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# 强磁场科学研究动态监测快报

主办单位：中国科学院合肥物质科学研究院信息中心

中 国 科 学 院 强 磁 场 科 学 中 心

# 目录

# 本 期 要 览

## ✧ 世界主要强磁场实验室介绍

### ——法国格勒诺布尔高场实验室

在 1962 年，法国科学研究中心开始在格勒诺布尔开始建设高磁场强度的装置即水冷磁体，René Pauthenet、Jean-Claude Picoche 和 Pierre Rub 负责管理建造这台新的装置，1971 年这台水冷磁体开始运行，这台水冷磁体在 5MW 的电源供应下可以达到 12 到 15T 的磁场强度。1972 年，与德国斯图加特的马普所合作将水冷磁体电源升级为 10MW，这样由 Hans Schneider-Muntau 设计的多螺旋结构的水冷磁体可以达到 25T 的磁场强度。1987 年，法国与德国的研究团队合作建造了一台混合磁体，该混合磁体由 11T 的超导磁体和 25T 的水冷磁体构成，形成当时最高 31.5T 的磁场强度。1997 年，实验室开始建造新的混合磁体，但由于 8T 的超导磁体研制失败，造成该项目取消。目前，格勒诺布尔高场实验室在以上基础上正在建造 34mm 孔径，磁场强度为 43T 的混合磁体。2009 年，法国将位于图卢兹的脉冲场实验室和位于格勒诺布尔稳态场实验室合并，组成新的高场实验室 LNCMI

## ✧ 强磁场装置研制

### ● 美国国家强磁场实验室宣称建成磁场强度最高的水冷磁体

2017 年 8 月 21 日，美国国家强磁场实验室建造的最新的水冷磁体达到 41.4T 的磁场强度，这个水冷磁体创造了最新的水冷磁体磁场强度记录，超过了位于中国合肥的中国强磁场实验室创造的 38.5T 的磁场强度和位于荷兰奈梅亨的荷兰强磁场实验室创造的 37.5T 的磁场强度，这个水冷磁体耗时两年半时间建成，为物理学家们提供了新的测试平台。

### ● 日本 25T 传导冷却超导磁体实现第一次性能测试

目前，日本东北大学的日本强磁场实验室建成一台 25T 传导冷却超导磁体，该超导磁体由高温超导磁体和低温超导磁体构成。该超导磁体的高温超导磁体和低温超导磁体分别采用两台 4K GM 制冷机和两台 GM/JT 制冷机冷却。低温超导磁体可以形成 14T 磁场强度，由 GdBaCuO 带材绕制的高温超导磁体在自场的情

况下形成了 10.15T 磁场，在 14T 的低温超导磁体形成的背景场情况下，最终达到了 23.55T 的磁场强度。由 Bi2223 带材绕制的高温超导磁体在自场情况下形成了 11.48T，在 14T 的背景磁场下达到了 24.57T 的磁场强度，

## ✧ 强磁场与材料科学

### ● 物理学家在超导晶体中发现奇异的物态

电子液晶相材料与其晶格相比具有更低的低维电子系统，与向列相液晶中没有周期性序的直接排列类似。这些向列相出现在铜基和铁基高温超导体中，然而它们在稳定超导电性方面的所起的作用仍然是一个未解之谜。电子液晶相频繁地出现在这些材料中，可能与超导共存或竞争，或者突然出现。这篇文章报道了在重费米子超导体 CeRhIn5 中发现了涨落向列特征相的实验证据。进一步来说，磁扭矩实验没有发现明显的异常，暗示着在这个磁场范围内不存在亚磁性。向列相行为的存在于一个原型重费米子超导体中，凸显了向列相与非常规超导体的关联，暗示着向列相是关联电子体系的共同的特点。

### ● 科学家在双层石墨烯发现了奇异量子粒子

由美国哥伦比亚大学 Cory Dean 副教授和哥伦比亚机械工程大学的 James Home， Wang Fong Jen 教授领导的研究人员，在凝聚态物理学中热门研究方向-双层石墨烯中-通过电输运测量观察到了分数量子霍尔态。

“在任何材料中观察到 5/2 态势一个令人瞩目的科学发现，因为这包含了现代凝聚态物理中许多复杂的概念。”Dean 教授说，“我们的发现，在双层石墨烯中的 5/2 态一直存在到比以往更高的温度，这不仅可以使我们以一种新方式研究这个物理现象，也改变了我们对于分数量子霍尔效应的观点， 使得我们可以把它从一个基本是物理兴趣转变为潜在的真实应用，尤其是在量子计算方面”。

### ● 强磁场对于 Ni 基单晶超合金直接固化过程的微结构效应

强磁场在固化过程中对于提高材料的微结构和物性已经被广泛地使用。在制备单晶发动机涡轮叶片过程中，超合金的微结构是决定其机械性能的主要因素。在这项工作中，实验研究的是在固化过程中强磁场对 Ni 基单晶超合金 PWA1483 and CMSX-4 的效应。这些结果显示，磁场改变了超合金的二次枝晶间距，γ′相尺寸，还有微偏析。另外，尺寸和相比例γ/γ′溶解度和微孔率在强磁场下

降低。可变分析结果显示，强磁场对于固化过程中的微结构置信度非常显著（$p < 0.05$）。基于实验结果和理论分析，微结构的改变是由于在强磁场下，晶支之间区域发生了热电磁转换。这个工作提供了一个利用强磁场来优化 Ni 基单晶超合金高温叶片的新方法。

- **双层石墨烯中直接测量分离的谷和轨道量子数**

双层石墨烯在强磁场下的电子结构由于自旋、谷类自旋和意外的谷退简并度的增强，导致了对称破缺态的复杂相图。这里，我们展示了测量层状分辨的电荷密度的技术，以此来直接确定零能 Landau 能级的谷和轨道极化率。层间极化演化成了不同谷、自旋和轨道序之间的分离的 32 个电场调节的相变，包括之前未发现的通过倾斜的层间跳跃来稳定的轨道极化态。我们通过模型拟合结果，捕捉到了单粒子和相互作用各向异性，提供了关联电子体系的完整图像。通向对称破缺的最终路线图为分数量子霍尔态的终极工程铺平了道路，而我们的层间分辨的技术是随时可以扩展到其他二维材料， 在这些材料中层间极化可以显示出了谷和自旋量子数。

- **强磁场下 LiCuVO4 中自旋-向列液晶相的核磁共振证据**

我们报道了阻挫自旋 1/2 链状化合物 LiCuVO4 在最高 56T 的脉冲强磁场下的 51V 核磁共振观察结果，并注意到了高场相。

当晶体放置取于不同磁场方向，H||c 和 H||b 时 u，我们发现了一个低于饱和磁场下的很窄的磁场区域，局域磁化强度仍保持标准和均匀，而它的值是磁场依赖的。这个行为是自旋-液晶相的第一个微观特征，破坏了自旋-旋转对称性而没有产生任何横向极化序，与 LiCuVO4 化合物的理论预言的结果一致。

- **三维拓扑半金属 LaBi 中磁场诱导的强谷极化**

LaBi 是一个岩盐结构的三维材料，具有奇异的准二维电子结构。它展示了非常奇特的电子物性，诸如非平庸 Dirac 锥，超大磁电阻，高载流子迁移率。当磁场从一个晶体轴转动到另一个晶体轴过程中，雪茄型的电子谷使得电荷输运具有高度各向异性。我们展示了在这些电子谷中通过旋转磁场，电子可以被有效极化。我们在 2K 下，由于有三维空穴袋的存在，仍实现了 60%的极化率。这个 LaBi 中的谷极化率可以和同结构化合物 LaSb 中可相比拟，但 LaSb 中的数值要略小。LaBi 的表现更像高度有效的 Bi 单质。

## ✧ 强磁场与生物医学

### ● 磁共振成像（MRI）显示心脏病与情绪障碍之间的联系

科学家利用一台强大的 11.75T 磁共振成像仪（MRI），分析了心肌异常增厚（被克利夫兰医学中心称为人肥厚性心肌病或 HCM，患病率为 1/500）小鼠的脑部。他们发现，与对照组小鼠相比，肥厚性心肌老年小鼠表现出高度的焦虑和抑郁。他们还发现，在 HCM 小鼠中，大脑中与情绪相关的区域（前额皮质和尾状壳核）体积较小。而在人类中，这些脑结构的体积较小与焦虑和抑郁有关。科学家还发现被认为是情绪和记忆中心的海马区的活跃度降低，而这是情绪障碍的另一个标志。

这一分析，连同神经化学和行为测量结果，表明情绪障碍更常见于长期遭受心力衰竭系统性压力的老年人。

这些结果强化的一种观点，即临床医生除了治疗 HCM 患者的心血管症状外，还应该评估其对大脑的影响，包括情绪障碍。临床医生应当同时治疗这两种病情，以改善患者的生活质量。

### ● 细胞表面运动神经元蛋白的研究

美国强磁场中心的科学家解析了一种诱发最严重的神经退行性疾病的蛋白质的结构。他们的研究结果发表在最新一期《CELL》杂志的封面，揭示了这些疾病背后的机制，并指导研究人员如何更好地理解和预防这些疾病。

利用强磁场中心的核磁共振仪（NMR）和美国国立卫生研究院的其它仪器，研究小组发现了蛋白液滴外生长的纤维，这是由蛋白质分子的重复单元组成的。经过精确的测量，科学家们能够得到一个 3D 图像，显示这些纤维的形态。研究小组还研究了磷酸化所起的关键作用，即细胞将磷酸分子连接到蛋白质的过程。该反应可以打开或关闭某些细胞进程。Murray 的研究表明磷酸化会在进行过程中组织原纤维蛋白的形成。

# 世界主要强磁场实验室介绍——Grenoble high field laboratory

## 1. The history of the Grenoble high field laboratory

The effects of magnetic fields namely in physics, have justified important technological efforts : first using electro-magnets and reducing their air gap to produce magnetic fields smaller than 2T- 3T, then using copper coils (Wood or Bitter) in which an efficient water cooling must eliminate the electrical losses (by Joule effect) associated to large electric currents. Thus, around 1970, magnetic fields reached 12-15 T with a 4 MW generator (in MIT Boston, Francis Bitter) or 8 T in Grenoble with a 1.8 MW generator (in LEPM, J.C. Picoche and P. Rub, see picture).

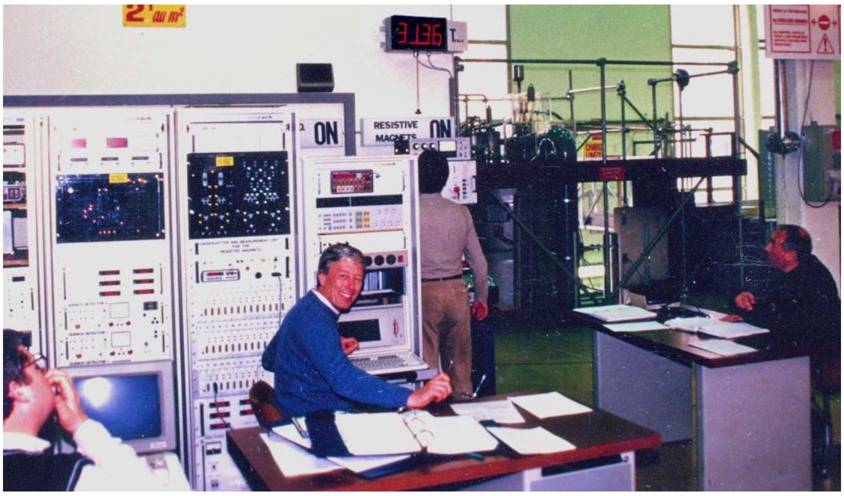
**High-field hall, 1968**

In 1962, as soon as the CNRS laboratories were built on the Grenoble-polygonearea,LouisNéel conceived the project of reaching higher magnetic fields, by taking the electrical network and redressing it to direct current. René Pauthenet was in charge of building a new facility with Jean-Claude Picoche and Pierre Rub. This new facility, the "Service National des Champs MagnétiquesIntenses" (National Service for High Magnetic Fields) started running under the direction of René Pauthenet in 1971. The installed power was only of 5MW but allowed to reach fields up to 12 to 15 T.

In 1972, a collaboration with the Max-Plank-InstitutfürFestkörperforschung (MPI-FKF) in Stuttgart is launched, and the power was raised to 10 MW. This allowed soon to reach 25 T in a 50 mm bore polyhelix coils designed by Hans Schneider-Muntau.

A new magnetic field world record (31.5T in 50 mm) was reached in 1987 with a magnet, composed of a superconducting coil providing 11 T, surrounding a resistive coil providing itself 20,5 T, which was built by a French and German team (J.C. Vallier et Hans Schneider-Muntau).

In 1990-1991, the electric and hydraulic powers of the facility was doubled to reach 24 MW, and the partnership MPI – CNRS was marked by the creation of a common laboratory: the GHMFL "Grenoble High Magnetic Field Laboratory" in 1992 which worked until 2004. In order to remain at the highest international level, the GHMFL started to build a new hybrid coil in 1997. Unfortunately, the superconducting part (of 8 T) was not working and a new superconducting coil is currently under construction (on the basis of new techniques) to reach 43 T in the future hybrid magnet, taking into account that resistive coils have made big progress since they've reached 35T in a 34mm bore diameter.




**First hybrid magnet reaching 31.35 T in a 50 mm bore diameter in 1987**

In 2009, the Laboratoire National des Champs MagnétiquesIntenses (LNCMI) was created, gathering the efforts of the Toulouse laboratory of pulsed magnetic fields and the Grenoble laboratory in static magnetic fields, under the direction of Geert Rikken.

**Information Sources：** http://lncmi-g.grenoble.cnrs.fr/spip.php?rubrique63&lang=en

# 强磁场装置研制

## 1. MagLab reclaims record for strongest resistive magnet

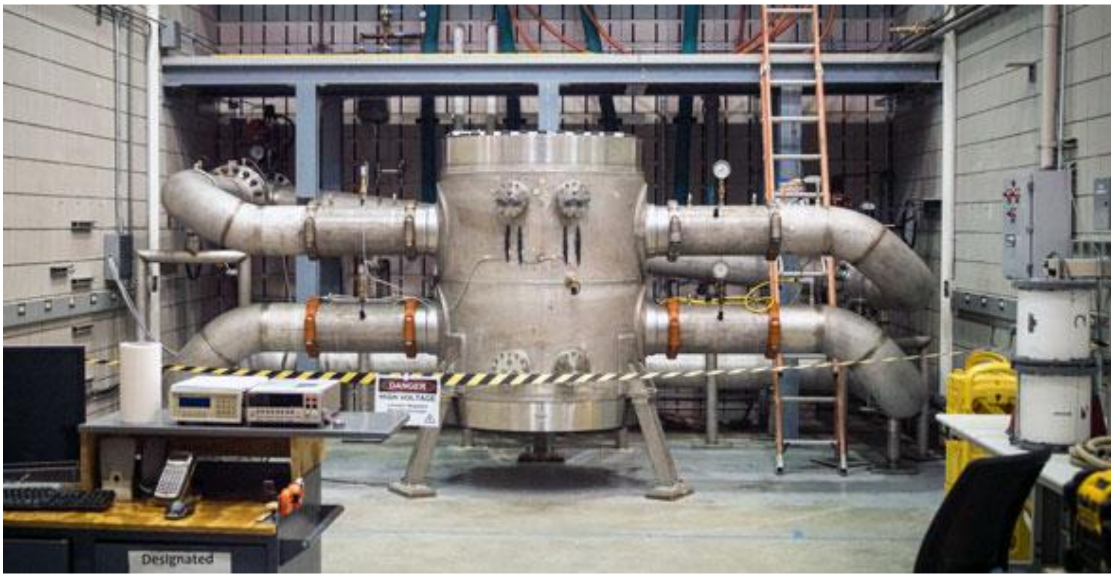
TALLAHASSEE, Fla. — While the rest of the country watched the solar eclipse Monday, engineers at the National MagLab pulled off an eclipse of a different sort. Not to be outdone by celestial events, they set a new world record that blotted out the previous one by about 8 percent — a sizable leap in magnet technology terms.

The new instrument reached 41.4 teslas (a unit of magnetic field strength) at 1:10 p.m. on Aug. 21, the culmination of two and a half intense years of design and development. In so doing, the lab reclaimed the record for the world's strongest resistive magnet, which it had held for 19 years up until 2014.

The effort has been known in-house as Project 11, a reference to the 1984 mockumentary "This Is Spinal Tap" about a fictional rock group. In one scene, a guitarist shows off his unique amplifier, which has a top setting of 11 — one notch higher than the standard 10.

That extra oomph has caused the lab's new magnet, fueled by 32 megawatts of DC (direct current) power, to leapfrog over the previous record-holders, a 38.5-tesla resistive magnet in Hefei, China, and a 37.5-tesla resistive magnet in Nijmegen, the Netherlands.

More importantly, however, the new instrument answers the call of physicists for ever-stronger resistive magnets — also called DC magnets — in order to observe new phenomena in the materials they are studying.



**The new world-record magnet connected to cooling water pipes. Some 4,275 gallons of cold water flush through it per minute to keep it cool.**

**Information Sources：** https://nationalmaglab.org/news-events/news/strongest-resistive-magnet

## 2. First performance test of a 25 T cryogen-free superconducting magnet

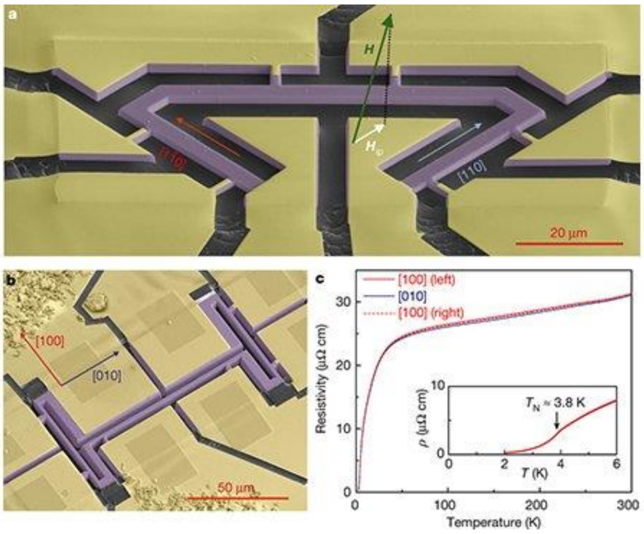
A 25 T cryogen-free superconducting magnet (25T-CSM) was developed and installed at the High Field Laboratory for Superconducting Materials (HFLSM), IMR, Tohoku University. The 25T-CSM consists of a high-temperature superconducting (HTS) coil and a low-temperature superconducting (LTS) coil. A high-strength CuNb/$Nb_3Sn$ Rutherford cable with a reinforcing stabilizer CuNb composite is adopted for the middle LTS section coil. All the coils were impregnated using an epoxy resin for conduction cooling. Initially, a $GdBa_2Cu_3O_y$ (Gd123) coil was designed as the HTS insert coil, and then a $Bi_2Sr_2Ca_2Cu_3O_y$ (Bi2223) coil was also developed. The HTS insert and the LTS (CuNb/$Nb_3Sn$ and NbTi) outsert coils are cooled by two 4K GM and two GM/JT cryocoolers, respectively. The LTS coils successfully generated a central magnetic field of 14 T at an operating current of 854 A without any training quench. The Gd123 coil generated 10.15 T at an operating current of 132.6 A in the absence of a background field. Subsequently, the operating current of the Gd123 insert was increased in a step-by-step manner under a background field of 14 T. The Gd123 coil could be operated up to 124.0 A stably, which corresponds to 23.55 T, but quenched at around 124.6 A (23.61 T). The Bi2223 insert coil using a Ni-alloy reinforced Bi2223 tape successfully generated 11.48 T at an operation current of 204.7A in a stand-alone test and 24.57 T in a background field of 14 T. The differences between the calculated and the measured values of the central magnetic fields are about 0.4 T for the Gd123 insert and 0.1 T for the Bi2223 insert around 24 T.

**Information Sources：** http://iopscience.iop.org/article/10.1088/1361-6668/aa6676/meta

## 强磁场与材料科学

### 1. Physicists find strange state of matter in superconducting crystal

Electronic nematic materials are characterized by a lowered symmetry of the electronic system compared to the underlying lattice, in analogy to the directional alignment without translational order in nematic liquid crystals. Such nematic phases appear in the copper- and iron-based high-temperature superconductors, and their role in establishing superconductivity remains an open question. Nematicity may take an active part, cooperating or competing with superconductivity, or may appear accidentally in such systems. Here we present experimental evidence for a phase of fluctuating nematic character in a heavy-fermion superconductor, $CeRhIn_5$. We observe a magnetic-field-induced state in the vicinity of a field-tuned antiferromagnetic quantum critical point at Hc ≈ 50 tesla. This phase appears above an out-of-plane critical field H* ≈ 28 tesla and is characterized by a substantial in-plane resistivity anisotropy in the presence of a small in-plane field component. The in-plane symmetry breaking has little apparent connection to the underlying lattice, as evidenced by the small magnitude of the magnetostriction anomaly at H*. Furthermore, no anomalies appear in the magnetic torque, suggesting the absence of metamagnetism in this field range. The appearance of nematicbehaviour in a prototypical heavy-fermion superconductor highlights the interrelation of nematicity and unconventional superconductivity, suggesting nematicity to be common among correlated materials.




***$CeRhIn_5$microstructured devices for measurements of in-plane resistivity anisotropy.***

**Information Sources: [http://www.nature.com/nature/journal/v548/n7667/full/nature23315.html](http://www.nature.com/nature/journal/v548/n7667/full/nature23315.html)**

## 2. Scientists observe exotic quantum particle in bilayer graphene

A team of researchers led by Cory Dean, assistant professor of physics at Columbia University, and James Hone, Wang Fong-Jen Professor of Mechanical Engineering at Columbia Engineering, have definitively observed an intensely studied anomaly in condensed matter physics — the even-denominator fractional quantum Hall (FQH) state — via transport measurement in bilayer graphene.

"Observing the 5/2 state in any system is a remarkable scientific opportunity, since it encompasses some of the most perplexing concepts in modern condensed matter physics, such as emergence, quasi-particle formation, quantization, and even superconductivity," Dean says. "Our observation that, in bilayer graphene the 5/2 state survives to much higher temperatures than previously thought possible not only allows us to study this phenomenon in new ways, but also shifts our view of the FQH state from being largely a scientific curiosity to now having great potential for real-world applications, particularly in quantum computing."

A crucial component of the research was having access to the high magnetic fields available at the National High Magnetic Field Laboratory in Tallahassee, Fla., a nationally funded user facility with which Hone and Dean have had extensive collaborations. They studied the electrical conduction through their devices under magnetic fields up to 34 teslas, and achieved clear observation of the even-denominator states.

**Information Sources: [https://nationalmaglab.org/news-events/news/quantum-particle-bilayer-graphene](https://nationalmaglab.org/news-events/news/quantum-particle-bilayer-graphene)**

## 3. Effects of a High Magnetic Field on the Microstructure of Ni-Based Single-Crystal Superalloys During Directional Solidification

High magnetic fields are widely used to improve the microstructure and properties of materials during the solidification process. During the preparation of single-crystal turbine blades, the microstructure of the superalloy is the main factor that determines its mechanical properties. In this work, the effects of a high magnetic field on the microstructure of Ni-based single-crystal superalloys PWA1483 and CMSX-4 during directional solidification were investigated experimentally. The results showed that the magnetic field modified the primary dendrite arm spacing, $\gamma'$ phase size, and microsegregation of the superalloys. In addition, the size and volume fractions of $\gamma/\gamma'$ eutectic and the microporosity were decreased in a high magnetic field. Analysis of variance (ANOVA) results showed that the effect of a high magnetic field on the microstructure during directional solidification was significant ($p < 0.05$). Based on both experimental results and theoretical analysis, the modification of microstructure was attributed to thermoelectric magnetic convection occurring in the interdendritic regions under a high magnetic field. The present work provides a new method to optimize the microstructure of Ni-based single-crystal superalloy blades by applying a high magnetic field.

**Information Sources：** https://link.springer.com/article/10.1007%2Fs11661-017-4135-5

## 4. Direct measurement of discrete valley and orbital quantum numbers in bilayer graphene

The high magnetic field electronic structure of bilayer graphene is enhanced by the spin, valley isospin, and an accidental orbital degeneracy, leading to a complex phase diagram of broken symmetry states. Here, we present a technique for measuring the layer-resolved charge density, from which we directly determine the valley and orbital polarization within the zero energy Landau level. Layer polarization evolves in discrete steps across 32 electric field-tuned phase transitions between states of different valley, spin, and orbital order, including previously unobserved orbitally polarized states stabilized by skew interlayer hopping. We fit our data to a model that captures both single-particle and interaction-induced anisotropies, providing a complete picture of this correlated electron system. The resulting roadmap to symmetry breaking paves the way for deterministic engineering of fractional quantum Hall states, while our layer-resolved technique is readily extendable to other two-dimensional materials where layer polarization maps to the valley or spin quantum numbers.

**Information Sources：** https://www.nature.com/articles/s41467-017-00824-w

## 5. Nuclear Magnetic Resonance Signature of the Spin-Nematic Phase in $LiCuVO_4$ at High Magnetic Fields

We report a 51V nuclear magnetic resonance investigation of the frustrated spin-1/2 chain compound LiCuVO4, performed in pulsed magnetic fields and focused on high-field phases up to 56 T.

For the crystal orientations H∥c and H∥b, we find a narrow field region just below the magnetic saturation where the local magnetization remains uniform and homogeneous, while its value is field dependent. This behavior is the first microscopic signature of the spin-nematic state, breaking spin-rotation symmetry without generating any transverse dipolar order, and is consistent with theoretical predictions for the LiCuVO4 compound.

**Information Sources：**[http://www.emfl.eu/single/newsartikel/nuclear-magnetic-resonance-signature-of-the-spin-nematic-phase-in-licuvo4-at-high-magnetic-fields.html](http://www.emfl.eu/single/newsartikel/nuclear-magnetic-resonance-signature-of-the-spin-nematic-phase-in-licuvo4-at-high-magnetic-fields.html)

### 6. Magnetic field induced strong valley polarization in the three-dimensional topological semimetal LaBi

LaBi is a three-dimensional rocksalt-type material with a surprisingly quasi-two-dimensional electronic structure. It exhibits excellent electronic properties such as the existence of nontrivial Dirac cones, extremely large magnetoresistance, and high charge-carrier mobility. The cigar-shaped electron valleys make the charge transport highly anisotropic when the magnetic field is varied from one crystallographic axis to another. We show that the electrons can be polarized effectively in these electron valleys under a rotating magnetic field. We achieved a polarization of 60% at 2 K despite the coexistence of three-dimensional hole pockets. The valley polarization in LaBi is compared to the sister compound LaSb where it is found to be smaller. The performance of LaBi is comparable to the highly efficient bismuth.

**Information Sources：**[https://journals.aps.org/prb/abstract/10.1103/PhysRevB.96.161103](https://journals.aps.org/prb/abstract/10.1103/PhysRevB.96.161103)

## 强磁场与生物医学

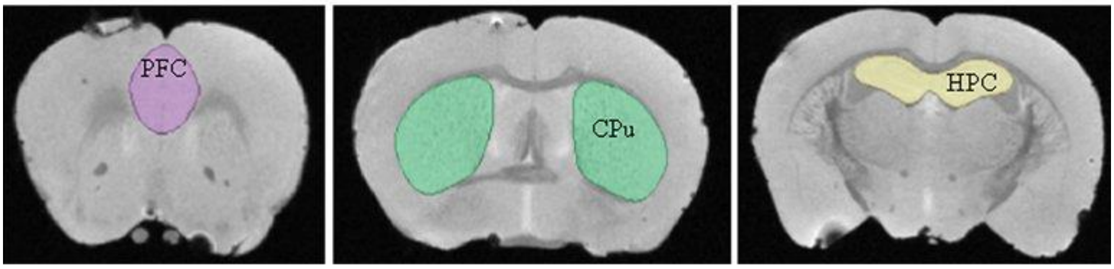
### 1. MRI illuminates link between heart disease and mood disorders

Using a powerful, 11.75-tesla magnetic resonance imaging (MRI) machine, scientists analyzed the brains of mice suffering from abnormal thickening of the heart muscle (called human hypertrophic cardiomyopathy, or HCM, which affects an estimated one in 500 people, according to the Cleveland Clinic). They found that older female mice with HCM, when compared to control mice, exhibit high anxiety and depression. They also found that, in the mice with HCM, regions of the brain associated with mood (the prefrontal cortex and caudate putamen) were smaller in volume. In humans, smaller volume of these brain structures has been associated with anxiety and depression. Scientists also found reduced activity in the hippocampus, thought to be the center of emotion and memory, another sign of mood disorder.

This analysis, together with neurochemical and behavioral measures, show that mood disorders are more common in older subjects experiencing the prolonged, systemic stress of heart failure.

These results reinforce the notion that, in addition to treating the cardiovascular symptoms of HCM, clinicians should assess its effect on the brain, including the presence of mood disorders. Clinicians should then treat both conditions to improve their patients' quality of life.

This research was conducted in the 11.75-T magnet located near the MagLab's Tallahassee headquarters at the FAMU-FSU College of Engineering.




***MRI images of mice brains, with regions related to mood segmented out: the prefrontal cortex (PFC) and caudate putamen CPu).***

**Information Sources : https://nationalmaglab.org/user-facilities/nmr-mri/publications-nmr-mri/highlights-nmr-mri/depression-anxiety-heart-disease**

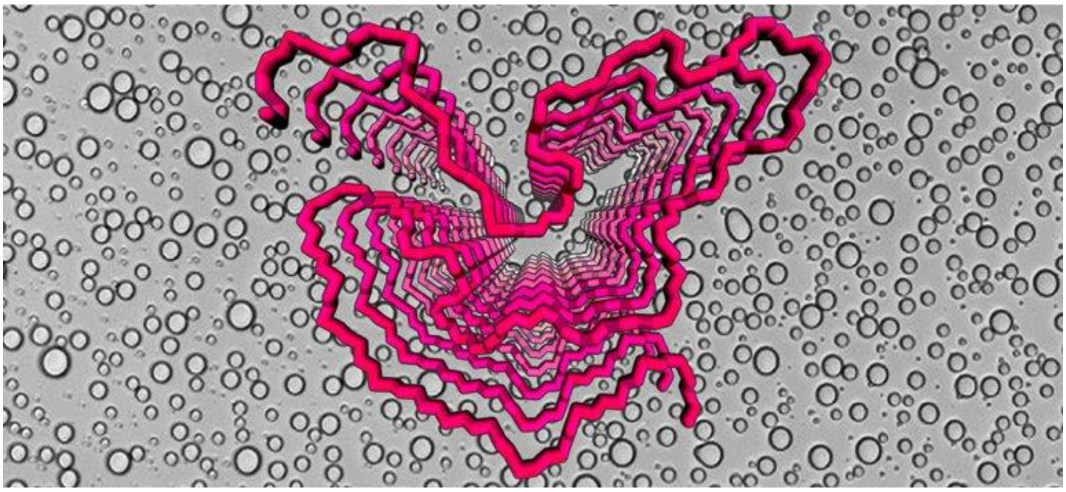
## 2. Study on motor neuron proteins lands on cover of Cell

Scientists doing research at the National MagLab have for the first time characterized the structure of a protein implicated in the onset of some of the most devastating neurodegenerative diseases. Their study, published today on the cover of the prominent biology journal Cell, sheds light on the mechanisms behind these diseases and may guide researchers toward ways to better understand and prevent them.

To better understand the formation of protein fibrils, Dylan Murray, a biophysicist at the National Institutes of Health (NIH), decided to observe it in a test tube. Specifically, he examined a kind of low complexity domain (LCD) protein called the FUS protein, which is known to coalesce into liquid droplets, or a liquid-liquid phase separation, that, over time, mature into something very similar to amyloids.

Using NMR instruments at the MagLab and NIH as well as other tools, the research team determined the molecular structure of the FUS protein. Notably, they characterized the fibrils that grow out of protein liquid droplets, which are made of repeating units of protein molecules. After taking precise measurements, the scientists were able to generate a 3D picture of what these fibrils look like.

The team also examined the critical role played by phosphorylation — the process whereby cells attach phosphate molecules to proteins. That action can turn on — or off — certain cell processes. Murray's research indicated that phosphorylation nips pernicious protein fibrils in the bud.



***Solid state NMR structure of the FUS low complexity domain. In the foreground is a backbone trace of nine repeating units (in pink) in the protein fibrils. In the background is a light microscope image of liquid droplets formed by the FUS low complexity domain that are melted by phosphorylation of the fibril core region.***

**Information Sources：** https://nationalmaglab.org/news-events/news/neuron-protein-cell

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