料国际发展趋势高层论坛	2017.11.10-2017.11.12	新型超导电子器件及应用	西安

国内会议

序号	姓名	会议名称	时间	报告题目	地点
16	孙 亮	第十四届全国超导学术研讨会	2017.08.20-2017.08.24	高性能超导滤波器及示范应用	天津
17	周兴江	The KITS 2017 Forum: New Horizon in Condensed Matter Physics	2017.03.27-2017.03.29	Laser ARPES on High Temperature Superconductors and Topological Materials	北京
18	周兴江	2017 Workshop on Frontier Research at High Magnetic Field	2017.06.03-2017.06.05	Laser ARPES on High Temperature Superconductors and TopologicalMaterials	合肥
19	周兴江	The 3rd National Conference on Condensed Matter Physics	2017.06.24-2017.06.27	Quantitative Determination of the Pairing Interactions for High Temperature Superconductivity in Cuprates	上海
20	周兴江	14th National Conference on Superconductivity	2017.08.21-2017.08.23	Introduction to High Temperature Superconductors and the Forum	天津
21	周兴江	Forum of Science and Technology Frontier of “High Temperature Superconductors”, Scientific Meeting Hall of CAS	2017.09.28-2017.09.28	Laser ARPES on High Temperature Superconductors	北京
22	赵 林	中国科学院青年创新促进会2017年学术年会暨会员代表大会	2017.11.05-2017.11.09	FeSe薄膜的电子结构研究	兰州
23	赵 林	第十四届全国超导学术研讨会	2017.08.20-2017.08.24	MBE和PLD方法生长的FeSe薄膜的电子结构研究	天津

国内会议

序号	姓名	会议名称	时间	报告题目	地点
24	黄 元	中国物理学会秋季学术会议	2017.09.07-2017.09.10	新型机械解理技术的探索及在二维材料研究中的应用	成都
25	刘国东	第三届凝聚态物理会议	2017.06.24-2017.06.27	Electronic properties of several new topological quantum materials	上海
26	李世亮	凝聚态物理会议	2017.06.25-2017.06.27	A Unified Phase Diagram for Iron-based Superconductors	上海
27	李世亮	第二届“自旋阻挫与自旋液体”上海论坛	2017.11.25-2017.11.26	Cu3Zn(OD)6FBr非弹性中子散射研究	北京
28	罗会仟	第三届凝聚态物理会议	2017.06.24-2017.06.27	Spin driven nematicity in 122-type iron pnictides	上海
29	罗会仟	第十四届全国超导学术研讨会	2017.08.20-2017.08.24	铁基超导体中的自旋共振模	天津
30	罗会仟	第五届全国中子散射会议	2017.11.01-2017.11.03	112型铁基超导体中的自旋共振模	成都
31	张汶良	第三届凝聚态物理会议	2017.06.24-2017.06.28	The shift of the quantum critical point in slightly Cr-doped non-superconducting BaFe2(As1-xPx)2	上海

国内会议

序号	姓名	会议名称	时间	报告题目	地点
32	谢 涛	第三届凝聚态物理会议	2017.06.25-2017.06.27	Spin excitations in 112-type iron pnictide superconductor	上海
33	魏 源	第五届全国中子散射会议暨国家中子源多学科应用研讨会	2017.10.01-2017.10.03	量子自旋液体Cu3Zn(OD)6FBr低能自旋激发	成都
34	郑国庆	Beijing Forum for High Temperature Supercnductivity	2017.04.10-2017.04.14	Gapped Spin-1/2 Spinon Excitations in a New Kagome Quantum Spin Liquid Compound Cu3Zn(OH)6FBr	烟台
35	李 政	第二届“自旋阻挫与自旋液体”上海论坛	2017.11.24-2017.11.26	核磁共振首次观测到有能隙的自旋子	北京
36	杨 杰	第十四届全国超导学术研讨会	2017.08.20-2017.08.24	Structural phase transition, precursory electronic anomaly and strong-coupling superconductivity in quasi-skutterudite (Sr1−xCax)3Ir4Sn13 and Ca3Rh4Sn13	天津
37	单 磊	第七届全国凝聚态物理青年科学家论坛	2017.11.17-2.17.11.19	利用点接触技术在拓扑金属表面诱导超导电性	北京
38	彭 健	2017年中国物理学会秋季学术会议	2017.09.07-2017.09.10	HfAs1.67Te0.12单晶的超导电性和化学价态	成都

学术组织任职

序号	姓名	任职情况	职务	任期
1	郑东宁	中国电子学会超导电子学分会	副主任委员	2017-2022
2	郑东宁	超导标准化技术委员会	副主任委员	2017-2022
3	董　成	中国物理学会X射线专业委员会	委员	2015-2018
4	单　磊	AIP Publication China Advisory Board	Member	2015-2017

国际期刊任职

序号	姓名	任职情况	职务	任期
1	周兴江	Superconductor Science and Technology	编委	2011.06至今
2	周兴江	International J. of Modern Phys. B and MPL	编委	2010.05至今
3	周兴江	Journal of Physics and Chemistry of Solids	编委	2016.05至今
4	周兴江	物理学报和Chinese Physics B	编委	2015.01至今

超导基础理论和实验技术系列讲座

序号	报告人	报告题目	机构
1	Prof.Wei Ku	Can high-temperature superconductivity be an entirely different beast within our reach?	Shanghai Jiao Tong University
2	Prof. Shin-ichi. Uchida	Road to Higher Tc Superconductivity	University of Tokyo
3	Prof.Venkat Selvamanickam	Recent Advances in High Temperature Superconductor Tapes for Electric Power and Magnetic Applications	University of Houston
4	Prof. Frank Steglich	Heavy fermions: Interplay between Kondo entanglement, quantum criticality and unconventional superconductivity	MPI for Chemical Physics of Solids
5	Prof. Rafael Fernandes	Nematicity and beyond: emergent electronic states in iron-based high-temperature superconductors	University of Minnesota
6	Prof. Valerii Vinokur	Vortices in superconductors: All the physics in a single grip	Argonne National Laboratory
7	Prof. Alejandro V. Silhanek	A tutorial introduction to electromigration and its applications to superconducting circuits	Université de Liège

超导实验室学术报告

序号	报告人	报告题目	机构
1	Prof. Yi Zhang	现代低温超导SQUID系统	Shanghai Institute of Microsystem and Information Technology, CAS
2	Dr. Devashibhai Adroja	Magnetism and spin-orbital coupling in the spin-chain systems A3MM’ O6	Rutherford Appleton Laboratory
3	Dr. Ming Yi	Emergent Electronic Orders in Iron-Based Superconductors	University of California, Berkeley
4	Prof. Yosef Yeshurun	Fromnano-structured superconductors to commercial high-current applications	Institute of Superconductivity and Institute of Nano Technology Bar-Ilan University
5	Prof. Yoram Dagan	Tuning superconductivity and spin-orbit interaction across the phase diagram of (111) LaAlO3/SrTiO3 interface	Tel Aviv University
6	Prof. TsuyoshiTamegai	Flux Penetrations and Thermomagnetic Instabilities in Three-Dimensional Superconducting Nanostructures	University of Tokyo
7	Prof. Aviad Frydman	Experimental probing of quantum criticality at the Superconductor-Insulator Quantum Phase Transition	Bar Ilan University
8	Dr. Yingying Peng	Resonant Inelastic X-ray Scattering study of Magnetic Excitations in high-Tc cuprate superconductors	Polytechnic University of Milan
9	Prof. Joris Van de Vondel	Direct visualization of degeneracy and vortex ice in nanostructured superconductors	KU Leuven

超导国家重点实验室内部交流

序号	报告人	报告题目
1	袁 洁	高通量组合薄膜技术简介
2	贾艳丽	尖晶石氧化物超导体LiTi2O4薄膜的制备及电输运性质的研究
3	何 格	尖晶石氧化物超导体LiTi2O4薄膜隧道谱研究

超导国家重点实验室内部交流

序号	报告人	报告题目
4	于伟强（外请）	NMR evidence for a field-induced quantum spin liquid and gapless excitations in -RuCl3
5	王 哲	新型量子材料的高压研究
6	王红红	重费米子材料的高压研究
7	孙 亮	高温超导微波器件及其应用
8	李贺康	XmonQubit的理论基础和实验方法简介
9	黄海波	超导滤波器的设计与应用
10	黄 元	机械解理技术的探索及其在层状材料研究领域的应用
11	刘 静	Electronic Structure and Pairing Interactions of Bi2212 Measured by New Generation Laser-Based ToF-ARPES
12	吕守鹏	Charge Density Wave Effect and Splitting feature on Three-dimensional Fermi Surface of ZrTe3 by ARPES
13	刘国东	新型拓扑材料ZrTe5和WTe2的高分辨激光ARPES研究
14	赵文娟	关于过渡金属二硫族化合物（TMDC）碱金属掺杂的ARPES研究
15	鲁兴业（外请）	共振非弹性X射线散射技术在关联电子材料研究中的应用
16	魏 源	反铁磁自旋梯材料BaFe2S3中的自旋激发谱
17	谷延红	铁基超导体的普适相图
18	李源（外请）	Topological spin excitations in a three-dimensional antiferromagnet
19	谢 涛	Neutron spin resonance in 112 type iron-based superconductor
20	毛慧灿	Neutron diffraction study in ThFeAsN and Cr2GaN
21	张 帅	单d电子体系中的超导探索
22	穆青隔	准一维Cr基超导材料探索
23	杨占海	液相剥离法制备1T-TaS2-xSex超导薄层
24	单 磊	从隧道到点接触以及利用点接触技术在拓扑材料中诱导超导电性
25	潘伯津	Fe1+yTe1-xSex临界电流密度的研究
26	梁 慧	新型Kondo晶格材料YbPtAs的磁性研究以及石墨烯薄膜和纤维的超导实现
27	戴耀民（外请）	利用红外光谱揭示声子和外尔费米子的耦合
28	杨 润	铁基超导材料(CaFe1-xPtxAs)10Pt3As8中的绝缘体-超导转变
29	魏鑫健	Pr2CuO4超导薄膜的制备以及电输运性质的研究

主办国际会议

International Symposium
on Frontier of Superconductivity Research (VII)

Optical Spectroscopy on Unconventional Superconductors

Program and Abstracts

October26-29, 2017
National Lab for Superconductivity
Institute of Physics, Chinese Academy of Sciences
Beijing National Laboratory for Condensed Matter Physics

No.8, 3rd South Street, Zhongguancun, Haidian District,
Beijing 100190, China

Organizing Committee:

Chair:Prof. Zhong-xian ZHAO
Chairman of Academic Committee,
National Lab for Superconductivity

Co-Chair:Prof. Xingjiang ZHOU
Director, National Lab for Superconductivity

Co-Chair:Prof.XianggangQiu
National Lab for Superconductivity

Secretaries: Prof. Beiyi ZHU, Ms. Lingqian WANG

National Lab for Superconductivity
Institute of Physics
Chinese Academy of Sciences
Beijing 100190, China
Tel: +86-10-82649167
Fax: +86-10-82649167
Email: nlsc@iphy.ac.cn

Brief Schedule:
Friday, October 27
Registration and Opening (M-building Room 234)
Scientific program

Saturday, October 28
Scientific program
11:50 Closing remarks

Scientific Program

(Each presentation includes 40 minutes talk plus 10 minutes Q&A)

October 27, 2017, Friday, M234, IOP

Morning Session

Chair: Prof. Nanlin Wang

09:00- 09:05	Zhongxian Zhao	Institute of Physics, Beijing	Institute of Physics, Beijing Welcome Speech
09:05- 09:15	Xingjiang Zhou	Institute of Physics, Beijing	Institute of Physics, Beijing Brief Introduction to National Lab for Superconductivity and the Symposium
09:15- 10:05	S. Uchida	University of Tokyo	University of Tokyo Physics of Josephson Plasma Modes in High-Tc Copper Oxides
10:05- 10:30 Break & group photo			

Chair: Prof. Rudi Hackl

10:30- 11:20	Nanlin Wang	Peking University	Light-induced new collective modes in $La_{1.905}Ba_{0.095}CuO_4$ superconductor
11:20- 12:10	Setsuko Tajima	Osaka University	Fermi surface development with doping and the superconductivity in the pseudo-gapped state in the high T_c cuprates
12:10-14:00 Lunch			

Afternoon Session

Chair: Prof. Wei-Sheng Lee

14:00 -14:50	Rudi Hackl	Walther Meissner Institute	Light scattering on electronic and magnetic excitations in unconventional superconductors
14:50 -15:40	Qingming Zhang	Renmin University of China	Raman scattering in FeSe-based superconductors
15:40-16:00 Break			

Chair: Prof.Thomas Timusk

16:00 -16:50	Wei-Sheng Lee	Stanford University	X-ray studies of CDW and excitations in high-Tc cuprate
16:50 -17:40	Jimin Zhao	Institute of Physics	Ultrafast Quasiparticle Dynamics in Single-Layer FeSe/SrTiO3 and $(Li_{0.84}Fe_{0.16})OHFe_{0.98}Se$
17:40 - Dinner			

Scientific Program

(Each presentation includes 40 minutes talk plus 10 minutes Q&A)

October 28, 2017, Saturday, M234, IOP

Morning Session

Chair: Prof. S. Uchida

09:00-09:50	Thomas Timusk	McMaster University	Search for the mechanism of superconductivity using optical spectroscopy
09:50-10:40	Yuan Li	Peking University	Light scattering from correlated electrons: a glimpse at symmetry-breaking mechanisms
10:40 -11:00 Break			

Chair: Prof. Yuan Li

11:00 -11:50	Xiang Gang Qiu	Institute of Physics	Infrared Spectroscopic Studies of the Phonon Dynamics in Iron-based Superconductors
11:50-12:10		Summary & Closing remarks	
12:10 -14:00 Lunch			

Afternoon Session

14:00-18:00	Lab Tour

October 29, 2017

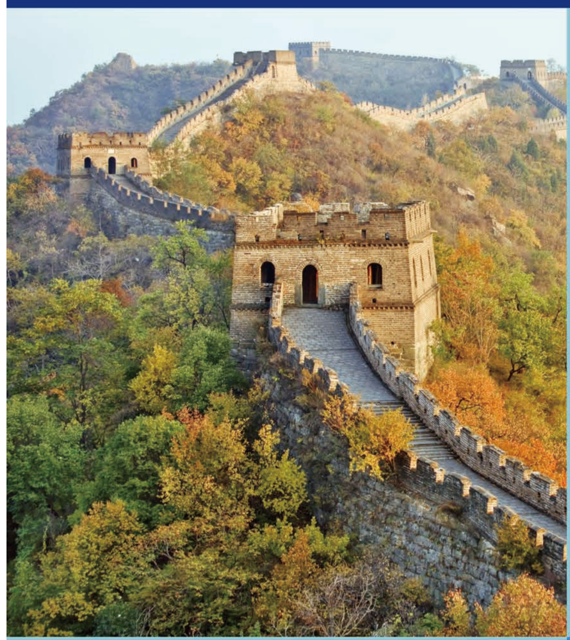
Free discussion

国际会议海报

International Symposium
on Frontier of Superconductivity Research (VII)

Optical Spectroscopy on Unconventional Superconductors

Beijing, China, October 26 - 29, 2017



The National Lab for Superconductivity at the Institute of Physics, Chinese Academy of Sciences, Beijing, is a national premier base for superconductivity research in China and an important hub for academic exchange among domestic and foreign scholars in this field. Aiming to strengthen international scientific exchanges and collaborations, the National Lab for Superconductivity has decided to hold "International Symposium on Frontier of Superconductivity Research" once a year.

This seventh symposium in 2017 will focus on “Optical Spectroscopy on Unconventional Superconductors”. Leading experts will provide overview, personal experience, latest results and future perspectives on optical spectroscopy studies of unconventional superconductors, including cuprate superconductors, iron-based superconductors and other unconventional superconductors. We hope to make the Symposium informative, stimulating and fruitful, particularly to young scientists and graduate students.

List of Invited Speakers

Rudi Hackl (Garching, Germany)
Weisheng Lee (Stanford, USA)
Yuan Li (Beijing, China)
Xianggang Qiu (Beijing, China)
Thomas Timusk (Hamilton, Canada)
Setsuko Tajima (Osaka, Japan)
Shinichi Uchida (Tokyo, Japan)
Nan-Lin Wang (Beijing, China)
Qingming Zhang (Beijing, China)
Jimin Zhao (Beijing, China)

Conference organizers:
Chair: Zhong-Xian ZHAO
Co-Chair: Xing-Jiang ZHOU
Co-Chair: Xiang-Gang QIU

Conference Secretaries:
Bei-Yi ZHU Ling-Qian WANG

Conference contact:
National Lab for Superconductivity (NLSC)
Institute of Physics, Chinese Academy of Sciences
No.8, 3rd South Street, Zhongguancun, Haidian District,
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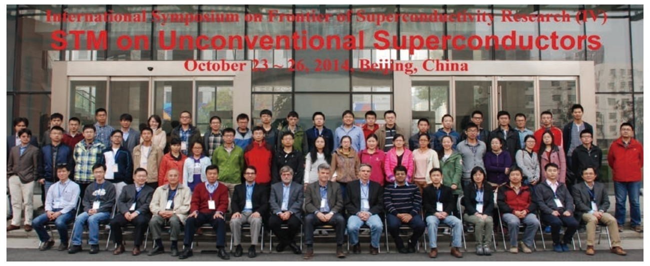

①	②
③	④
⑤	⑥
⑦	

① 第七届超导研究前沿国际论坛会议合影
② 第七届超导研究前沿国际论坛会议合影
③ 第七届超导研究前沿国际论坛会议合影
④ 第七届超导研究前沿国际论坛会议合影
⑤ 第七届超导研究前沿国际论坛会议合影
⑥ 第七届超导研究前沿国际论坛会议合影
⑦ 第七届超导研究前沿国际论坛会议合影

人才引进及培养

研究组和研究方向 Research Groups & Directions

吴云 Yun Wu

1984年生，2007年在北京科技大学获理学学士学位，2013年在北京科技大学获理学博士学位，2013年-2015年中国科学院物理研究所博士后，2015年-2017年英国格林尼治大学博士后。2017年底加入物理所，入选中国科学院物理研究所“关键技术人才”，进入超导实验室工作。主要研究方向为超导材料的微波特性研究和高温超导微波器件研究。代表性工作有：

1.研制并搭建用于超导体毫米波特性研究的低温测试平台：该平台集成了低温设备和测试设备。低温设备集成了用于毫米波测试的高次模式谐振器及传输波导，开发了多项新技术，实现了平台从2K~300K温度的自动化测量。以此为基础，发现了FeSe0.4Te0.6超导薄膜微波表面电阻在超导转变温度附近的反常行为。

2.设计并研制了用于天宫二号的高温超导接收机前端。包括研制一款具有极端频率特性的双通带高温超导滤波器，实现了极宽的通信带宽（相对带宽65%）和极好的抗干扰性（矩形系数1.19）、有针对性地研究和改进了高温超导滤波器的制作工艺和流程使其适用于低频振动环境和潮湿环境，以及参与制定了适用于航天飞行任务的高温超导滤波器加工工艺流程和标准。

3.提出了新的高温超导多工器设计方法，极大简化了高温超导多工器的设计和加工流程；提出了多种新型高温超导微波器件的原型、结构和设计理论，如大功率高温超导器件、高温超导滤波天线等。

黄元 Yuan Huang

1987年生，2008年毕业于中国石油大学（华东），2008至2013年在中科院物理所从事博士阶段的研究工作，2013年博士毕业后加入美国纽约布鲁克海文国家实验时（Brookhaven National Laboratory, BNL)担任科研助理，期间首次详细研究并阐述了机械解理过程中相互作用机制，成功的解理出亚毫米量级单层的石墨烯和Bi2212铜氧化物超导体材料。2015年12月至2017年7月，在韩国基础科学研究院多维碳材料中心担任助理研究员，期间又将机械解理技术拓展到更多的材料体系，包括MoS2, WSe2等AB2体系，以及多种类黑磷结构的层状材料，进一步将单层单晶样品的尺寸提高到亚厘米到厘米尺寸。博士及博士后阶段在Nano Lett., ACS Nano, Nat. Phys., Adv. Mat., APL 等国际学术期刊发表论文20余篇。2017年7月通过中科院物理所百人计划人才引进，加盟超导实验室。

主要代表性工作包括：

1.首次系统阐述了层状材料的层间相互作用以及与其他固体表面的范德瓦尔斯力相互作用机理，发展了一套简单高效的机械解理方法，并成功解理出高质量大面积的石墨烯和铋锶钙铜氧单层超导材料。

2.首次澄清了黑磷材料在空气中退化的机理，系统深入的研究了黑磷与水及氧气的相互作用。

3.首次成功解理出单层的SnS2并研究了该材料的能带结构随层数的变化关系

4.发展了一种新的门电场调控方法，该方法可以有效的调控材料的电子结构，开关比等多种性质。

博士后 Post Doctors

序号	姓名	合作导师	进/出站时间	研究方向	获博士学位时间、机构
1	周花雪	董晓莉	2017-2019	水热合成FeSe基超导晶体及相关物理问题研究	2017.06 重庆大学
2	侯兴元	单磊	2017-2019	新型量子材料的隧道谱研究	2017.06 中科院物理所
3	麻朝阳	陈根富	2017-2019	新型量子功能材料的探索和物理性质的研究	2017.06 中国人民大学

毕业生 Alumni

序号	学生类型	学生姓名	导师姓名	在读时间	论文题目	毕业后去向
1	硕博连读	于和善	金魁	2012.9-2017.6	电子型铜氧化物La2-xCexCuO4+δ超导薄膜的高维电输运相图	马里兰大学博后
2	工程硕士	张旭	金魁	2014.9 - 2017.6	La2-xCexCuO4+δ热输运特性研究与测量杆设计	留组读博
3	博士	张春旭	邱祥冈	2014.9-2017.6	掺钴CaFeO3体系的红外光谱学研究	不详

序号	学生类型	学生姓名	导师姓名	在读时间	论文题目	毕业后去向
4	工程硕士	裴子玺	邱祥冈	2014.9-2017.6	二维周期结构薄膜超导转变区输运性质的研究	留组读博
5	硕博连读	周亚洲	赵忠贤/孙力玲	2012.9-2017.6	高压下新型铁基超导体及稀土六硼化合物的物性研究	美国路易斯安娜州立大学博士后
6	硕博连读	张珊	赵忠贤/孙力玲	2012.9-2017.6	拓扑半金属与关联金属磷族化合物超导电性的高压探索	清华大学博士后
7	博士	黄克强	郑东宁	2014.9-2017.6	用于超导量子计算的参量放大器 及量子芯片的制备和研究	日本东京理科大学
8	硕博连读	王晨露	刘国东	2011.9-2017.7	新型量子材料WTe2及石墨插层超导体的角分辨光电子能谱研究	曙光信息产业（北京）有限公司
9	硕博连读	孙璇	周兴江	2012.9-2017.11	角分辨光电子能谱对两种铜氧化物超导体的研究	国家电投集团中央研究院
10	硕博连读	沈兵	周兴江	2011.9-2017.7	铁基超导体和重费米子材料的角分辨光电子能谱研究	海尔家电产业集团开放创新中心
11	硕博连读	张艳	刘国东	2011.09-2017.06	量子拓扑材料ZrTe5和HfTe5的角分辨光电子能谱研究	上海华力微电子

序号	学生类型	学生姓名	导师姓名	在读时间	论文题目	毕业后去向
12	硕博连读	龚冬良	李世亮	2012.9-2017.11	电子型掺杂122体系铁基超导体的物性研究	待定
13	博士	郭琦	任治安	2013-2016	类122型层状过渡金属化合物的超导探索	工作
14	硕博连读	陈东云	任治安	2011-2016	三元Ca-Fe-As体系等层状化合物的超导探索 单晶生长与物性研究	博后
15	博士	王小川	任治安	2014-2017	类Fe2As2 结构层状化合物的超导探索与研究	工作
16	博士	于佳	任治安	2013-2017	新型Eu112铁基体系及相关结构超导探索	待定
17	博士	侯兴元	单磊	2010-2017	过渡金属氧硫族元素的扫描隧道谱研究	博后
18	博士	赵凌霄	陈根富	2014-2017	拓扑材料单晶生长和磁电输运性质的研究	博后

在读研究生情况 Graduate Students

序号	姓名	导师	入学日期
1	何 格	金魁	2013.09
2	冯中沛	金魁	2013.09
3	胡 卫	金魁	2013.09
4	张 旭	金魁	2014.09
5	贾艳丽	金魁	2015.09
6	魏鑫健	金魁	2015.09
7	杨 桦	金魁	2015.09
8	秦明阳	金魁	2016.09
9	魏忠旭	金魁	2016.09
10	江星宇	金魁 朱北沂	2017.09
11	王 凯	邱祥冈	2014.09
12	杨 润	邱祥冈	2012.09
13	邱子阳	邱祥冈	2014.09
14	随强涛	邱祥冈	2014.09
15	裴子玺	邱祥冈	2014.09
16	郭伟贵	邱祥冈	2014.09
17	胡志伟	邱祥冈	2017.09
18	廖知裕	邱祥冈	2017.09
19	李晓川	董成	2014.09
20	周孟虎	董成	2014.09
21	刘 玙	董成	2014.09
22	黄裕龙	赵忠贤 董晓莉	2013.09
23	毛义元	赵忠贤 董晓莉	2013.09
24	岳绍圣	赵忠贤 董晓莉	2017.09
25	林泽丰	董晓莉 金魁	2016.09
26	田金朋	董晓莉	2016.09
27	李 栋	董晓莉 金魁	2017.09
28	沈沛沛	董晓莉	2017.09
29	周 辉	董晓莉	2017.09
30	王 哲	孙力玲	2013.09
31	王红红	孙力玲	2013.09
32	蔡 树	孙力玲	2014.09
33	盛玉韬	孙力玲	2016.09
34	林恭长	孙力玲	2016.09
35	黄 程	孙力玲	2017.09
36	岳 敏	孙力玲	2017.09
37	倪顺利	周放	2014.09
38	刘少博	周放	2015.09
39	郭学仪	郑东宁	2014.09
40	李贺康	郑东宁	2012.09
41	Mudassar Nazir	郑东宁	2014.09
42	宋鹏涛	郑东宁	2016.09
43	苏鹭红	郑东宁	2016.09
44	王 战	郑东宁	2016.09
45	黄海波	孙 亮	2013.09
46	代金豪	孙 亮	2017.09
47	胡 成	周兴江	2011.09
48	胡 勇	周兴江	2012.09
49	黄建伟	周兴江	2012.09
50	丁 颖	周兴江	2012.09
51	刘 静	周兴江	2013.09
52	吕守鹏	周兴江	2013.09
53	徐 煜	周兴江	2013.09
54	艾 平	周兴江	2014.09
55	李 聪	周兴江	2014.09
56	戎洪涛	周兴江	2015.09
57	贾俊杰	周兴江	2017.09
58	罗海兰	周兴江	2017.09
59	罗翔宇	周兴江	2017.09
60	赵文娟	刘国东	2012.09
61	高 强	刘国东	2014.09
62	王 阳	刘国东	2014.09
63	蔡永青	刘国东	2015.09
64	宋春尧	刘国东	2016.09
65	闫宏涛	刘国东	2016.09
66	吴定松	刘国东	2016.09
67	刘曌玉	李世亮	2012.09
68	张汶良	李世亮	2012.09
69	谷延红	李世亮	2013.09
70	魏 源	李世亮	2013.09
71	谢 涛	李世亮	2013.09
72	洪文山	李世亮	2016.09
73	王兴玉	李世亮	2017.09
74	刘 畅	李世亮	2017.09
75	刘 迪	李世亮	2017.09
76	罗 军	郑国庆	2014.09
77	王春光	郑国庆	2014.09
78	马 倩	郑国庆	2015.09
79	汪 雯	郑国庆	2017.09
80	梁 慧	陈根富	2013.09
81	杨占海	陈根富 薛面起	2013.09
82	李 婧	陈根富	2014.09
83	朱文亮	陈根富	2014.09
84	高默然	陈根富	2014.09
85	王欣敏	陈根富	2014.09
86	黄奕飞	陈根富	2017.09
87	董庆新	陈根富	2017.09
88	张 凡	陈根富 单磊	2017.09
89	于 佳	任治安	2013.09
90	阮彬彬	任治安	2011.09
91	穆青隔	任治安	2012.09
92	潘伯津	任治安	2013.09
93	刘 通	任治安	2014.09
94	赵 康	任治安	2015.09
95	毛慧灿	单磊 李世亮	2013.09
96	张孟迪	单磊	2017.09
97	谷亚东	单磊	2015.09
98	王 宗	单磊	2015.09

联合培养学生情况

序号	姓名	导师	所属单位
1	刘彦军	郑东宁	湖南师范大学
2	牟 超	周兴江	河北师范大学
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实验室设备

序号	仪器名称	简介
1	脉冲激光沉积系统Pulsed Laser Deposition	生长沉积氧化物薄膜，温度可以达到800℃，背景真空3*10^-8Torr。 To grow oxide films.Temperature can be 800℃. Base pressure:3*10^-8Torr.
2	激光分子束外延组合薄膜沉积系统Combi-Laser MBE System	用于生长组合薄膜，主腔体背景真空可以达到1*10^-10Torr；主腔体能够同时装六个靶材；采用激光加热与红外测温，生长温度可以达到1000℃；具有高压RHEED，可以在20~30Pa的氧压下进行工作； Focus on growing combinatorial films. The basal pressure can reach 1*10^-10 Torr; we can put six targets in the chamber at the same time; The substrate is heated by the laser, and the temperature can be up to 1000℃; A high pressure RHEED is also equiped and it can work well at 20 ~ 30Pa.
3	五温区管式炉Multiple temperature zone tube furnace	可以在同一个气氛不同温区下同时生长样品，提高样品生长效率。功率：7.5KW；最高工作温度：1200℃。石英管尺寸（直径*长度）60*1650mm To grow samples under the same atmosphere at different temperature zones simultaneously. Power: 7.5KW, the highest working temperature: 1200℃, the size of quartz tube (diameter*length): 60*1650mm
4	STX-1202型金刚石线切割机STX-1202 Diamond Wire Raw	主要用途、功能：切割晶体材料。技术参数：(1) 切割丝直径<0.45mm (2) Z,Y轴进给精度0.01mm (3) 水平工作平台转角分辨率 0.01° (4) 切割最大工件尺寸 300mm*300mm Main application and function: Cutting crystal materials Technical parameters: (1) Cutting wire diameter <0.45mm (2) Z, Y axis precision 0.01mm (3) Work platform rotation resolution 0.01° (4) Maximum dimensions of workpiece 300mm*300mm
5	马弗炉muffle furnace	主要用途、功能：用于靶材的烧制。技术参数：（1）工作温度 <1200℃ （2）升温速率1~15℃/min （3）控温精度±1℃ Main application and function: prepare targets. Technical parameters: (1) Temperature range <1200℃ (2) Heating rate: 1~15℃/min (3) Temperature controlling precision ±1℃
6	低温强磁场综合物性测量系统（PPMS）	测量低温强磁场下的电输运（R-T、I-V）和磁性（磁扭矩）。最大磁场：7T，温度范围：2-300K Measuring the electric characteristics and magnetic properties under low temperautre and high magnetic field.
7	傅里叶变换远红外光谱仪FTIR spectrometer	凝聚态材料的远红外反射谱测量 温度范围：5-300K，光谱范围：10-12000波数 measuring the reflectivity of condensed matter. Temperature range: 5-300K; Spectrum range: 10-12000cm-1
8	高压低温联合测试系统Integrated system with HP/LT/MF	探索新性超导体及相关机理的研究。P=100GPa， T=4K， H=9T。 Exploring for new superconductors and related mechanisms, P=100GPa， T=4K，H=9T.
9	高压旋转磁场测量系统Integrated system with rotating magnetic fields	探索新性超导体及相关机理的研究。P=100GPa， T=4K， Hc=8T， Ha=Hb=2T。 Exploring for new superconductors and related mechanisms, P=100GPa， T=4K，Hc=8T， Ha=Hb=2T.
10	高温高压材料合成装置Two-stage high pressure and high temperature press	新材料合成，P=20GPa，T=2000K New material synthesis, P=20 Gpa, T=2000K
11	MPMS-XL1	用于材料的磁性质包括超导材料的Meissner效应测量; 温度:1.8-300K; 磁场: 0-1Tesla; 压力: 0-1 GPa; 磁场均匀性(ULF功能): <4mOe Magnetic property measurement system; Temperature range: 1.8-300K; Magnetic Field: 0-1 Tesla; Pressure: 0-1GPa; Field uniformity: <4mOe within 4cm scan
12	PPMS-9	多功能物理性质测量(电阻\磁性质\热电势等); 磁场: 0-9Tesla; 压力: 0-2 GPa; Multiple physical property measurement system(Resistance/VSM/thermal power); Magnetic Field: 0-1 Tesla; Pressure: 0-1GPa; Field uniformity: <4mOe within 4cm scan
13	红外浮区单晶生长炉Infrared heating floating-zone furnace	用于生长各类可被红外辐射加热的功能材料晶体；尤其适用于非同成分熔材料。 Crystal growth of various functional materials which can be heated by infrared radiation; especially useful for incongruently melting materials.

序号	仪器名称	简介
14	超高真空磁控溅射设备UHV magnetron sputtering system	用于溅射Nb、Al单质及相应氮化物的单层或多层膜，衬底可加热，可通氮气进行反应溅射。所制备薄膜用于研究超导纳米线单光子探测器及微波谐振腔等。极限真空好于1E-9mbar，双直流或射频磁控溅射靶，样品台可加热至400摄氏度。 used for sputtering of Nb, Al elemental or nitride single/multi layer thin films. Substrates can be heated during sputtering, reactive sputtering is available under Ar/N2 mixed atmosphere. Films deposited were mainly supplied for research about superconducting nanowire single photon detectors, microwave co-planar transmission line resonators, and so on. base vacuum better than 1E-9mbarr, double DC or RF magnetron sputtering source, substrate holders capable of heat up to 400 centi degrees.
15	超低磁场核磁共振及成像系统Ultra-low field nuclear magnetic resonance/ magnetic resonance imaging system	用于研究□T量级磁场下的核磁共振及成像技术，可进行低场下的FID、自旋回波及J-耦合谱测量。可进行直接背投影和滤波背投影成像及磁性纳米粒子T1加权成像。 测量磁场67□T，极化磁场约34mT，单发测量的核磁共振谱信噪比约12/ml水。二维背投影成像分辨率~1mm。 Development of a new generation NMR/MRI system under ultra-low field in □T range.FID, Spin-echo and J-coupling spectrum can be obtained with high SNR. 2D imaging reconstructed by direct back projection or filtered back projection. Furthermore, T1 weighted images using magnetic nano particles as contrast agent can also be obtained. Measurement field ~67□T, pre-polarization field ~34mT, signal to noise ratio of single shot FID spectrum measurements ~12/ml water. Spatial resolution of filtered back projection imaging was about 1mm.
16	超高真空电子束蒸发设备UHV electron beam evaporation system	用于蒸发Al和Au薄膜以及制备超导量子比特器件。 电子束沉积室极限真空为2.0E-6Pa，进样室真空为6E-4Pa。配备Telemark281电子束蒸发源，4坩埚，最大功率8kW，最大输出电压-10kV。配备Model880膜厚测试和控制仪。样品台可绕相互垂直的两轴转动。 Used for deposition of Al and Au films. The system is used for making superconducting qubit samples via double-angle evaporation technique. Deposition chamber background pressure lower than 2.0E-6 Pa,Load- lock chamber background vacuum 6E - 4Pa, Equipped with a 4-pocket Telemark281 electron beam source of 8kW，Model 880 deposition rate control,double-axes rotating sample holder .
17	脉冲激光溅射沉积系统Pulsed Laser Deposition System	用于氧化物功能性薄膜和异质结构的生长及实时监测薄膜生长动力学模式，实现对薄膜厚度的单胞层精度控制。 主沉积室真空好于5.0´10-5 Pa；国产电子枪加速电压最高40 kV，三级差分气路。样品台三维不独立可调。样品台加热温度可达摄氏900度，耐氧。可同时装4个靶。10bit灰度数据采集系统，采集速度高于50Hz。 For the in situ monitoring of the growth process and growth mode of functional oxide thin films and heterostructures, and the realization of unit-cell control of the film thickness. minimum pressure of the system: <5.0´10-5 Pa; electron energy: 1-40 keV; three-stage diffrential pumping of e-gun; heater temperature: up to 900°C in oxygen environment, manipulated with 3 dependent degree of freedom;4 targets at the same time;10 bit grayscale image collection system with sampling frequency 50 Hz.
18	K13-415型配备高气压RHEED的脉冲激光沉积系统K13-415 Pulsed Laser Deposition System with High-Pressure RHEED	用于氧化物功能性薄膜和异质结构的生长及实时监测薄膜生长动力学模式，实现对薄膜厚度的单胞层精度控制。主沉积腔极限真空好于5.0´10-7 Pa，Staib电子枪加速电压30kV，二级差分气路。样品加热台5维自由度彼此独立，计算机控制。样品台加热温度可达摄氏900度，耐氧。可同时装4个靶。12bit灰度数据采集系统，采集速度高于50Hz。 For the in situ monitoring of the growth process and growth mode of functional oxide thin films and heterostructures, and the realization of unit-cell control of the film thickness. background pressure of the deposition chamber: <5.0´10-7 Pa,Maximum electron energy of the RHEED system: 30 keV, two-stage diffrential pumping of e-gun,heater temperature: up to 900 °C in oxygen environment,sample holder manipulated with 5 independent degrees of freedom,fully automated 4 target carousel,12 bit grayscale image collection system with sampling frequency >50 Hz.

序号	仪器名称	简介
19	脉冲激光溅射沉积系统Pulsed Laser Deposition System	可用于制备各种超导和其它氧化物薄膜。主沉积室真空好于5.0x10^{-5} Pa；样品台为硅加热器，加热温度可达摄氏1000度。 For the growth of cuprate and other oxide thin films. backgraound pressure lower than 5.0x10^{-5} Pa, silicon heater temperature over 1000 °C in oxygen environment;
20	BlueFors BF-LD-250无液氦稀释制冷机BlueFors BF-LD-250 Cryogen-free dilution refrigerator	超导量子计算元件和线路的测量，量子力学和量子光学基本问题研究。最低温度小于7mK,100mK制冷功率大于300uW，20mK制冷功率大于13uW。 For measurement of Josephson junction based superconducting quantum circuits, including quantum state manipulation, coupling to cavity or other quantum system, entanglement, readout, and so on. Base temperature less than 7 mK, cooling power: >300 uW @100 mK, >13 uw @20mK.
21	离子束刻蚀系统Ion Beam Etching System	刻蚀各种材料，刻蚀线条：小于0.05um。 Etching various materials by ion beam, Etching line width: less than 0.05um.
22	网络分析仪Network Analyzer	测量微波二端网络参数，频率范围：45MHz~26.5GHz。 Measuring S-parameters for 2-port microwave network, Frequency range: 45MHz~26.5GHz
23	多功能压焊机Multifunctional Ball-Wedge Wire Bonder	电子元器件芯片引线压焊工具，压焊头手控XY范围：15mm×15mm。 Bonding the electric devices and chips, X-Y range by Manipulator: 15mm×15mm
24	真空烘烤除气装置cuum Bake System	在真空条件下加热工件，加热温度：室温—600℃ Heating devices in vaccum, Heating temperature: RT-600℃
25	超导芯片切割机HTS chip dicing machine	超导薄膜芯片切割，切割速度：0.1-400mm/s Dicing HTS thin films, Dicing speed: 0.1-400mm/s

序号	仪器名称	简介
26	真空紫外激光角分辨光电子能谱仪 vacuum ultra violet laser ARPES	对以下材料展开电子结构的测量。(1)对强关联电子体系, 如高温超导材料和其它新型的超导体, 庞磁电阻材料, 重费米子材料等; (2).磁学材料和自旋电子学材料; (3).低维材料和纳米材料等。 (4).狄拉克费米子材料和拓扑绝缘体等。 1. 主腔的真空度好于1X10-10 Torr，实际可达到5X10-11Torr； 2. 真空室中样品位置的剩余磁场远远小于10mGuass，达到0.51mGuass； 3. 电子能量分析器的最佳能量分辨率~1 meV，最佳角度分辨率~0.3度； 4. 样品转角仪所有运动自由度（3平动，3转动）工作正常，采用液氦冷却，样品最低温度低于15K，达到9.2K； 5. 紫外激光光子能量 6.994 eV（波长为177.3 nm），工作功率 ～ 0.5mW，最高达到1.59mW。 Electronic structure measurements on the following materials (1) strongly correlated electron systems, such as high Tc superconductors and other newly discovered superconductors, giant magnetoresistive materials, heavy fermion systems; (2)magnetic materials and spintronic materials; (3)low dimensional systems and nanomaterials; (4) Dirac fermion materials and topological insulators. laser：output wavelength 177.2nm; average power,0.5mW; tuanble linear and elliptical polarization； Spectroscopy:vacuum,5X10-11mbar;residual magnetic,0.51mGuass;6 axis manipulator work well; sample temperature, 9.2K；best energy resolution 1meV, angle resolution 0.3 degree.
27	基于深紫外激光的同时具有自旋分辨和角分辨功能的高分辨光电子能谱仪研制VUV laser-based spin-and angle-resolved photoemission spectrometer	对以下材料展开电子结构的测量。(1)对强关联电子体系, 如高温超导材料和其它新型的超导体, 庞磁电阻材料, 重费米子材料等; (2).磁学材料和自旋电子学材料; (3).低维材料和纳米材料等。 (4).狄拉克费米子材料和拓扑绝缘体。 激光： 输出波长177.2nm，平均功率1.24mW, 脉冲宽度 12.06ps 120.1MHz，偏振状态，线偏振跟椭圆偏振可调。 谱仪：真空度，4.5X10-11mbar; 主腔内剩磁，0.96mGuass;样品转角仪，六个自由度正常，样品最低温度9K。自旋能量分辨率2.5meV Electronic structure measurements on the following materials： (1) strongly correlated electron systems, such as high Tc superconductors and other newly discovered superconductors, giant classical magnetic resistivity materials, heavy fermion materials; (2)magnetic materials and spintronic materials; (3) low dimensional systems and nanomaterials; (4) Dirac fermion materials and topological insulators. laser：output wavelength 177.2nm; average power,1.24mW;pulse width,12.06ps; tuanble linear and elliptical polarization；Spectroscopy:vacuum,4.5X10-11mbar;residual magnetic,0.96mGuass;6 axis manipulator work well; sample temperature, 9K；spin energy resolution 2.5meV
28	基于飞行时间能量分析器的深紫外激光角分辨光电子能谱仪研制 VUV laser-based ARPES using Time-of-the-Flight Electron analyzer	对以下材料展开电子结构的测量。(1)对强关联电子体系, 如高温超导材料和其它新型的超导体, 庞磁电阻材料, 重费米子材料等; (2).磁学材料和自旋电子学材料; (3).低维材料和纳米材料等。 (4).狄拉克费米子材料和拓扑绝缘体。 激光： 输出波长177.2nm，平均功率44.47uw@250.6KHz, 脉冲宽度 8.4ps 重复频率250.6kHz，偏振状态，线偏振跟椭圆偏振可调。 谱仪：真空度，2.5X10-11mbar;主腔内剩磁，0.81mGuass;样品转角仪，六个自由度正常，样品最低温度9.3K。 Electronic structure measurements on the following materials： (1) strongly correlated electron systems, such as high Tc superconductors and other newly discovered superconductors, giant classical magnetic resistivity materials, heavy fermion materials; (2)magnetic materials and spintronic materials; (3) low dimensional systems and nanomaterials; (4) Dirac fermion materials and topological insulators. laser：output wavelength 177.2nm; average power,44.47uw@250.6kHz;pulse width,8.4ps; repeat frequency,250.6kHz; tuanble linear and elliptical polarization；Spectroscopy:vacuum,2.5X10-11mbar;residual magnetic,0.81mGuass;6 axis manipulator work well; sample temperature, 9.3K；
29	光子能量连续可调深紫外激光光电子能谱仪ARPES based on tunable UV laser	对以下材料展开电子结构的测量。(1)对强关联电子体系, 如高温超导材料和其它新型的超导体, 庞磁电阻材料, 重费米子材料等; (2).磁学材料和自旋电子学材料; (3).低维材料和纳米材料等。 (4).狄拉克费米子材料和拓扑绝缘体。 激光： 输出波长175~210nm，平均功率1.16mW@193nm, 脉冲宽度 1.65ps 重复频率80.49MHz，偏振状态，线偏振跟椭圆偏振可调。 谱仪：真空度，7.2X10-11mbar;主腔内剩磁，0.51mGuass;样品转角仪，四个自由度正常，样品最低温度3.58K。 Electronic structure measurements on the following materials： (1) strongly correlated electron systems, such as high Tc superconductors and other newly discovered superconductors, giant classical magnetic resistivity materials, heavy fermion materials; (2)magnetic materials and spintronic materials; (3) low dimensional systems and nanomaterials; (4) Dirac fermion materials and topological insulators. laser：output wavelength 175-210nm; average power,1.16mW@193nm;pulse width,1.65ps; repeat frequency,80.49MHz; tuanble linear and elliptical polarization；Spectroscopy:vacuum,7.2X10-11mbar;residual magnetic,0.51mGuass;4 axis manipulator work well; sample temperature, 3.58K；
30	"翠竹"热中子三轴谱仪 "Bamboo"Thermal Neutron Triple-axis Spectrometer	凝聚态物质的非弹性中子散射研究，主要包括材料中自旋激发和晶格激发等元激发信息。其技术参数：束流强度1*10^8n/cm^2/s,能量范围 7~65 meV，动量范围 <9 A^-1，样品环境：低温4~300K。 Applicable for inelastic neutron scattering research on condensed matter, especially for the spin and lattic excitation in the materials . Flux：1*10^8n/cm^2/s，Energy Transfer Range: 7~65 meV，Momentum Transfer Range: <9 A^-1;Sample Environment: temperature 4~300K.
31	Cyberstar光学浮区单晶炉Cyberstar Optical Floating-zone Furnance	各种氧化物、合金的浮区法单晶生长, 气压0~100bars，温度<2400摄氏度。 Single crystal growth of oxides and alloys, Pressure:0~100bars,Temperature:<2400℃
32	多功能物性测量系统Physical Property Measurement System（PPMS）	多种电学、热学等物性测量，温度1.8 K~400 K，磁场 0~9 T 。 Measurement on resistivity and heat capacity, Temperature 1.8 K~400 K, Magnetic field 0~9 T.
33	核磁共振谱仪和超导磁体NMR spectrometer and supconducting magnet	核磁共振测量，12T，15T NMR measurement, 12T, 15T
34	MPMS 磁性测量系统Magnetic Property Measurement System	高精度的DC磁化强度测量和AC磁化率测量，磁场:±7.0 Tesla 温度区间:1.9K～400K 。 Field:±7.0 Tesla, Temperture Range :1.9K～400K, DC Susceptibility measurement and AC Susceptibility measurement
35	PPMS 综合物性测量系统 Physical Property Measurement System	主要用于电阻、霍尔、DC磁矩、比热、热传导、磁扭矩、转角等的测量。磁场：±9 T,温度：0.5K～800K Field：±9 T, Temperature: 0.5K～800K. For performing Resistance，Hall Effect, magnetic torque，specific heat， thermal transport， magnetic torque， rotater and so on the measurements.

序号	仪器名称	简介
36	R-T电阻测量系统Resistant Measurement System	电阻测量，温度范围:5K～300K。 Temperture range:5K～300K, Resistant measurement.
37	18kW转靶粉末X射线衍射仪 18kW Rotating Anode X-Ray Diffractometer	粉末物相分析，晶粒大小判断，定量分析，晶胞参数精确确定，结晶度分析，Rietveld精修，薄膜物相分析，结晶质量，薄膜外延。 最大输出功率: 18kW，管电压: 20 to 60kV，管电流: 10 to 300mA，测角仪: θ/2θ，测角仪半径: 185mm，探测器: 闪烁计数器，高温附件：R.T-1000ºC，低温附件： 10K-R.T，薄膜附件： φ= 0 ~ 360° Phase identification, Crystallite size, Quantitative analysis, Precise lattice parameter determination, Percent crystallinity, Rietveld refinement, Film composition, Crystalline perfection, Epitaxial relationship between substrate and thin film. Maximum rated output: 18kW, Rated tube voltage: 20 to 60kV, Rated tube current: 10 to 300mA, Goniometer: θ/2θ, Goniometer radius: 185mm, Sample stage: The φ axis of film measurement attachment：0～360°, Detector: Scintillation counter, High temperature attachment: R.T-1000ºC, Low temperature attachment: 10K-R.T, Thin-film attachment: φ= 0 ~ 360°).
38	UltimaIV 3kW X射线衍射仪UltimaIV 3kW X-Ray Diffrctomete	1.粉末衍射分析：粉末物相分析，晶粒大小判断，定量分析，晶胞参数精确确定，结晶度分析，Rietveld精修； 2.薄膜分析：组成，薄膜厚度，界面粗糙度，薄膜密度 最大输出功率：3kW，管电压：20-60kV，管电压：2-60mA 测角仪：θ/θ，测角仪半径：285mm，样品台：Z：-4～+1mm，χ：-5～+95°，φ：0～360° 探测器：闪烁计数器，D/teX Ultra一维高速探测器。 附件：微区微量测量附件，点光源为ϕ0.4mm。 1. Powder dirraction: Phase identification, Crystallite size, Quantitative analysis, Precise lattice parameter determination, Percent crystallinity, Rietveld refinement; 2. Thin film analysis:Composition, Thickness, Interface roughness, Density; Maximum rated output: 3kW, Rated tube voltage: 20 to 60kV, Rated tube current: 2 to 60mA, Goniometer: θ/θ, Goniometer radius: 285mm, Sample stage: Z：-4～+1mm, χ：-5～+95°,φ：0～360° Detector: Scintillation counter, D/teX Ultra high-speed one-dimensional detector Attachment: Micro-area measurement attachment, ϕ0.4mm point-focus mode

序号	仪器名称	简介
39	SmartLab（9kW）高分辨X射线衍射仪SmartLab (9kW) X-Ray High-Resolution Diffraction System	1.粉末衍射分析：粉末物相分析，晶粒大小判断，定量分析，晶胞参数精确确定，结晶度分析；Rietveld精修 2.薄膜分析：物相分析，薄膜厚度，织构，界面粗糙度，结晶质量，薄膜密度，应力。 最大输出功率：9kW， 管电压：20～45kV，管电压：10～200mA，测角仪：θ/θ，测角仪半径：300mm，样品台：Z：-4～+1mmχ：-5～+95°，φ：0～360°，Rx，Ry：-5～5° 入射光：CBO光路，Ge(220)、Ge(400) 接受光：PSA， Ge(220) 探测器：闪烁计数器，PILATUS 100K二维探测器 1. Powder dirraction: Phase identification, Crystallite size, Quantitative analysis, Precise lattice parameter determination, Percent crystallinity, Rietveld refinement 2. Thin film analysis:Composition, Thickness, Orientation, Interface roughness, Perfection, Density, Strain/stress; Maximum rated output: 9kW, Rated tube voltage: 20 to 45kV Rated tube current: 10 to 200mA, Goniometer: θ/θ, Goniometer radius: 300mm, Sample stage: Z：-4～+1mm, χ：-5～+95°, φ：0～360°, Rx，Ry：-5～5° Incident side: CBO, Ge 2-bounce and 4-bounce monochromators Recieving side: PSA, Ge 2-bounce Detector: Scintillation counter, Pilatus 100K two-demension counter
40	STX-1202全自动金刚石线切割机 STX - 1202 fully automatic diamond wire cutting machine	切割线运丝速度：0-5m/s可调，数显；切割线总长：≤150m；切割线直径：≤0.45mm；Y轴行程：≤300mm，数显；Z轴行程：≤300mm，数显；Y、Z 轴进给示值精度：0.01mm；工作台转角：0-360˚，分辨率0.01˚，数显；用于切割不同硬度的材料，如晶体、陶瓷、玻璃、蜂窝陶瓷等； Cutting speed: 0-5 m/s,adjustable & digital display; Total cutting length: 150 m or less; Cutting wire diameter: 0.45 mm or less; Y axis stroke: 300 mm or less, digital display; Z axis stroke: 300 mm or less, digital display; Y and Z feeding precision: 0.01 mm; Workbench Angle: 0-360°with resolution 0.01°, digital display; Used for cutting different materials of varied hardness, such as crystal, ceramic, glass, ceramic honeycomb, etc;
41	BV-HTRV 70-250/18布里奇曼炉 Bridgman furnace	主要功能：利用布里奇曼坩埚下沉法生长单晶；技术指标：惰性气体保护下最高温度1800°C，可抽粗真空，最高温度1450°C，最大加热区间250mm。 The BV-HTRV is as a special crystal growing furnace according to the Bridgman method. The melted material moves through a decreasing temperature gradient and forms a single crystal. Technical specifications: with 250 mm heated length up to 1800°C in an inert gas or 1450°C in vacuum; equipped with a pre-vacuum pump.
42	lkj-1c等离子刻蚀机Lkj-1c Ar ion plasma etching machine	国产老设备，经过升级改造。用于紫外曝光之后氩离子刻蚀。 Updated domestic made old equipment.Used for argon ion etching after UV lithography.

序号	仪器名称	简介
43	MDA-400M光刻机 MDA-400M Mask Aligner & Exposure System	韩国MIDAS公司产品。系统控制：全手动（掩膜板对准）；掩膜版尺寸：最大5" x 5"；基片尺寸：最大直径4英寸；光源功率：350W紫外灯；最大光束：4.25" x 4.25"；光束均匀性：<±3%；光束波长： 350 ~ 450nm；365nm光束强度：15~20mW/cm2；对准精度：1um；光刻分辨率：1um（1um厚光刻胶，真空吸附式接触方式）；光刻模式：真空,硬接触, 软接触，渐进（Proximity）；真空卡盘移动：X, Y: 10 mm, Theta: ±5°。 Krean MIDAS system. Type: Fully manual (Mask Aligner); Mask size：up to 5" x 5"; Substrate size: piece to 4" dia;UV lamp & Power: 350W & power supply;Uniform beam size:4.25" x 4.25";Beam Uniformity:<±3%;Beam wavelength: 350 ~ 450nm;365nm Intensity: ~30mW/cm2;Alignmentaccuracy:1um;Process resolution:1um@1um PR thickness with vacuum contact;Process mode:Soft, Hard, Vacuum contact & Proximity;Substrate chuck moving:x,y,z & θ.
44	PSL劳厄衍射仪PSL X-ray Laue systems	使用X射线源发出的X射线照射单晶样品，观测到衍射现象，通过对这些衍射点的分析，可测定晶体取向。相机成相传感器可输入区域大小：143,52 × 96,04 mm；相机曝光时间：1毫秒-20分钟；相机可用增益范围：10:1；X射线源光斑大小：0.7 mm；X射线源最小通量：钼靶108光子，钨靶3×108光子；三轴测角仪参数：Rx/Ry旋转范围±28°，误差0.001°；360°旋转基底误差0.001°；X/Y方向位移范围±10 mm，Z方向位移范围5 mm。 Irradiate single crystal samples with X ray to observe the diffraction points, through which the crystal strucutre and orientation can be determined.CCD size: 143.52×96.04 mm; Exposure time: 1 ms - 20 minutes; Gain range: 10:1; X-ray spot size: 0.7 mm; X-ray source minimum flux: molybdenum target 108 photons, tungsten target 3× 108 photons; Three axis goniometer parameters: Rx/Ry rotation range ±28°with 0.001 °error; 360 ° basement rotation error 0.001 °; X/Y direction displacement range ±10 mm, Z direction 5 mm.

2017年新增设备介绍：

1.

组合外延薄膜制备与真空转移系统

Combined epitaxial thin film fabricating and vacuum transfer system

升级组合外延薄膜制备系统；拓展样品超高真空转移功能，将高质量梯度组分样品无误转移到相关尖端测试设备，实现电子态和电子结构的连续表征。背景真空1*10^-8Torr。

Upgrading the combinatorial epitaxial thin films fabricating system. It can transfer the gradient-component samples with high quality to the relevant advanced test equipment and realize the continuous characterization of electronic states and structures.Background pressure:1*10^-8Torr.

2.

双室磁控溅射沉积系统

Double room magnetron sputtering deposition system

生长金属和其他材料的薄膜 极限真空<1.3*10^-6Pa

Growing metal or other kinds of films Ultimate vacuum<1.3*10^-6Pa

3.

日立SU5000热场发射扫描电子显微镜

Schottky Field Emission Scanning Electron Microscope SU5000

电子枪：ZrO/W肖特基式；加速电压：0.5~30 kV；着陆电压：（减速模式）0.1~2.0 kV；最大束流：>200 nA。配高分辨率顶位二次电子探测器，背散射电子衍射探测器（EBSD），iXRF能谱仪。

Electron gun: ZrO/W schottky type; Accelerating voltage: 0.5 ~ 30 kV. Landing voltage: (deceleration mode) 0.1 ~ 2.0 kV; Maximum beam intensity: > 200 nA. With a high resolution top secondary electron detector, an electron back scattering diffraction detector (EBSD) , and an iXRF spectrometer.

荣誉和奖励

职工获奖情况

职工获奖情况

姓名	所获荣誉
周兴江	“万人计划”科技创新领军人才

研究生获奖情况

1. 中科院院长奖学金优秀奖

张汶良（导师：李世亮）

2. 中国科学院大学2016——2017学年优秀学生

优秀毕业生： 张艳
三好学生标兵： 刘曌玉
三好学生： 张汶良、胡勇、龚冬良、王晨露、周亚洲、何格、黄裕龙、杨润、于和善、黄克强、王红红、阮彬彬、王哲、贾艳丽

3. 国家奖学金

张汶良、刘曌玉

4. 中国科学院物理研究所所长奖学金优秀奖

谷延红、何格、黄裕龙、杨润、冯中沛、胡勇

8. 中国科学院物理研究所所长奖学金表彰奖

王红红、穆青隔、谢涛、刘曌玉、吕守鹏、张汶良、李婧、李贺康、李聪、周孟虎、王哲、贾艳丽、梁慧、刘通、毛义元、黄建伟、艾平、毛慧灿、倪顺利、刘玙、杨占海、彭健、刘静、黄海波、魏源、高强、蔡树、胡成、赵文娟、王阳、魏鑫健、李晓川、郭学仪、王春光、胡卫、张旭、罗军

相关报道

研究简报

研究简报一：

硅烯中新型狄拉克锥的直接实验观测和起源

硅烯是指单层硅原子构成的二维单晶结构。由于它具有和石墨烯类似的蜂窝状晶体构型，因此理论预言它将具有和石墨烯类似的电子结构，即在布里渊区的顶角(K点)存在狄拉克锥。在石墨烯中，狄拉克点附近的准粒子近似为无质量的狄拉克费米子，从而导致众多有趣的物理现象及高的电子迁移率。硅烯除了具有石墨烯所具有的类似物理性质外，预计还将表现出一些独特的性质。由于硅原子比碳原子重，硅烯中的自旋轨道耦合作用增强导致狄拉克点处具有较大的能隙，从而有可能在实验能达到的温度范围内实现量子自旋霍尔效应。此外，由于硅烯的所有硅原子不完全处在同一个平面内，利用电场有可能调节其狄拉克点处能隙的大小，从而实现多种拓扑相的转换。尤其是硅烯与传统硅工业的兼容性，使得其在将来纳米电子学中有可能具有更广阔的应用前景。

近年来，人们在不同的衬底上已经成功地合成了硅烯，其中大多数硅烯的实验主要集中在Ag（111）衬底上。根据制备条件的不同，硅烯在Ag（111）衬底上可以形成多种结构，包括相对于硅烯1x1周期的3x3和 (√3x√3)R30o等重构。由于到目前为止，硅烯必须依附在衬底上存在，这种情况下，硅烯体系中是否仍存在着狄拉克费米子存在着激烈的争论。已有的实验提供相互矛盾的结果，理论则预言硅烯与Ag（111）之间的相互作用有可能会破坏狄拉克锥的存在。这个问题的定论，离不开对硅烯电子结构的直接观测和系统研究。

中科院物理研究所 / 北京凝聚态物理国家实验室（筹）超导国家重点实验室周兴江研究组的博士生冯娅、刘德发、刘旭、副研究员赵林等与表面物理国家重点实验室吴克辉研究组的博士生冯宝杰等合作，利用高分辨角分辨光电子能谱技术，并与美国东北大学Arun Bansil 等理论研究者合作，系统研究了Ag（111）

衬底上生长的（3X3）硅烯的电子结构，发现了由硅烯与Ag(111)相互作用产生的一种新型狄拉克锥结构，澄清了关于硅烯中狄拉克锥问题的争论。

实验发现，在Ag(111）衬底上生长的高质量（3x3）硅烯表现出一种独特的电子结构：在Ag（111）对应的第一布里渊区六条边上存在六对狄拉克锥，其中每对狄拉克锥中心位于M点（图1）。进一步研究发现，狄拉克锥呈现类似三角形的形状（图2），其能带结构和费米速度表现出明显的各向异性（图3）。由于制备的硅烯在低温下只能观察到下锥的结构，我们采用高温测量和表面蒸钾两种方法来探测上锥的结构（图4）。 通过在样品表面蒸钾进行电子掺杂，硅烯的狄拉克点位置逐渐下移，当蒸钾足够多时，可以清楚地观察到狄拉克上锥的结构（图4H）。

在(3x3)硅烯/Ag(111)中观察到的六对狄拉克锥结构，表现出一些非同寻常的特性。首先，这六对狄拉克锥存在于Ag（111）的布里渊区边界M点附近，这与理论预言的独立硅烯在硅烯对应的布里渊区K点具有六个狄拉克锥显著不同。其次，硅烯（3x3）重构预计应该导致能带折叠，但实验上并没有观测到。 这六对狄拉克锥只出现在Ag（111）布里渊区边界上靠近（3x3）硅烯布里渊区的K点，说明它们既不单独存在于纯的（3x3）硅烯中，也不单独存在于纯Ag（111）中，而是两者相互作用的结果。已有的理论计算还不能解释这种新型狄拉克结构的起源，希望这些实验结果能进一步推进相关理论方面的工作。

这项工作首次在硅烯中通过光电子能谱实验直接观察到一种新型狄拉克锥的存在，这也是第一次发现通过两种材料的相互作用能产生新的狄拉克结构。对硅烯中这种狄拉克锥结构的直接观测，澄清了相关理论和实验上的争论和分歧，为硅烯中新量子现象的发现和应用奠定了基础。

相关研究工作发表在近期的PNAS上［PNAS 113 (51)， 14656-14661 （2016）］。上述科研工作得到国家自然科学基金委、科技部和科学院先导B项目等基金的资助。

相关工作链接：http://www.pnas.org/content/113/51/14656.full.pdf

研究简报二：

ZrTe5中温度诱导Lifshitz转变的发现及其拓扑本质

自上世纪70年代以来，科学家们就发现过渡金属碲化物$ZrTe_5$和$HfTe_5$在电阻-温度曲线上表现出一个宽峰，并且在宽峰温度的上下，霍尔效应和热电势所测得的载流子发生变号。尽管许多研究组对这一奇异的输运性质做了研究，但其起源一直是一个悬而未决的问题。近年来，量子拓扑材料研究的兴起导致发现了一大批包括拓扑绝缘体、狄拉克半金属、外尔半金属等具有特殊电子结构和性质的材料。然而，已证实的二维拓扑绝缘体（量子自旋霍尔绝缘体）极其稀少，基本上还是局限于需要复杂制备工艺的人工材料如HgTe/CdTe和InAs/GaSb量子阱等。 因此，寻找并合成理想的大能隙二维拓扑绝缘体材料对于基础研究和高性能自旋电子学应用尤为重要。最近，理论计算预言，单层的$ZrTe_5$/ $HfTe_5$是大能隙的量子自旋霍尔材料，在体能隙中存在着受拓扑保护的边缘态。块材$ZrTe_5$/ $HfTe_5$可能处于强弱拓扑绝缘体态的边界，随着层间距的减小，$ZrTe_5$/ $HfTe_5$有可能会由弱拓扑绝缘体转变为强拓扑绝缘体，并且温度引起的层间距减小有可能诱导这种拓扑相变。理论预言引发了大量关于$ZrTe_5$的实验研究，但对其拓扑本质仍然众说纷纭，没有定论。高分辨角分辨光电子能谱对$ZrTe_5$电子结构的直接测量，对理解其奇特输运性质以及拓扑性质具有重要意义。

中国科学院物理研究所/北京凝聚态物理国家实验室（筹）周兴江研究组，与理化技术研究所陈创天院士研究组及许祖彦院士研究组合作，在2013年研制成功了国际首台基于真空紫外激光和飞行时间电子能量分析器的高分辨激光角分辨光电子能谱系统。该系统具有同时探测二维动量空间电子结构信息、高能量动量分辨、体效应增强和低非线性效应等优点 (图1)。

该研究组的刘国东研究员及他的博士生张艳、王晨露、俞理副研究员、以及周兴江研究员的博士生梁爱基、黄建伟等人，利用以上基于飞行时间电子能量分析器的高分辨激光角分辨光电子能谱技术，通过与方忠、戴希小组博士生聂思敏和翁红明研究员进行理论合作，与陈根富研究员及其博士生赵凌霄进行样品合作，系统地研究了$ZrTe_5$的完整电子结构及其随温度的演化情况。

实验获得了高质量的$ZrTe_5$的费米面结构和能带结构（图2），发现$ZrTe_5$具有很大的费米速度（2 - 4 eVÅ），并且表现出明显的各向异性。 首次同时观察到导带和价带的能带结构，并研究了其随温度的演变（图3）。在高温下费米能穿越价带，形成空穴型费米面；随着温度的降低，能带向高结合能方向移动，到135K时，费米能正好处于导带和价带的中央；温度继续降低，费米能则穿越导带，变为电子型费米面。这些结果表明在$ZrTe_5$中存在温度诱导的Lifshitz转变（图4）。而且该Lifshitz转变与$ZrTe_5$的输运性质直接对应，自然地解释了$ZrTe_5$中出现的电阻宽峰以及载流子类型在电阻峰值温度上下的转变。

此外，实验发现价带与导带之间存在能隙。随着温度的降低，能隙在不断减小，到测量的最低温度仍然没有关闭（图3）。在表面有许多一维裂纹的样品中，观测到了准一维的能带结构和费米面，极有可能对应于理论预言的单层$ZrTe_5$中受拓扑保护的边缘态（图5）。 这些结果表明，随着温度降低层间距减小，$ZrTe_5$有从弱拓扑绝缘体向强拓扑绝缘体转变的趋势。但是即使在最低温2K下，导带与价带之间的带隙仍然存在，而且带隙中没有观测到对应强拓扑绝缘体表面态的狄拉克线性色散能带，说明$ZrTe_5$依然处于弱拓扑绝缘体状态。

这项工作首次观测到了$ZrTe_5$中存在的温度诱导Lifshitz转变，解决了长久以来一直处于争论状态的反常输运行为的起源。首次给出了二维$ZrTe_5$边缘态的角分辨光电子能谱证据，澄清了块材$ZrTe_5$的拓扑本质。本工作为推动量子自旋霍尔效应的进一步研究和实际应用，以及对拓扑相变的相关研究，提供了重要的信息。

这一研究成果发表在近期的Nature Communications上 [Nat. Commun. 8, 15512 (2017)]。相关工作得到国家自然科学基金委（11574367），科技部（2013CB921700,2013CB921904，2015CB921300）和科学院先导B（XDB07020300）项目等基金的资助。

相关工作链接：https://www.nature.com/articles/ncomms15512

研究简报三：

在新型自旋液体材料Cu3Zn(OH)6FBr中首次观测到有能隙的自旋子

量子自旋液体是凝聚态物理学家追寻已久的新奇物质形态。它由诺贝尔奖得主P. W. Anderson在70年代首次提出，80年代末被用来尝试解释当时刚发现的高温超导现象。传统的物质形态可以用能带理论和对称性自发破缺理论来描述，而自旋液体做为没有对称性破缺的量子物质形态需要用新的理论框架来描述。这个新框架下的重要概念是拓扑序，它是讨论诸如分数量子霍尔效应以及量子自旋液体的语言。不同的拓扑序体现了自旋液体这类量子多体系统中不同程度的量子纠缠，系统也因此遵从既不同于玻色-爱因斯坦也不同于费米狄拉克形式的分数统计。通过引入载流子，自旋液体材料有可能形成新的非传统超导体。由于拓扑序的稳定性和纠缠性，自旋液体材料还有望成为实现拓扑量子计算的材料基础。

具有 Kagome（笼目）晶格的阻挫磁体材料，是可能实现量子自旋液体的舞台。目前，$ZnCu_3(OH)_6Cl2$ (Herbertsimithite)是一种被很多人接受的 Kagome 晶格量子自旋液体材料。为了探索更多新型的量子自旋液体，人们不断寻找新的kagome晶格自旋体系化合物。通过第一原理计算，刘峥，邹小龙，梅佳伟和刘锋等人预言了一种新的 Kagome 晶格阻挫磁体材料，$Cu_3Zn(OH)_6FBr$ （Phys. Rev. B 92, 220102 (2015)）。这个材料和herbertsmithite类似，都有二维kagome铜平面。但是，$Cu_3Zn(OH)_6FBr$具有相对简单的晶体结构（比如，herbertsmithite的二维kagome铜平面是ABC叠积，而$Cu_3Zn(OH)_6FBr$却是AA叠积的），给实验测量带来的干扰因素较少。

最近，中国科学院物理研究所/北京凝聚态物理国家实验室（筹）EX01组冯子力研究生、石友国研究员成功合成了$Cu_3Zn(OH)_6FBr$。物理所郑国庆研究组（SC09组）的李政副研究员展开了核磁共振研究。这项工作是一个理论和实验通力合作的典型例子：南方科技大学梅佳伟助理教授，物理所SC08组李世亮研究员；T03组孟子杨副研究员，复旦大学李世燕教授以及清华大学刘峥副研究员参加组成了研究团队。研究团队发现，该材料具有与 Herbertsimithite 相似量级的强反铁磁相互作用（J~17 meV），然而极低温下（50mk）

热力学测量没有观测到任何磁性长程序形成，表明$Cu_3Zn(OH)_6FBr$是Kagome 晶格量子自旋液体的新的代表性系统。通过^{19}F的NMR测量，研究团队确定了有能隙的1/2自旋的自旋子激发。

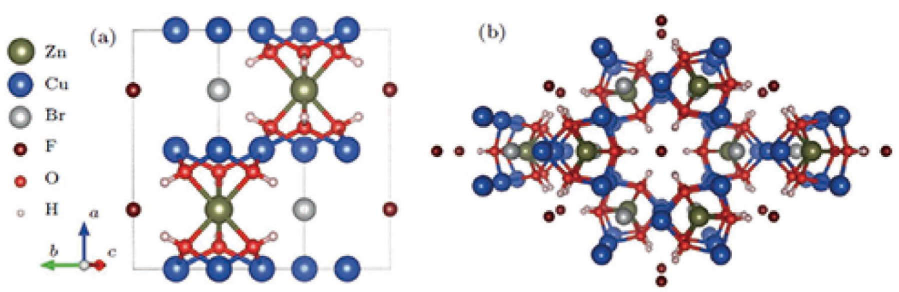

图1：（a）$Cu_3Zn(OH)_6FBr$侧视图，层间的Cu原子被无磁性的Zn原子所替代，隔出层状的Kagome Cu原子二维晶格。（b）$Cu_3Zn(OH)_6FBr$ 俯视图，层状Kagome 晶格清晰可见。在六边形的中心，可以F原子，不同于 Herbertsmithite，在 $Cu_3Zn(OH)_6FBr$中，由于F原子的核磁共振信号灵敏度高，Kagome 面内的自旋能隙可以被探测到。

如图1所示，$Cu_3Zn(OH)_6FBr$为层状的 Kagome 晶格，Kagome 面由自旋1/2 的Cu原子构成，系统可以理解为具有反铁磁相互作用的阻挫Kagome晶格模型。磁化率、比热等热力学测量显示在50 mK时，系统仍然没有磁性（虽然反铁磁相互作用的强度在200 K）。

由于$Cu_3Zn(OH)_6FBr$中的^{19}F原子核具有1/2自旋，如图2所示核磁共振谱只有一个峰。因此信号不会受到电场梯度的影响，能够更本质地反映磁性信息。而以往研究的Herbertsmithite材料中的原子核自旋大于1/2从而受到电场梯度影响，出现多个共振峰，干扰对磁性的研究。因此，虽然在Herbertsmithite材料中观测到了自旋能隙，但无法分辨自旋激发是自旋1/2还是整数自旋。与此相反，$Cu_3Zn(OH)_6FBr$的独特性质为验证自旋激发提供了绝好机会。实验结果显示，在零磁场时，系统具有个～7 K 的自旋能隙；如果把系统放置在磁场中，这个自旋能隙会随着磁场的增大而减小。而能隙随磁场变化的斜率，恰恰反应了系统中磁性元激发的自旋量子数。对于常规的磁性材料，其元激发是自旋为1的磁振子（magnon）。而图2中的数据清晰地显示，在$Cu_3Zn(OH)_6FBr$中，系统的元激发是自旋1/2的，即带有分数化自旋的自旋子（spinon）。

有能隙的量子自旋液体，并且具有1/2自旋的spinon 元激发，是Z2类型（即Toric code） 拓扑序的量子自旋液体的确定性信号。这是在具体材料中观察到 Z2拓扑序量子自旋液体的第一个确定性例子。这项成果一经发表，便受到了国际同行的广泛关注，Herbertsmithite 的合成人，Stanford 大学的 Young Lee 教授反复在各个重要学术会议中介绍（包括2017 Gorden Conference on Topological and Correlated Matter, 2017 KITP Conference on Order, Fluctuations, and Strong Correlations: New Platforms and Developments）。拓扑序理论的创始人麻省理工学院的文小刚教授，也应邀为这项成果专门撰文评价(Chin. Phys. Lett. 34 (9) (2017))。文小刚教授对于这项工作的重要性有如下的描述： Just like the direct discovery of fractional charge, the discovery of a totally new fractionalized neutral spin-1/2 excitation is a very exciting result. （正如在量子分数霍尔效应中直接观测到分数化的电荷，直接观测到电中性且具有分数化自旋1/2的激发，是十分令人振奋的结果）。研究团队对于$Cu_3Zn(OH)_6FBr$的后续实验观测和理论计算，正在逐步深入下去。

这项工作得到了科技部（2016YFA0300502，2016YFA0300503, 2016YF0300300， 2016YFA0300802 & 2015CB921304），国家自然科学基金委（11421092, 11474330, 11574359, 11674406, 11374346 & 11674375），科学院先导B（XDB07020000, XDB07020200 & XDB07020300.）项目等基金的资助。

文章链接： http://cpl.iphy.ac.cn/10.1088/0256-307X/34/7/077502

研究简报四：

具有奇异特性的近藤稀土硼化物SmB6研究进展

SmB_6 是上世纪60年代就开始研究的经典近藤（Kondo）稀土硼化合物，其令人困惑的低温电阻平台一直是强关联物理领域研究的一个重要问题。近年随着奇异的低温量子振荡和与体绝缘态共存的金属表面态在SmB_6中的发现，使其重新成为研究热点。最近，中国科学院物理研究所/北京凝聚态物理国家实验室（筹）超导实验室孙力玲研究员与合作者提出了SmB_6在低温下呈现出的一系列奇异性的低温现象均源自其Sm离子中f电子独特的构型与其所处的具有“负膨胀”特性的B_6框架结构在不同温度下相互作用导致的特殊的价态变化， 使其基态处于一种不稳定的“伴随型”价态涨落，即由f电子构型所决定的磁性Sm离子数量与传导电子的数量在涨落中同时增加或减少，这与常见的其它磁性离子价态变化中的情况完全不同。在稀土六硼化物中，只有SmB_6和YbB_6具有这种特殊的价态涨落形式。这一新观点以“Puzzle maker in SmB_6: accompany type of valence fluctuation state”为题作为Key issue review文章发表在Reports on Progress in Physics (RoPP 80，112501, 2017)上。

上述观点的提出是基于近年来她和博士生周亚洲（与赵忠贤院士联合培养）与物理所杨义峰研究员、 孙培杰研究员等以及人民大学俞榕教授和美国Rice大学斯其苗教授合作，对加州大学Z. Fisk教授组提供的高质量SmB_6和YbB_6单晶样品进行的一系列高压下电阻、磁阻、Hall测量以及高压同步辐射XRD和吸收等多种原位手段的协同研究所取得的实验结果和深入分析。在对SmB_6的极低温高压研究中发现，在4 GPa的压力下SmB_6发生了由常压奇异量子态到具有重费米子行为的量子态转变，澄清了SmB_6在4 GPa压力下其基态是非费米液体还是费米液体的长期争论。此外，还揭示了SmB_6 中奇异拓扑表面态消失的临压力与价态变化的内在关联性，并给出了高压相图中不同的电子态与价态、Hall系数及能隙随压力演化的对应关系。在对SmB_6的姊妹化合物YbB_6研究中，发现了压力诱导的常压半导体相→半金属相→绝缘相的量子相变，并在15 GPa的压力下观察到了与SmB_6类似的低温电阻平台和X射线吸收谱中的Yb离子由2价到3价谱权重的转移，说明高于该压力下YbB_6出现了混合价的特征。由此提出了新的绝缘相可能起源于Yb的d-f杂化，并且很可能是一个类似于SmB_6的拓扑近藤绝缘相。这些结果以Quantum phase transition and destruction of Kondo effect in pressurized SmB_6，Pressure-induced quantum phase transitions in a YbB_6 single crystal和Pressure-induced exotic states in rare earth hexaborides为题目分别发表在【Sci. Bulletin -2017，PRB（R）& Editor suggestion -2015和RoPP -2016】上。

该系列研究得到了科技部（No.2016YFA0300300, No. 2017YFA0302900），基金委（No.91321207, No.11427805, No. U1532267）和中科院B类先导项目（XDB07020300）的资助。在上海光源和北京高能所同步辐射高压站完成了高压XRD和吸收实验。

相关工作链接：
http://iopscience.iop.org/article/10.1088/1361-6633/aa7e3a/pdf
http://iopscience.iop.org/article/10.1088/0034-4885/79/8/084503/pdf
https://journals.aps.org/prb/pdf/10.1103/PhysRevB.92.241118
https://doi.org/10.1016/j.scib.2017.10.008

研究简报五：

铜氧化物高温超导体中发现新颖电荷有序态

电子具有自旋和电荷两个重要的特性。铜氧化物高温超导是通过掺杂破坏自旋有序态（反铁磁有序）而实现的。因此，在过去的30年里，高温超导机制的研究主要集中在对自旋行为的理解，而缺乏对电荷功能的认识。

最近，中国科学院物理研究所/北京凝聚态物理国家实验室（筹）郑国庆研究组（SC09组）的李政副研究员等人利用物理所的15特斯拉强磁场核磁共振装置，通过对高温超导体$Bi_2Sr_{2-x}La_xCuO_6$的研究发现，在超导出现的低掺杂浓度范围内，取代自旋有序态的是长程电荷密度波有序态。在常规的超导体里，超导出现之前的物态是电子之间无相互作用的费米液态。研究团队还发现，电荷密度波有序态的临界温度是自旋有序态临界温度的连续延伸，随着载流子的上升而减小，最后在载流子浓度0.14附近消失。而且，它与高温存在的赝能隙温度成比例关系。这个新发现揭示了电荷在产生超导中的重要作用，为研究高温超导机制提供了崭新的视角。研究团队推测，过去20多年人们注力研究但还没有定论的赝能隙现象就是长程电荷密度波有序态的某种涨落形式。

铜氧化物高温超导体通常在高于液氮温度(77K)的区域内实现超导，相比于液氦温区(4.2K)的传统超导体，其应用范围更广阔，可用来制造输电线、变压器、量子计算、强磁场磁体等。但是，高温超导的机理尚不清楚，从而也阻碍了新材料的研发。在常规的超导体里，超导出现之前的正常态（费米液态）得到了充分的理解。而高温超导体的正常态却不正常。谜团之一是超导相之上的物态存在赝能隙，即在很高的温度一大部分的态密度就已经消失了。赝能隙最早在核磁共振实验中被发现，随后在其它实验中也观察到这种能隙。人们普遍认为，对赝能隙的理解直接关系到高温超导机理的解决。

这项成果近日在Nature Communications上公布出版了（Nature Communications 8, 1267 (2017); DOI: 10.1038/s41467-017-01465-9）。它是通过与日本冈山大学Kawasaki博士以及德国马普研究所的林成天材料组长等人合作而取得的。李政和Kawasaki共同第一作者。这项工作得到了科技部（No.2016YFA0300502 and No. 2015CB921304）以及自然科学研究基金（No. 11634015）的支持。

文章链接：http://www.nature.com/articles/s41467-017-01465-9

研究简报六：

铁基超导体的统一相图

自2008年被发现以来，已有至少20种不同结构铁砷化物或铁硒化物被证实存在超导电性，它们统称为铁基超导体。由于铁基超导体同样可以突破BCS强耦合理论预言的40 K的麦克米兰极限，它和铜氧化物超导体一起被列入高温超导家族，其超导微观机理问题至今仍然是凝聚态物理前沿领域皇冠上的明珠。

经过多年的研究，人们普遍认为铜氧化物高温超导电性均可视作对反铁磁莫特绝缘体的母体进行掺杂而获得，从而存在一个统一描述的相图。对于铁基超导体而言，其所谓“母体”也具有反铁磁性，但却表现出金属导电性(具有一定浓度的载流子)，通过对母体掺杂电子、空穴甚至同价掺杂都可以诱导出超导电性。更令人难以理解的是，相当一部分未掺杂的铁基超导“母体”本身甚至具有超导电性，进一步掺杂反而可能抑制超导。不同体系的铁基超导体，具有千奇百怪的电子态相图，单纯用掺杂浓度作为变量，已经不足以准确描述其物理行为。因此，寻找描述铁基超导体物理性质的统一变量，以及严格物理意义上的母体，成为铁基超导机理研究的重点之一。

最近，中国科学院物理研究所 / 北京凝聚态物理国家实验室(筹)SC8研究组通过测量单轴压力下的电阻行为，对大量铁基样品母体和掺杂样品的向列相涨落性质进行了详细研究，发现反铁磁有序磁矩反比于向列居里常数。这暗示铁基超导体的磁基态可以通过调节向列涨落的强度获得。由此可以建立一个统一的铁基超导体相图，其中超导诞生于某一假设理想母体，该母体具有很大的有序磁矩及较弱的向列涨落。

仔细观察不同体系铁基超导体掺杂相图，就可以发现其中反铁磁有序、超导电性和电子向列相三者是最为显著的特征 (图1)。其中电子向列相指的是系统中呈现出打破晶格固有的旋转对称性的电子态，在铁基超导体中表现为晶体ab面内二重对称的电子态性质。寻找反铁磁、超导和向列相三者之间的具体关系，是理解铁基超导微观机理的关键。尽管在某些铁基超导体中并不存在反铁磁序，但电子向列相或向列涨落总是存在的。SC8研究组基于他们最近独立设计搭建的一套基于压电陶瓷片的单轴压力电测量装置，实现了对电子向列型涨

落进行非常精密的测量，并首次揭示了向列型量子临界点与铁基超导电性的密切联系(Physical Review Letters 117, 157002 (2016))。通过更加广泛地测量1111、122、 11、111、112等多个铁基超导体的系列样品，他们发现对存在二级结构相变的样品，或最佳掺杂的样品，其向列相磁化率温度依赖行为皆可用居里-外斯定律来描述 (图2)。由此，可以定义一个居里常数A_n，用于描述向列相涨落强度。非常令人惊讶的是，该居里常数绝对值的倒数$|An|^{-1}$，和铁基超导体的静态有效磁矩M，成一个非常简单的线性标度关系，即：向列涨落越强，其反铁磁性就越弱。这是实验上首次将反铁磁有序磁矩大小与另一物理量相联系。当反铁磁和向列相消失时，会形成一个量子临界点，正好对应最佳掺杂超导电性 (图3)。由此，我们可以从物理上定义一个严格意义的铁基超导母体(HPC)，它具有很大的有序磁矩及极弱的向列涨落。通过增强向列涨落，就可以抑制其反铁磁性并最终获得高温超导电性 (图4)。该统一电子态相图的建立，为理解不同铁基超导体系中复杂的掺杂物理行为开启了一个崭新的视角，对铁基超导微观机理研究具有重要启示。需要指出的是，这一相图可能仍然无法解释一些特殊的铁基超导体材料，如LiFeAs、 “1111”体系中第二个超导区域，加压下FeSe相图，以及不超导的Cu、Cr、Mn掺杂体系等。这一工作发表在Physical Review Letters 119, 157001 (2017)。

上述研究工作由SC8研究组李世亮和罗会仟负责，其中向列涨落的测量主要由谷延红博士生完成，SC8组的刘曌玉、谢涛、张汶良、龚冬良、胡定、马肖燕等参与了该工作。在理论方面与中科院物理所的孟子杨和杨义峰等开展了密切合作，中科院物理所的李春红、赵凌霄、陈根富及北京师范大学的林莉芳、徐状、谈国太等提供了部分样品。

该系列研究工作得到了中科院B类先导（XDB070000, XDPB01）、中科院青促会、科技部973项目（2015CB921300）、国家重点研发计划（2017YFA0302903, No. 2016YFA0300502）、国家自然科学基金（11674406, 11374346, 11374011, 11305257, 11674372, 11421092, 11574359, 11522435, 11774401）、国家青年千人计划等项目的支持。

研究简报七：

高熵合金Ta–Nb–Hf–Zr–Ti在超高压力下超导电性稳定性的发现

高熵合金的概念是20世纪90年代基于对大块非晶合金研究的背景下提出的。高熵合金通常由五种以上等原子比或近等原子比的元素组成，并且每种元素在晶格点阵上呈无规则分布构成的具有简单晶体结构的固溶体，其在热力学上表现为混合熵高。高熵合金在多方面表现出优异的性能，如突出的比强度、优异的高温机械性能和低温断裂韧性等，使人们对其应用前景有所期待。近年，在具有体心立方结构的五元高熵合金Ta-Nb-Hf-Zr-Ti中发现了超导电性，而且在电阻-温度曲线上表现出独特的超导转变特性。

最近，中国科学院物理研究所/北京凝聚态物理国家实验室（筹）超导国家重点实验室郭静副研究员、博士生王红红和孙力玲研究员及合作者与普林斯顿大学Cava教授研究组合作，对其提供的高质量高熵合金$(TaNb)_{0.67}(HfZrTi)_{0.33}$样品的超导电性进行了系统的原位超高压研究。发现该合金在压力下具有令人惊奇的稳定零电阻的超导电性：在高达190.6 GPa 的压力范围内能保持其电阻-温度曲线的超导转变陡降和清晰的零电阻行为（见图），而且在如此大的压力范围内其超导转变温度变化很小。在上海光源完成的高压同步辐射XRD实验结果表明在96 GPa的压力下，样品的体积被压缩~28 %，但没有发生结构相变。该项研究结果表明$(TaNb)_{0.67}(HfZrTi)_{0.33}$高熵合金超导体在超高压产生的大变形量下仍能很好的保持其常压相所具有的超导电性。该发现不仅丰富了人们对超导实验现象的了解，也对超导理论方面完整的理解超导机制提供了新的实验依据。此外，还为满足对在超高压等极端条件下服役的超导材料的潜在需求提供了一种候选合金。该项研究结果发表在美国科学院院刊【PNAS 114(2017)13144】上。Nature对该项成果在其 Research Highlight 栏目中以 “Super-squeezing can't crush this superconductor's powers” 为题做了报道。

该项研究得到了科技部（2017YFA0302900，2016YFA0300300，2017YFA0303103）， 基金委（91321207，11427805, U1532267，11604376）和中科院B类先导项目（XDB07020300)的资助。

相关工作链接：

http://www.pnas.org/content/114/50/13144.full.pdf

https://www.nature.com/articles/d41586-017-08237-x

中科院院长白春礼发来贺信祝贺赵忠贤院士荣获国家最高科学技术奖

1月9日上午，国家科学技术奖励大会在京召开，中国科学院物理研究所赵忠贤院士荣获2016年度国家最高科学技术奖。中国科学院院长、党组书记白春礼向赵忠贤院士发来贺信，代表院党组并以个人名义致以热烈祝贺和崇高敬意。

工程院原院长宋健发来贺信祝贺赵忠贤院士荣获国家最高科学技术奖

近日，全国政协原副主席、中国工程院原院长宋健向赵忠贤院士发来贺信，祝贺赵忠贤院士荣获2016年度国家最高科学技术奖。

铁基高温超导体研究团队荣获中国科学院“十二五”突出贡献团队表彰

1月5日,中国科学院人才工作会议在京举行。会议期间，对“十二五”突出贡献团队入选单位进行了表彰。我所“铁基高温超导体研究团队”（团队成员：赵忠贤、陈仙辉、王楠林、闻海虎、方忠）荣膺中国科学院“十二五”突出贡献团队称号，白春礼院长、刘伟平书记亲自为团队代表方忠研究员颁发了获奖证书。

突出贡献团队的选拔及表彰旨在激励院属单位和广大科技人员迎难而上、再创佳绩，全院共12支团队获此殊荣。

中国科协书记、常务副主席、书记处第一书记尚勇一行慰问物理所赵忠贤院士

1月19日下午，中国科协党组书记、常务副主席、书记处第一书记尚勇一行来到物理所看望慰问中国科学院院士赵忠贤，代表科协向赵忠贤院士致以诚挚问候和新春祝福。物理所所长王玉鹏，党委书记、副所长孙牧，副所长、党委副书记、纪委书记文亚等陪同慰问。

尚勇书记向赵忠贤院士获得2016年国家最高科学技术奖表示热烈祝贺，与赵院士进行了亲切交谈，关切地询问了赵院士的生活和身体情况，并听取了赵院士对科协发展的建议和意见。赵忠贤院士对尚勇书记与中国科协的关心表示感谢，表示将一如既往地参与和支持科协工作，为我国科技事业的发展贡献自己的力量。

北京市海淀区党委、区人民政府发来贺信祝贺赵忠贤院士荣获国家最高科学技术奖、物理所研究成果荣获国家自然科学奖

1月9日上午，国家科学技术奖励大会在京召开，中国科学院物理研究所赵忠贤院士荣获2016年度国家最高科学技术奖，物理所“磁电演生新材料及高压调控的量子序”成果荣获国家自然科学二等奖。1月18日，北京市海淀区党委、北京市海淀区人民政府向赵忠贤院士及中国科学院物理研究所发来贺信，向赵忠贤院士及中国科学院物理研究所多年潜心钻研、勇攀高峰的严谨治学精神和辛勤付出致以崇高的敬意！

超导国家重点实验室召开2017年学术大会暨第四届学术委员会第二次全体会议

2017年1月11-12日，超导国家重点实验室召开了2017年学术大会暨第四届学术委员会第二次会议，并举办了“庆祝钇钡铜氧高温超导体发现三十周年专题报告会”。

在超导实验室学术大会上，超导实验室学术委员会主任赵忠贤院士致欢迎辞，实验室主任周兴江研究员向学术委员会委员和实验室全体师生介绍了2017年学术年会的内容。超导实验室各课题组向超导实验室学术委员会委员和实验室全体师生报告了2016年度的代表性工作。学术委员会委员在听取各个报告后，评选出超导实验室2016年度优秀工作。委员代表们为超导实验室优秀工作以及实验室内部学术交流优秀报告人颁发了获奖证书。

2017年初恰逢钇钡铜氧高温超导体发现三十周年，超导实验室在年会期间举办了“庆祝钇钡铜氧高温超导体发现三十周年专题报告会”。周兴江主任主持报告会，并首先就本次“高温超导和专题报告会”做了简要介绍，包括钇钡铜氧高温超导体的发现和超导国家重点实验室发展的历程。他特别介绍了超导实验室学术委员会主任赵忠贤院士刚刚获得的2016年度国家最高科学技术奖，并代表全体师生向赵忠贤院士多年来对超导实验室以及超导研究的杰出贡献表示感谢和祝贺。在报告会上，清华大学的王亚愚教授、物理所的向涛院士、中科院电工所的肖立业研究员、南京大学的吴培亨院士/超导室的郑东宁研究员分别作了关于高温超导研究在实验、理论、强电应用和弱电应用方面的综述报告。精彩的报告吸引了许多物理所以及周边高校的师生来参加，报告厅座无虚席，听众超过300人。 在专题报告会自由讨论环节，物理所王玉鹏所长、基金委张守著处长、龚昌德院士、张裕恒院士、向涛院士、闻海虎教授、冯世平教授、张广铭教授、封东来教授、王楠林教授、许祝安教授、潘庶亨研究员、杨乾声研究员等对高温超导发现及其影响与意义畅谈自己的体会，赵忠贤院士作了总结发言。全体师生对超导实验室的未来充满信心，整个活动在热烈欢快的气氛中进行。

第四届学术委员会第二次会议由向涛院士主持。实验室主任周兴江研究员代表实验室全面介绍了实验室的各项工作。随后各课题组长分别向委员们汇报了2016年的工作成果及未来展望。委员们对超导实验室的工作给予了高度肯定。委员们同时对超导实验室也提出更高的要求，就如何进一步开展原创性研究、人才引进和培养，团队的竞争力，科研的创新能力等方面提出了许多宝贵的建议。

本次会议参加者包括超导实验室全体师生、超导实验室学术委员会部分委员。参会的学术委员会委员包括龚昌德院士（南京大学）、吴培亨院士（南京大学）、张裕恒院士(中国科技大学)、于渌院士（中科院物理所）、朱道本院士（中科院化学所）、熊光成教授（北京大学）、封东来教授（复旦大学）、肖立业研究员（中科院电工所）、王楠林教授（北京大学）、冯世平教授（北京师范大学）、张富春教授（浙江大学）、王亚愚教授（清华大学）、卢仲毅教授（中国人民大学）、鲍威教授（中国人民大学）、许祝安教授（浙江大学）、李建新教授（南京大学）、翁征宇教授（清华大学）、张广铭教授（清华大学）、闻海虎教授（南京大学）、王强华教授（南京大学）以及物理所向涛院士、吕力研究员、杨乾声研究员和潘庶亨研究员等。

白春礼院长来我所看望赵忠贤院士

1月25日，中国科学院院长、党组书记白春礼专程前来物理所看望赵忠贤院士，并致以新春问候和祝福。物理所所长王玉鹏，党委书记、副所长孙牧，副所长、党委副书记、纪委书记文亚陪同探望。

白春礼院长对赵忠贤院士荣获2016年度国家最高科学技术奖表示祝贺，并同赵忠贤院士一同亲切回顾了中科院在低温，超导等领域不平凡的发展历程，及在满足国家重大战略需求方面的突出贡献。最后，白春礼院长还特别询问了赵忠贤院士的身体状况，叮嘱他要保重身体。赵忠贤院士对白春礼院长和中国科学院党组的关心表示感谢，并表示会尽自己最大的努力为我国在超导领域的研究和应用贡献自己的力量。

全国政协副主席、科技部部长万钢一行慰问物理所赵忠贤院士

2017年1月25日下午，全国政协副主席、科技部部长万钢一行来到物理所看望慰问中国科学院院士赵忠贤，代表科技部向赵忠贤院士致以诚挚问候和新春祝福。国家科学技术奖励工作办公室副巡视员滕跃，人物奖励处研究员姚昆仑，综合处黄亚丽，中国科学院副院长张涛，发展规划局副局长黄晨光，评估奖励处副研究员李陛，物理所所长王玉鹏，党委书记、副所长孙牧，副所长、党委副书记、纪委书记文亚等陪同慰问。

万钢部长向赵忠贤院士获得2016年国家最高科学技术奖表示热烈祝贺，与赵院士进行了亲切交谈，关切地询问了赵院士的生活和身体情况，并听取了赵院士对科技部发展的建议和意见。赵忠贤院士对万钢部长与科技部的关心表示感谢，表示将一如既往地参与和支持科技部工作，为我国科技事业的发展贡献自己的力量。

全国超导标准化技术委员会换届大会暨2016年年会在物理所顺利召开

全国超导标准化技术委员会（SAC/TC265）换届大会暨2016年年会于2017年2月22日在中科院物理研究所召开。新、老委员及各界来宾共47人参会，其中包括中国国家标准化管理委员会工业标准二部的田昭莹主任，中国科学院条财局装备办公室张红松主任，中科院物理所的相关领导，以及北京大学的甘子钊院士、物理所的赵忠贤院士和西北有色金属研究院的周廉院士。

换届会议由第一届超导标委会秘书长刘宜平主持。 田昭莹主任首先宣读了换届批文及第二届委员会委员、顾问名单，并给新委员颁发了证书。第二届全国超导标准化技术委员会由31名委员及4名顾问组成。周兴江任主任委员，郑东宁、张国民、尤立星任副主任委员，李洁任委员兼秘书长，赵忠贤、吴培亨、林良真、杨乾声任顾问。秘书处由中国科学院物理研究所承担。

第二届主任委员周兴江为第一届标委会的老委员、老顾问颁发了荣誉证书，感谢他们过去十几年在标准化工作中坚持不懈的努力和持之以恒的献身精神。他宣读了来自22个委员单位的贺信。各委员单位对新一届标委会的成立表示祝贺，表示将在新一届标委会的带领下，为我国超导标准化工作迈向更高的台阶做出贡献。

第一届标委会主任杨乾声做了标委会2003年至2016年工作总结。第一届标委会副主任郑东宁做了标委会2016年年度工作报告，第二届标委会主任周兴江就标委会下一步的工作安排做了报告。

田昭莹主任在讲话中指出，在中国经济不断发展的今天，标准化工作的意义逐渐凸显。全国超导标委会自2003年成立以来，在超导技术标准化方面做了大量的工作，初步构建了超导标准体系。在超导产业化的早期，标准化工作及时跟进，使我国有机会在这一领域与世界强国同台竞争。张红松主任介绍，全国超导标委会的工作在中科院下属9个标委会中是很出色的，做出了非常好的成绩。他希望全体委员继续努力，不仅跟踪国际标准化工作动态，更要争取有自己的发言权。物理所所长助理李明研究员表示物理所对超导标准化工作一直很重视，今后会在各方面对超导标准化工作给予力所能及的支持。甘子钊院士认为，目前我国在超导应用的很多方面都处于世界上领先的地位，现阶段超导标准化工作很重要。赵忠贤院士指出，做应用才能体会标准的重要性。项目带动新科技，找到合适的项目，对超导材料的需求就可能取得突破。很多来自产业部门和超导产品用户单位的新委员也纷纷发表自己的意见，对超导技术应用的前景非常乐观，对超导标准化工作充满了热情。

在接着召开的全国超导标准化技术委员会第二届委员会第一次全体会议上，通过了超导标委会章程、超导技术标准体系和秘书处工作细则；在研标准项目负责人汇报了工作进展；并对2017年新项目的申请，以及在国际IEC/TC90 各工作组中的人员安排进行了讨论。

参加此次会议的来宾还有：中国国家标准化管理委员会工业标准二部的张成宇同志，中科院物理所科技处冯国星处长，第一届超导标委会副主任委员肖玲教授，第一届超导标委会委员、原IEC/TC90第四工作组组长华崇远教授，原中科院基础局领导李满园同志。

赵忠贤院士获得“影响世界华人大奖”

3月31日晚，由凤凰卫视主办的“世界因你而美丽2016-2017影响世界华人盛典”在清华大学揭晓。物理学家、中科院物理所赵忠贤院士获得科研技术领域“影响世界华人大奖”。原全国人大常委会副委员长、中国关心下一代工作委员会主任顾秀莲为其颁奖。

当晚一同获奖的还有建筑设计师贝聿铭、电影演员成龙、物理学家张首晟、神舟十一号飞行任务飞行乘组等11位取得令世界瞩目成就的杰出华人。

“第七届超导研究前沿国际论坛——非传统超导体的光谱学研究”在我所成功召开

由超导国家重点实验室主办的超导研究前沿国际论坛的第七次专题会议：“非传统超导体的光谱学研究”于2017年10月26-29日在物理所成功召开。超导实验室学术委员会主任赵忠贤院士、实验室主任周兴江研究员和超导实验室邱祥冈研究员担任本次会议主席。会议就利用红外及超快光谱、拉曼光谱和X射线散射等光谱测量手段研究铜氧化物高温超导体和铁基超导体等非常规超导体中的集体激发、各种有序态和超导机理等进行了广泛深入的探讨。

会议邀请到来自国内外在超导光谱学研究领域的10位专家做报告，详细介绍了光谱测量手段在超导领域的研究概况，分享他们在研究非常规新超导体中的个人经历和经验，报告了他们最新的研究成果，探讨了光谱测量手段在超导领域未来的前景。东京大学的Uchida教授最后做了总结性发言。这次专题会议吸引了所内外100余人参加，会议期间气氛热烈，展开了充分的讨论和交流。此次论坛为中外科学家在利用光谱研究超导相关的物理和机理方面提供了相互交流和合作的平台，也为广大师生提供了用光谱测量手段研究超导进一步学习和了解的契机。

本次会议作特邀报告的国内外专家有：美国斯坦福大学的Weisheng Lee博士，德国Walther-Meissner研究所的Rudi Hackl教授，日本东京大学的Shinichi Uchida教授，加拿大McMaster大学的Thomas Timusk教授，日本大阪大学的Setsuko Tajima教授，以及来自北京大学的王楠林教授，中国人民大学的张清明教授，清华大学的李源教授，物理所表面实验室的赵继民研究员和超导实验室的邱祥冈研究员等。

超导国家重点实验室从2011年开始，每年针对超导研究领域的一个重要专题，举办一次超导研究前沿的国际论坛。2011-2016年已成功举办了六届超导研究前沿国际论坛：“新超导体探索”、“非传统超导体的角分辨光电子能谱研究”、“非传统超导体的中子散射研究”、“非传统超导体的扫描隧道显微学研究”、“非传统超导体的输运和热力学性质研究”、“非传统超导体中的NMR和 SR研究”。这些超导国际论坛的开展，加强和促进了国内外超导研究的交流与合作，不仅得到超导实验室、物理所广大师生的积极参与，也吸引了许多国内其它高校和研究所师生的积极参与。

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ARTICLE

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Nematic superconducting state in iron pnictide superconductors

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Nematic order often breaks the tetragonal symmetry of iron-based superconductors. It arises from regular structural transition or electronic instability in the normal phase. Here, we report the observation of a nematic superconducting state, by measuring the angular dependence of the in-plane and out-of-plane magnetoresistivity of $Ba_{0.5}K_{0.5}Fe_2As_2$ single crystals. We find large twofold oscillations in the vicinity of the superconducting transition, when the direction of applied magnetic field is rotated within the basal plane. To avoid the influences from sample geometry or current flow direction, the sample was designed as Corbino-shape for in-plane and mesa-shape for out-of-plane measurements. Theoretical analysis shows that the nematic superconductivity arises from the weak mixture of the quasi-degenerate *s*-wave and *d*-wave components of the superconducting condensate, most probably induced by a weak anisotropy of stresses inherent to single crystals.

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Temperature-tunable Fano resonance induced by strong coupling between Weyl fermions and phonons in TaAs

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Strong coupling between discrete phonon and continuous electron–hole pair excitations can induce a pronounced asymmetry in the phonon line shape, known as the Fano resonance. This effect has been observed in various systems. Here we reveal explicit evidence for strong coupling between an infrared-active phonon and electronic transitions near the Weyl points through the observation of a Fano resonance in the Weyl semimetal TaAs. The resulting asymmetry in the phonon line shape, conspicuous at low temperatures, diminishes continuously with increasing temperature. This behaviour originates from the suppression of electronic transitions near the Weyl points due to the decreasing occupation of electronic states below the Fermi level (E_F) with increasing temperature, as well as Pauli blocking caused by thermally excited electrons above E_F. Our findings not only elucidate the mechanism governing the tunable Fano resonance but also open a route for exploring exotic physical phenomena through phonon properties in Weyl semimetals.

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PNAS

Robust zero resistance in a superconducting high-entropy alloy at pressures up to 190 GPa

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We report the observation of extraordinarily robust zero-resistance superconductivity in the pressurized $(TaNb)_{0.67}(HfZrTi)_{0.33}$ high-entropy alloy—a material with a body-centered-cubic crystal structure made from five randomly distributed transition-metal elements. The transition to superconductivity (T_C) increases from an initial temperature of 7.7 K at ambient pressure to 10 K at ~60 GPa, and then slowly decreases to 9 K by 190.6 GPa, a pressure that falls within that of the outer core of the earth. We infer that the continuous existence of the zero-resistance superconductivity from 1 atm up to such a high pressure requires a special combination of electronic and mechanical characteristics. This high-entropy alloy superconductor thus may have a bright future for applications under extreme conditions, and also poses a challenge for understanding the underlying quantum physics.

superconductivity | high pressure | high-entropy alloy

High-entropy alloys (HEAs) are a new class of materials that are composed of multiple transition-metal elements in equimolar or near-equimolar ratios (1, 2). The diverse elements in HEAs are arranged randomly on the crystallographic positions in a simple lattice, and thus have been referred to as a metallic glass on an ordered lattice. By applying this concept, many HEAs have been found in disordered solid-solution phases with body-centered-cubic, hexagonal closest-packed, and face-centered-cubic crystal structures (3–6).

In many respects, HEAs display novel properties, including ultrahigh fracture toughness at cryogenic temperatures (7, 8), excellent specific strength (9), and superior mechanical performance at high temperatures (10). In addition to their promising mechanical properties, some HEAs also exhibit interesting electronic properties: $[TaNb]_{1-x}(ZrHfTi)_x$ HEAs were found to display superconductivity, for example (11, 12). The combination of the promising physical properties found in the HEAs points to great potential for application.

Pressure is one of the variables that can uncover unexpected phenomena and properties (13–16). For superconductors in particular, the pressure-induced enhancement of critical transition temperatures in copper-oxide and iron-pnictide superconductors (17–20), the reemergence of superconductivity in the alkaline iron selenide (21) and heavy fermion superconductors (22), pressure-induced superconductivity in H_3S (23–25) and elements (26, 27), are examples. Therefore, looking for new phenomena in the superconducting HEA under pressure is of great interest. Here we report high-pressure studies on the superconducting HEA $(TaNb)_{0.67}(HfZrTi)_{0.33}$, which has a critical transition temperature to the superconducting state (T_C) of about 7.8 K at ambient pressure (11, 12). Our observations demonstrate that this alloy exhibits extraordinarily robust superconductivity—its zero-resistance superconducting state is still achieved even at a pressure of 190.6 GPa, or almost 2 megabars (1 Mbar = 10^{11} pascal), a pressure like that within the outer core of the earth. Such a superconductor with a highly robust zero-resistance state, existing continuously from 1 atm to geological pressures, is extremely unusual and is in fact unique to the best of our knowledge. We attribute this surprising behavior to the stable crystal structure of the HEA combined with the apparent robustness of its electronic structure against very large amounts of lattice compression.

Results

Superconductivity Under Pressure. Fig. 1*A* shows the temperature dependence of the electrical resistance at ambient pressure for a $(TaNb)_{0.67}(HfZrTi)_{0.33}$ sample. A sharp drop to a zero-resistance superconducting state is observed at ~7.7 K (we define T_C as the temperature where the resistance changes from a finite value to zero), consistent with the results reported in ref. 12. Applying a magnetic field on the sample shows that its superconducting transition temperature (T_C) systematically shifts to lower temperature (Fig. 1*A*, *Inset*), as expected. Temperature-dependent constant-current magnetic susceptibility characterization was also performed for the ambient-pressure sample. As shown in Fig. 1*B*, a strong diamagnetic response is observed starting at 7.6 K, indicative of a bulk superconducting nature.

High-pressure resistance measurements were performed for four samples that were cut from the material used as the standard for the superconductivity at ambient pressure. The electrical resistance measurements for these samples were performed between 4 and 300 K. Fig. 2*A* shows the temperature

Significance

High-entropy alloys (HEAs) are made from multiple transition-metal elements in equimolar or near-equimolar ratios. The elements in HEAs arrange themselves randomly on the crystallographic positions of a simple lattice. In addition to their excellent mechanical properties, one HEA has been reported to display superconductivity. In this work, we report that the Ta–Nb–Hf–Zr–Ti high-entropy alloy superconductor exhibits extraordinarily robust zero-resistance superconductivity under pressure up to 190.6 GPa. This is an observation of the zero-resistance state of a superconductor all the way from 1-bar pressure to the pressure of the earth's outer core without structure phase transition, making the superconducting HEA a promising candidate for new application under extreme condition.

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The authors declare no conflict of interest.

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Superconducting (Li,Fe)OHFeSe Film of High Quality and High Critical Parameters *

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A superconducting film of ($Li_{1-x}Fe_x$)OHFeSe is reported for the first time. The thin film exhibits a small in-plane crystal mosaic of 0.22°, in terms of the full width at half maximum of the x-ray rocking curve, and an excellent out-of-plane orientation by x-ray φ-scan. Its bulk superconducting transition temperature T_c of 42.4 K is characterized by both zero electrical resistance and diamagnetization measurements. The upper critical field H_{c2} is estimated to be 79.5 T and 443 T for the magnetic field perpendicular and parallel to the ab plane, respectively. Moreover, a large critical current density J_c of a value over 0.5 MA/cm^2 is achieved at ∼20 K. Such a ($Li_{1-x}Fe_x$)OHFeSe film is therefore not only important to the fundamental research for understanding the high-T_c mechanism, but also promising in the field of high-T_c superconductivity application, especially in high-performance electronic devices and large scientific facilities such as superconducting accelerator.

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High-quality superconducting thin films take an important role in applications and basic research of high-T_c superconductivity. In both the aspects, iron-based superconductors feature the merit of rich physical phenomena, high superconducting critical parameters (including the transition temperature T_c, the upper critical field H_{c2} and the critical current density J_c) and small anisotropy.[1−12] Much progress has been made in the synthesis of iron-based superconducting thin films with high performances.[6,9,13−19] Among them, the monolayer film of binary FeSe on a $SrTiO_3$ substrate, showing an energy gap above 65 K, has triggered great interest due to its different electronic structure from the bulk material of FeSe and the highest T_c for the iron-based family to date.[8,20−24] However, the FeSe monolayer samples are very sensitive to air and the promoted superconductivity fades away quickly once the number of FeSe layers is increased. These drawbacks make it difficult for most measuring techniques to probe the nature of the high-T_c superconductivity and also hamper practical applications. Therefore, it should be put on the agenda to attain a substitute that is compatible with routine experimental measurements and is more suitable for applications.

The newly discovered ($Li_{1-x}Fe_x$)OHFeSe (FeSe-11111) superconductor,[25] with a comparable T_c and similar electronic structure to the monolayer FeSe, turns out to be a good candidate. However, due to the hydroxyl ion inherent in the compound, it is impossible to obtain ($Li_{1-x}Fe_x$)OHFeSe materials, in both bulk and thin film forms, by conventional high-temperature synthesis methods. Most recently, by developing a hydrothermal ion-exchange technique, we have successfully synthesized big and high-quality single crystals of FeSe-11111.[26] In this Letter, we report for the first time a high-quality single-crystalline superconducting film of ($Li_{1-x}Fe_x$)OHFeSe, which has been grown on a $LaAlO_3$ (LAO) substrate by a hydrothermal epitaxial method.[27] The high crystalline quality of the film is demonstrated by x-ray diffraction (XRD) results, showing a single (001) orientation with a small crystal mosaic of 0.22° in terms of the full width at half maximum (FWHM) of the rocking curve and a uniform fourfold symmetry by the φ scan of (101) plane. The bulk superconducting transition at T_c of 42.4 K is confirmed by both electrical transport and magnetic measurements. Based on sys-

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Electronic evidence of temperature-induced Lifshitz transition and topological nature in $ZrTe_5$

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The topological materials have attracted much attention for their unique electronic structure and peculiar physical properties. $ZrTe_5$ has host a long-standing puzzle on its anomalous transport properties manifested by its unusual resistivity peak and the reversal of the charge carrier type. It is also predicted that single-layer $ZrTe_5$ is a two-dimensional topological insulator and there is possibly a topological phase transition in bulk $ZrTe_5$. Here we report high-resolution laser-based angle-resolved photoemission measurements on the electronic structure and its detailed temperature evolution of $ZrTe_5$. Our results provide direct electronic evidence on the temperature-induced Lifshitz transition, which gives a natural understanding on underlying origin of the resistivity anomaly in $ZrTe_5$. In addition, we observe one-dimensional-like electronic features from the edges of the cracked $ZrTe_5$ samples. Our observations indicate that $ZrTe_5$ is a weak topological insulator and it exhibits a tendency to become a strong topological insulator when the layer distance is reduced.

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Unified Phase Diagram for Iron-Based Superconductors

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High-temperature superconductivity is closely adjacent to a long-range antiferromagnet, which is called a parent compound. In cuprates, all parent compounds are alike and carrier doping leads to superconductivity, so a unified phase diagram can be drawn. However, the properties of parent compounds for iron-based superconductors show significant diversity and both carrier and isovalent dopings can cause superconductivity, which casts doubt on the idea that there exists a unified phase diagram for them. Here we show that the ordered moments in a variety of iron pnictides are inversely proportional to the effective Curie constants of their nematic susceptibility. This unexpected scaling behavior suggests that the magnetic ground states of iron pnictides can be achieved by tuning the strength of nematic fluctuations. Therefore, a unified phase diagram can be established where superconductivity emerges from a hypothetical parent compound with a large ordered moment but weak nematic fluctuations, which suggests that iron-based superconductors are strongly correlated electron systems.

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Iron pnictides share some common behaviors with many other unconventional superconductors, such as cuprates and some heavy-fermion superconductors, where superconductivity is achieved by suppressing the long-range antiferromagnetic (AFM) order in parent compounds [1,2]. What we learn from cuprates is that all parent compounds can be treated as Mott insulators and a unified phase diagram can thus be drawn [3]. Superconductivity can be obtained by either hole or electron doping, suggesting that carrier doping can be directly associated with a microscopic quantum parameter. These consensus in cuprates naturally leads to the use of similar terms in iron-based superconductors, such as parent compound, electron, and hole doping [4], despite the fact that there are many phenomena querying these simple adaptions. For example, the ordered moments of the AFM ground states in the parent compounds of iron pnictides vary significantly [5–11], leading to many theoretical efforts, but a consensus has not been reached yet [12–15]. In $NaFe_{1-x}Co_xAs$ [16], filamentary superconductivity can be found in the AFM parent compound. The differences among these materials seem to disqualify them as the parent compound, which has long thought to be a Mott insulator [17–21]. Efforts to find such an insulating parent compound have not met with much success [22–24]. Moreover, achieving superconductivity in iron-based superconductors can be done by not just carrier doping but also isovalent doping [25]. It has been found that chemical substitution leads to the reduction of electronic correlations in most systems [26], but the reason is unknown. These diversities for both parent compounds and their doped materials make it hard to obtain a general picture for the low-energy physics of iron pnictides as that in cuprates, which seems to suggest that our understanding of antiferromagnetism and superconductivity in iron-based superconductors is not generic but material dependent.

A unique feature for the AFM order in iron pnictides is that it is always closely accompanied by a nematic order, which breaks the in-plane C_4 rotational symmetry of the high-temperature tetragonal lattice structure while preserving the translational symmetry [27,28]. Similar nematic order has also been found in cuprates but it is rather associated with the pseudogap [29]. It has been shown that the nematic order and its fluctuations may overshadow the whole phase diagram of iron-based superconductors [30–34]. Moreover, a nematic quantum critical point (QCP) has been found in many near optimally doped iron pnictides [31–34]. It has been theoretically suggested that quantum nematic fluctuations may induce attractive pairing interaction and thus enhance or even lead to superconductivity [35,36]. Therefore, nematicity should play a significant role in both antiferromagnetism and superconductivity, and a quantitative relationship between the AFM and nematic orders may provide key information on the unified phase diagram of iron-based superconductors.

Here, we perform a detailed investigation on the nematic susceptibility of a variety of iron-based superconductors by studying the uniaxial pressure effect on the in-plane resistivity. The temperature dependence of the nematic

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Charge-density-wave order takes over antiferromagnetism in $Bi_2Sr_{2-x}La_xCuO_6$ superconductors

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Superconductivity appears in the cuprates when a spin order is destroyed, while the role of charge is less known. Recently, charge density wave (CDW) was found below the superconducting dome in $YBa_2Cu_3O_y$ when a high magnetic field is applied perpendicular to the CuO_2 plane, which was suggested to arise from incipient CDW in the vortex cores that becomes overlapped. Here by ^{63}Cu-nuclear magnetic resonance, we report the discovery of CDW induced by an in-plane field, setting in above the dome in single-layered $Bi_2Sr_{2-x}La_xCuO_6$. The onset temperature T_{CDW} takes over the antiferromagnetic order temperature T_N beyond a critical doping level at which superconductivity starts to emerge, and scales with the pseudogap temperature T^*. These results provide important insights into the relationship between spin order, CDW and the pseudogap, and their connections to high-temperature superconductivity.

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