National High Magnetic Field Laboratory

2010 ANNUAL REPORT

Florida State University · University of Florida · Los Alamos National Lab

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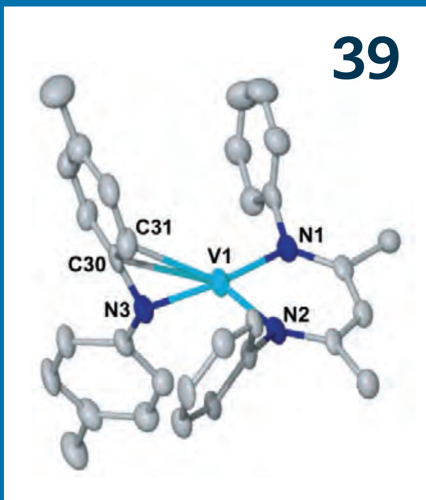

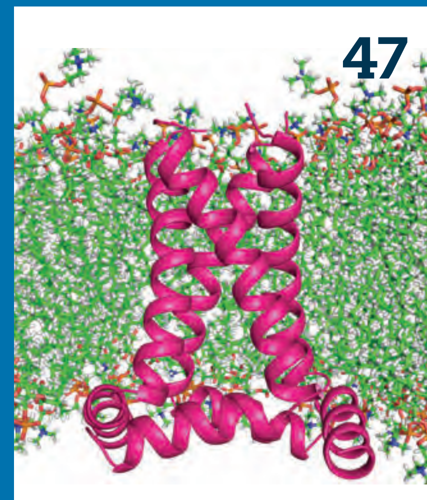

On the cover

Sites around the Magnet Lab facilities in 2010.

2010 ANNUAL REPORT

PUBLISHED BY
The National High Magnetic Field Laboratory
1800 East Paul Dirac Drive
Tallahassee, FL 32310-3706

PHONE NUMBER
(850) 644-0311

FAX NUMBER
(850) 644-8350

NHMFL DIRECTOR
Greg Boebinger

ASSOCIATE DIRECTOR
Brian Fairhurst

EDITOR
Kathy Hedick

GRAPHIC DESIGNER
Liz Vernon

This document is available in alternate formats upon request. Contact Kathy Hedick for assistance. If you would like to be added to our mailing list, please e-mail *hedick@magnet.fsu.edu*.

The Magnet Lab is supported by the National Science Foundation and the State of Florida

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2010 YEAR IN REVIEW by Gregory Boebinger

ABOVE Magnet Lab Director Greg Boebinger, in front of the 45 T.

It was a year of landmarks at the Magnet Lab. 2010 saw anniversaries of the lab's two most ambitious magnet projects, a symposium to celebrate one of its living (and working) legends, and the 100th anniversary of the discovery of superconductivity— a phenomenon receiving more intense study now than ever.

The 45 T Hybrid magnet system, in its tenth year of operation, continued its essential role in graphene exploration. Interest has also continued in topological insulators, with some user groups utilizing the 45 T and the Pulsed Field Facility in concert to chase interesting questions. Since 2001, "the 45" has provided data for 49 publications in *Nature, Nature Physics, Physics Review Letters, Science*, and *PNAS*. It's a decade-long span of productivity and relevance that shows no sign of waning.

The lab celebrated the 5-year anniversary of the 900 MHz ultra wide bore magnet, a system that has already yielded world-unique experimental results and continues to break new ground. Its potential, particularly in *in vivo* functional MRI, is still being realized with each experiment. Research from users Michael Harrington and Eduard Chekmenev at the close of the year was a particular standout. Their study represents the first *in vivo* MRI detection of the functional changes in sodium during migraine, and one of the first functional studies in the brain to utilize sodium instead of blood oxygenation to monitor neurological pain.

In December, around 100 colleagues and friends gathered to celebrate a milestone of a different kind at the Gor'kov symposium. Lev Gor'kov is a founding member of the Magnet Lab staff, and the occasion both marked his eighty-first birthday and celebrated his contribution to physics. Gor'kov is universally regarded as one of the top living theoretical physicists, and is widely acclaimed for his seminal contributions to the theory of superconductivity and the theory of metals, for his pioneering work on low dimensional organic materials, and more generally for his groundbreaking achievements in developing modern theoretical methods for quantum many-body systems.

The lab showed its flexibility and responsiveness when the Magnet Lab's Ion Cyclotron Resonance team, in partnership with Woods Hole Oceanographic Institute, mounted a rapid and sophisticated approach to analyzing the Deepwater Horizon oil spill. The team uses FT-ICR to analyze oil collected from the Gulf of Mexico to build a comprehensive compositional archive of molecular data from spill samples.

Research Reports ride wave of user investigation

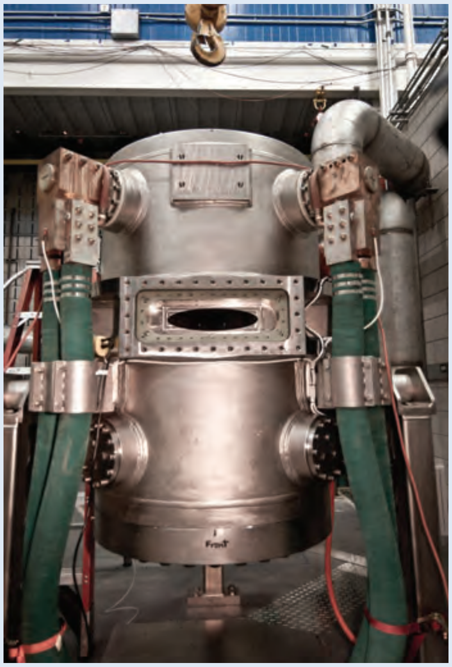
Our user community continued to thrive after experiencing a boom of new PIs in 2009, with the number of research reports we've received holding steady. Users successfully investigated a myriad of topics, with many riding the previous year's wave of interest in iron-based superconductors, graphene, and topological insulators.

Those lines of inquiry proved worthwhile, as the following stats can attest.

In 2010, 417 research reports were received in 18 categories, representing the life sciences, chemistry, magnet science and technology, and condensed matter physics.

- 22% of the research activities (92 reports) were already published in 2010, many in prominent journals.
- 18 reports were accepted for publication; 49 were submitted for publication; and 155 have manuscripts in preparation.
- The majority of research projects were funded by the U.S. National Science Foundation, the U.S. Department of Energy, and the U.S. National Institutes of Health. Other funding organizations included: American Heart Association, Electric Power Research Institute, ITER,

ABOVE Some of the publications which highlighted research done by Magnet Lab users and staff in 2010. See page 38 to read about P.J. Hirschfeld's work on superconductor grain boundaries, featured on the cover of *Nature Physics* (left).



Split Coil Magnet Construction

Pictured at left is the nearly completed Split Florida Helix Magnet, newly installed in the DC Field Facility's Cell 5. The magnet features a traditional bore tube, along with four elliptical scattering ports. First modeled and tested in 2007, the magnet was fabricated in 2009-2010 and will be fully installed and operational for users in June of this year. The centerpiece of the magnet is the four-opening elliptical port apparatus (pictured at left), an engineering feat in its own right. The world-unique magnet system is expected to provide magnetic fields in the range of 25 tesla using less than 28 megawatts of DC power.

NASA, NOAA, U.S. Air Force Office of Scientific Research, U.S. Army, U.S. Navy, and numerous universities. Research was also supported by science federations, ministries, and universities in countries around the world including: Denmark, Slovenia, China, Brazil, India, United Kingdom, European Commission, Germany, Israel, Japan, Korea, Poland, Canada, Russia, and Greece.

• The Magnet Lab User Collaboration Grants Program supported 43 of the 418 research activities and was the primary support for 17 projects.

User Program enhancements

Technical improvements across the board meant more accurate data and less downtime for our user community.

The DC Field facility concentrated this year on nuts-and-bolts improvements to the user experience. Users enjoyed a major renovation to the sample prep room, with more space, better light, and added microscopes. The DC Field has also achieved better temperature control and stability for experiments, along with faster temperature changes — translating to less prep time and more time taking data for users. New probes for the SCM-2 cryostat are more reliable, modifiable, and better wired.

In the millikelvin facility, a top-loading system for users allows for automated slow-loading and slow-cooling of samples, a boon for precision-seeking users and a time-saver for staff.

At AMRIS, six of eight instruments in the facility were upgraded or received funding for upgrades in 2010, for a total of $2.6 M in instrumentation investment. National Institutes of Health instrumentation awards provided $1 M in funding. The Magnet Lab funded an additional $600,000; the remainder came from NIH grants and the University of Florida's match. Upgrades to the 3T magnet were paid for through the McKnight Brain Institute Director's fund. AMRIS also partnered with the Magnet Lab's High B/T Facility on a successful ARI-R^2 proposal to revitalize the UF helium liquefaction and recovery system.

At Los Alamos, the new 4-megajoule capacitor bank is operational for user research, providing users with reliable operation and significantly greater flexibility for configuration. The lab has also made various safety improvements.

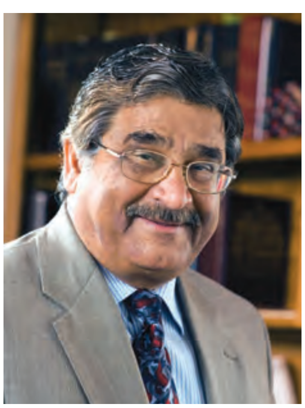
Honors, awards and promotions

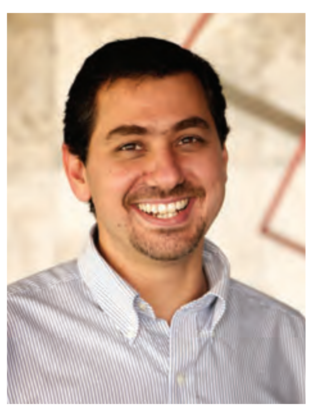
This year, Chuck Mielke and Jon Betts, both LANL veterans, took on new responsibilities. Mielke was promoted to Director of the Pulsed Field Facility, and Betts took on the role of LANL User Program Director after serving in an interim role.

Several Magnet Lab staff members and affiliates were named fellows of the American Physical Society, including:

• Scott Crooker, staff member at the lab's Pulsed Field Facility at Los Alamos National Lab, "for the development of magneto-optical spectroscopies and their applications to colloidal quantum dots and electron spin transport and noise in semiconductors."

• Vladimir Dobrosavljevic, Professor of Physics at The Florida State University and director of the Magnet Lab's Condensed Matter Science-Theory program, "for research on fundamental localization processes near the metal-insulator transition, particularly the interplay of strong electronic correlations, disorder,





ABOVE Naresh Dalal (left) became an ACS fellow, while APS fellowships went to Lloyd Engel (middle) and several other Magnet Lab scientists in 2010. Chuck Mielke (right) was recently promoted to Director of the Pulsed Field Facility at the lab's Los Alamos branch.

and quantum glassy dynamics."
• Lloyd W. Engel, graduate research faculty member in physics at FSU and a scholar/scientist at the Magnet Lab, "for contributions to the study of the quantum Hall effects and associated electron solid phases using microwaves in very high magnetic fields."
• Huan-Xiang Zhou, Professor of Physics at FSU and an affiliate of the Magnet Lab's Nuclear Magnetic Resonance program, "for his pioneering contributions to theoretical and computational biophysics, in particular by developing elegant theories and methods on protein-ligand binding and the effects of intracellular environment on biophysical properties of proteins."

Naresh S. Dalal, FSU's Dirac Professor of Chemistry and Biochemistry and an active member of the Magnet Lab's Electron Magnetic Resonance program, was elevated to the rank of fellow by the American Chemical Society (ACS). His work has contributed greatly to fundamental knowledge about electricity and magnetism, and has potentially major applications in such areas as medical imaging and the development of new, solid-state devices.

Finally, Joan Crow, a mentor to scores of middle school students since the lab's early days, retired after 15 years of coordinating a program that married gifted middle school students to productive, working lab environments. Crow is the widow of Magnet Lab founding Director Jack Crow, and their twin goals of research and education helped to cement the lab's educational reach in the region.

ABOVE Research Experience for Undergraduates (REU) class of 2010.

CIRL's outreach approach inventive, comprehensive

The Center for Integrating Research and Learning's creative approach to nurturing young people's interest in science continued to widen its reach in schools, the community and in increasingly vital social networks.

The past year saw the launch of CIRL's Science Café, a monthly lecture headquartered in a local bar. The goal of the Café is to spark conversations about science in daily life. The series, facilitated by CIRL postdoctoral researcher Roxanne Hughes with support from Public Affairs, enjoys standing-room-only crowds on the first Tuesday of each month. Topics have ranged from applied subjects (alternative energy, the Deepwater Horizon oil spill) to more esoteric ones (the physics of time).

Kids and their families get nontraditional access to lab outreach (and grad students, the opportunity to conduct it) during Science Nights, which take place at local schools and can attract up to 250 parents and students.

The lab's REU and RET programs remain an established success, with 22 undergraduates and 14 K-12 teachers gaining valuable hands-on lab experience in 2010. An initiative to track the past REUs via social networking kept those students connected to both CIRL and to each other.

Local and regional schools continue to utilize CIRL's classroom outreach offerings in droves. In 2010, classroom outreach was conducted for 9,099 students from 11 counties in North Florida and South Georgia; 970 students came to the Magnet Lab for field trips and tours.

Middle school mentorship and SciGirls I and II camps for middle and high school girls ensured that the lab provides attention-getting, immersive programming at the very age many children begin losing interest in science. Thirteen middle school students participated in the mentorship program, and 32 young women learned about everything from magnet science to animal surgery through SciGirls.

More information about CIRL's outreach, as well as info about their research and diversity initiatives, can be found in Chapters 6 and 9.

Diversity Committee launches new program

This year marked the launch of the Diversity Committee's Dependent Care Travel Grant Program (DCTGP), which seeks to assist and advance the careers of underrepresented groups, including women, by providing grants for travel-related expenses for dependents. The DCTGP was approved by the FSU administration in July, and it was first announced at the User Committee meeting in October. The information and the application form have been posted on the User Portal and on the Diversity webpage.

The Diversity Committee proved that small gestures can make a big impact, particularly for early career scientists, providing travel support for undergraduate, grad students and postdocs from underrepresented groups, facilitating their attendance at both external conferences and in-house research/ educational opportunities.

See Chapter 9 for a complete rundown of the ways the Diversity Committee and the Magnet Lab reach early career and aspiring scientists from underrepresented groups.

Public Affairs reaches out to users, community

Public Affairs continued its effort to reach both users and the general public in new and inventive ways, partnering with CIRL to hold and promote the Science Café events described above.

Also new this year was December's **Spare Part Art** show. The lab invited 25 local and regional artists, including several FSU faculty, to create artwork made wholly or in part from Magnet Lab waste — everything from scrap metal to outright garbage. The event attracted an opening night crowd, press coverage in several cities, and tour groups.

For the science community, the content of *Mag Lab Reports* was retooled with a more user-centric focus, with user science featured in each issue, detailed magnet system advertisements, and explanations of the web portal and renewal proposal input process. Magnet Mystery Hour, our ongoing quarterly lecture series, continued to draw robust attendance, and MLR's sister publication for non-scientists, *Flux*, continued production.

The Magnet Lab annual Open House featured a brace of new demonstrations and as always, curious visitors of all ages packed the building to the gills.

ABOVE In 2010 about 5,700 people attended the Magnet Lab's 15th annual Open House — more than any other Open House held so far.

Open House 2010 BY THE NUMBERS

Number of visitors	5,709
Pounds of food collected for Second Harvest Food Bank	1,139
Cups of cornstarch used in oobleck (a non-Newtonian fluid!)	674
Pounds of potatoes fired in potato cannon	200
Number of science demonstrations	77
Quarts of dairy products used to make Einstein Ice Cream	62
Number of quarters shrunk in shrinking quarter machine and given away	40
Number of participating organizations	17

CHAPTER 2
Research Highlights

	Reports Received	Highlights Selected
Condensed Matter Science	191	22
Magnets & Magnet Materials	46	5
Chemistry	102	8
Life Sciences	78	5
TOTAL	417	40

This year's 40 highlights were selected by combing through the annual report's 417 user and faculty submitted research reports from 18 categories representing the life sciences, chemistry, magnet science and technology and condensed matter science.

The highlight-selection criteria emphasize research that is published, features a new technique for future users, and showcases outstanding research. Together, the highlights span all three Magnet Lab sites and seven user programs. After we receive the reports, the lab's Science Council, composed of scientists representing all three Magnet Lab sites, reviews each report and narrows the field to a few dozen standouts. That field is then narrowed into a final list by lab Director Greg Boebinger.

The Science Council is made up of Chair Albert Migliori, and members Art Edison, Gail Fanucci, Zhegong Gan, Lev Gor'kov, Stephen Hill, Jurek Krzystek, David Larbalestier, Denis Markiewicz, Dragana Popović, Ryan Rodgers, Theo Siegrist, Glenn Walter and Huub Weijers.

The 2010 Science and Engineering Highlights are published as Special Edition of the laboratory's magazine *Mag Lab Reports*, and are presented in this report as representative of the lab's broad research portfolio. For more information on the scientific productivity of the Magnet Lab, including presentations and theses, see Chapter 10 of this report.

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Technique Development

YbAgGe is a stoichiometric heavy-fermion compound that has attracted the attention of the correlated-electron-system community since its discovery by Bud'ko *et al.* in 2004 because of its frustrated antiferromagnetic ground state. While a number of phase boundaries have been discussed as a function of magnetic field, temperature and pressure — Tokiwa *et al.* (2006) and Kubo *et al.* (2010) — Schmiedeshoff *et al.* here report unprecedented details of the (H,T) phase boundaries that could help to further develop a global theory for heavy-fermion compounds.

- Accepted for publication as a Rapid Communication in *Physical Review B.*

Magnetostriction as a Phase Diagram Probe for Quantum Criticality of YbAgGe

G.M. Schmiedeshoff (Occidental College);
E.C. Palm, S.T. Hannahs, J.–H. Park, T.P. Murphy (Magnet Lab, Florida State University);
S.L. Bud'ko and P.C. Canfield (Ames Laboratory and Iowa State University)

YbAgGe is a stoichiometric heavy-fermion antiferromagnet exhibiting non-Fermi liquid (nFL) behavior attributed to a field-induced quantum critical point (QCP) near 4.5 T[1]. Thermal-expansion measurements (made at Occidental College) and magnetostriction measurements (made at the Magnet Lab/Tallahassee, see Figure 1) made with capacitive dilatometers[2] reveal a phase diagram of YbAgGe studied with unprecedented detail in the regions near 4.5 T (labeled "c" and "d" in Figure 2). The phase transition at 4.5 T, labeled H_3 in Figure 1, has a first-order character that is not consistent with the existence of a QCP (which are generally continuous phase transitions). We suggest that this is a metamagnetic transition and that YbAgGe is close to a quantum critical end-point at 4.5 T. The phase transition on the high field side of the d-phase (labeled H_5 in Fig 1.), however, is continuous and we suggest that a QCP at H_5 =7.2 T is responsible for the observed nFL behavior nearby.

Recent theoretical work characterizing several quantum critical materials on a global phase diagram incorporating Kondo coupling and degree of magnetic frustration [3] suggests that YbAgGe may evolve from AF order (d-phase) through a spin-liquid phase (e-phase) before a Fermi liquid (FL) phase (f-phase) is recovered. FL behavior has been observed above 12 T [1] and the large magnetostriction we observe in the e-phase is consistent with spin-liquid behavior [4]. More details on these measurements and the arguments underlying our proposals and interpretation will appear elsewhere [5].

Acknowledgements

This work was supported by the National Science Foundation under Grant No. DMR-1006118 and by the U.S. Department of Energy, Basic Energy Sciences, under Contract No. DE-AC02-07CH11358. We also acknowledge support through the Magnet Lab's User Collaboration Grant Program (UGCP).

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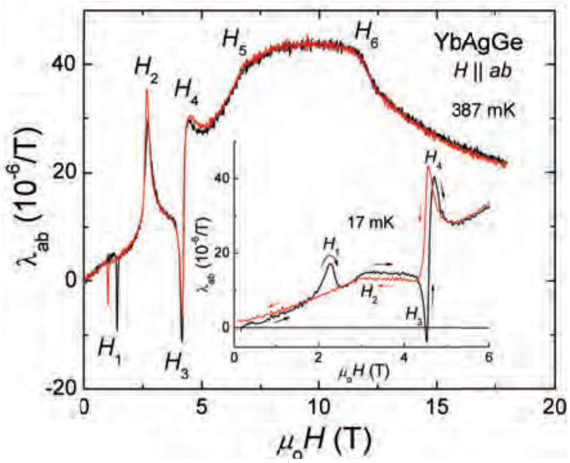

FIGURE 1. Typical magnetostriction data with H applied in the basal plane.

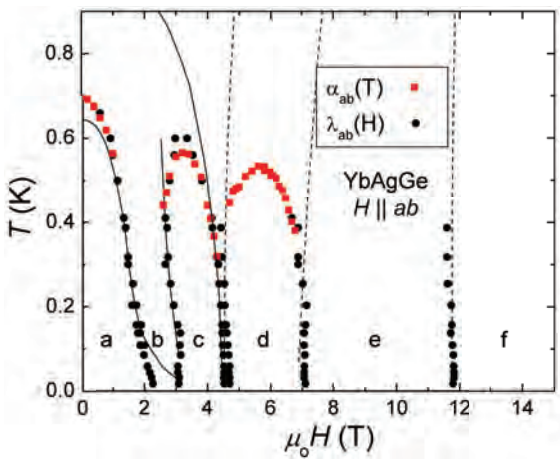

FIGURE 2. Phase diagram of YbAgGe from dilation measurements. The solid lines represent earlier measurements of thermodynamic phase boundaries, the dashed lines represent features in the Hall resistivity.

Technique Development

Here the authors report a significant improvement to the capabilities offered in the DC Field Facility, with the implementation of new brushless motors to rotating probes in DC superconducting magnets. The probes furbished with the new motors show unprecedented signal-to-noise levels, resolution and versatility, and will certainly have a big impact in the quality of the data acquired at the facility. These noise-free rotating probes will be particularly valuable for users researching anisotropic metals and molecular magnets in the soon-to-be-commissioned split magnet.

Improvement of the Rotating Probes at the Mag Lab DC Field Facility

A. Suslov; T. Murphy; S. Hannahs (Magnet Lab, FSU)

Introduction

Currently stepper motors[1] are installed on the rotating probes[2] at all systems of the Magnet Lab's DC Field Facility. These motors allow researchers to perform measurements in tilted magnetic fields and to achieve precise orientation of a sample with respect of the field when required. At the same time, it is known that these motors produce strong electrical noise, thus decreasing the signal-to-noise ratio and even compromising temperature stabilization at dilution refrigerator temperatures. Nowadays, compact brushless motors are available[3]. We performed extensive tests to understand if installation of brushless motors is beneficial in comparison with the currently used stepper motors.

Experimental Results, Discussion and Conclusions

A brushless motor was installed at the rotating probe used for the 18 tesla (T) magnet with Variable Temperature Insert (VTI) and/or ^{3}He cryostat (SCM2). Software allowing control of the brushless motor was designed and incorporated into the data-acquisition software used at the entire DC Field Facility. We tested the ability of the motor to perform proper operations while the experiments were conducted in magnetic field and at a temperature down to 0.3K. The tests were repeated at various parameters, i.e. rotation speed, rotation distance/step, proportional-integral-derivative (PID) coefficients, maximal acceleration/deceleration, etc. Software bugs were found and fixed during the tests.

For the testing, we simultaneously measured longitudinal and Hall voltage of a two-dimensional system in a Si/SiGe heterostructure. The results of 48-hour continuous rotation [Figure 1(a)] show the suitability of the motor for long time measurements. Several runs (note red curves) were performed at the same field values to test reproducibility of the sample position. Note that due to the design of the probe, 90 degrees of the sample rotation corresponds to about 10,000 degrees of the motor rotation. Also, measurements were performed on the same sample using our standard stepper motor and the new brushless motor. The motors were exchanged at the top of the probe without unloading the sample from the cryostat. Thus, the same experimental conditions, i.e., the field values, the temperature value, and the angle position, were assured. The results of these measurements are presented in Figure 1(b) and show that the brushless motor significantly reduces noise in the transport measurement compared to the stepper motor. Our tests confirm that brushless motors are a good replacement for the stepper motors. We are installing brushless motors and testing them on other DC Field systems including dilution refrigerators.

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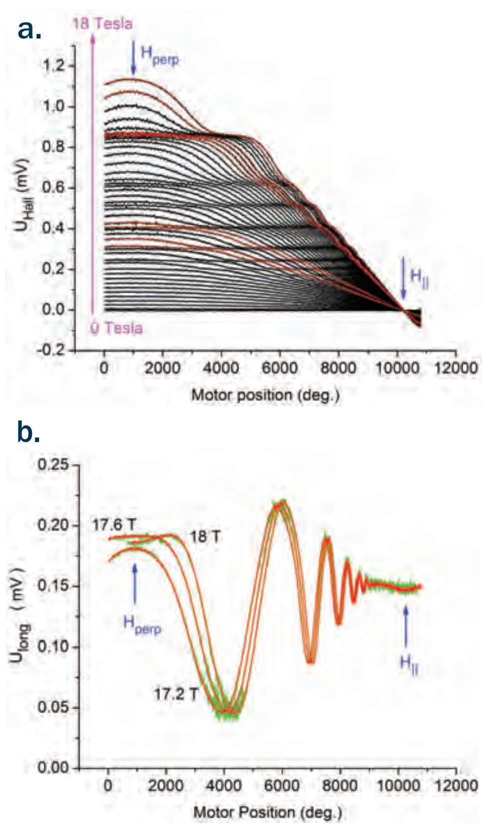

FIGURE 1.
a. Hall voltage dependence on the tilt angle measured on a Si/SiGe Hall bar at various magnetic fields of up to 18 T and temperature 1.7 K. Field step 0.4 T.
b. Longitudinal magnetoresistance measured on the same Hall bar using a stepper motor (green) and a brushless motor (red).

Technique Development

This is a beautiful set of skin-depth results that show clean quantum oscillations in the pressure-induced metallic state of the title compound. The data, taken as a function of field and angle, reveal an anisotropic Fermi surface displaying a single fundamental frequency, as well as other features that suggest magnetic breakdown in small pockets. This report illustrates an elegant example of the use of a contactless tunnel diode oscillator (TDO) technique in a pressure cell for high magnetic field Fermi surface investigations to ^{3}He temperatures.

Quantum Oscillations in $EtMe_3P[Pd(dmit)_2]_2$ Under Pressure

D. Graf, T. M. Murphy, E. C. Palm, R. L. Stillwell, J.-H. Park, S. W. Tozer (Magnet Lab, FSU);
R. Kato, H. B. Cui (Condensed Molecular Materials Laboratory RIKEN, Saitama, Japan)

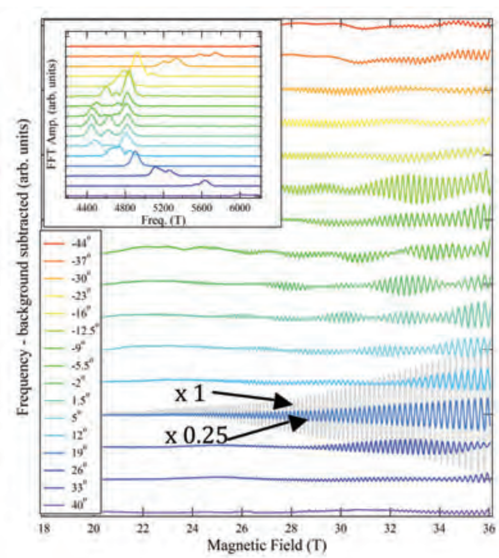

FIGURE 1. Skin-depth measurements of $EtMe_3P[Pd(dmit)_2]_2$ at T ~ 350 mK and 2.3 kbar. A 3 term polynomial was subtracted from the background. Inset: Fast Fourier transforms of the data.

Introduction

The quasi-two-dimensional (Q2D) organic compound $EtMe_3P[Pd(dmit)_2]_2$ contains conduction layers composed of [Pd(dmit)2] molecules and insulating layers containing $EtMe_3P$. Dimers of $[Pd(dmit)_2]$ contain one electron each and have a Coulomb repulsion larger than the bandwidth leading to a Mott insulator. When cooled below ~ 25 K, a lattice distortion allows for the formation of an insulating valence bond solid (VBS) state. Previous transport measurements under 2 kbar of pressure have shown the suppression of the VBS, revealing resistivities as low as 100 mΩ cm preceding a superconducting state at T_c ~ 5 K[1]. Here we report on contactless skin-depth measurements undertaken in a miniature non-metallic diamond anvil cell.

Experimental

Skin-depth measurements were performed at the Magnet Lab's DC Field Facility in a 35-tesla DC magnet using "System D" (sorb pumped He-3). The ~ 400 μm diameter sample was wrapped with a coil of wire and placed in the gasket of a diamond anvil cell. An oil medium was used for quasi-hydrostatic pressure and the pressure was calibrated at the experimental temperature using the fluorescence peak of a small chip of ruby.

Results and Discussion

The TDO frequency was amplified, mixed and recorded as the field was swept (Figure 1). Fast Fourier transforms (FFT) of each trace were taken, finding a fundamental frequency of F_α ~ 4600T (Inset of Figure 1). The behavior of the frequencies deviates slightly from the F/cos(θ) dependence expected from a 2D Fermi surface cylinder where we observed a number of closely spaced peaks near θ ~ 0°. In this orientation, a set of three peaks occurs near ~ 4600 T with another peak at F_β ~ 180 T. This is reminiscent of another $M(dmit)_2$ compound, $Et_2Me_2N[Ni(dmit)_2]_2$, where similar frequencies were found but pressure was not required[2]. The FFT peaks suggest magnetic breakdown orbits, where we observe the $F_{\alpha-\beta}$, F_α and $F_{\alpha+\beta}$ frequencies.

A warped Fermi surface topology may explain the sharp increase in oscillation amplitude observed at θ ~ 19°, where the grey trace shows the unchanged amplitude. With a warped Q2D Fermi surface tilted into a specific orientation with respect to the applied field, all of the carriers at the highest Landau level contribute to the same sized orbit, rather than different sizes from necks and bellies, and a single dominant oscillation frequency emerges.

Conclusions

Skin-depth measurements have confirmed that the insulating VBS state of $EtMe_3P[Pd(dmit)_2]_2$ is suppressed by moderate pressures of ~ 2 kbar. At low temperatures an anisotropic Fermi surface is revealed with a fundamental frequency of F_α ~ 4600T, and features suggesting the possibility of magnetic breakdown with small pockets.

Acknowledgements

This work was funded by the DOE/NNSA under DE-FG52-06NA26193. HBC and RK acknowledge support from a Grant-in-Aid for Scientific Research on Innovative Areas (20110003).

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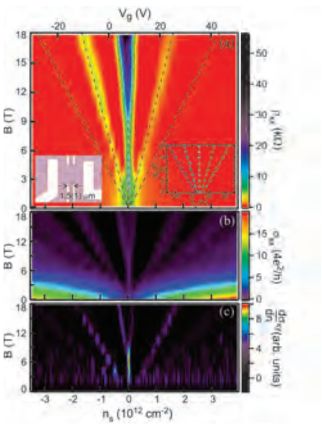
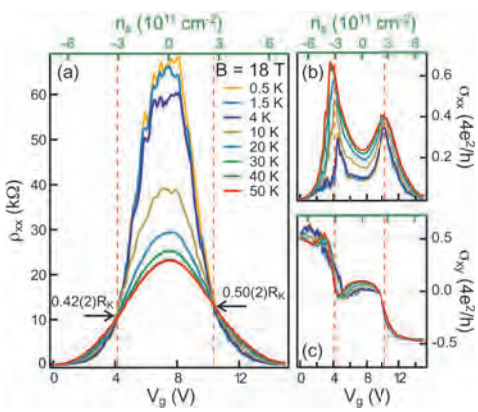
Graphene

The nature of the electronic states at the zero-energy (*N*=0) Landau level (LL) has not been well understood. This report describes magnetotransport experiments in single-layer graphene that have allowed the mapping of the low-temperature (B, n_s) phase diagram of the electronic states at the *N*=0 level. The metal-insulator transition (MIT) from the quantum Hall effect plateau state to an insulating phase is identified, reconciling at the same time various conflicting data reported earlier by other groups.
• Published in *Physical Review Letters* **105**, 046804 (2010).

Metal to Insulator Transition on the *N*=0 Landau Level in Graphene

L. Zhang, **Tonica Valla**, **I. A. Zaliznyak** (Brookhaven National Laboratory, Condensed Matter Physics and Materials Science Department);
Y. Zhang, **E. Mendez** (State University of New York, Physics)





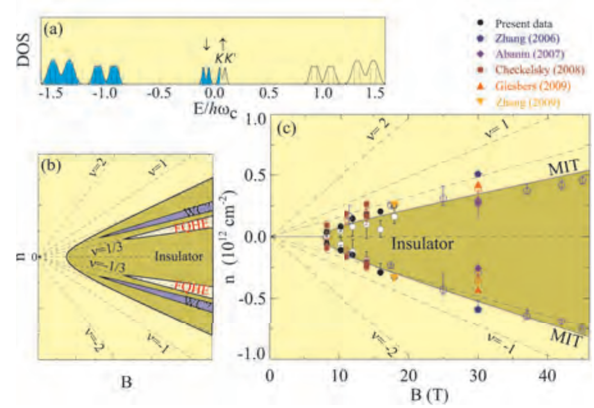


FIGURE 1. a., b. & c. A well-defined insulating region is seen in resistivity ρ_{xx}(ns, B),conductivity σ_{xx}(ns, B),and the derivative of the Hall conductivity, $d\sigma_{xy}/dn_S$.
FIGURE 2. a., b. & c. ρ_{xx}(ns), σ_{xx}(ns) and σ_{xy}(ns) at different temperatures for B = 18 T. Broken vertical lines bound insulator region at low charge density, ns.
FIGURE 3. a., b. & c. Schematics of the Landau levels and the proposed phase diagram for graphene system.

Introduction

Graphene has remarkable electronic properties. In a perpendicular magnetic field B, where electron states are quantized Landau levels (LL), it develops an anomalous semi-integer quantum Hall effect (QHE). At the N=0 LL, the nature of the electronic states is still unclear. The primary goal of this portion of our program is to investigate the quantum Hall transport in graphene samples under high magnetic field with the goal to improve our understanding of the local structure of quantum Hall states in graphene.

Experimental

We used the cell-12 system (He-3 system, magnetic field up to 35 T) and the He-3 system in SCM2 (T down to 0.3 K, B up to 18 T). The sample preparation and device fabrication was done at the Brookhaven Center for Functional Nanomaterials. We carried out a series of measurements of magnetoresistance in graphene devices aimed at exploring and quantifying the insulator behavior emerging in strong magnetic field in samples with high mobility (above 5,000 cm^2/Vs).

Results and Discussion

Figure 1 illustrates the breakdown of the $N = 0$ quantum Hall state and the appearance of the insulating behavior in our graphene sample in high magnetic field and at low temperature. A clear feature corresponding to quantum phase transition is observed near ns=0. The temperature dependence in Figure 2 is completely consistent with Figure 1. Here the metal-insulator transition is also clearly revealed by the crossing of ρ_{xx}(ns) curves measured at different T.

Conclusions

We thus establish a phase diagram of the metal-insulator transition at the N =0 LL for graphene. MIT occurs in the regime of the dissipative transport, where Rxx>$R_K/2$, and at $\rho_{xx} \approx R_K/2$. It is surprisingly similar to the plateau insulator transition in a two-dimensional electron gas. The main difference is clearly seen in the low-field part of the phase diagram of Figure 3, where Klein tunneling of Dirac electrons in graphene impedes the low density insulating phases.

Acknowledgements

We thank J.-H. Park, T. Murphy and E. Palm for help with the measurements. This work was supported by the U.S. DOE under the Contract No. DE-AC02-98CH10886. Work at the Magnet Lab is supported by the NSF through Grant No. DMR-0084173 and by the state of Florida.

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Graphene

This report describes two-terminal magnetoconductance measurements on suspended graphene samples. The results represent the first evidence for the fractional quantum Hall effect in bilayer graphene, as well as the first observation of the quantum Hall effect of any kind in trilayer-graphene devices.
•Published in *Physical Review Letters* **105**, 246601 (2010).

Evidence for Fractional Quantum Hall States in Suspended Bilayer and Trilayer Graphene

C.N. (Jeanie) Lau, W. Bao, J. Velasco Jr., L. Jing, Z. Zhao (U. California, Riverside, Physics);
D. Smirnov (Magnet Lab, FSU, Physics)

Introduction

Graphene, with its anomalous "half-integer" quantum Hall effect (QHE), has emerged as a new platform for physics in low dimensions and special symmetry groups such as SU(4). Bilayer graphene and trilayer graphene have attracted significant attention, as their charge carriers are massive Dirac fermions with many predicted novel phenomena, such as tunable band gap, tunable excitons with possibility of condensation, and unusual flavor symmetry.

Experiment Results

Using low-temperature transport measurements, we experimentally investigated magnetoconductance on suspended bilayer graphene and trilayer graphene devices with mobilities up to 270 000 cm^2/V s[1]. For bilayer devices, we observe clear resolution of all integer QH states with 0 ≥ ν ≥ -8, indicating lifting of the degeneracies for the zeroth, first and second Landau levels (LL). At higher magnetic fields up to 31 tesla (T), we observe the *n*=1/3 fractional QH state, which disappears at ~ 2-5 K (Figure 1a). For the trilayer devices, we observe QH features at filling factors -4, -2, -1 and 0, as well as a feature at filling factor ν~0.5 that persists up to 5 K, which may correspond to the ν =1/2 or 2/5 state in the SLG-like branch of the trilayer's energy spectrum. This is the first time that QH features of any kind have been observed in trilayer devices.

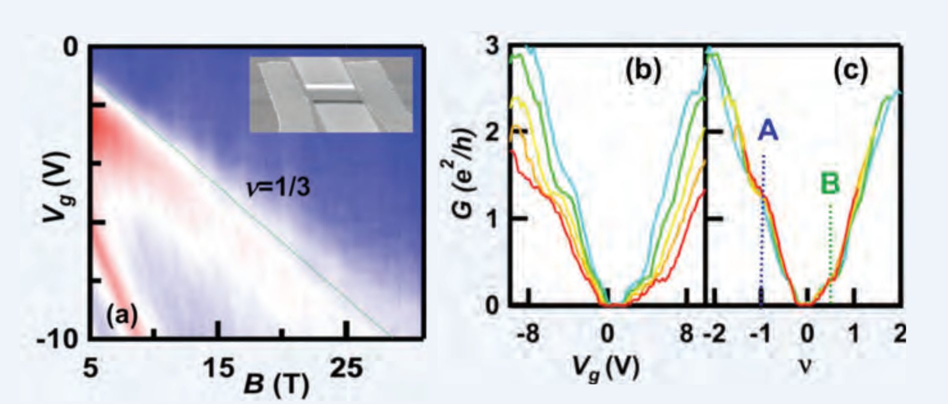

FIGURE 1.
a. Bilayer device: conductance G vs. gate voltage V_g and magnetic field B at 300 mK. Inset: SEM image of a suspended graphene device.
b. Trilayer device: $G(V_g)$ and $G(\nu)$ at B=2.2, 2.5, 3.0, 3.5, 3.8 T.

Acknowledgements

We acknowledge the support of NSF CAREER DMR/0748910, NSF/ECCS 0926056, ONR N00014-09-1-0724, and FENA Focus Center. D.S. acknowledges the support by NHMFL UCGP #5068.

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Graphene

This report describes the observation of the fractional quantum Hall effect (FQHE) in high-mobility, multi-terminal single-layer graphene devices fabricated on a single-crystal boron nitride substrate. The observed FQHE states exhibit an unusual hierarchy, which is attributed to the special symmetry of graphene.

Fractional Quantum Hall Effect in Graphene on Boron Nitride

C. R. Dean (Columbia University, Electrical Engineering and Mechanical Engineering);
P. Kim, H. Ren, A.Y. Young (Columbia University, Physics);
P. Cadden-Zimansky (Columbia University, Physics and Magnet Lab, FSU);
J. Hone, L. Wang (Columbia University, Mechanical Engineering);
T. Taniguchi, K. Watanabe (National Institute for Materials Science, Japan);
K.L. Shepard (Columbia University, Electrical Engineering)

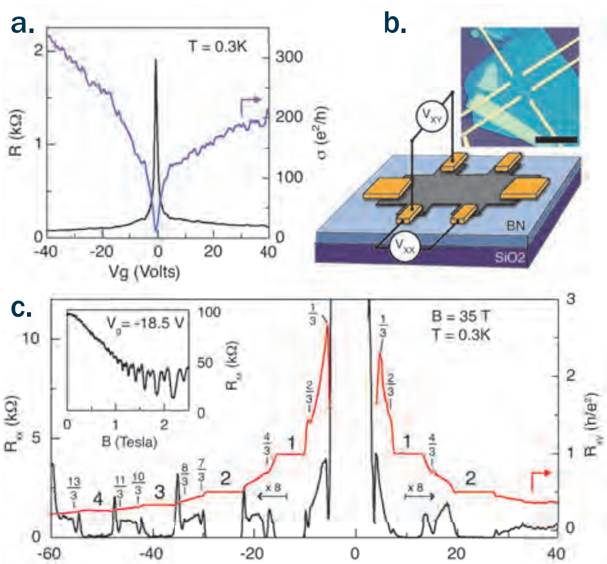

FIGURE 1.

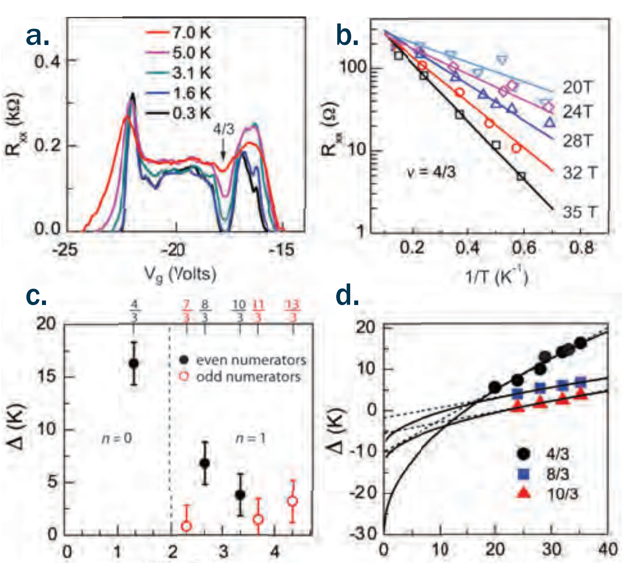

FIGURE 2.

Introduction

The fabrication of graphene devices on single-crystal boron nitride (BN) substrates has lead to an order-of-magnitude improvement in sample quality over previous devices fabricated on silicon substrates. This improvement has enabled the first transport measurements of high-mobility graphene in a multi-terminal Hall bar geometry over a wide range electron densities. Unambiguous signatures of the fractional quantum Hall effect (FQHE) were observed in both the lowest and first excited Landau levels (LL).

Experimental

Graphene/BN heterostructures were fabricated by mechanically exfoliating graphene and BN separately onto Si/SiO_2 substrates. Graphene flakes were then mechanically transferred onto BN, patterned into a Hall bar using conventional electron beam lithography techniques, and contacted with electrical leads consisting of a Cr/Au metal stack. Four-terminal transport measurements were performed using standard low-frequency lock-in techniques. All measurements were performed in a 35 tesla (T) resistive magnet with the sample mounted in a ^{3}He cryostat (sample in vapor) at an approximate 300 mK base temperature.

Results and Discussion

At 35 T our samples show clear evidence of the FQHE (Figure 1). Signatures of the $\nu = 1/3$ and $\nu = 2/3$ states, previously detected only in two-terminal measurements of suspended graphene samples, are found, with the best developed fraction appearing at $\nu = 4/3$. The FQHE is also observed at several filling fractions in the second Landau level with the gaps measured by thermal activation (Figure 2) to be approximately 10 times larger than those reported for the best GaAs samples, despite our graphene sample possessing an order-of-magnitude lower mobility. In the lowest LL, an unexpected hierarchy of the FQHE states is found, which we ascribe to the approximate SU(4) symmetry of the quantum states expected for graphene.

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Magnetism & Magnetic Materials

In the complex material Co_3V_2O with competing magnetic interactions, an external magnetic field influences the cobalt atoms and their local bonds to oxygen atoms. It was found that the cobalt atoms locally distort their enviroment and change their vibration frequency. This gives rise to a large magnetoelastic response of the material.
•Published in *Physical Review B.* **81**, 012403 (2010).

Magneto-elastic Coupling in Magnetically Frustrated $Co_3V_2O_8$

J.L. Musfeldt, L.I. Vergara, J. Cao (University of Tennessee);
L.-C. Tung, Y.J. Wang (Magnet Lab, FSU);
F. Yen, Y.Q. Wang, B. Lorenz (University of Houston);
N. Rogado, R.J. Cava (Princeton University)

Introduction

Competition between charge, structure and magnetism forms the basis for many properties of novel materials. Recent investigations reveal strong evidence for lattice flexibility in coupled systems although the microscopic aspects of these interactions and the effect of magnetic field on local structure are not well established. This is because direct observation of field-dependent phonons is rare, and there are few physical systems with which to evaluate specific changes in bond lengths and angles that accompany magnetic transitions. As a candidate for a frustrated solid that can exhibit substantial magnetoelastic coupling, we considered the Kagome staircase material $Co_3V_2O_8$ and employed high-field vibrational spectroscopy to evaluate magnetic-ordering-induced local lattice distortions.

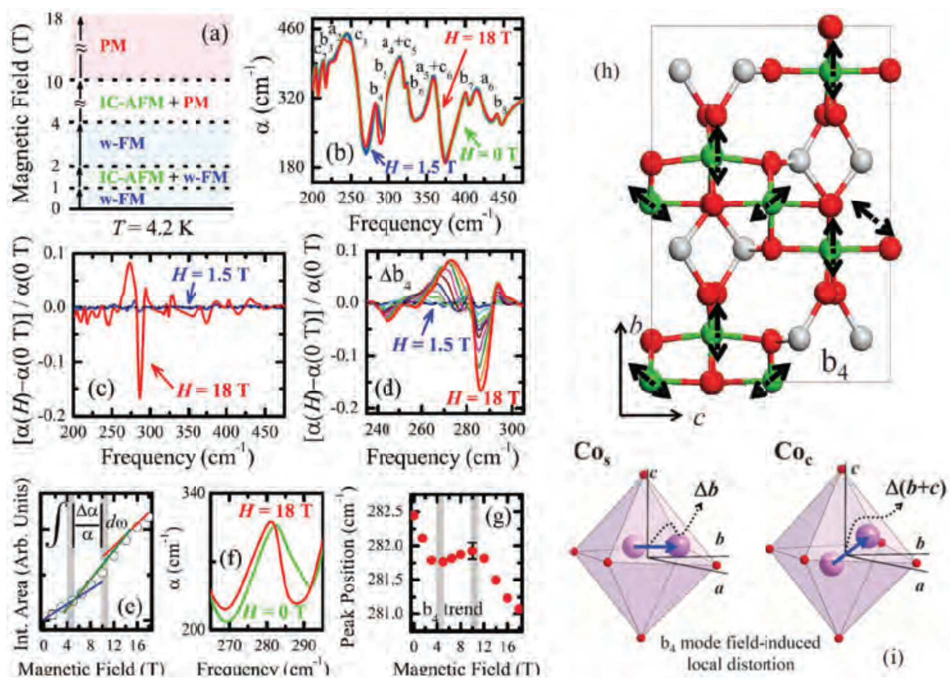

FIGURE 1. a. Schematic phase diagram. **b.** Absolute absorption spectra at low frequency. **C.** Absorption difference spectra calculated from data shown in b. **d.** Close-up view of the absorption difference spectra near 280 cm-1. The data are shown for 1.5, 3, 5, 6.5, 8, 10, 12, 14, 16, and 18 T. **e.** Integrated area in arbitrary units, the solid straight lines show trend changes. **f.** Close-up view of the b4 absorption for 0 and 18 T. **g.** Frequency shift of the b4 peak in the absolute absorption spectra as a function of applied magnetic field. In (e) and (g), the grey vertical lines highlight positions of magnetic phase boundaries. **h.** Schematic displacement pattern of the b4 mode. **i.** Diagram of local structure changes, specifically Co center displacement, through the field driven transition to the paramagnetic state.

Results and Discussion

Specifically, we measured the magneto-infrared response of $Co_3V_2O_8$ from the weakly ferromagnetic phase to the high-field paramagnetic phase (Figure 1).[1] Three vibrational modes (b_4, b_{11}, and c_8) are sensitive to the series of field-induced transitions; changes in b_4 are substantial and involve Co center displacement, mainly along the direction perpendicular to the buckled Kagome planes. Combining field-induced frequency shifts and area changes with calculated displacement patterns, we evaluated the local lattice distortion (Figure 1). The field-driven transition from the weak ferromagnetic to the paramagnetic state involves Co center displacements and "squashing" of the octahedron, local structure changes that modify superexchange interactions and dovetail with thermal expansion studies[1]. This result is important for understanding the microscopic aspects of magnetically driven transitions in functional oxides.

Acknowledgements

We thank the Materials Science Division, Basic Energy Sciences, U.S. Department of Energy for support.

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Magnetism & Magnetic Materials

This report describes the magnetic-field-induced quantum phase transition from a gapped quantum phase that has no magnetic long-range order into a gapless phase in the spin-1/2 ladder compound bis(2,3-dimethylpyridinium) tetrabromocuprate (DIMPY). At temperatures below about 1 K, the specific heat in the gapless phase attains an asymptotic linear temperature dependence, characteristic of a Tomonaga-Luttinger liquid.
•Published in *Physical Review Letters* **105**, 137207 (2010).

Field-Induced Tomonaga-Luttinger Liquid Phase of a Two-Leg Spin-1/2 Ladder with Strong Leg Interactions

T. Hong (Oak Ridge National Lab); **Y. H. Kim, Y. Takano** (University of Florida, Physics); **C. Hotta** (Kyoto Sangyo University, Physics); **C. Broholm** (Johns Hopkins University, Physics); **M. M. Turnbull, C. P. Landee** (Clark University, Chemistry and Physics)

Introduction

A novel S=1/2 organo-metallic compound $(2,3\text{-dimethylpyridinium})_2CuBr_4$ (DIMPY) was recently revealed. Based on the material structure, bulk measurements[1] and inelastic neutron scattering measurements[2], it is concluded to be a Heisenberg antiferromagnetic (AFM) two-legged spin ladder with a spin energy gap Δ=0.32(3) meV. In finite-field neutron-scattering measurements, it eventually closes and the system appears to be in a gapless phase for applied fields above a critical field H_c=3.0(3) T. At H=5.0 T, the low-energy feature in the gapless phase is much broader than the experimental resolution, suggesting that it arises from a two-spinon continuum, not from one-particle excitations.

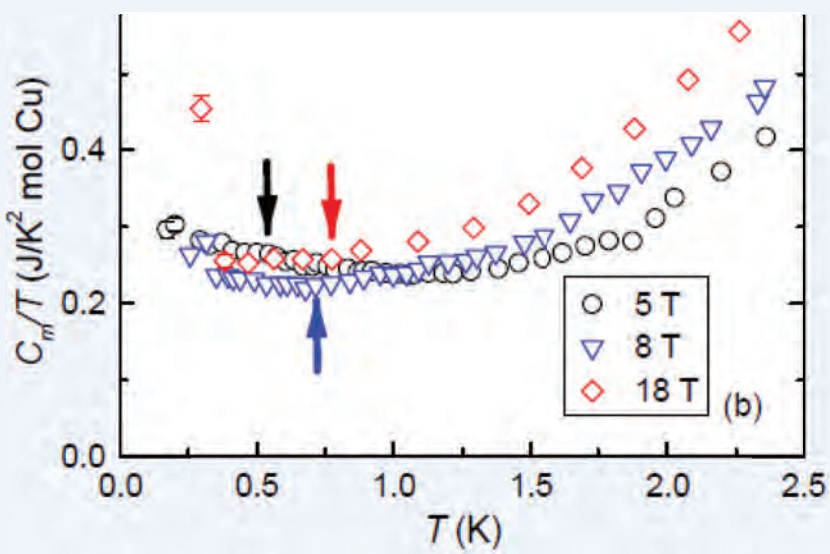

FIGURE 1. Magnetic specific heat C_m/T of DIMPY as a function of temperature T for $H > H_c$ after subtracting the nuclear-quadrupole contribution. The arrow indicates the upper limit of the T-linear region.

Experimental

To augment the neutron scattering results, we performed specific-heat, magnetocaloric and magnetic-torque measurements of DIMPY at the Mag Lab's DC-Field Facility using SCM1, at magnetic field up to 18 tesla (T) and temperature down to 150 mK.

Results and Discussion

At zero field and 2 T, exponentially activated behavior is found, providing additional clear evidence for a spin gap below H_c. Above H_c, the specific heat shows remarkable behavior. There is no λ-like peak, indicative of a phase transition, at temperatures down to 300 mK and magnetic fields up to 18 T. Figure 1 shows the magnetic specific heat divided by temperature, C_m/T, at 5, 8, and 18 T. As temperature decreases, C_m reaches an asymptotic T-linear limit, characteristic of Tomonaga-Luttinger liquid (TLL).

Conclusions

DIMPY undergoes a quantum phase transition at H_c =3.0(3) T from a gapped phase to a TLL. The experiments yielding the exchange constants with consistency and in excellent agreement with theory establish DIMPY unambiguously as the first ideal realization of an S=1/2 AFM two-leg ladder in the strong-leg regime, thus opening up an avenue for investigating the properties of such a ladder in this poorly explored regime.

Acknowledgements

The work at ORNL was partially funded by the Division of Scientific User Facilities, Office of BES, DOE.

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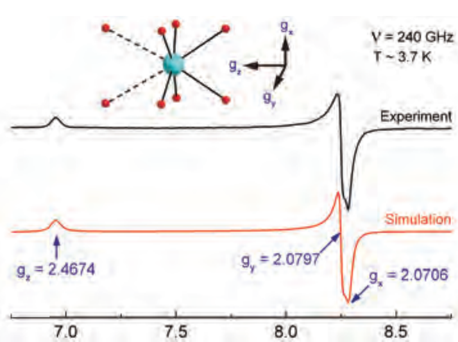
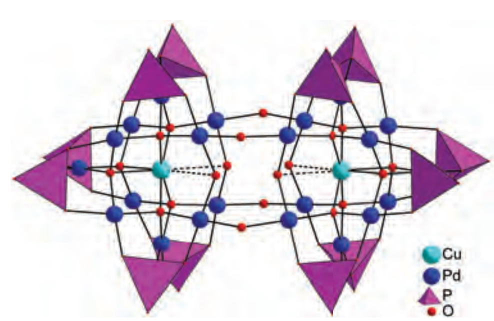
Magnetism & Magnetic Materials

Di-valent copper in unusual oxygen environments is expected to show interesting magnetic properties. The novel polyanion $[Cu_2Pd_{22}P_{12}O_{60}(OH)_8]^{20-}$ shows copper in a rare eight-fold oxo-coordination. First electron paramagnetic resonance (EPR) studies found the so-far largest g_z factor for di-valent copper, indicating that the Cu^{2+} is dominated by the $d_{x^2-y^2}$ orbital.
•Published in *Angew. Chem. Int. Ed*. **50**, 2639 (2011).

EPR Study on a Di-Copper(II) Containing 22-Palladate(II), $[Cu^{II}_2Pd^{II}_{22}P^{V}_{12}O_{60}(OH)_8]^{20-}$

Maria Barsukova-Stuckart, Natalya V. Izarova, Ulrich Kortz (School of Engineering & Science, Jacobs U., Germany);
Geoffrey B. Jameson (Institute of Fundamental Sciences, Massey U., New Zealand);
Vasanth Ramachandran, Zhenxing Wang, Johan van Tol, Naresh S. Dalal (Chemistry & Biochemistry, FSU and Magnet Lab);
Rosa Ngo Biboum, Bineta Keita, Louis Nadjo (Laboratoire de Chimie Physique, Université Paris-Sud, France)





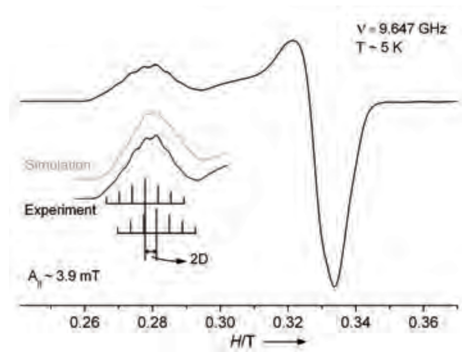


FIGURE 1. Experimental and simulated powder EPR spectra at 240 GHz and 3.7 K. Inset: The $\{CuO_8\}$ unit is shown with three principal directions.
FIGURE 2. Molecular structure of the $Pd_{22}Cu_2P_{12}$ polyanion.
FIGURE 3. Powder EPR spectrum at 9.67 GHz (X-band) and 5 K. Inset: Magnified low-field part showing a simulation of the hyperfine splitting.

Introduction

$[Cu^{II}_2Pd^{II}_{22}P^{V}_{12}O_{60}(OH)_8]^{20}$ ($Pd_{22}Cu_2P_{12}$) is a novel double-cuboid-shaped copper(II)-containing polyanion that contains the largest number of palladium ions yet found in polyoxopalladate chemistry. The two Cu^{II} ions (7.6 Å apart) present in $Pd_{22}Cu_2P_{12}$ exhibit a very rare eight-fold oxo-coordination. It is synthesized and isolated as a hydrated sodium salt $Na_{20}[Cu^{II}_2Pd^{II}_{22}P^{V}_{12}O_{60}(OH)_8]\bullet 58H_2O$, (Na-$Pd_{22}Cu_2P_{12}$). To study the magnetism of Cu^{II} and to verify the magnetic susceptibility results, EPR of Na-$Pd_{22}Cu_2P_{12}$ is studied at X-band (9.6 GHz) and 240 GHz.

Experimental

Magnetic susceptibility measurements on Na-$Pd_{22}Cu_2P_{12}$ powder were measured over 1.8 – 280 K using a Quantum Design SQUID MPMS at FSU Chemistry. X-band (9.6 GHz) EPR at 5 K and 240 GHz EPR at 3.7 K were measured using the spectrometers available at the National High Magnetic Field Laboratory.

The magnetic susceptibility (χ) of Na-$Pd_{22}Cu_2P_{12}$ goes through a maximum at about 2.4 K providing direct evidence for a significant antiferromagnetic interaction [J = -4.0(1) K (~ -2.8(1) cm^{-1})] between the two Cu^{II} ions within the polyanion. Figure 3 shows a typical powder EPR spectrum at X-band (9.67 GHz) of Na-$Pd_{22}Cu_2P_{12}$. The low-field part of the spectrum provides an accurate measure of $g_{||}$ as well as hyperfine structure from the two coupled Cu^{II} nuclei: a 1:2:3:4:3:2:1 septet. Computer simulation yielded a hyperfine coupling of 3.9 mT.

Conclusions

This work reports the first EPR of a Cu^{II} ion in an eight-fold coordination. A gz value as high as 2.4674 exhibited by Na-$Pd_{22}Cu_2P_{12}$ has not been reported for any Cu^{II} complex. The fact that $g_{||} > g_{\perp}$ indicates that the Cu^{II} ion is clearly dominated by the $d_{x^2-y^2}$ orbital.

Acknowledgements

The work at FSU was supported by NSF grant NIRT-DMR-0506946; the Mag Lab is supported by the state of Florida and NSF DMR-0654118.

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Magnetism & Magnetic Materials

Skyrmions are stable topological defects, or spin textures (particle-like knots) that have been observed in several ferromagnetic metals, where they form a periodic skyrmion lattice. Isolated skyrmions, on the other hand, have been predicted to emerge in lightly doped antiferromagnetic insulators, but they have remained elusive until now. The experiment described in this report provides the first experimental support for the existence of isolated skyrmions in antiferromagnetic insulators.
• Accepted to *Physical Review Letters*

Evidence for Quantum Skyrmions in a Doped Antiferromagnet

I. Raičević, D. Popović (FSU, Physics and Magnet Lab);
C. Panagopoulos (Department of Physics, University of Crete and FORTH, & Division of Physics and Applied Physics, Nanyang Technological University);
L. Benfatto (CNR-ISC and Department of Physics, "Sapienza" University of Rome);
M. B. Silva Neto (Instituto de Física, Universidade Federal do Rio de Janeiro);
E. S. Choi (FSU, NHMFL);
T. Sasagawa (Materials and Structures Laboratory, Tokyo Institute of Technology)

Introduction

A remarkable manifestation of complexity in magnetic systems is the emergence of topologically non-trivial arrangements of spins, such as skyrmions. These are "knots" in an otherwise ordered spin texture, which behave as excitations with particle-like properties. Skyrmions have been observed in various ferromagnetic (FM) metals. They have been predicted to emerge also in the ground state of doped antiferromagnetic (AF) insulators, such as La_2CuO_4 lightly doped with Li (Li-LCO)[1], but the identification of such isolated skyrmions has been a challenge. It turns out that in Li-LCO, the magnetoresistance (MR) is a key probe to identify such spin textures.

Experimental

The magnetization and the in-plane MR were measured on a single crystal of $La_2Cu_{0.97}Li_{0.03}O_4$ over a wide range of temperatures *T*, magnetic fields *B*, and field orientations. Some of the MR measurements were performed in SCM2 with a ^{3}He system (0.300 < *T* (K) < 70 K) up to 18 T.

Results and Discussion

The magnetic properties of Li-LCO resemble very much those of Sr- and O-doped La_2CuO_4 where skyrmions cannot form. The general mechanism of the MR in the insulating La-based cuprates is well understood theoretically, and the effect of the magnetic structure on the MR is widely recognized. The behavior of the MR in Li-LCO is similar to that of other La-based cuprates. For example, when the applied *B* is parallel to the *c* axis, the MR exhibits a step-like decrease at the critical field where the first-order, weak FM transition occurs. The increase of the step size with decreasing *T* is also well understood. However, at even lower *T*, this behavior is reversed in Li-LCO, *i.e.* the step size exhibits a striking non-monotonic *T*-dependence (Figure 1). We show that the experimental data are described very well by including the effect of skyrmions within the existing theoretical framework for the MR. The combination of the magnetization and the MR data rule out all other known mechanisms as a possible explanation.

Conclusions

The low-T magnetic and transport properties of the AF $La_2Cu_{1-x}Li_xO_4$ provide the first experimental support[2] for the predictions of quantum skyrmions in AF insulators. The interpretation of this extensive set of data in terms of skyrmions is consistent with all previous measurements on Li-LCO and similar compounds and with previous theory. Our work may offer new insights into the mechanisms that can stabilize or suppress topological excitations in complex magnetic systems.

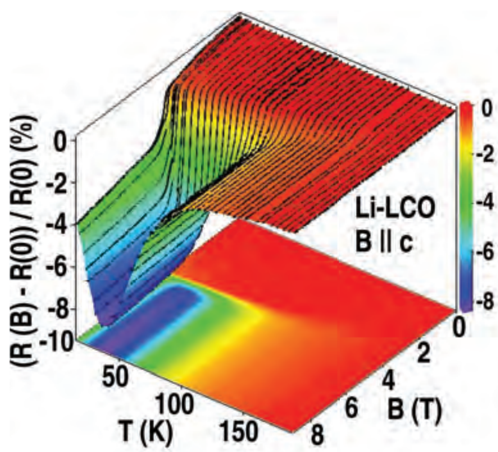

FIGURE 1. The non-monotonic *T*-dependence of the MR step size.

Acknowledgements

We thank X. Shi for technical help, V. Dobrosavljević, J. Lorenzana, A. N. Bogdanov for discussions, NSF DMR-0403491 and DMR-0905843, Magnet Lab via NSF DMR-0654118, MEXT-CT-2006-039047, EURYI, Italian MIUR Project PRIN-2007FW3MJX, and the National Research Foundation, Singapore for financial support.

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Magnetism & Magnetic Materials

In this report, the coupling between the magnetic and electric degrees of freedom in a multiferroic material is exploited in order to use magnetocapacitance (dielectric) measurements to expose a magnetic-field-induced quantum phase transition in $Ba_2CoGe_2O_7$. Studies performed in the 45-tesla (T) hybrid magnet reveal a quantum critical point separating T = 0 K antiferromagnetic and paramagnetic phases at 37 T.

Investigation of a Quantum Critical Point in Multiferroic $Ba_2CoGe_2O_7$

Jae Wook Kim, Seung Hyun Khim, Sae Hwan Chun, Kee Hoon Kim (Seoul National University); **E. Choi, Y. Jo, L. Balicas, N. Harrison** (Magnet Lab); **H. Yi, S.-W. Cheong** (Rutgers University); **Jung Hoon Han** (Sungkyunkwan University); **C. D. Batista** (Los Alamos National Laboratory)

Introduction

Magnetoelectric multiferroics are attractive in both physical and applications aspects due to its functionality in magnetic and electric degree of freedom. Strong coupling between magnetism and dielectric properties makes it possible to study phase transition in a completely new manner. In this study, a magnetic quantum phase transition in a multiferroic $Ba_2CoGe_2O_7$ is observed under high magnetic fields. Antiferromagnetic order is continuously suppressed to T=0 by applying longitudinal magnetic field and approaches a quantum critical point (QCP). Above the QCP, a gapped paramagnetic state is observed.[1] All phase transition features could be observed by dielectric constant measurements and suggests a new route to study phase transition in multiferroics.

Experimental

A capacitance bridge was used for dielectric constant (ε) measurement. Electric polarization was obtained by integrating current while sweeping temperature or magnetic field using an electrometer. Magnetic torque was measured using a capacitive torque magnetometer. Static magnetic fields were applied using a resistive or hybrid magnet at the Mag Lab. A pickup-coil magnetometer was used to measure magnetization in a pulse magnet in at the lab's Pulsed Field Facility. Magnetic field applied along the c-axis and ε was measured along the a-axis of the sample.

Results & Discussion

Large peak in ε is observed in temperature-sweep measurements (Figure 1a, also in magnetic-field sweeps). The peak position shifts to lower temperature as magnetic field is increased to 37 T, which is the full saturation point of magnetization (i.e. no antiferromagnetic order). These peak positions coincide with the minimum point in temperature-dependent torque signals (Figure 1b), which indicates the magnetic ordering temperature.

Above the saturation magnetization, where spins are fully aligned to the applied magnetic field, unexpected anomalies were observed in dielectric constant (Figure 1c). Above 41.5 T, an anomaly in ε is found ~4 K. At higher magnetic fields, this anomaly shifts to higher temperatures. It seems that this feature is extended from T=0 K at 37 T, though it is hidden by strong peak intensities below 40 T.

Conclusions

Our overall investigations strongly suggest that there exists a field-induced antiferromagnetic to paramagnetic quantum phase transition. A unique feature of this work is that two distinct ground states of a quantum-phase transition are observed in dielectric properties.

Acknowledgements

This study was supported by the NRF, Korea through National Creative Research Initiatives. Work at the National High Magnetic Field Laboratory was performed under the auspices of the National Science Foundation, the state of Florida, and the U.S. Department of Energy.

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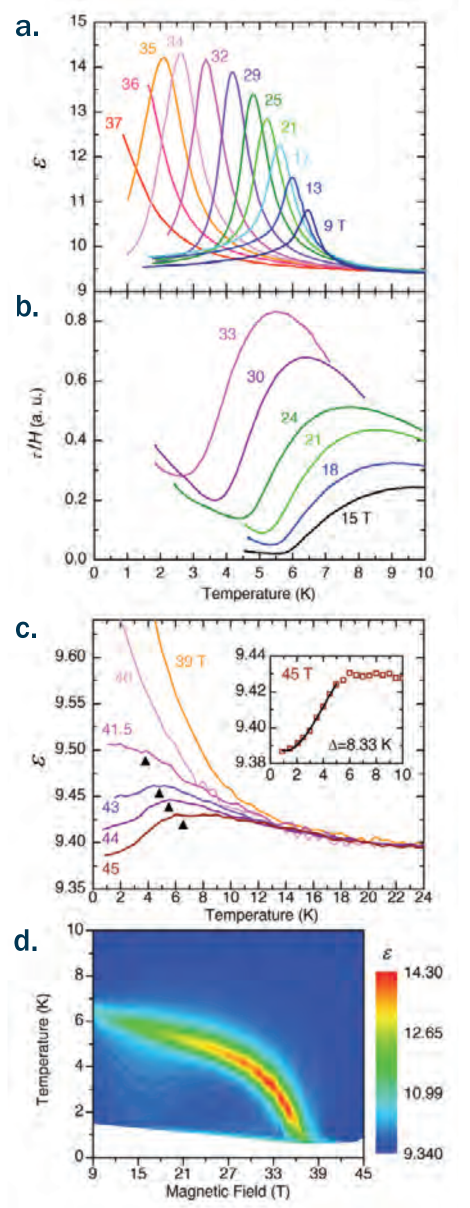

FIGURE 1. Temperature-dependent ε at magnetic fields below (a.) and above (c.) the saturation magnetic field. **b.** Torque signal as a function of temperature. **d.** Contour plot of ε in *T-H* phase space.

Magnetism & Magnetic Materials

Daou *et al.* report exceptionally sensitive strain measurements performed on a small crystal of $SrCu_2(BO_3)_2$ at the Pulsed Field Facility in Los Alamos. $SrCu_2(BO_3)_2$ is a well known model antiferromagnetic system for studying the interplay between geometrical frustration and quantum fluctuations. These strain measurements reveal that the lattice is strongly coupled to the spins on the Cu-dimers, and responds closely to anomalies observed in magnetic measurements.

Study of Spin-Lattice Coupling in $SrCu_2(BO_3)_2$ with Magnetostriction to 65 T

R. Daou, F. Weickert, F. Steglich (Max-Planck Institute.);
M. Jaime, S. Crooker (Magnet Lab, Los Alamos);
H. Dabkowska, B. Gaulin (McMaster University)

Introduction

$SrCu_2(BO_3)_2$ is a quasi-two dimensional spin system with a singlet dimer ground state. It is a realization of the Shastry-Sutherland model[1], and exhibits a sequence of magnetization plateaus at high magnetic fields *H*[2] as shown in Figure1. The unique behavior of this quantum spin liquid results from the interplay between two different fascinating aspects of strongly correlated spin systems: *geometrical frustration and strong quantum fluctuations*. The magnetization plateaus at μ0*H*·(*g*///*2*) ~30 T, ~38 T, and ~45 T, observed when *H* // c-axis, are a direct consequence of spin superstructures forming at triplet concentrations 1/8, 1/4, and 1/3, respectively.

Experimental

We measured the magnetostriction over 50 tesla in $SrCu_2(BO_3)_2$ parallel and perpendicular to the Cu-dimer planes using a new high-resolution technique suitable for cryogenic temperatures in pulsed high magnetic fields. In our setup optical fiber strain gauges based on fiber Bragg gratings are used to measure the strain in small (~1 mm) samples, with a resolution in the order of 10^{-7} with a full bandwidth of 47 kHz. [3]

Results and Discussion

We have succeeded in measuring the magnetostriction (ΔL/L) with excellent resolution for the longitudinal orientations: H //ΔL // *c*-axis, and H //ΔL ⊥ *c*-axis. We have some information on the magnetostriction in the transverse orientations: Δ*a*/*a* with H//c, Δ*c*/*c* with H//a. The resolution allows us to identify several features at the same fields as the steps and plateaux seen in magnetization. For H //ΔL // *c*-axis, the magnetostriction resembles the magnetization closely, with an increase in the sample length for most of the magnetization steps. For H //ΔL ⊥ *c*-axis, however, while the magnetization is qualitatively unchanged, the magnetostriction has opposite sign with changes in both senses at the magnetization steps.

Conclusions

Magnetostriction measurements in pulsed fields to 65 T were carried out with unprecedented sensitivity in single crystal samples of $SrCu_2(BO_3)_2$. Our results show that the lattice is strongly coupled to the spins in Cu-dimers, and responds closely to the observed magnetization plateaus.

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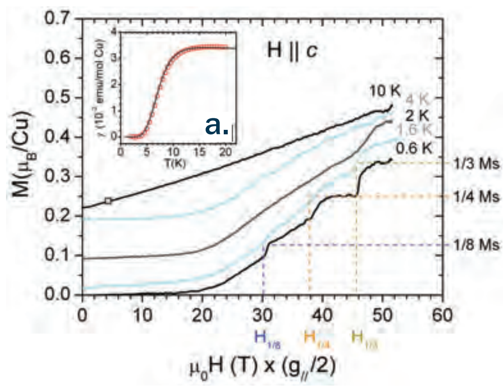

FIGURE 1. Magnetization vs. field scaled by the g//-factor measured at constant temperature shows plateaus at 1/8, 1/4, and 1/3 of saturation magnetization M_S. **a.** Magnetic susceptibility vs. temperature shows gapped ground state.

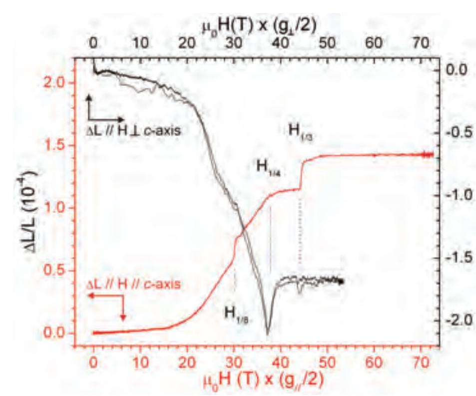

FIGURE 2. Magnetostriction ΔL/L vs. magnetic field measured parallel (red) and perpendicular (black) to the crystallographic *c*-axis. The magnetic field axis was scaled by anisotropic g-factor with g⊥ = 2.05 and g// = 2.28[4]. The fields at which magnetization steps are observed are indicated with dashed lines.

Topological Insulators

The detection of a metallic surface state in topological insulators using transport techniques has been a challenge so far, since the conductivity is dominated by the bulk. This report describes an experiment where first the samples have been specially prepared such that the bulk conductivity is reduced considerably. Sufficiently high magnetic fields are then applied to reveal quantum oscillations in the magnetotransport that arise from the two-dimensional (2D) surface state.
•Published in *Nature Physics* **6**, 960 (2010).

High Magnetic Field Studies of Topological Insulators

James G. Analytis, Jiun-Haw Chu and Ian R. Fisher (Stanford Institute for Materials and Energy Sciences, SLAC National Accelerator Laboratory; Geballe Laboratory for Advanced Materials and Department of Applied Physics, Stanford University);
Ross D. McDonald (Magnet Lab, Los Alamos); **Scott C. Riggs, G. S. Boebinger** (Magnet Lab, FSU, Physics)

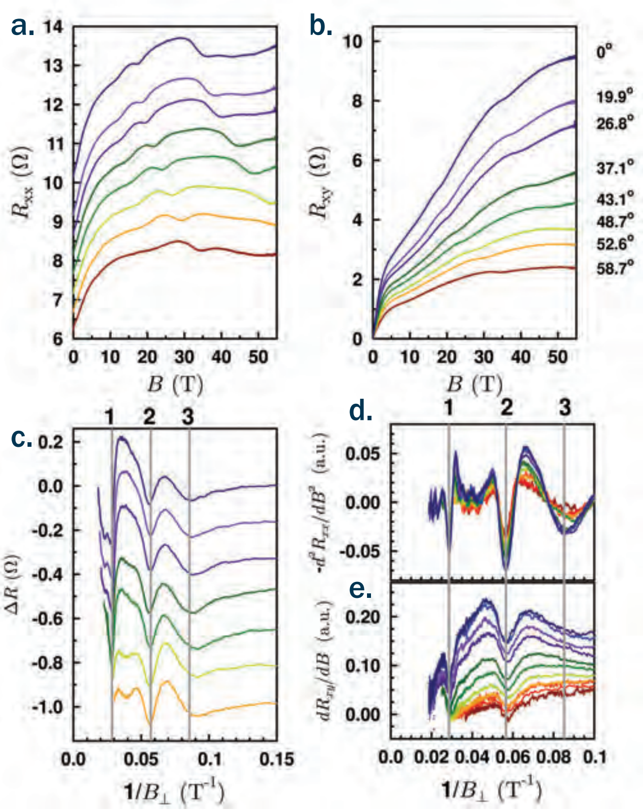

FIGURE 1. a. b. *Rxx* (a) and *Rxy* (b) data traces as a function of magnetic field for indicated angles for a single crystal with n~4×10^{16}cm−3 (sample Σ1). The *Rxx* traces are offset for clarity. The deviation from linearity of the low-field *Rxy* indicates the 3D quantum limit (*B*~4 T), which does not vary with angle. Beyond this limit, additional features in both *Rxy* and *Rxx* move smoothly up in field as the tilt angle *θ* is increased. *θ*=0 is defined to be when the field is perpendicular to the surface (parallel to the trigonal *c* axis). **c.** A smooth second–third order polynomial can be fitted as background and subtracted from the raw *Rxx*, revealing oscillations that grow with field. **d. e.** −d2*Rxx*/dB2 (d) and d*Rxy*/d*B* (e) as a function of 1/$B_\perp$, where *B*⊥ = Bcos*θ* aligns all features associated with the 2D surface state. The vertical lines in c–e indicate the first three Landau levels N=1,2,3 of the 2D state.

Introduction

The topological insulator is a unique state of matter that possesses a metallic surface state of massless particles known as Dirac fermions, which have coupled spin and momentum quantum numbers. We have systematically reduced the number of bulk carriers in Bi_2Se_3 to the point where a magnetic field can collapse them to their lowest Landau level. Beyond this field, known as the three-dimensional (3D) "quantum limit," the signature of the 2D surface state can be seen[1].

Experimental

Magnetoresistance and Hall effect measurements were carried out at the National High Magnetic Field Laboratory Pulsed Field Facility in the short-pulse (~10 ms rise time) 55-tesla (T) magnet.

Results and Discussion

In Figure 1a,b we illustrate the longitudinal and transverse (Hall) resistances, *Rxx* and *Rxy* respectively, taken at 1.5 K on sample Σ1 with n~4×10^{16} cm−3. Strong features appear in *Rxy* and *Rxx* at similar fields in the bulk ultra-quantum limit. To investigate the dimensionality of these features, we rotate the crystal in the field. For the 2D surface state of a topological insulator, quantum oscillatory phenomena depend only on the perpendicular component of the field $B_\perp$ and are periodic in 1/*B*. Pronounced dips that are periodic align at all angles, providing unambiguous evidence that the plateau-like features in the Hall and minima in the SdHOs originate from a 2D metallic state.

Conclusions

Experimental access to the transport of the surface state of $Bi_{(1-x}Sb_x)_2Se_3$ provides a new laboratory for studying topologically non-trivial quantum matter and perhaps the effects of correlations among Dirac fermions, too.

Acknowledgements

The Magnet Lab is supported by NSF Division of Materials Research through DMR-0654118. R.D.M. acknowledges support from the U.S. DOE, Office of Basic Energy Sciences "Science in 100 T" program. This work is supported by the Department of Energy, Office of Basic Energy Sciences under contract DE-AC02-76SF00515.

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Topological Insulators

In this remarkable piece of work, Qu *et al.* show the first quantum oscillations originated in surface states of the three-dimensional (3D) topological insulator Bi_2Te_3. Shubnikov de Hass oscillations are found to be a function of cos θ, where θ is the field-tilt angle, which is proof of a two-dimensional (2D) nature. Additionally, the authors obtained preliminary thermoelectric power data that confirms the presence of quantum oscillations with 1/H periodicity. The data allowed an estimate of the surface mobility of 10,000 cm2/Vs.These experiments are some of the best examples of utilization of high-field capabilities at the cutting edge of materials science.
•Published in *Science* **329**, 821 (2010).

High-field Transport Experiments on the Topological Insulator Bi_2Te_3

Dong Xia Qu, Jun Xiong and N. P. Ong (Princeton University, Department of Physics)

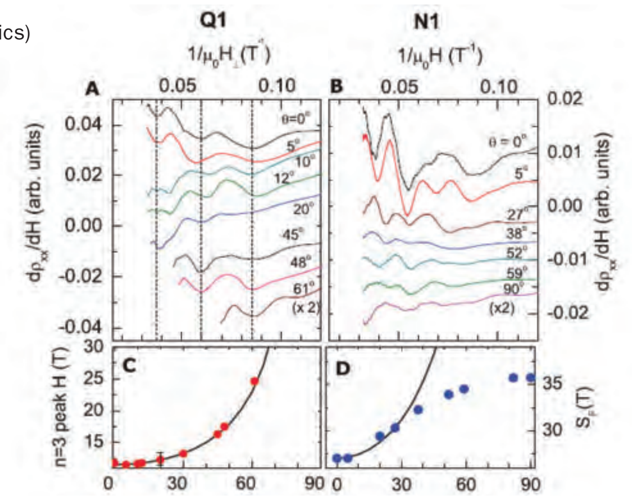

FIGURE 1. Shubnikov de Haas oscillations in Bi_2Te_3 at selected field-tilt angles *q*. In the non-metallic crystal Q1, the period scales as 1/cos *q* whereas in the metallic sample N1, it deviates from the 2D form.

Introduction

The surface states in 3D topological insulators are predicted to be massless Dirac states in which backscattering is suppressed because the spin is locked transverse to the momentum. While these states have been observed by surface spectroscopy experiments (Angle-resolved photoemission spectroscopy and scanning tunneling microscopy), transport studies have been difficult because of the large bulk conductance present in most crystals. Recently, we finally succeeded in measuring the surface mobility using high-field measurements on non-metallic crystals of Bi_2Te_3[1]. In addition, we made preliminary high-field measurements of the thermopower of the surface states.

Experimental

We used the 35-tesla DC magnet in all experiments reported here.

Results and Discussion

In non-metallic crystals of Bi_2Te_3, we detected[1] weak Shubnikov de Haas (SdH) oscillations in the Hall resistivity ρyx, despite the large bulk resistivity ρxx (~10 mΩcm). By varying the tilt angle θ of the magnetic field H, we showed that the SdH period depends only on cos θ (Sample Q1 in Figure 1A, C). By contrast, in a metallic sample N1, the period deviates from the 2D form (Figure 1B, D). By analyzing the SdH amplitudes, we inferred a surface mobility μ ~10,000 cm^2/Vs. This value was confirmed by analysis of a distinctive Hall anomaly observed in weak *H*.

In a second experiment, we observed pronounced oscillations in the thermopower *S* vs. *H* in non-metallic Bi_2Te_3. The thermopower displays peaks when the chemical potential lies between Landau Levels (solid line, Figure 2). These preliminary results suggest that *S* may provide a powerful probe for Landau levels in topological insulators. Also, results from a previous project in which high-field torque magnetometry was used to measure the magnetization curves in several cuprate families were published this year[2].

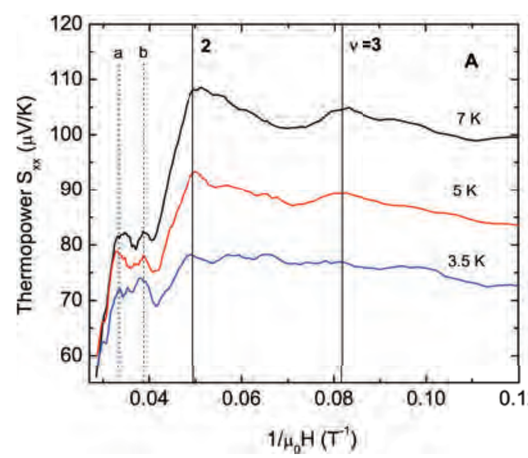

FIGURE 2. The thermopower vs. 1/*H* in Bi_2Te_3 at temperatures 3.5, 5, and 7 K. Two peaks ("a", "b") emerge when *H* exceeds 25 T.

Acknowledgements

The research is supported by the National Science Foundation under a DMR MRSEC grant DMR 0819860.

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Topological Insulators

The authors effectively utilize high-frequency radio-frequency (rf) and microwave conductivity measurements to selectively probe the surface state of this topological insulator. The combination of reduced skin depth at high frequency, and rotation with respect to the applied magnetic field, enabled the observation of two-dimensional (2D) cyclotron resonance from a material whose bulk Fermi-surface is three dimensional (3D). Moreover the frequency-magnetic-field scaling of this resonance is inconsistent with the bulk effective mass, indicating substantial many-body renormalization of the surface state.
•Submitted to *Phys. Rev. Lett*.

The Surface-state of the Topological Insulator Bi_2Se_3 Revealed by Cyclotron Resonance Using Pulsed Field Facilities at NHMFL-LANL

O.E. Ayala-Valenzuela, M.M. Altarawneh, R.D. McDonald (Magnet Lab, Los Alamos);
J.G. Analytis, J.-H. Chu, I. R. Fisher (Stanford University, SLAC)

Introduction

Transport measurements of topological insulators are dominated by the conductivity of the bulk, leading to substantial difficulties in resolving the properties of the surface. To this end, we use high magnetic field, rf- and microwave-spectroscopy to selectively couple to the surface conductivity of Bi_2Se_3 at high frequency. In the frequency range of a few GHz we observe a crossover from quantum oscillations indicative of a small 3D Fermi surface, to cyclotron resonance indicative of a 2D surface state.

Experimental

The conductivity at microwave frequencies was measured using a cavity perturbation technique, whereby the change in cavity transmission at resonance reflects the field-induced changes in the complex conductivity of the sample. Two microwave cavities were used, one a fixed-angle multimoded cylindrical cavity in the frequency range of 10-40 GHz, the other a monomoded cavity resonating at 71 GHz that can be rotated with respect to the applied magnetic field at cryogenic temperatures. Both were measured using an MVNA spectrometer manufactured by AB-mm. For 71 GHz the bulk conductivity yields a skin depth of 2 μm, only 50 times the thickness of the depletion region estimated for this carrier concentration[1]. It should be further noted that these estimates do not account for the possible screening effect of a high mobility surface state. For both microwave cavity geometries the sample is located with the oscillating magnetic field in the plane of the (001) surface so induces screening currents both in and perpendicular to this plane. Magnetic fields were provided by both superconducting solenoids (up to 17 T). Standard ^{4}He techniques were employed to regulate temperature down to 1.5 K.

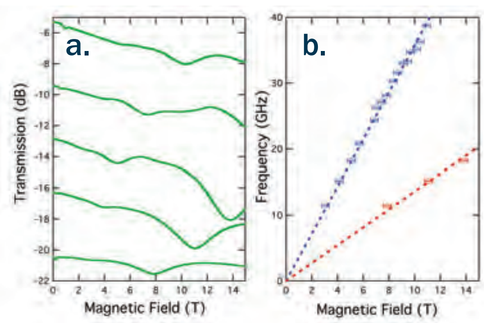

FIGURE 1. a. Magnetic field dependence of the cavity transmission for a selection of frequencies, top to bottom: 36.3, 27.1, 18.2, 15.1, 11.4 GHz, offset for clarity. **b.** The corresponding frequency vs. magnetic field for the two main cyclotron resonances observed in the field range 10 to 40 GHz. It should be noted that the two resonances observed do not have a simple harmonic relation leading us to believe they originate from opposite sample surfaces. The factor of ~2 variation in ω_C and hence E_F between surfaces is consistent with the ARPES results from this growth reported in reference 1.

Results and Discussion

Figure 1a plots the microwave transmission measured at different microwave frequencies, indicating that this is a resonant phenomenon with linear frequency field scaling. This linear frequency scaling as opposed to the square root of field scaling observed in other Dirac materials is consistent with the Fermi energy relative to the Dirac point being large in comparison to the temperature and measurement frequency. However, unlike the case for massive quasi-particles, where resonant condition is determined solely by the effective mass, in this case it is determined by both the Fermi velocity and Fermi energy and is hence dependent upon the filling of the Dirac cone.

Conclusions

By probing the conductivity at reduced skin depths, we have observed a 2D cyclotron resonance from a material whose bulk Fermi-surface is 3D. The frequency-magnetic field scaling of this resonance is inconsistent with the bulk effective mass, but more consistent with the dispersion and band filling of a Dirac-like surface state as observed by angle-resolved photoemission spectroscopy[1], with substantial many-body renormalization.

Acknowledgements

We would like to thank Steve Hill and Saiti Data for technical assistance with the Tallahassee MVNA. RMcD acknowledges support from the U.S. DOE, Office of Basic Energy Sciences “Science in 100 T” program. Work at Stanford was supported by the U.S. DOE, Office of Basic Energy Sciences under contract DE-AC02-76SF00515.

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Quantum Fluids & Solids

An intriguing peak in the temperature dependence of the nuclear-spin-lattice relaxation time observed for 20ppm concentration of ^{3}He impurities in ^{4}He is interpreted as originating in the supersolid phase of ^{4}He host. These first results might need confirmation and cross checking, but could be a significant breakthrough as they uncover a method to identify and characterize exotic states of matter with nuclear magnetic resonance (NMR) probes.

•Published in *Journal of Low Temperature Physics* **158**, 584 (2010).

NMR Studies of Microscopic Dynamics of the Proposed "Supersolid" Phase of Solid ^{4}He

S. S. Kim, C. Huan, L. Yin, J. S. Xia, N. S. Sullivan (University of Florida, Physics);
D. Candela (Physics, University of Massachusetts)

Introduction

NMR measurements are particularly useful for probing the dynamics of solids at low temperatures. As a result of the motions the nuclear spin-spin interactions become time dependent and the Fourier transform of these dipolar fluctuations, known as the spectral density, determine the nuclear spin relaxation rates. The spectral densities at the Larmor frequency ω_L and at $2\omega_L$ determine the spin-lattice relaxation rate T_1^{-1}, while the component at zero frequency determines the spin-spin lattice relaxation rate T_2^{-1}. We used these properties to probe the local dynamics of very dilute ^{3}He impurities in solid ^{4}He in order test for changes in the quantum tunneling of the ^{3}He impurities near the temperatures for which non-classical rotational inertia fractions (NCRIFs) have been observed[1]. It is thought that these fractions signal the existence of macroscopic supersolid flow. Addition of ^{3}He impurities has been shown by others[2] to suppress the so-called "supersolid" effects and previous experiments[3] have confirmed that the ^{3}He impurities (at least for concentrations down to 250 ppm) diffuse by quantum mechanical tunneling[4].

Experimental

The experiments are particularly challenging because of (i) the low signal-to-noise from the dilute samples and (ii) the need to restrict the measurements to low Larmor frequencies to keep the spin-lattice relaxations times below a few hours. These two challenges had to be addressed to carry out successful experiments. In order to overcome the weak signal-to-noise ratios we developed a special low-temperature preamplifier that could be operated at dilution-refrigerator temperatures and in an applied magnetic field[5]. Standard radio frequency (rf) pulse techniques were used to measure the relaxation times.

Results and Discussion

The temperature dependence of the nuclear-spin-lattice relaxation times are shown in Figure 1. A pronounced peak in T_1 is observed at the same temperatures (~ 170 mK) as those for which anomalies in the NCRIFs and shear modulus[6] are observed. After the peak in T_1 a sharp drop in T_1 is observed at about 90 mK corresponding to the phase separation in which the ^{3}He atoms form nanoscale droplets of Fermi liquid. Changes in T_2 are also observed at 170 mK but the features are less clear and it must be remembered that other effects such as wall collisions and interactions with dislocations can affect the spectral density at very low frequencies.

Conclusions

NMR studies have shown unequivocally that there is a pronounced change in the dynamics of solid ^{4}He in a narrow temperature range close to that for which NCRIF anomalies have been reported by other workers.

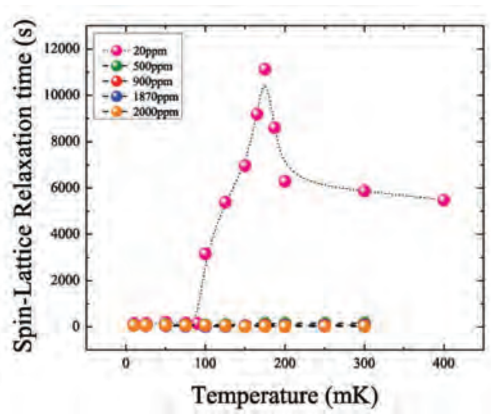

FIGURE 1. Temperature dependence of the nuclear spin-lattice relaxation time observed for ^{3}He impurities in solid ^{4}He.

Acknowledgements

The research was supported by the NHMFL through an award from the User Collaboration Grants Program.

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Qubits & Quantum Entanglement

Bismuth dopants in silicon are shown to have long spin coherence times, and are therefore well suited for storing quantum information. The spin flip time is of the order of 13ns, about 10^5 times shorter than the T_2 time of 2ms. Thus, bismuth dopants in silicon may be used in a similar way to store quantum information as phosphorus dopants in silicon, while providing a 20-dimensional Hilbert space, in contrast to the four-dimensional Hilbert space available for phosphorus. •Published in *Nature Materials* **9**, 725 (2010).

The Initialization and Manipulation of Quantum Information Stored in Silicon by Bismuth Dopants

Gavin W. Morley, Marc Warner, A. Marshall Stoneham, P. Thornton Greenland (University College London, Physics and London Centre for Nanotechnology); Johan van Tol (Magnet Lab, FSU); Christopher W. M. Kay (University College London, London Centre for Nanotechnology and Institute of Structural and Molecular Biology); Gabriel Aeppli (University College London, Physics and London Centre for Nanotechnology)

Introduction

High magnetic fields can be used to polarize spin qubits, initializing them for a quantum computation[1-4]. Phosphorus dopants in silicon (Si:P) are a leading candidate for these applications, but heavier impurities such as bismuth in silicon (Si:Bi) could be used in conjunction with Si:P for quantum information proposals that require two separately addressable spin species [5,6]. We have found that such schemes are indeed feasible as the electron spin coherence time (T_2) of Si:Bi is at least 2 ms, which is longer than for Si:P with non-isotopically purified silicon[7,8]. Si:Bi also presents novel opportunities for quantum information processing at low magnetic fields[9].

Experimental

We used the pulsed electron magnetic resonance (EMR) spectrometer developed at the Mag Lab[10,11], as well as a Bruker E580 in UCL.

Results and Discussion

Figure 1 shows that the ^{209}Bi nuclear spin can be hyperpolarized at 3 K with a high magnetic field of 8.6 T, in the presence of white light. We also demonstrated pulsed manipulation (not shown) of this nucleus at 8.6 T with electron-nuclear double resonance (ENDOR)[7].

Conclusions

We have found that bismuth atoms in silicon have long electron spin coherence times and we used high magnetic fields to polarize the electronic and nuclear spins of these qubits.

Acknowledgements

This work was supported by the EPSRC COMPASSS grant and by the Magnet Lab through Visiting Scientist Program grant #12488. GWM acknowledges support from the Royal Commission for the Exhibition of 1851.

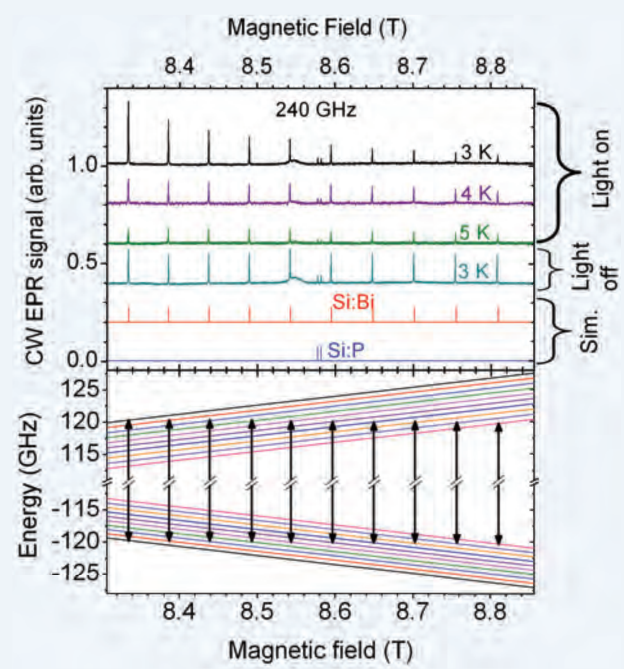

FIGURE 1. EMR spectra of Si:Bi at 240 GHz with simulations based on the energy levels shown. Adapted from reference [7].

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Semiconductors

The two-dimensional electron gas (2DEG) formed at the interface between two perovskites is a subject of intense scientific interest, both for its intriguing origin and properties and for potential applications in spintronics. This report describes magnetotransport studies of this 2DEG at low temperatures, where it finds itself in a superconducting ground state. The experimental results point to the presence of multiple bands, and to the existence of a strong spin-orbit interaction, which may be tuned by an applied electric field (gate voltage). This study suggests that oxide interfaces may indeed offer a new path to controlling the orbital motion of electrons by acting on their spins, a necessary feature of spin-based electronics.
•Published in *Physical Review Letters* **104**, 126802 (2010) and *Phys. Rev. Lett.* **105**, 206401 (2010).

Magneto-transport Properties of $SrTiO_3\backslash LaAlO_3$ Interfaces

Y. Dagan, M. Ben Shalom, A. Ron (Physics, Tel Aviv University, Israel)

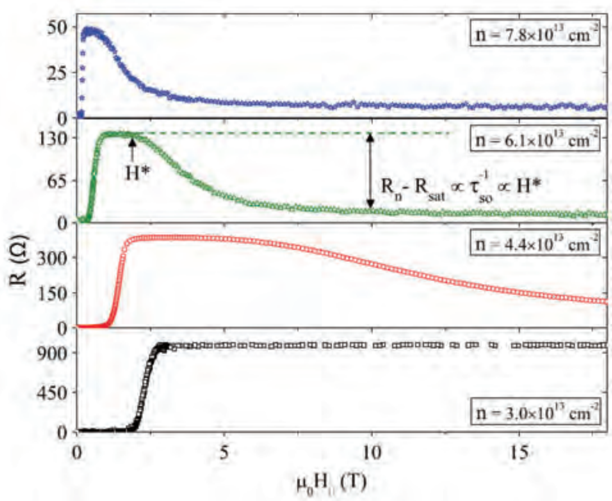

FIGURE 1. Sheet resistance vs. the magnetic field applied parallel to the interface and current for various charge densities. (Adapted from reference No. 1)

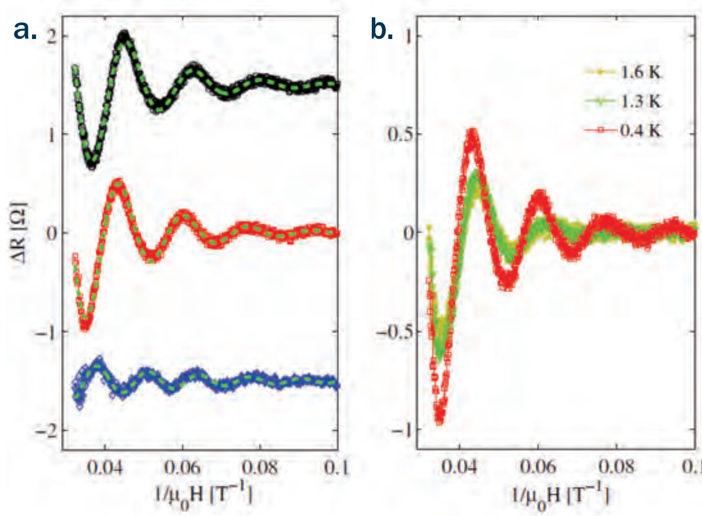

FIGURE 2. SdH signal (a) at 0.4 K for various gate voltages, dashed line is a fit to the SdH theory. **b.** Temperature dependence. (Adapted from reference No. 2)

Introduction

It has been demonstrated that the interface between $SrTiO_3$ (STO) and $LaAlO_3$ (LAO) has the properties of a 2DEG with a gate tunable superconducting ground state. In the reported research we measured the magnetotransport properties of this 2DEG at low temperatures and high field.

Experimental

The two main experiments were done on LAO\STO bridges fabricated at Tel Aviv University. The first experiment was conducted at 20 mK and a field of up to 18 T. The MR was measured as a function of field orientation at 20 mK. In the second experiment we used a 32-tesla magnet and an He3 refrigerator.

Results and Discussion

At low temperatures we were able to tune the superconducting transition. Hc_2 is found to be strongly anisotropic. Hc_2 for parallel field exceeds the Clogston limit (see Figure 1). The parallel field MR is explained by the existence of magnetic scattering and strong spin-orbit interaction. At high magnetic fields Shubnikov-de Haas (SdH) effect is observed (See Figure 2). The SdH frequency corresponds to a carrier concentration of $\sim 2\times 10^{11}$ cm^{-2} from the temperature dependence we find an effective mass $m^*=2.1\pm 0.4$ m_e.[1,2]

Conclusions

Strong, tunable, spin-orbit interaction takes place at the STO/LAO interface. The large Hc_2 for parallel field and the behavior of the MR can be explained using this interaction. The discrepancy between the frequency of the SdH and the Hall coefficient suggests the existence of multiple bands.

Acknowledgements

This research was partially supported by the ISF under grants No. 1543/08 and No. 1421/08.

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Semiconductors

This report describes magnetoresistance measurements on a two-dimensional (2D) electron system in AlAs quantum wells, where strain is used to tune the relative occupation of two conduction band valleys. The valley polarization energies for composite fermion states around the filling factors 1/2 and 3/2 are found to be different, contrary to theoretical expectations and thus pointing to the particle-hole symmetry breaking in the AlAs 2D system. The origin of this symmetry breaking is not understood.
•Published as a *Brief Report* in *Physical Review B* **81**, 113301 (2010).

Composite Fermion Valley Polarization Energies: Evidence for Particle-hole Asymmetry

Medini Padmanabhan, T. Gokmen, and M. Shayegan (Department of Electrical Engineering, Princeton University)

Introduction

The influence of discrete degrees of freedom such as spin and valley on the fractional quantum Hall effect (FQHE) is of fundamental importance[1-3]. Here we report our studies on electrons confined to AlAs quantum wells in which there are two equivalent conduction band minima (valleys). We compare the energies required to completely valley-polarize the composite fermions (CFs) around Landau level filling factors, $\nu = 1/2$ and 3/2 and find that the CFs around $\nu = 1/2$ need smaller energies to completely valley-polarize.

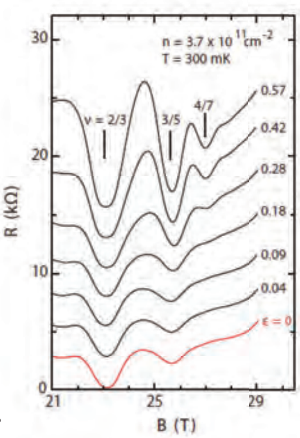
Experimental

We perform our studies in AlAs two-dimensional electron systems (2DESs) with tunable density (*n*). Our measurements were done in SCM1 (18 T, 20 mK), SCM2 (18T , 300 mK) and resistive magnet (33T , 300 mK). We apply strain (ε) to tune the relative occupation of the two valleys.

Results and Discussion

Figure 1 shows magnetoresistance traces taken around $\nu = 1/2$ at different ε. Note that the strength of the various FQH minima vary with varying strain[2]. In Figures 2a. and 2c., we follow the strength of the FQH states as a function of strain. The x-axis is the valley splitting energy ($E_v = \varepsilon E_2$, where $E_2 = 5.8$eV is the deformation potential for AlAs) normalized to the Coulomb energy, V_C. Comparing the shape of these traces to a simple fan diagram drawn for single-spin, two-valley CFs, we find that the outermost peaks signify complete valley polarization[2].

In an ideal theoretical picture, the FQH states around $\nu = 1/2$ are the particle-hole conjugate states of the FQH states around $\nu = 3/2$ for a two-valley, single-spin system. Hence, the normalized valley polarization energies are expected to be the same for both cases. To verify this conjecture, we plot in panels 2b. and 2d. the strain evolution of the FQH states at $\nu = 4/3$ and 7/5 which are the conjugate states of $\nu = 2/3$ and 3/5 respectively. Surprisingly, we find that the states around $\nu = 1/2$ require much less energy to valley polarize. The trend is also followed by the compressible states at $\nu = 1/2$ and 3/2 as shown in Figures 2e. and 2f.



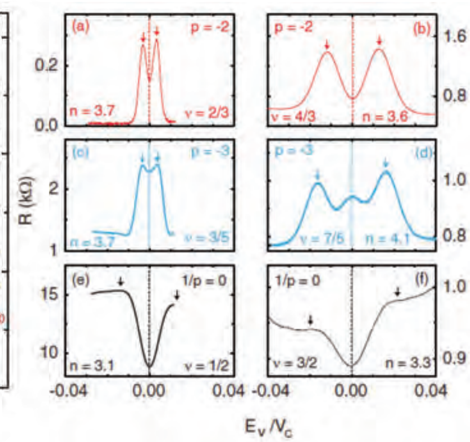


FIGURE 1. Magnetoresistance around $\nu = 1/2$ for different ε.
FIGURE 2. Resistance at various ν's as a function of normalized valley-splitting energy. Corresponding CF electron densities (n) and filling factors (p) are also shown.

where the valley polarization energies are denoted by the arrows[2].

Conclusions

We compare the valley polarization energies for CF states around $\nu = 1/2$ and 3/2. In an ideal case, these states are supposed to be related by particle-hole symmetry and hence expected to have identical valley-polarization energies. However, we find that their energies are very different, pointing toward particle-hole symmetry breaking in our system. Influences of Landau level mixing and Fermi contour anisotropy need to be investigated theoretically before we can understand these observations[2].

Acknowledgements

This work was supported by the NSF. We thank G. Jones, S. Maier, T. Murphy, E. Palm and J.H. Park for technical help.

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Superconductivity/Basic

There are the two interesting results in this report by A.M. Mounce *et al.* Although the physics addressed in the first part of the report is not in the forefront of the HTc studies in cuprates, still, the observed effect is rather elegant. Namely, as known, onset of superconductivity slightly shifts the chemical potential. In cuprates where the Levanyuk-Ginsburg parameter is considerably larger than in most ordinary superconductors, the shift would result in a small but reasonable charge located in the vortex core. Its presence was observed by A.M. Mounce *et al.* by ^{17}O NMR in the overdoped single crystal of $Bi_2Sr_2CaCu_2O_{8+x}$ where the Fermi liquid description becomes restored. In this material the pronounced layered structure manifests itself in the two-dimensional vortices whose cores consist of "pancakes" on each conducting layer and weakly coupled along the c-axis. The magnetic field tends to organize the pancakes into the 3D-vortex line. However, with the field increase when vortices begin to overlap, the role of the magnetic attractive interaction decreases and the Coulomb repulsion between the charges on the pancakes in the adjacent planes results in the new pattern for the pancakes' organization.

Another result seems to be a rather important one; it concerns the elaboration of the new nuclear magnetic resonance (NMR) technique with high contrast and spatial resolution by the use of which the authors revealed the antiferromagnetic order (in Bi2212) emerging in the vicinity and on the background of an individual vortex.

•Published in *Nature Physics* **7**, 125-128 (2011).

Charged Vortices & Vortex Structure Instability in $Bi_2Sr_2CaCu_2O_{8+\delta}$

A.M. Mounce, S. Oh, S. Mukhopadhyay and W.P. Halperin (Northwestern University);
A.P. Reyes and P.L. Kuhns (Magnet Lab, FSU), **H. Takagi and S. Uchida** (University of Tokyo)

Introduction

Pancake vortices in highly anisotropic $Bi_2Sr_2CaCu_2O_{8+\delta}$ (BSCCO), are only weakly coupled between layers in a two-dimensional vortex solid at low temperatures[1]. If there is electrical charge accumulation in the vortex core, as has been theoretically predicted[2], pancakes on adjacent planes will repel one another overcoming the attractive magnetic interaction between vortex supercurrents. At sufficiently high magnetic field, the Abrikosov configuration of vortices will become unstable, an effect we have observed in NMR measurements of the vortex magnetic field distribution.[3]

Experimental

Our samples for ^{17}O NMR are overdoped (T_c = 75, 82 K) crystals prepared with ^{17}O exchange and annealed with the c-axis parallel to the field. We performed measurements of the spectrum from H = 4 to 30 T at temperatures of 4.2 K, in cell 7 of the DC Field Facility at the Magnet Lab, and in superconducting magnets at the Mag Lab and at Northwestern University.

Results and Discussion

Measurements of the NMR spectra in the mixed state show a collapse of the second moment of the magnetic-field distribution with increasing applied magnetic fields ≈10 T. This phenomenon is inconsistent with expectations from Ginzburg-Landau theory[1,3]. However, our calculations of the effect of charge on the vortex core give a phase diagram for a predicted instability of the Abrikosov configuration, which could account for the observations with the charge per pancake of ≈ 2 x 10^{-3} of an electronic charge. In Figure 1 we show the NMR measurements compared with a calculation of the total energy for the displacement of a plane of vortex pancakes, relative to others on adjacent planes, as a function of magnetic field. In our calculation the charge on the vortex core is adjusted such that the minimum energy matches the minimum in the local field distribution giving a vortex charge that decreases with increasing doping, similar to theoretical expectations[2]. At higher magnetic fields an increase in the NMR linewidth, Figure 1, is evidence for a spin-density wave associated with the vortex core[4].

Conclusions

There is evidence for vortex core charge and spin-density modulations associated with vortices in the highly anisotropic high-temperature superconductor, $Bi_2Sr_2CaCu_2O_{8+\delta}$.

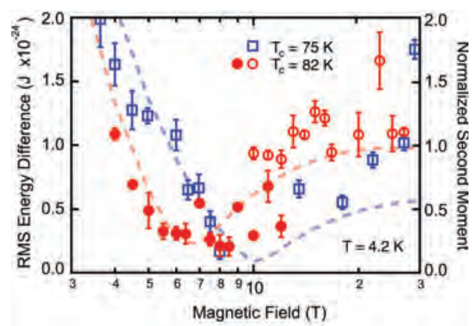

FIGURE 1. Second moment of the NMR line and energy of vortex pancakes.

Acknowledgements

This work is supported by DOE/BES: DE-FG02-05ER46248 and the Magnet Lab by NSF and the state of Florida.

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Superconductivity/Basic

In this report by S.E. Sebastian *et al.*, quantum oscillations (QO) were measured in underdoped YBCO in the high fields up to 85 tesla (T). The emphasis was on studying the angular dependence of QO, which in the quasi-two-dimensional YBCO may, in principle, shed some light on the origin of the recently discovered (in high fields) metallic pockets in these HTc superconductors.

Angles up to 71° were measured for the first time in underdoped YBCO, enabled by the development of a new worm-drive rotator capable of precise rotation in the 85 T pulse magnet. The extensive angular study enabled an unambiguous disentanglement of spin and orbital degrees of freedom, by the detection of special 'spin zero' angles, when the amplitude of oscillations crosses zero, and the phase of the oscillations invert by 180°. Whilst earlier reports in a limited angular range either reported no phase inversion (S. E. Sebastian *et al.,* Phys. Rev. B, **81**, 214524 (2010)), or a single phase inversion (B. J. Ramshaw *et al.,* Nature Phys., **7**, 234 (2011)), this resulted in some ambiguity as to the extracted value of m^*g^*, the rigorous determination of which requires the observation of at least two spin zero angles.

The current measurements up to 71° have been successful in locating two spin zeros at 53° and 65° (for 25 T < B < 28 T), thereby unambiguously identifying the value of $m^*g^* \approx 2.7$.

Angular Dependence of Quantum Oscillations in Underdoped YBCO up to 85 T

S. E. Sebastian, **G. G. Lonzarich** (University of Cambridge),
N. Harrison, M. A. Altarawneh, F. F. Balakirev (Magnet Lab, Los Alamos),
Ruixing Liang, W. N. Hardy, D. A. Bonn (University of British Columbia)

Summary

An important clue to the nature of order associated with the electronic structure in underdoped YBCO is provided by the angular dependence of the measured quantum oscillations. The spin and orbital degrees of freedom may be disentangled by this method, since only the latter varies with angle. Previous studies have traced the angular dependence up to ≈57° in magnetic fields of ≈60 T [1,2]. Here, we use a recently developed high-precision rotator capable of use in conjunction with the 85 T multi-shot pulsed magnet to extend the measured angular range of quantum oscillations in YBCO. Two spin zeros (i.e. angle where an inversion in oscillatory phase and vanishing amplitude) are observed (Figure 1).

Acknowledgements

Funding from the Royal Society, BES 100 T program is acknowledged.

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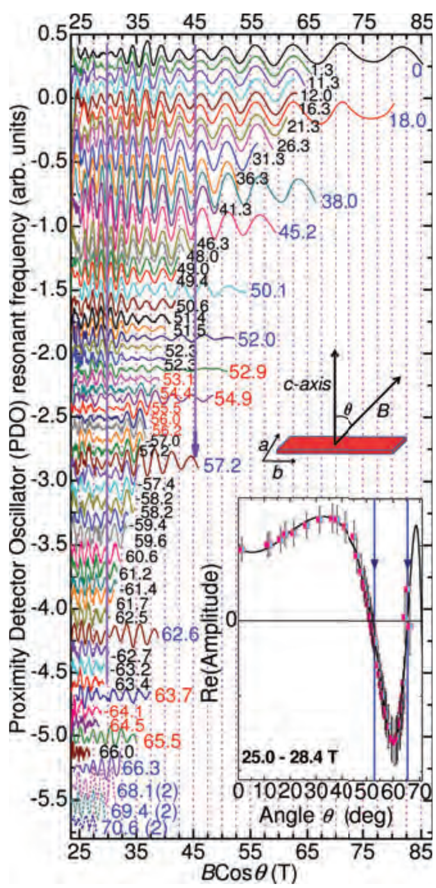

FIGURE 1. Quantum oscillations measured as a function of angle in the 65 T and 85 T (angles labeled in blue) pulsed magnets. The oscillations are seen to undergo a minimum in amplitude accompanied by an inversion in phase in the angular regime 53°– 56°, and at a second spin zero in the angular regime 64°– 65° (shown in inset). The phase remains uninverted in the remaining angular regime. Precise in-situ calibration by means of a projection coil affixed under the sample is performed.

Superconductivity/Basic

R.R. Urbano *et al.* studied the sequence of the structural and magnetic (spin-density wave) phase transitions in underdoped ferropnictide $BaFe_2As_2$ ($Ba_{0.84}K_{0.16}Fe_2As_2$). Although driven by the SDW order parameter, the transition turns about to be of the first order. In most experiments it is claimed that the orthorhombic and magnetic order appear below T_{Neel} simultaneously. While the first-order character of the transition is expected to be caused by strong quadratic magnetostriction coupling, the theory, however, seems to be unable to resolve the details of this phase transition. In fine ^{75}As nuclear magnetic resonance experiments, it was shown that the transition realizes as the sequence of the two phase transitions: the tetragonal-to-orthorhombic structural transition at $T_{str} \approx 110$ K is then followed by the magnetic transition below $T_{SDW} \approx 102$ K.

An unexpected strong magnetic anisotropy is found for the staggered magnetization. The latter parameter grows remarkably with the in-plane field *H* increase above a threshold ~5 T. Another important finding is that below T_c=20 K the emerging superconductivity coexists microscopically with magnetism. Both results await an explanation.

・Published in *Physical Review Letters* **105**, 107001 (2010).

High Field Dependence and Ordered Moment Anisotropy in Underdoped $Ba_{1-x}K_xFe_2As_2$

R. R. Urbano, E. L. Green, W. G. Moulton, P. L. Kuhns, A. P. Reyes (Magnet Lab, FSU);
E. M. Bittar, C. Adriano, P. G. Pagliuso (Unicamp)

Introduction

The surprising discovery of superconductivity (SC) in layered iron-based materials, with transition temperatures as high as 56 K, has led to an avalanche of publications on this subject and naturally raised comparisons with the high-T_c copper oxides over the past two years. The antagonistic relationship between SC and magnetism has previously led researchers to avoid using magnetic elements as potential building blocks of new SC materials. Because elemental iron is strongly magnetic, the discovery of Fe-based superconductors with high T_c values was completely unexpected. This has opened a new avenue of research driven by the necessity of our better understanding of the origins of unconventional SC. Although there is general consensus on the nature of the SC state of these materials, many crucial questions still remain — including the role of magnetism, the nature of chemical and structural tuning, and the resultant pairing symmetry. It is clear that the search for universal underlying physical properties still continues.

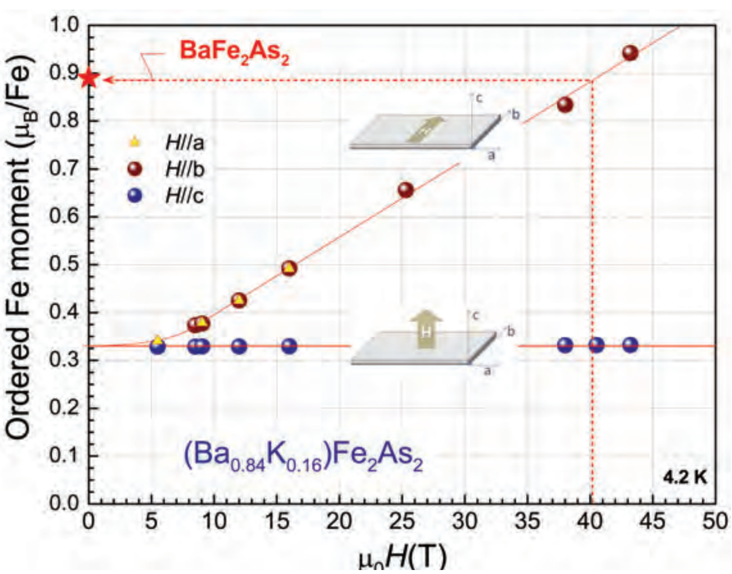

FIGURE 1. Ordered moment ⟨M⟩ of $Ba_{0.84}K_{0.16}Fe_2As_2$ for various magnetic fields with $H \perp c$ and *H*//c at 4.2 K.

Experimental, Results and Discussion

Here we report ^{75}As NMR measurements in an underdoped $Ba_{0.84}K_{0.16}Fe_2As_2$, single crystal under high magnetic fields up to 45 T. The high-*H* experiments were carried out at the Magnet Lab using the Hybrid magnet.

In contrast with the *simultaneous* structural and magnetic first-order transition T_0 previously reported for Ba-122, our investigation revealed that the transitions are not concomitant[1]. The tetragonal (τ) - orthorhombic (ϑ) structural transition occurs at $T_S \sim = 110$ K, followed by a long-range antiferromagnetic (AFM) transition at $T_N \sim = 102$ K. Our data also show that SC develops in the ϑ phase below $T_c = 20$ K coexisting microscopically with AFM. This new observation firmly establishes another similarity between the hole-doped $BaFe_2As_2$ and other iron-arsenide superconductors[1]. Furthermore, the ordered Fe moment $\langle M \rangle_{H \to 0}$ is reduced upon K-doping suggesting that the addition of "holes" into the electronic system dramatically changes the local

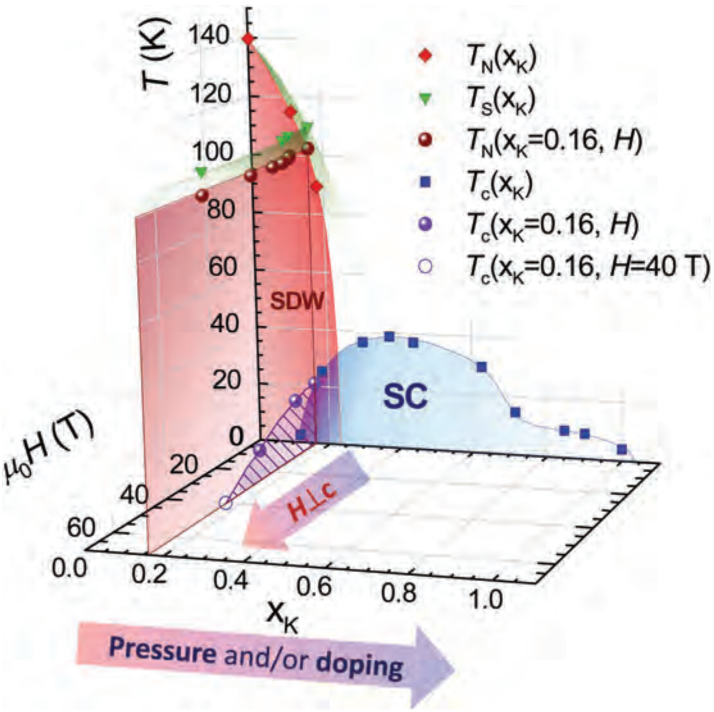

FIGURE 2. *H-x-T* phase diagram of $Ba_{1-x}K_xFe_2As_2$.

charge distribution associated with the hybridization of the Fe-3*d* and As-4*p* orbitals. Surprisingly, when $H \perp c >> 0$, we observe a strong anisotropy with $\langle M \rangle$ enhanced by the applied magnetic field. Thus, as inferred from Figure 1, the material recovers the value of $0.87\mu_B$/Fe when $H \sim 40$ T — the same value of $\langle M \rangle$ reported for the undoped Ba-122 compound. In addition, the fact that the SC is fully suppressed with fields around 40 T suggests this field is the $H_{c2}^{(T\rightarrow 0)}$ for our underdoped Ba-122. We therefore conclude that the magnetic field may be considered as another *control parameter* that, in contrast to the chemical doping and pressure, tunes the system towards the AFM state along with increased localization of the electrons[2]. Our recent findings shed new light on the underlying physics of this novel class of materials and might establish a new window to explore the effects of *magnetic field* on the Fermi surface of $BaFe_2As_2$ as an alternative *tuning parameter.*

Work at Magnet Lab was performed under the auspices of the NSF (DMR-0654118) and the state of Florida. R. Urbano thanks the Jack. E. Crow Fellowship. Work at Unicamp was supported by Fapesp, CNPq and Capes.

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Engineering Materials

Because of their unique diffusive properties, mesoporous materials have attracted tremendous interest as catalysis, materials for separations, and for the selective adsorption and immobilization of biomolecules. In this report, researchers use pulsed field gradient (PFG) and tracer zero length column (TZLC) nuclear magnetic resonance (NMR) techniques to study the diffusion of small molecules in a prototypical mesoporous material (Mesoporous Silica; SBA-15). NMR studies were carried out using a high gradient strength probe at 750 MHz in the Advanced Magnetic Resonance Imaging and Spectroscopy facility. Menjoge *et. al.* determined the self-diffusion of toluene under conditions in which toluene completely filled all the meso- and micropores of the SBA-15 particles. Discrepancies in diffusivities were detected when these measurements were made using either PFG or TZLC techniques. TZLC measurements indicated the presence of long, string-like aggregates of primary SBA-15 particles. On the other hand, PFG experiments captured the much faster sorbate transport. These results demonstrate that both microscopic and macroscopic diffusion can be measured in mesoporous materials at 750 MHz using strong diffusion gradients.
•Published in the *Journal of Physical Chemistry C* **114**, 16298–16308 (2010).

Combined Application of Pulsed Field Gradient (PFG) NMR and Tracer Zero Length Column (TZLC) Technique for Studies of Diffusion of Small Sorbate Molecules in Mesoporous Silica SBA-15

Amrish R. Menjoge, Sergey Vasenkov (University of Florida, Chemical Engineering);
Qinglin Huang, Mladen Eic (University of New Brunswick, Chem. Eng.);
Serge Kaliaguine (Université Laval, Chem. Eng.)

Introduction

Mesoporous silica SBA-15 attracts significant interest of the research community due to the possibility to use this type of mesoporous material in catalysis and separations as well as for selective adsorption and immobilization of biomolecules.

Experimental

PFG NMR technique was applied to study self-diffusion of toluene in SBA-15 samples. The measurements were performed by proton PFG NMR using a wide-bore 17.6 tesla (T) Bruker BioSpin spectrometer located at AMRIS, University of Florida. Magnetic-field gradients were generated using diff60 diffusion probe and Great60 gradient amplifier (Bruker BioSpin). PFG NMR studies were carried out for different diffusion times using the PFG NMR stimulated echo sequence with the longitudinal eddy-current delay. TZLC technique was used to measure toluene diffusivity in SBA-15 by monitoring the rate of desorption of deuterated toluene from the SBA-15 samples.

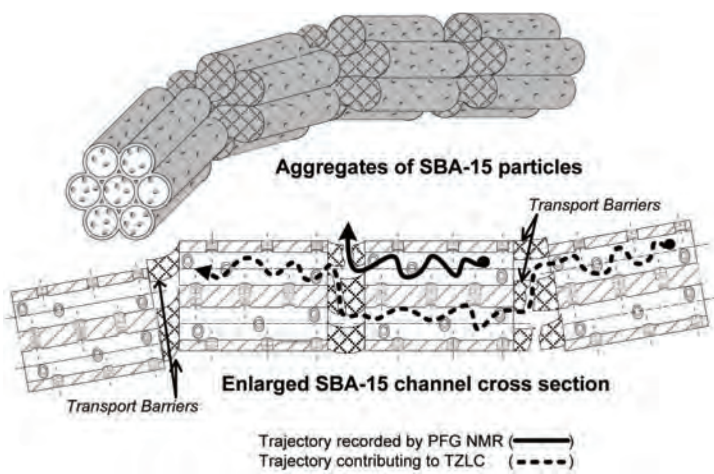

FIGURE 1. Schematic presentation of the channel system of SBA-15 aggregates and of the typical trajectories of sorbate molecules contributing to the PFG NMR and TZLC data.

Results and Discussion

TZLC and PFG NMR techniques were employed to study self-diffusion of toluene in two SBA-15 samples under the conditions when toluene completely fills all meso- and micropores of SBA-15 particles. For diffusion inside pore systems of SBA-15 particles the estimates of toluene diffusivities obtained by TZLC were found to be several orders of magnitude smaller than the corresponding diffusivities measured by PFG NMR. This discrepancy is attributed to the presence of long, string-like aggregates of primary SBA-15 particles (Figure 1).

Formation of such aggregates leads to the possibility of the existence of mesoporous channels, which are as long as the aggregate lengths (~30 µm). These long channels are likely to have transport resistances at the points of the connections of channels of individual SBA-15 particles forming the aggregates. TZLC is expected to be especially sensitive for detecting sorbate diffusion in such long channels where the diffusivity can be significantly reduced by the transport resistances. At the same time, such slow diffusion is bound to remain undetected by PFG NMR because the T_2 NMR relaxation times of slowly diffusing sorbate molecules are too short for detection of this sorbate fraction.

In contrast to the slow diffusion in long channels with defects, much faster sorbate transport in shorter (~1 μm) channels with no or insignificant defects can be (and was) recorded by PFG NMR. Such data are not only of fundamental interest, but also of interest for applications of SBA-15 materials. In particular, knowledge of intrachannel diffusivities in SBA-15 can be important for understanding catalysis on active sites introduced on the pore walls of the main mesoporous channels because these diffusivities determine the frequencies of visits of such sites by guest molecules.

Conclusions

Microscopic and macroscopic diffusion measurements performed, respectively, by PFG NMR and TZLC provide complementary information on different types of sorbate transport in SBA-15 materials.

Acknowledgements

This work was financially supported by NSF CAREER award (CBET#0951812).

Magnet Technology

The 32-tesla (T) magnet will be transformative to the field of superconducting magnets through the use of Rare-earth-BCO high-temperature superconductors. Quench protection using active heaters is one of several key enabling technological developments underway.

YBCO Pancake Wound Test Coil for 32-T Magnet Development

W.D. Markiewicz, P.D. Noyes, A.J. Voran, W.R. Sheppard, K.W. Pickard, J. Lu (Magnet Lab, FSU)

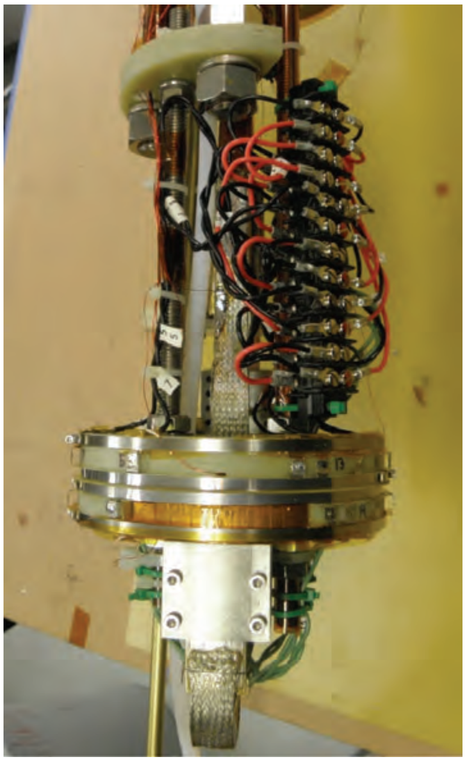

FIGURE 1. Double pancake coil on test probe.

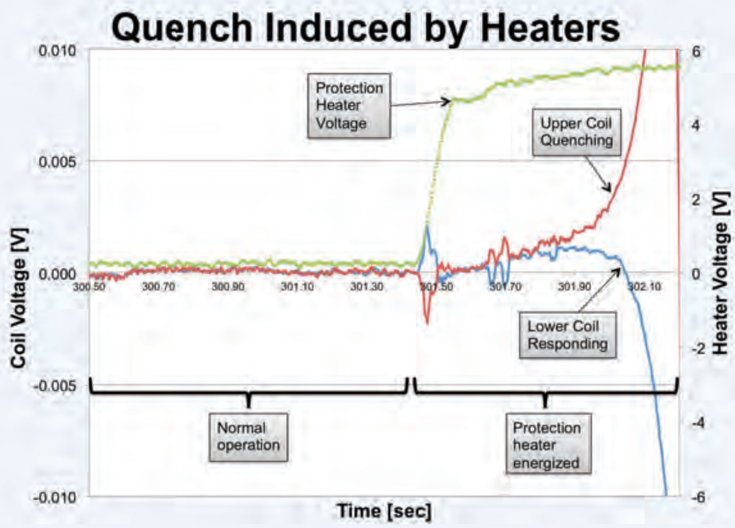

FIGURE 2. Coil response to protection heater showing rapid formation of induced quench.

Introduction

A project is underway at the Magnet Lab for the development and fabrication of a 32-T all superconducting magnet to be installed in the Millikelvin user facility. As part of the general development activity, a double pancake coil was designed, fabricated and tested. The double pancake coil uses component designs and fabrication processes intended for use in the 32-T magnet. The coil, with inner and outer winding diameter of 84 mm and 124 mm respectively, was wound with YBCO conductor and includes stainless steel co-winding for reinforcement. The coil assembly also includes quench-protection heaters.

Experimental

The YBCO double pancake coil (Figure. 1) on the test probe was tested in the DC Field Facility, making use of the unique large bore resistive magnet to provide a background field of 20 T. A high-speed data-acquisition system was employed to monitor coil ramping and quench performance. The coil was ramped to progressively higher currents, with many ramps to the design operating current of the 32-T magnet, where a series of quenches were induced by the embedded protection heaters to study the coil response as a part of quench-protection development. The coil was then ramped to high current to simulate and exceed the maximum stress that will be incurred in the 32-T magnet.

Results and Discussion

The YBCO coil generally performed well, ramping numerous times to intermediate currents and subjected to numerous heater-induced quenches as indicated in Figure 2. The basic coil-design concept was confirmed and the coil-fabrication process demonstrated to give reliable performance. The coil was ramped progressively to a maximum current of 300 A with a maximum stress of 500 MPa. At a current of 275 A, some damage was incurred at one of the terminals resulting in an increase in coil voltage, and suggesting further design changes in the terminal joint.

Acknowledgements

This work was supported by the National Science Foundation grant DMR-Award 0923070 and the Mag Lab User Collaboration Grants Program.

Superconductivity/Applied

Pnictides can accept a very high density of nanoscale, pillar defects that produce very strong vortex pinning and high H_{irr} without degrading the superconducting properties of the matrix. The nanopillars are almost perfectly sized, being 2 coherence lengths in diameter at a density of about 10 tesla.
•Published in *Applied Physics Letters* **96**, 142510 (2010).

Strong Vortex Pinning in Co-doped $BaFe_2As_2$ Single Crystal Thin Films

C. Tarantini, J. Jiang, J. D. Weiss, A. Polyanskii, A. Gurevich, E. E. Hellstrom, D. C. Larbalestier (Magnet Lab, FSU);
S. Lee, C. W. Bark, H. W. Jang, C. M. Folkman, S. H. Baek, C. B. Eom (U. of Wisconsin);
Y. Zhang, T. Nelson, X. Q. Pan (U. of Michigan)

Introduction

In the high-temperature superconductors a strong effort was made in the last years to reduce the intrinsic material anisotropy. In YBCO, for instance, the increase of the critical current density J_c when the field is along the c-axis is possible but only at low field. On the contrary we were able to strongly increase J_c in cobalt-doped $BaFe_2As_2$ thin films up to high field and in a wide angular range.

Experimental

We characterized Ba122 thin films by high-resolution transmission electron microscopy (TEM) to study the defect structure. We also performed $J_c(H,\theta)$ measurements to verify how those defects affect the superconducting properties.

Results

The TEM images in Figure 1 reveal the film has a high density of nanocolumns. Their diameter is about 5 nm and they grow up from the buffer layer through the whole sample. Figure 2 shows that J_c is then only weakly field dependent and that it has a strong and broad c-axis peak.

Conclusions

These nanocolumnar defects have sizes comparable to 2ξ (the superconducting coherence length) making them extremely effective in increasing the critical current density without compromising the primary superconducting properties. The c-axis peak is so intense as to affect the whole angular J_c up to high fields and to invert the natural material anisotropy[1-3].

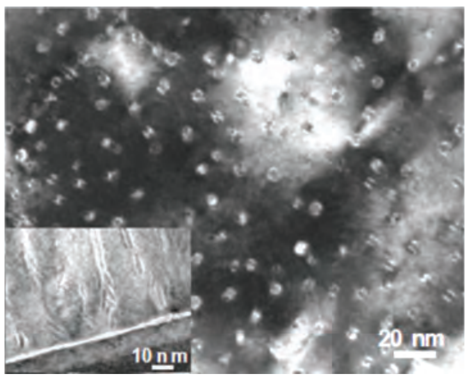

FIGURE 1. Planar view TEM of a Ba122 thin film showing a high density of randomly distributed defects. In the inset the cross section reveals the nanocolumns are vertically aligned.

Acknowledgements

Work at the Magnet Lab was supported under NSF Cooperative Agreement No. DMR-0084173, by the state of Florida, and by AFOSR grant FA9550-06-1-0474. Work at the UW was supported by funding from the DOE Office of Basic Energy Sciences under award number DE-FG02-06ER46327. TEM work at the University of Michigan was supported by the DOE grant DE-FG02-07ER46416. TEM facility was supported by NSF.

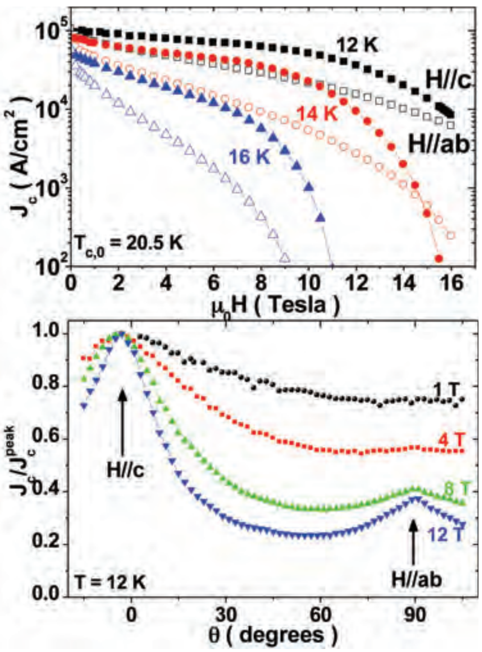

FIGURE 2. (a.) Field and (b.) angular dependence of J_c in a Ba122 thin film showing a strong increase of the critical current when H is parallel to the c-axis.

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Superconductivity/Applied

Extensive characterization of REBCO-coated conductors provides a technological and scientific underpinning for understanding the field and angular dependence of the critical current density of coated conductors to be used in 30+ tesla (T) magnets, showing, rather surprisingly, that correlated pinning centers like $BaZrO_3$ reduce the anisotropy of the current density at 4 K.
•Published in *Superconductor Science and Technology* **24**, 035001 (2011).

Properties of Recent IBAD-MOCVD Coated Conductors Relevant to Their High Field, Low Temperature Magnet Use

V. Braccini, A. Xu, J. Jaroszynski, D. C. Larbalestier (Magnet Lab, FSU);
Y. Chen, G. Carota, J. Dackow (SuperPower Inc.);
I. Kesgin, Y. Yao, A. Guevara, T. Shi, V. Selvamanickam (University of Houston)

Introduction

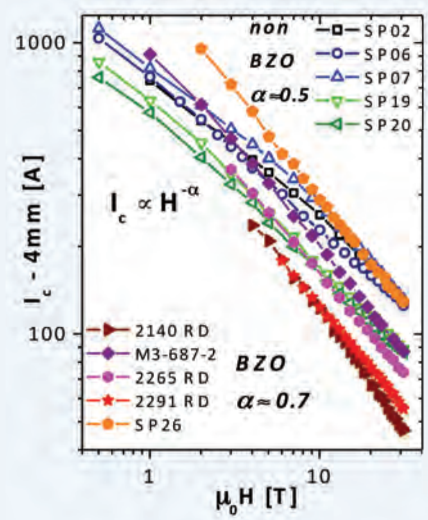
YBCO is now the prime choice for superconducting magnet technology to go to 30 T and beyond. Thus characterization of the angular critical current $I_c(\theta,H)$ at 4.2 K of YBCO coated conductors (CCs) is important for magnet design as well as to understand pinning. We performed detailed angular studies of I_c in different CCs from SuperPower Inc. focusing on the effect of Zr doping, which produces $BaZrO_3$ (BZO) precipitates.

Experimental

We measured $I_c(\theta,H)$ at 4.2 K with θ varying between -20° and 110° in several CCs at 4.2 K with a home-built, 500 A rotator probe in the 31-T, 52-mm warm bore, Bitter magnet, fitted with a 3-8mm bore He cryostat by means of four probe transport using high current (up to 500 A) rotator.

Results and Discussion

Figure 1 shows I_c as a function of H at 4.2 K and with H perpendicular to *ab* for several CCs. Power law dependence on field $I_c \propto H^{-\alpha}$: is clearly seen for all samples with α approximately 0.5 and 0.7 for undoped and Zr doped samples, respectively. Figure 2 shows angular dependence of four samples at 5, 10, 20 and 25 T, after normalizing I_c to its value perpendicular to the ab plane. Notably, Zr doping widens the maxima, leading to a higher current 5°-20° off the *ab* plane where it is valuable for magnet construction[1].



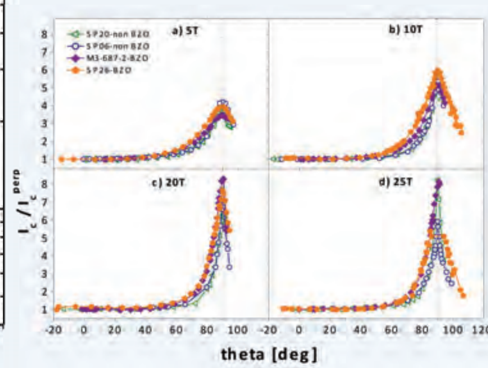


FIGURE 1. I_c vs. H at 4.2 K and H perpendicular to the *ab* plane in different CCs from SuperPower Inc. and from UT Houston. Open/solid symbols are for samples without/with BZO additions.
FIGURE 2. I_c vs. angle at 4.2 K at different magnetic fields in four CCs. It is clearly seen that samples with BZO (solid symbols) have wider maxima around *ab* plane.

Conclusions

We found that Zr doping substantially modifies the $I_c(\theta,H)$ angular dependency at 4.2 K. In particular, it widens the cusp-like I_c maxima around the CC plane. Thus BZO-doped CCs are more suitable for magnet construction than undoped CCs, despite their faster decrease of I_c with increasing magnetic field in the off-plane configuration.

Acknowledgements

Work at Magnet Lab was supported by NSF Cooperative Agreement DMR-0654118, by the state of Florida, and by the DOE. The work at University of Houston and SuperPower was partially supported by the DOE.

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Superconductivity/Applied

Phenomena at the grain boundaries are one of the key factors that determine the overall current carrying capability of high-temperature superconductors, and thereby their usefulness in, for example, magnets and electronics applications. This work increases our understanding of these phenomena by providing a link between the theory of superconductivity and experimentally observed properties.

Modeling High-Temperature Superconductor Grain Boundaries

P.J. Hirschfeld (University of Florida), S. Graser, T. Kopp, and J. Mannhart (U. Augsburg)

Introduction

We present a proposed solution to a longstanding and important problem of cuprate superconductivity, namely the exponential suppression of the critical current J_c in the cuprates as a function of the misorientation angle θ between two superconducting grains. This effect is held to be responsible for the fact that it is difficult to enhance the critical current in HTS wires and tapes, and has been understood and recognized as very important since the late 1980s[1]. Using a hierarchical approach, we succeeded in reproducing the exponential dependence of J_c on θ, and its statistical scatter with grain-boundary type, and showed that it depends only weakly on the symmetry of the superconducting order[2].

Results and Discussion

The reconstruction algorithm, based on earlier work on homogeneous crystals, successfully reproduced the statistical distribution of structural units occurring near actual YBCO brain boundaries (GBs) seen in transmission electron microscope experiments. Positions of atoms in this layer were then assumed to determine the local charging and distribution of effective hoppings for a two-dimensional, tight-binding Bogoliubov-de Gennes model, whose critical current was then calculated using standard techniques.

Conclusions

Exponential dependence on misorientation angle in HTS GBs arises from the complexity of the oxide interface and the angle-dependent effective charge barrier, and is only weakly related to the order parameter symmetry.

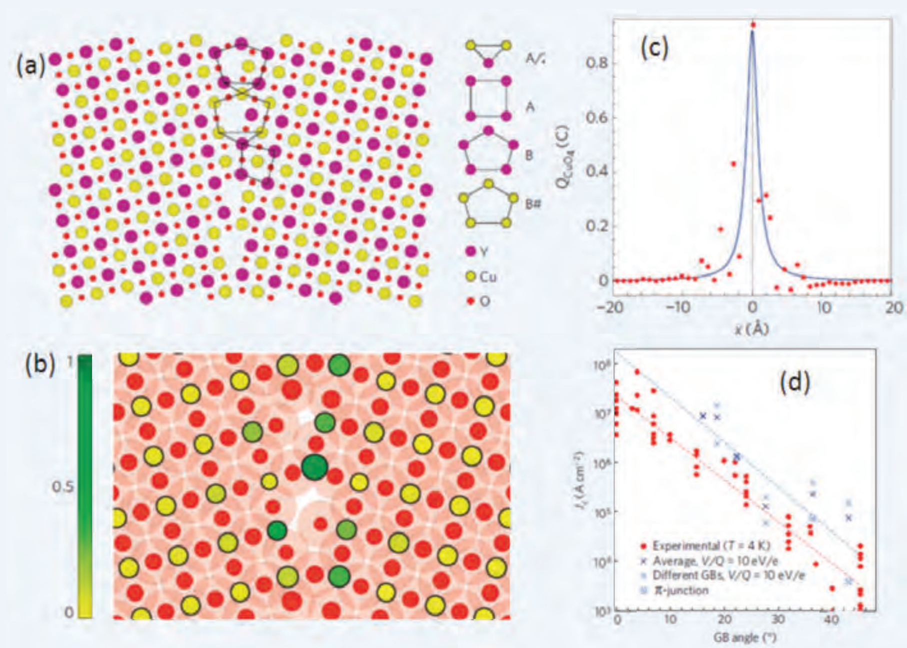

FIGURE 1.
a. Reconstruction of a (410) grain boundary of YBCO by molecular dynamics; **b.** charging of Cu and O atoms in CuO_2 plane; **c.** Average charge distribution as function of distance to boundary (x=0) averaged over grain boundary length; **d.** critical current calculated from Bogoliubov-de Gennes equations compared with experiment[2].

Acknowledgements

Supported by DE-FG02-05ER46236.

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Inorganic/Organometallic Chemistry

As published in *Angew. Chem. Int. Ed.*, this constitutes the first High Frequency Electron Paramagnetic Resonance (HFEPR) report in the literature on a strongly reduced oxidation state of vanadium, V(II). A broader significance lies in the magnetic characterization of catalytically active complexes of vanadium.

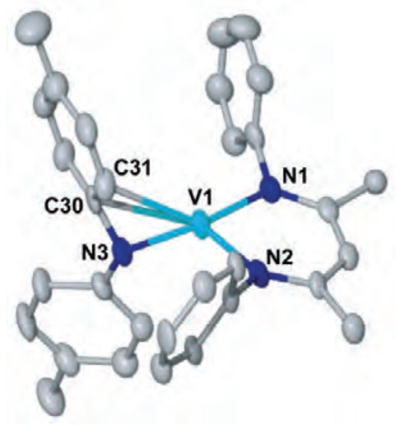
•Published in *Angew. Chem. Int. Ed.* **49**, 9871–9875 (2010).

HFEPR Studies of a Three-Coordinate Organometallic Vanadium(II) Complex

B. L. Tran, M. Singhal, H. Park, M. Pink, D. J. Mindiola (Indiana University, Chemistry); **J. Krzystek, A. Ozarowski** (Magnet Lab, FSU); **J. Telser** (Roosevelt U., Chemistry); **O. P. Lam, K. Meyer** (Erlangen U., Germany, Chemistry)

Introduction

Vanadium can access a wide range of oxidation states, many of which are paramagnetic. These include V(IV) ($3d^1$, S =1/2), well-studied by EPR, as well as states with multiple unpaired electrons such as V(III) ($3d^2$, S =1), which has been studied by HFEPR at Magnet Lab[1], and V(II) ($3d^3$, S =3/2), hitherto unstudied by HFEPR. V(II) is best known in vanadocene, Cp_2V (Cp = cyclopentadiene monoanion), but recent synthetic work has led to the preparation of V(II) complexes with a wider variety of ligands, such as nacnac, the β-diketiminato ligand[2]. Mindiola and co-workers have prepared a "masked" three-coordinate vanadium(II) complex, [(nacnac)V($Ntol_2$)], where nacnac = RN=C(CH_3)CH=C(CH_3)NR monoanion, with R = 2,6-diisopropylphenyl, and tol = tolyl ($CH_3C_6H_4$).



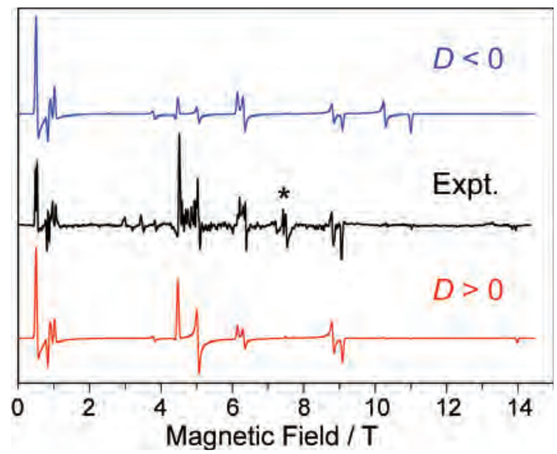


FIGURE 1. Molecular structure of [(nacnac)V(N(tol)$_2$)]. Atoms coordinated to V(II) are labeled.
FIGURE 2. HFEPR spectra of polycrystalline [(nacnac)V(Ntol$_2$)] recorded at 10 K and 208 GHz (black trace). Simulated traces are given above and below: $S = 3/2$, $|D| = 2.99$, $|E| = 0.11$ cm^{-1}, $g_{iso} = 1.98$, $\Delta B_{iso} = 250$ G; for the upper (blue) trace, (D, E) < 0 was used; for the lower (red) trace, (D, E) > 0 was used. The asterisk indicates a minor V(IV) impurity which is not simulated.

Experimental

The Magnet Lab EMR Facility with the superconducting 17-tesla magnet was used to study [(nacnac)V($Ntol_2$)] both as a polycrystalline sample and in frozen toluene solution.

Results and Discussion

The structure of [(nacnac)V($Ntol_2$)] is shown in Figure 1. In addition to coordination by the two imino N atoms of the nacnac ligand and the amido nitrogen of [N(tol)$_2$]−, there is an interaction with one of the tolyl rings, which "masks" the V(II) center. This unusual coordination geometry is reflected in the HFEPR spectrum of the complex, both as a solid and in frozen toluene solution. A representative spectrum is shown in Figure 2. The pattern is that of a nearly axial spin quartet with axial zero-field splitting, $D = 3.0$ cm^{-1}, unusually high for a $3d^3$ ($^4A_2$) system, in particular compared to values reported for typical V(II) coordination complexes[3], for which $|D| <$ ~0.2 cm^{-1}.

Conclusions

This study represents the first application of HFEPR to V(II) and is a rare application of this technique to an organometallic complex. It is hoped that the observation of a large magnitude zero-field splitting for V(II) in this case will stimulate computational investigations as well as spectroscopic studies on related d^3 complexes. These include "true" three-coordinate V(II) complexes (recently prepared in the Mindiola group) since this will allow us to understand the effect of the "masking" arene moiety in the electronic structure of these low-valent metal ions.

Acknowledgements

This work was supported by the Chemical Sciences, Geosciences and Biosciences Division, Office of Basic Energy Science, Office of Science, U.S. Department of Energy (No. DE-FG02-07ER15893).

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Chemistry

As published in *J. Natural Products*, this report identifies novel structurally diverse natural products from marine cyanobacteria with different potencies of cytotoxicity to cancer cells.

•Published in *Journal of Natural Products* **73**, 1544-1552 (2010); Vol. **73**, 1606-1609 (2010).

New Cytotoxic Macrolides and Modified Peptides from Marine Cyanobacteria

L.A. Salvador, S. Matthew, H. Luesch (UF, Medicinal Chemistry);
P.J. Schupp (University of Guam Marine Laboratory); **V.J. Paul** (Smithsonian Marine Station)

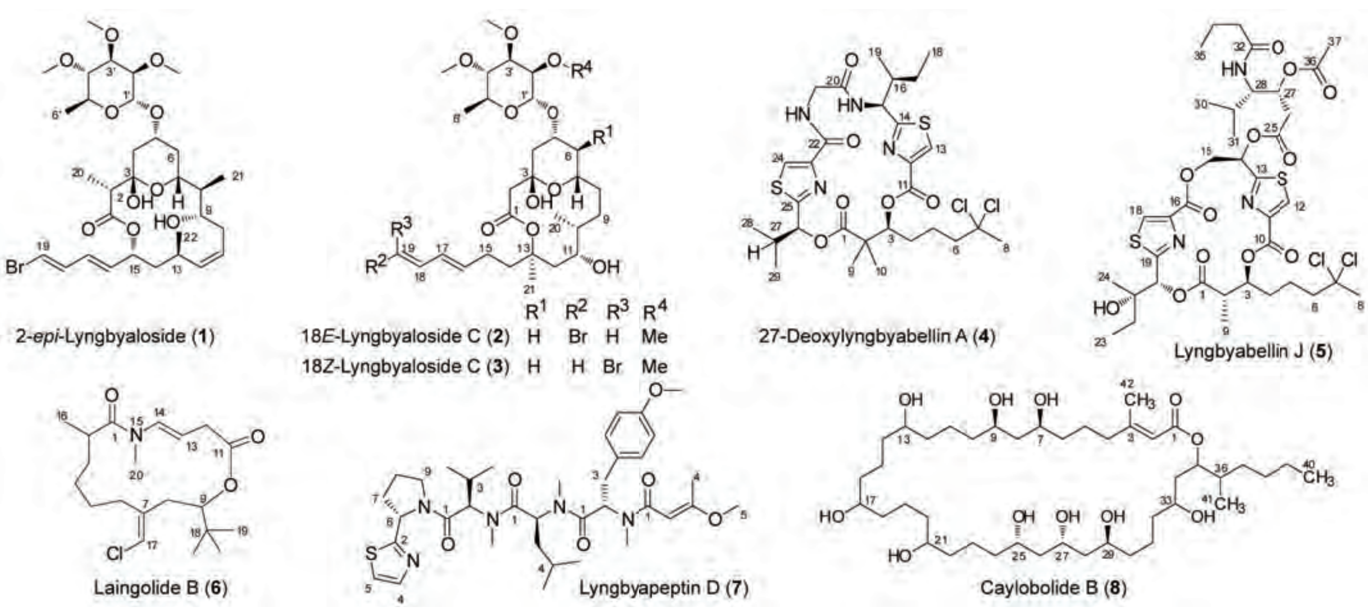

FIGURE 1. New natural products from marine cyanobacteria *L. bouillonii* (1–7) and *Phormidium* spp. (8).

Introduction

Marine cyanobacteria have been a source of bioactive secondary metabolites, the majority of which are modified peptides and depsipeptides, peptide–polyketide hybrids, and polyketides. We aim to find new classes of compounds from marine cyanobacteria through either a bioactivity-directed or nuclear magnetic resonance (NMR)-guided purification method.

Experimental

^{1}H and two-dimensional NMR spectra were recorded on a Bruker Avance II 600-MHz spectrometer equipped with a 1-mm HTS cryogenic probe or 5-mm TXI cryogenic probe using residual solvent signals as internal standards.

Results and Discussion

Collections of *Lyngbya bouillonii* from Guam yielded new glycosidic macrolides (2-*epi*-lyngbyaloside, 18*E*- and 18*Z*-lyngbyaloside C), members of the actin depolymerizing lyngbyabellins (27-deoxylyngbyabellin A and lyngbyabellin J), a macrolide with enamide and *t*-butyl functionalities (laingolide B), and a linear modified peptide (lyngbyapeptin D).[1] A collection of *Phormidium* spp. from Florida afforded the macrolactone caylobolide B with contiguous 1,3- and 1,5-diol moieties.[2] The majority of these compounds are halogenated, a hallmark of marine-derived compounds. These natural products have weak to moderate cytotoxic activity against cancer cells.

Conclusions

We identified new secondary metabolites with activity against cancer cells from marine cyanobacteria.

Acknowledgements

NIGMS grant P41GM086210, James & Esther King Biomedical Research Program Grant No. 06-NIR07 (H.L.), NIH MBRS SCORE grant S06-GM-44796 (P.J.S), Magnet Lab User Program (NSF), and J. R. Rocca.

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Analytical Chemistry

This work published in *Energy and Fuels* is the second installment of a five-part series on the evolution of petroleum composition as a function of boiling point. The work validates a 20-year-old hypothesis on the composition of heavy petroleum and resolves a decades-old dispute on the nature of petroleum heavy ends.
•Published in *Energy & Fuels* **24**, 2939-2946 (2010).

Heavy Petroleum Composition 2. Progression of the Boduszynski Model to the Limit of Distillation by Ultrahigh Resolution FT-ICR Mass Spectrometry

A. G. Marshall, A. M. McKenna, R. P. Rodgers (FSU, Mag Lab, Chemistry);
G. T. Blakney (Mag Lab, Chemistry);
F. Xian (FSU, Chemistry);
P. B. Glaser (General Electric Global Research, Chemistry)

Results and Discussion

Heavy petroleum fractions are structurally and compositionally complex mixtures that defy characterization by traditional analytical techniques. Here, we provide detailed characterization of a Middle Eastern heavy crude oil distillation series in further support of the Boduszynski model: namely, that petroleum is a continuum in composition, molecular weight, aromaticity, and heteroatom content as a function of boiling point. Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) provides ultrahigh resolving power and mass accuracy and thereby allows for elemental assignment for each of the tens of thousands of peaks in a single crude-oil sample. Part 1 of our five part series established the validity of the Boduszynski model for heavy vacuum gas oil (HVGO) distillation series. Here, we extend our analysis to fractions from a Middle Eastern heavy crude with cut temperatures including and beyond the middle distillate range. Collectively, the detailed compositional results for all heteroatom classes strongly support the continuity model. Interestingly, extrapolation of distillable compositional space to high carbon number (up to 1 MDa — see Figure 1) cannot account for the bulk H:C ratio ≈ 1.2 of nondistillable (asphaltenic) species. As we later show, those species are absent from the MS samples due to aggregation.

Acknowledgements

The authors thank John P. Quinn for maintenance of the 9.4 tesla instrument and Christopher L. Hendrickson for help in optimizing instrument parameters. This work was supported by NSF Division of Materials Research through DMR-0654118 and the state of Florida. We thank Shell Global Solutions, Houston, TX for financial support.

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Extrapolation of S1 Class Compositional Space into the Nondistillables (Asphaltenes)

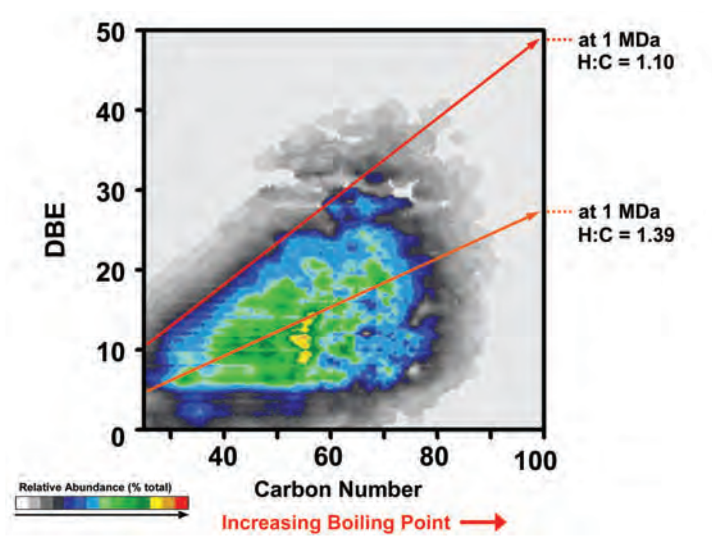

FIGURE 1. Composite isoabundance contoured plot of DBE vs. carbon number for the species containing hydrogen, carbon, and one sulfur, for Middle Eastern heavy crude oil distillation series and residue.

Analytical Chemistry

Published in *Analytical Chemistry*, the report describes the use of a one-step chromatographic pre-treatment of dissolved organic matter (Fulvic acids) that can be used to sufficiently simplify the complex mixture to allow for MS/MS structural analysis of components. The report combines the detailed compositional analysis afforded by Fourier transform ion cyclotron MS (FT-ICR MS) with the structural information provided by tandem (MS/MS) mass spectrometry.

•Published in *Analytical Chemistry* **82**, 8194-8202 (2010).

Chromatographic Reduction of Isobaric and Isomeric Complexity of Fulvic Acids To Enable Multistage Tandem Mass Spectral Characterization

E. N. Capley (U. South Alabama, Chemistry); **A. C. Stenson** (U. South Alabama);
J. D. Tipton (Magnet Lab, Biochemistry); **A. G. Marshall** (FSU, Magnet Lab, Chemistry)

Results and Discussion

Humic substances and related material commonly denoted natural organic matter (NOM) are of interest in fields ranging from marine and geochemistry to industry, agriculture, and pharmacology. High-field FT-ICR MS enables resolution and identification of elemental compositions of up to thousands of components from a single mass spectrum. Here, we introduce an offline pre-fractionation to reduce the number of species of the same nominal (nearest-integer) mass, allowing for isolation of ions of one or a few m/z values, from which structural information can be obtained by low-resolution multistage tandem mass spectrometry (MS^n). Alternatively, pre-characterized fractions can be generated for other types of analysis. As an example, we demonstrate significant reduction of isomeric and isobaric complexity for Suwannee River fulvic acid (SRFA). The combined MS and MS^n analyses support the hypothesis that early eluting material comprises older, highly oxidized SRFA, whereas later-eluting material is younger, retaining some similarity with precursor material.

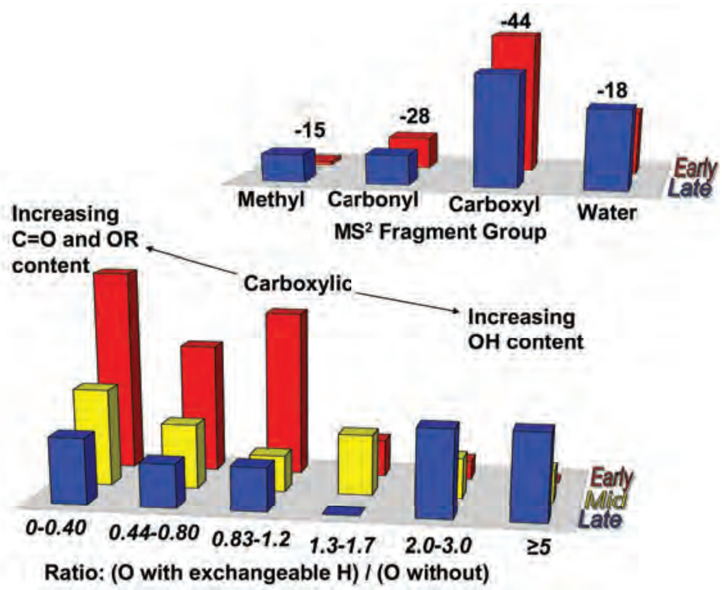

FIGURE 1. Top: Fragment ion relative abundances, grouped according to common neutral losses: e.g., methyl (-15 Da), water (-18, -36, -62 Da, etc.); carbonyl (-28, -72 Da, etc.), and carboxyl (-44, -88 Da, etc.). Bottom: Fragment ion relative abundances for each of three different elution stages, grouped according to their ratio of oxygens with exchangeable hydrogens to oxygens without. Because the listed elemental compositions include only $C_cH_hO_o$ species, the maximum number of deuteriums (D_{max}) defines the number of oxygens with exchangeable hydrogens. The number of oxygens without exchangeable hydrogens is calculated by difference (i.e., O - D_{max}). The error in D_{max} can be ~1-2, given that low-abundance ions with high D_{max} may fall below the specified abundance threshold of 3%.

Acknowledgements

The authors thank Nicole Novotny, Priscillia Ajaegbu, and Dr. Amy M. McKenna for assisting in data collection, and Dr. June E. Ayling for access to the ion trap instrument at USA College of Medicine, supported through funding from NSF-EPSCoR 0091853-353. We also thank Jerry Koncar (ThermoFisher) for providing the conversion between NCE and collision energy in V. Financial support from NSF EAR-0848635, NSF DMR-0654118, the state of Florida, and the University of South Alabama is also gratefully acknowledged.

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Inorganic Chemistry

This is the first high frequency electron paramagnetic resonance (HFEPR) work in the literature on a mononuclear rhenium(IV) complex. Re(IV) is a 5d row transition metal ion and its complexes are becoming ever more used as building blocks in nanomagnets.

•Published in *Journal of the American Chemical Society* **132**, 3980-3988 (2010).

High-Field EPR Study of a $[ReCl_4(CN)_2]^{2-}$ Magnetic Molecular Building Block

T. D. Harris, J. R. Long (UC Berkeley, Chemistry); J. Liu (Magnet Lab, University of Florida, Physics); S. Hill (Magnet Lab, FSU, Physics)

Introduction

Slow magnetic relaxation has been reported in the $(DMF)_4MReCl_4(CN)_2$ (M = Mn, Fe, Co, Ni) single-chain magnets (SCM) at low temperature[1]. To better understand the origin of the relaxation barrier, crystals of a $[ReCl_4(CN)_2]^{2-}$ (1) building block were synthesized in order to assess the contribution to the anisotropy from the Re ion ($5d^3$).

Experimental

Electron Paramagnetic Resonance (EPR) measurements were first carried out in a 7-tesla (T) superconducting magnet prior to high-field studies in a 36-T resistive magnet. A Millimeter Vector Network Analyzer and several different multipliers were used as a microwave source and detector.

Results and Discussion

The high-field spectra display one sharp peak at low field and two broader peaks at high field. Temperature dependent measurements (Figure 1) indicate that all three transitions originate from the ground state; the low-field peak occurs within the lowest Kramers doublet (note that S = 3/2) while the high-field peaks are inter-Kramers transitions, which can explain the difference in linewidth. Figure 2 displays the frequency versus field plot at 1 K. The data have been fit to the following spin Hamiltonian:

$$\hat{H} = D\hat{S}_z^2 + E\left(\hat{S}_x^2 - \hat{S}_y^2\right) + g\,\mu_B \hat{S}\cdot\vec{B}$$

The fit yields the following parameters: $D = +9.93$ cm^{-1}, $E = \pm 2.17$ cm^{-1} and $g = 1.44$.

Conclusions

Surprisingly, these EPR studies clearly indicate that 1 possesses an easy-plane type ($D > 0$) anisotropy, and should not show slow magnetic relaxation by itself. A theoretical model is currently under development to understand the slow magnetization dynamics in the coupled SCM systems.

Acknowledgements

T.D.H. and J. R.L acknowledge support from NSF (CHE-0617063).

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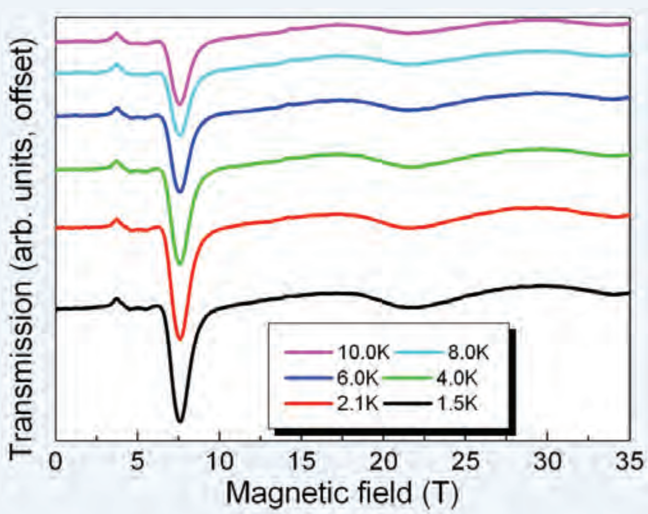

FIGURE 1. Temperature dependence of the spectra at 126 GHz.

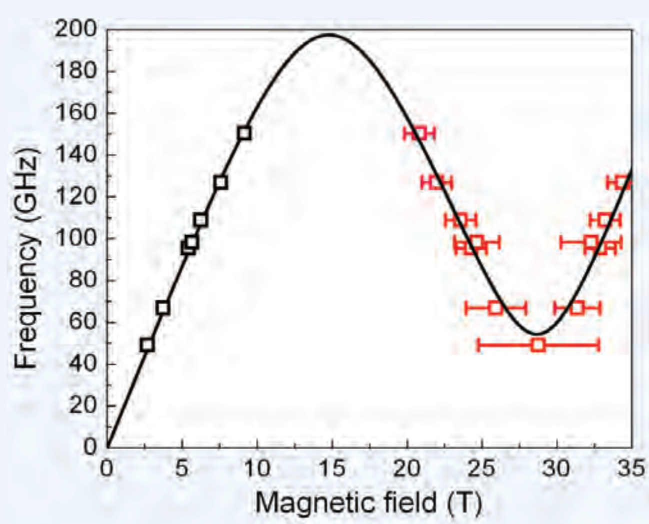

FIGURE 2. Frequency vs. peak position at 1.3 K. The solid line corresponds to the best fit.

Geochemistry

Work submitted for publication employs the links between the lithium isotope ratio of seawater and the same ratio preserved in marine foraminifera calcite shells over the past 68 million years to track changes in continental and seafloor silicate rock weathering processes. A unique Quadrupole ICP-MS method is used to measure $^7Li/^6Li$ isotope ratios. An observed rise in $^7Li/^6Li$ of seawater $(\delta^7Li)_{sw}$ is attributed to massive increases in silicate weathering and/or dramatic changes in aluminosilicate (clay) formation (likely both) over the past 60 million years.

Lithium Isotope Evolution of Cenozoic Seawater – A New Proxy for Silicate Weathering

S. Misra and P. N. Froelich (Magnet Lab; FSU, Department of Earth, Ocean and Atmospheric Sciences)

introduction

The lithium isotope ratio of seawater ($^7Li/^6Li$) is intricately linked to the global silicate weathering and reverse weathering cycles. Calcite shells of marine planktonic foraminifera preserve the seawater $^7Li/^6Li$ ratio (δ^7Li_{SW}), providing a record of δ^7Li_{SW} through geologic time. The modern day δ^7Li_{SW} is in balance with its input sources via chemical weathering of the silicate continents (erosion and river fluxes), hydrothermal weathering of seafloor silicate basalts (hot spring fluxes), recycled lithium flux associated with fluid expulsion at the convergent continental margins, and lithium removal by low temperature reverse weathering reactions like authigenic aluminosilicate clay sediment formation and low temperature seafloor basalt alteration. Each of these silicate sources and sinks to/from the ocean carries distinct $^7Li/^6Li$ signatures with very large fractionation factors, providing a unique time tracer of changes in the global silica cycle that is diagnostic of long-term variations in seawater chemistry. We present the first long-term (68 Ma), high-resolution lithium isotope record of seawater constructed from analyses of chemically cleaned planktonic foraminifera. We argue that these variations in paleo-δ^7Li_{SW} reflect tectonics and climate-driven perturbations in the global silicate weathering cycle leading to imbalances in both magnitude and isotopic composition of lithium mass fluxes in and out of the ocean system.

Experimental

An improved method for δ^7Li_{SW} determinations by Quadrupole-ICP-MS was created. The key features of this method are low total lithium consumption (< 0.2 ng-Li / analysis), high column yields (> 99.98%), high isotope ratio precision (< ±0.8‰, 2s), and low blanks (1.0 ± 0.5 pg). Species-specific and bulk sample $^7Li/^6Li$ analyses of chemically cleaned core-top foraminifera and down-core forams (0-68 Ma) were done to reconstruct the lithium isotopic composition of seawater across the Cenozoic.

Results and Discussion

Seawater $^7Li/^6Li$ history reconstructed from planktonic forams records an 8-9‰ increase over the past 60 Ma. Unlike the seawater Sr isotope history the lithium isotope composition of Cenozoic seawater does not exhibit a monotonic increasing trend. The last 60 Ma history of δ^7Li_{SW} can be divided into periods of quasi-linear rise and periods of steady state. Most significantly the periods between 52 - 47 Ma, 35 - 31 Ma, and 14 - 6 Ma records an average rate of increase in δ^7Li_{SW} ($\Delta\delta^7Li_{SW} / \Delta t$) of ~ 0.4 ± 0.1 ‰ / Ma (3s). The net result is a total ~ 9‰ rise in δ^7Li_{SW} in the last 60 Ma. This enormous 8-9‰ rise between the 60 Ma low-stand (22‰) to modern-day high-stand (30.5‰) requires massive increases in either silicate weathering fluxes and weathering intensity, or dramatic changes in the lithium sink (aluminosilicate formation), or both, suggesting an increase in $[Li]_{ocean}$ and τ_{Li} during the Cenozoic.

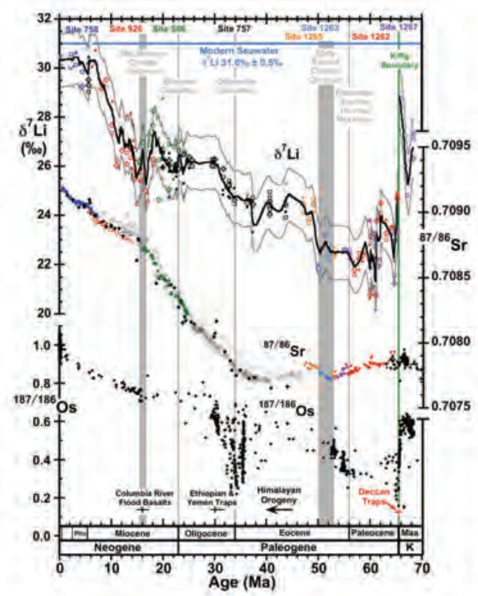

FIGURE 1. Cenozoic seawater history of $^7Li/^6Li$ (δ^7Li_{sw}) from forams. The $^{87}Sr/^{86}Sr$ and $^{187}Os/^{186}Os$ records are from the literature. The three records all point toward increased continental weathering during the past 60 million years, but δ^7Li_{sw} is uniquely hosted only in rock silicates.

Conclusions

Seawater $^7Li/^6Li$ rose dramatically by 8-9‰ during the Cenozoic (66-0 Ma).

Acknowledgements

Support: NSF (MG&G), ACS (PRF) and FSU Eppes Foundation.

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Magnetic Resonance Technique Development

Electron paramagnetic resonance (EPR) spectroscopy is a powerful tool to investigate local structure in materials and metalloproteins, as examples. Many transient radicals generated in proteins have very narrow and sharp signals. Determination of exact spectral parameters is critical for full structural elucidation of such spin centers. The Angerhofer group is developing encapsulated hydrogen atoms as "rulers" to measure the exact magnetic field as standards for biological EPR spectroscopy.
• Published in *Journal of Magnetic Resonance* **207**, 158-163 (2010).

Atomic Hydrogen as High-precision Field Standard for High-field EPR

S. Stoll, R. David Britt (University of California, Davis);
A. Ozarowski (Magnet Lab, FSU);
Alexander Angerhofer (University of Florida, Gainesville)

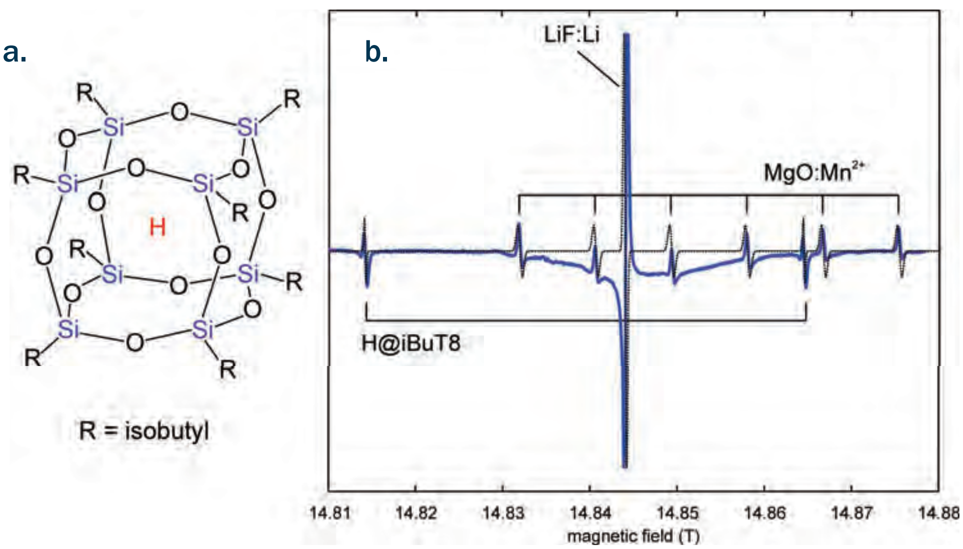

FIGURE 1. a. Structure of H@iBuT_8, hydrogen trapped in octaisobutylsilsequioxane.
b. 416 GHz EPR spectrum of a mixture of three common field standards, at 60 K.

Introduction

Many important spin centers, such as organic radicals in proteins, feature narrow EPR spectra with *g* values very close to *g* = 2. The *g* values are valuable reporters on the radical type, protonation state, and the local environment. However, their accurate determination via high-field EPR is hampered by the problem of accurately measuring the magnetic field axis. For this, secondary field standards – compounds with precisely known magnetic parameters – are used. The ones commonly in use have disadvantages: their spectra overlap with the spectra of organic radicals (MgO:Mn^{2+}), or they feature only one line (LiF:Li) that does not allow calibration of a field range. We introduce a new superior spin-1/2 field standard based on atomic hydrogen.

Experimental

Encapsulated hydrogen atoms were generated by irradiating a solution of octabutylsilsequioxane iBuT_8 in a ^{60}Co chamber.[1] MgO:Mn^{2+} was obtained commercially, and LiF:Li samples were kind gifts of Roger Isaacson (UCSD) and Andre Stesmans (Leuven). 400 GHz/15-T EPR spectra were measured at the EMR facility of the Magnet Lab using a broadband transmission spectrometer. 9 GHz and 35 GHz EPR spectra were measured at the CalEPR center at UC Davis, using a high-precision NMR teslameter (Bruker ER036TM) for field calibration.

Results and Discussion

Figure 1A shows the structure of the compound H@iBuT_8. Surprisingly, it is stable at room temperature and below. Figure 1B shows its 416 GHz EPR spectrum, together with the spectra of two other common field standards, LiF:Li (Li nanoclusters in LiF host) and MgO:Mn^{2+} (Mn^{2+} doped into MgO host). From EPR at 9 and 35 GHz (not shown), we obtain a temperature-independent isotropic *g* factor of 2.00294(3) and a hyperfine coupling constant of 1416.8(2) MHz below 70 K, decreasing to 1413.7(1) MHz at room temperature.

Conclusions

Atomic hydrogen trapped in a substituted silsesquioxane nanocage is an excellent field standard, as its spectrum consists of two lines that frame the field region of organic radical spectra without overlap. Also, the temperature dependence of the g value and the hyperfine coupling has been accurately determined.

Acknowledgements

This work was additionally supported by NIH (GM73789 to R.D.B) and NSF (CHE-0809725 to A.A.).

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Magnetic Resonance Technique Development

Spectral sensitivity and resolution are of paramount importance for nuclear magnetic resonance (NMR) applications to macro-biomolecules. The report by Gor'kov *et al.* of the Magnet Lab and Polenova's group at the University of Delaware describes an innovative triple-resonance magic-angle-spinning (MAS) probe — essential equipment for biological solid-state NMR. The probe features an extended detection coil, a loop-gap resonator (LGR) for decoupling that generates very little heating to fragile protein samples, and an efficient electronic circuit. The probe benefits not just Polenova's group, but other users as well (see report No. 303 at magnet.fsu.edu) and is now available for use in the 900-MHz wide-bore magnet system.

Efficient Triple-resonant ^{1}H/X/Y Low-E MAS Probe for Biological Applications

Peter L. Gor'kov, Ivan Hung, Chunqi Qian, Jason A. Kitchen, William W. Brey, Zhehong Gan (Magnet Lab, FSU);
Guangjin Hou, Yun Han, Tatyana Polenova (University of Delaware)

For concentration-limited samples, NMR sensitivity can be improved by increasing the amount of sample. Unfortunately, in solid-state MAS NMR, switching to a larger sample rotor generally weakens the applied B1 fields, slows the spinning rate, and increases frictional heating. To avoid these drawbacks, we propose to extend the coil and sample only along the spinning axis, leaving the spinning properties essentially unchanged but increasing the sensitivity. To test this approach, we developed and tested an efficient 3.2-mm ^{1}H/^{13}C/^{15}N 600 MHz MAS probe based on a custom stator from Revolution NMR (Fort Collins, CO). The probe, used for studies of dilute protein systems, shows that excellent results can be achieved by extending the sample length.

The probe employs independent, orthogonal resonators to produce the ^{1}H decoupling field (an outer loop-gap resonator) and lower X/Y frequency channels (the inner double-tuned solenoid). Separating the high- and low-frequency circuits benefits the probe in three ways[1-4]: a) use of ^{1}H LGR drastically reduces decoupling-induced sample heating; b) elimination of ^{1}H-tuned traps reduces low-frequency loss; and c) a longer coil can be wound since the ^{1}H wavelength does not impose restrictions on number of turns. All of the probe's three channels are electrically balanced, which leads to better resistance to arcing and improved B_1 homogeneity across the sample. Balancing the mid-frequency X-channel in triple-resonance circuits can be challenging and is often omitted. However, we find that in addition to improving homogeneity and reducing voltages, electrical balancing of the X-channel can also improve efficiency by a notable amount. The probe can be easily switched between double- and triple-resonance modes by means of removable elements.

In its ^{13}C-optimized ^{1}H/^{13}C/^{15}N circuit configuration, the ^{13}C channel reached 100 kHz at 165 W in triple- and at 110 W in double-resonance mode. Maximum ^{13}C B_1 was measured to be 160 kHz (4 ms pulse every 1 s with full-strength decoupling). For Y=^{15}N, power efficiency was 55 kHz at 262 W with maximum ^{15}N B_1 of at least 85 kHz (4 ms pulse every 1 s with full-strength decoupling). The maximum achievable B_1 fields for the ^{1}H channel were 160 kHz (45 ms pulse every 1s); power efficiency was 100 kHz at 190 W. B_1 homogeneity across a 22 µL, 6.7mm-long sample: $A_{810^\circ}/A_{90^\circ}$ was 0.86 for ^{13}C and >0.95 for ^{1}H. The ^{13}C S/N (glycine) in this 3.2-mm probe was similar to S/N in a Bruker 4.0-mm single-solenoid probe. A thin-wall rotor further raises signal-to-noise by 55%.

Figure 1 shows ^{13}C DARR and NCA spectra of a U-^{13}C,^{15}N enriched dynein light chain (DLC8) sample acquired using this probe on a 600 MHz Bruker Avance spectrometer. The sensitivity in both the homo- and heteronuclear experiments is increased by 50 percent compared with that of the spectra acquired on the same sample using a commercial 3.2-mm single-solenoid MAS probe at UD. The outstanding performance of this probe shows that extending the sample length along the spinning axis is important for structural studies of large proteins and assemblies.

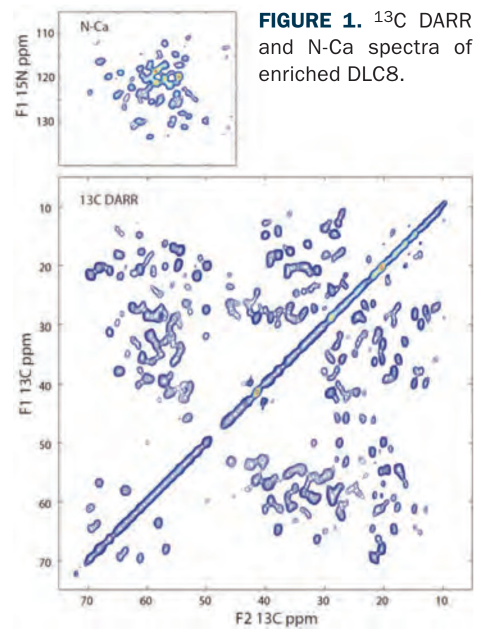

FIGURE 1. ^{13}C DARR and N-Ca spectra of enriched DLC8.

Acknowledgements

This work was supported by UCGP.

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Biochemistry

About 60 percent of drug-targeted proteins are membrane bound and the structure and functional studies in their native membrane environment are challenging. This report presents a joint work of three research groups (Cross/FSU, Zhou/FSU and Busath/BYU) on a M2 proton channel protein in Influenza A virus. They used high-field solid-state nuclear magnetic resonance (NMR) spectroscopy and molecular dynamics simulations to determine the three-dimensional structure of the channel and revealed the details of proton conducting mechanism.

•Published in *Science* **330**, 509 (2010).

Insight Into the Mechanism of the Influenza A Proton Channel from a Structure in a Lipid Bilayer

H. Qin, M. Sharma (FSU, Chemistry and Biochemistry);
T.A. Cross (Magnet Lab, FSU, Chemistry and Biochemistry);
H. Dong, M. Yi, H.X. Zhou (FSU, Physics);
David D. Busath, E. Peterson (Brigham Young University)

Introduction

The Influenza A drug target M2 proton channel has been the subject of extensive structural and functional studies accelerated by the recent dominance of the S31N mutation that induces resistance to the flu drugs amantadine and rimantadine. We have determined the three-dimensional structure of the conductance domain of M2, residue (22-62) using static solid-state NMR spectroscopy[1].

Experimental

Structural restraints were collected using static solid-state NMR spectroscopy on amino acid specific ^{15}N labeled M2(22-62) reconstituted in DOPC:PE(4:1) lipid bilayer, an environment in which M2(22-62) mimics the proton conductance characteristics of full-length M2 protein. The tetramer structure was calculated and refined in vacuum using simulated annealing and re-refined in explicit lipid bilayer using restrained molecular dynamics simulations. The His37-Trp41 side chains orientations were optimized using quantum mechanical calculations. All NMR data were acquired on the 600-MHz wide-bore NMR spectrometer and the ultra-wide-bore 900-MHz spectrometer equipped with a low-E double resonance probe with a flat coil.

Results and Discussion

The structure (Figure 1A) displays the defining features of the native protein that have not been attainable from previous structures solubilized by detergents. We propose that the tetrameric His37-Trp41 cluster guides protons through the channel by forming and breaking hydrogen bonds between adjacent pairs of histidines and specific interactions with the tryptophan gate. This mechanism explains the main observations for M2 proton conductance.

Acknowledgements

This work was supported by NIH grant AI23007.

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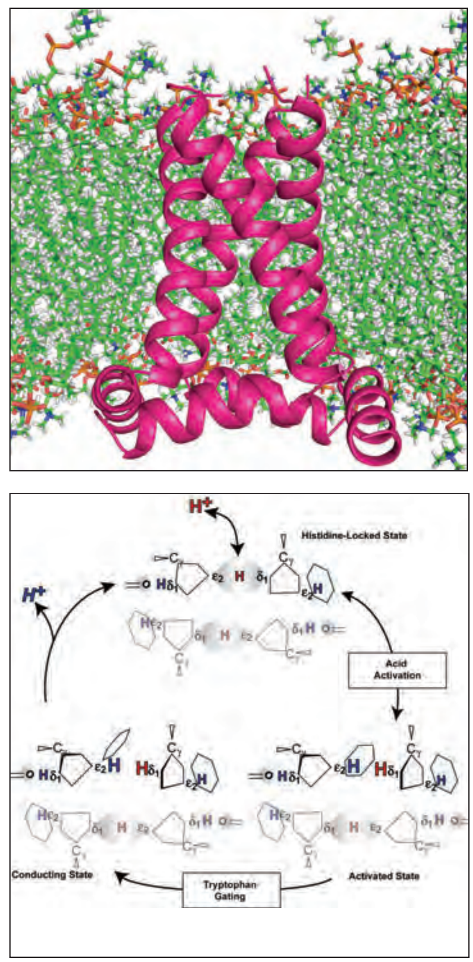

FIGURE 1. Three dimensional structure of M2(22-62) in lipid bilayer and conduction mechanism involving His37-Trp41 cluster.

Biochemistry

Nuclear magnetic resonance (NMR) spectroscopy is a powerful tool to determine structures of proteins and other biomolecules. Structure determination relies on the internuclear distances, torsion angles and chemical shifts that are measured by NMR experiments, and the force fields among the atoms that are usually predetermined by other methods. The report by Li and Brüschweiler presents a novel approach to the optimization of the force field itself from NMR data.

•Published in *Angew. Chem. Int. Ed.* **19**, 6778-6780 (2010).

NMR-Based Protein Force Field

D.-W. Li and R. Brüschweiler (Magnet Lab and FSU Department of Chemistry and Biochemistry)

Introduction

Molecular dynamics (MD) computer simulations fulfill an important complementary role with respect to experiment. The quality of molecular mechanics force fields is vital for the accurate characterization of proteins *in silico*. However, the development of better force fields has been a complex, labor-intensive and time-consuming task. In the past, all modern force fields have been parameterized based on both extensive quantum-chemical calculations and experimental data. Because of the complexity associated with the fitting of well over 100 force-field parameters, previous work has focused on fitting data of small molecules and peptides in gas phase.

Experimental

Our approach[1] starts with the calculation of NMR chemical shifts of all carbon nuclei for each snapshot of the parent MD trajectory, which are stored for subsequent analysis. Time-averaged chemical shifts are calculated with equal weights for all snapshots and compared with the experimental chemical shifts by means of the root mean square deviation (RMSD) in ppm. We then reweight a parent trajectory performed with the original force field for a new test force field by using Boltzmann's relationship. The force field is iteratively revised using a minimization algorithm, which in turn changes the weight of each snapshot and thereby allows a systematic improvement of the agreement between the experimental chemical shifts and the back-calculated average shifts from the new weights, i.e. a decrease in the average RMSD. This approach leads to a 10^5-fold speed-up over other approaches.

Results and Discussion

We demonstrate the method by deriving the new force field ff99SBnmr1 starting from ff99SB by modifying the backbone dihedral angle potential using the MD trajectories of four trial proteins. We then cross-validate the performance of ff99SBnmr1 for additional 18 proteins. The result (Figure 1) demonstrates both the improved performance of the new force field and its transferability to other protein systems.

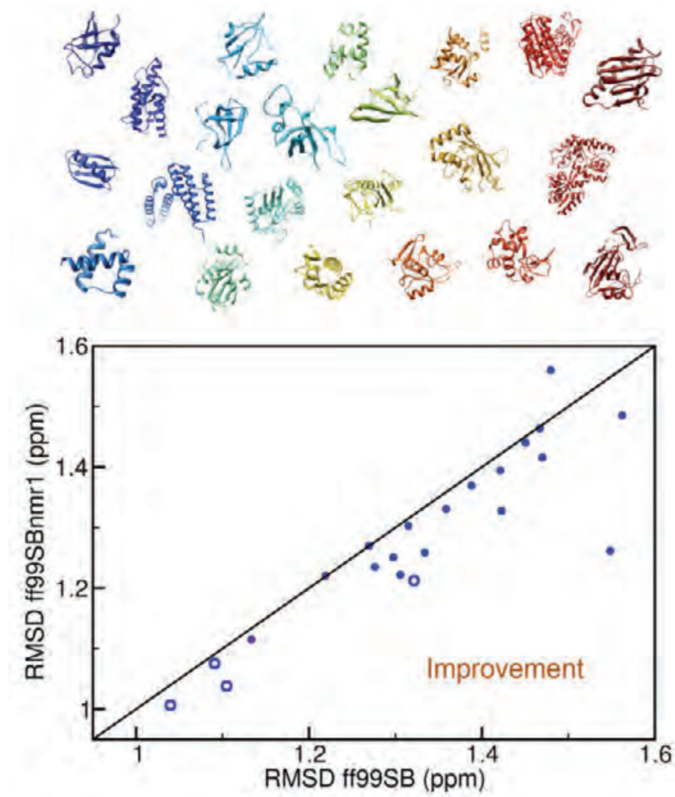

FIGURE 1. Cross-validation of new force field ff99SBnmr1 by comparison with parent force field ff99SB. Back-calculated Cα, Cβ and C' chemical shift RMSDs for 18 proteins (filled circles) and the four trial proteins (open circles) for trajectories with ff99SBnmr1 *vs.* ff99SB. Points on the diagonal indicate identical performance whereas points on the lower half indicate improved performance of ff99SBnmr1 over its parent potential ff99SB.

Conclusions

In the past, development of force fields relied mostly on small peptides in the gas phase. The approach reported here opens an entirely new angle to this problem: the confluence of an efficient algorithm, powerful computer hardware, and large protein structural and NMR databases make the development of force fields on fully intact proteins in their native environment reality.

Acknowledgements

This work was supported by the National Science Foundation (grant MCB-0918362).

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Biochemistry

Robinette and Edison report on a computational/statistical approach to analyze complex nuclear magnetic resonance (NMR) data. They developed a two-dimensional peak alignment algorithm for the Hierarchical Alignment of Two-Dimensional Spectra (HATS), enabling pattern recognition (PR) using full-resolution 2D spectra. The HATS-PR methodology is demonstrated using multiple 2D total correlation spectroscopy (TOCSY) spectra from two nematode species. HATS-PR was able to determine the degree to which each resonance cross peak contributed to the observed differences between species. HATS-PR is a new analytical analysis simplifying the complicated results commonly obtained during metabolomic studies.

•Published in *Analytical Chemistry* **83** (5), 1649-1657 (2011).

Alignment & Statistical Analysis of 2D NMR Spectra of Mixtures

Arthur S. Edison and Steven L. Robinette (UF, Biochemistry)

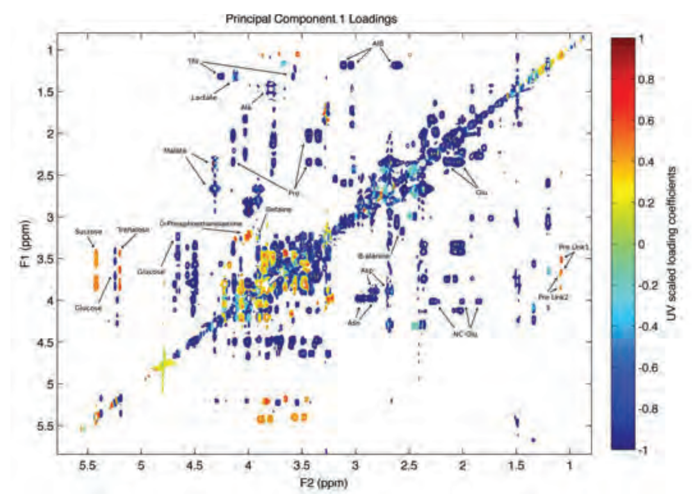

FIGURE 1. Spectral back-projection of PC1 loadings. Here, contours are defined by the back-projected intensities, while colors are defined by the unit variance-scaled loading coefficients. Crosspeaks with positive loading coefficients (red) represent compounds overexpressed by *P. redivivus* relative to *P. pacificus*. Blue crosspeaks represent negative loading coefficients indicating *P. pacificus* overexpressed compounds.

Introduction

Nuclear Magnetic Resonance (NMR) is the most widely used nondestructive technique in analytical chemistry. In recent years it has been applied to metabolic profiling due to its high reproducibility, capacity for relative and absolute quantification, atomic resolution, and ability to detect a broad range of compounds in an untargeted manner. While one-dimensional (1D) ^{1}H NMR experiments are popular in metabolic profiling due to their simplicity and fast acquisition times, two-dimensional (2D) NMR spectra offer increased spectral resolution as well as atomic correlations, which aid in the assignment of known small molecules and the structural elucidation of novel compounds. Given the small number of statistical analysis methods for 2D NMR spectra, we present here a new approach for the analysis, information recovery and display of 2D NMR spectral data.

Experimental

We developed a native 2D peak alignment algorithm we term HATS, for Hierarchical Alignment of Two-Dimensional Spectra, enabling pattern recognition (PR) using full-resolution spectra. Principle Component Analysis (PCA) and Partial Least Squares (PLS) regression of full resolution TOCSY spectra greatly aid the assignment and interpretation of statistical pattern recognition results by producing back-scaled loading plots that look like traditional TOCSY spectra but incorporate qualitative and quantitative biological information of the resonances. The HATS-PR methodology is demonstrated here using multiple 2D TOCSY spectra of the exudates from two nematode species: *Pristionchus pacificus* and *Panagrellus redivivus*. We show the utility of this integrated approach with the rapid, semi-automated assignment of small molecules differentiating the two species and the identification of spectral regions suggesting the presence of species-specific compounds. These results demonstrate that the combination of 2D NMR spectra with full-resolution statistical analysis provides a platform for chemical and biological studies in cellular biochemistry, metabolomics, and chemical ecology.

Results and Discussion

We aligned and statistically analyzed 10 different TOCSY spectra from independent sample preparations from the two species of nematode. HATS-PR was able to generate a loadings plot from PCA that indicate how much each resonance cross peak contributes to observed differences between the species. The NMR for this work was done on the 600 MHz Bruker instrument outfitted with a 5-mm cryogenic probe in the Advanced Magnetic Resonance and Imaging & Spectroscopy Facility at the University of Florida.

Conclusions

HATS-PR allows for efficient comparison of multiple 2D NMR datasets to obtain detailed chemical differences between different groups. This is a new tool that will enhance metabolomics efforts.

Acknowledgements

NIH funded this research: 5R01GM085285-02 and 3R01GM085285-01A1S1 to ASE

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Biochemistry

The determination of protein fold, dynamics and accessible surface area are key components in modern day investigations into proper protein function and often disease. Many extracellular proteins contain disulfide bonds that are critical components in stabilizing the three-dimensional protein fold. The Marshall lab is developing creative methods for applying hydrogen/deuterium exchange mass spectrometry methods that dramatically improve the sequence coverage and localization of solvent exposed protein segments, which aids immensely in determining protein structure and local dynamics and possible protein-protein interactions with insights into function.

•Published in *Analytical Chemistry* **82**, 1450-1454 (2010).

Simultaneous Reduction and Digestion of Proteins with Disulfide Bonds for Hydrogen/Deuterium Exchange Monitored by Mass Spectrometry

A.G. Marshall, H.-M. Zhang (Magnet Lab, Chemistry);
M. R. Emmett (FSU, Magnet Lab, Biochemistry);
S. D. Frausto, H. Tang (FSU, Biology);
S. M. McLoughlin (Abbott Laboratories, Chemistry)

Results and Discussion

Proteolyzed peptides provide the basis for mass-analyzed hydrogen/deuterium (H/D) exchange for mapping solvent access to various segments of solution-phase proteins. *Aspergillus saitoi* protease type XIII and porcine pepsin can generate peptides of overlapping sequences and high sequence coverage. However, if disulfide bonds are present, proteolysis can be severely limited, particularly in the vicinity of the disulfide linkage(s). Disulfide bonds cannot be reduced before or during the H/D exchange reaction without affecting the protein higher-order structure. Here, we demonstrate simultaneous quench/digestion/reduction following H/D exchange, for subsequent mass analysis. Proteolysis is conducted in the presence of TCEP·HCl (a disulfide reducing agent) and urea (a denaturant), and all other steps of the H/D exchange and analysis are maintained. This method yields dramatically increased sequence coverage and localization of solvent exposed segments for mass-analyzed solution-phase H/D exchange of proteins containing disulfide bonds (see Figure 1).

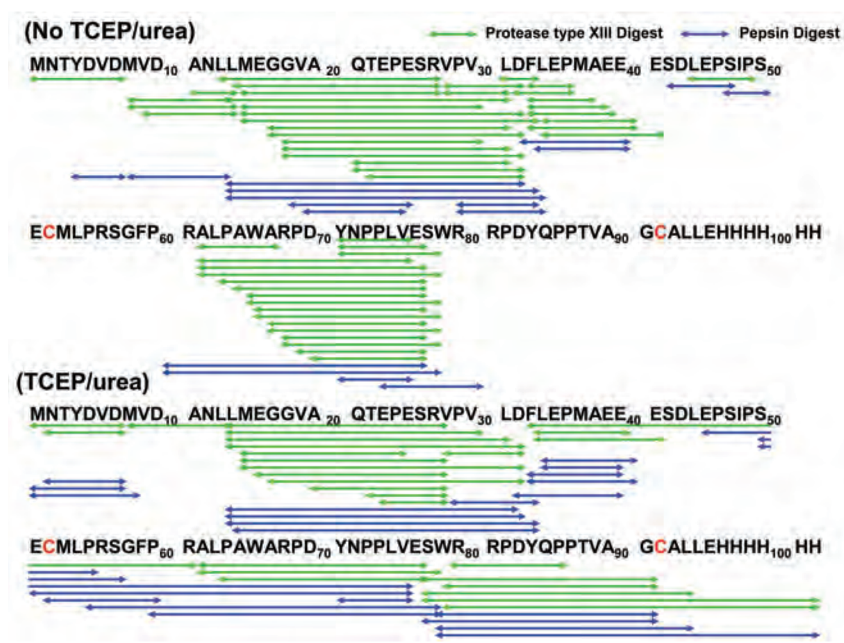

FIGURE 1. Proteolyzed peptides mapped onto the primary sequence of HCV wild-type NS5A domain II by protease type XIII and pepsin, without or with added TCEP/urea.

Acknowledgements

This work was supported by NIH (1R01 GM78359), NSF Division of Materials Research (DMR 0654118), and the state of Florida.

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Biology

Understanding the mechanism of how toxins enter and exit cells and interact with other proteins are key components in rational development of treatments. Researchers at Magnet Lab in collaboration with R. John Collier at Harvard are utilizing site-directed spin labeling (SDSL) electron paramagnetic resonance (EPR) methods to unravel the molecular details of how anthrax toxin interacts with cell membranes and other proteins. To date, there is no crystal structure for the protein pore and EPR methods are aimed at elucidating its structure.

•Accepted for publication in the *Proceedings of the National Academy of Sciences*

Probing Interactions Within Anthrax Toxin by Electron Paramagnetic Resonance

Laura D. Jennings-Antipova, **R. John Collier** (Harvard University);
Likai Song (Magnet Lab, FSU)

Introduction

The protective antigen (PA) moiety of anthrax toxin forms oligomeric pores that translocate the enzymatic moieties of the toxin — lethal factor (LF) and edema factor (EF) — across the endosomal membrane of mammalian cells (Figure 1A). Characterizing interactions between membrane-inserted PA pore and LF has been challenging. No crystal structure of the pore exists, and the resolution of electron micrograph images remains low[1]. SDSL-EPR represents an attractive approach to studying PA pore-LF interactions, as it allows molecular-level resolution of interactions and can be performed with detergent-bound, or liposome-inserted forms of PA pore[2].

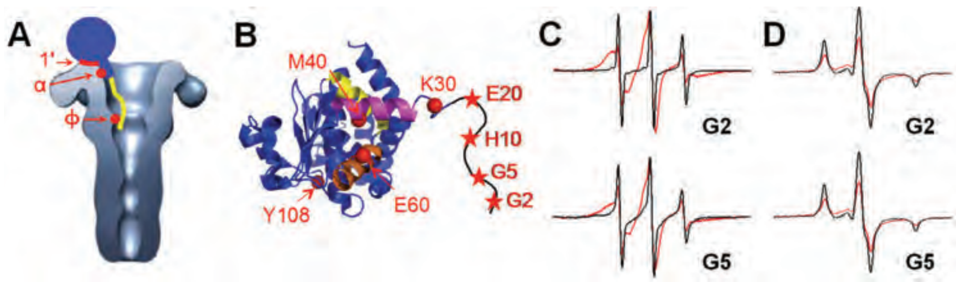

FIGURE 1. LFN-PA interactions. An EM reconstruction of the PA pore with a cartoon representation of LFN (in blue) bound (a). Crystal structure of LFN with spin-labeled residues marked in red (b). Interaction between PA pore and LFN residues G2 and G5 by EPR mobility (c) and distance (d) measurements. LFN alone (Black); with PA (Red).

Results and Discussion

Here we describe SDSL-EPR studies that identify interactions of LF N-terminal domain (LF_N) with the PA pore (Figure 1A and 1B). EPR mobility and distance measurements reveal a direct interaction between the N terminus of LF (residues 2-5) and the Φ clamp, a structure within the lumen of the pore that catalyzes translocation (Figure 1A). Binding of LF_N spin-labeled residues G2 and G5 to the PA pore induced a new and relatively immobilized state in the spectra, suggesting direct interaction between these residues and the pore (Figure 1 C). Also, both G2 and G5 interacted with PA residue S429 in the pore, with a spin-spin distance estimated to be 12-13 Å (Figure 1D). In addition, consistent with a recent crystallographic model, we find that, upon binding of the translocation substrate to PA, LF helix α1 separates from helices α2 and α3 and binds in the α clamp of PA (not shown). These interactions, together with the binding of the globular C-terminal domain of LF to domain 1' of PA, indicate that LF interacts with the PA pore at three distinct sites. Our findings elucidate the state from which translocation of LF and EF proceeds through the PA pore. These results have been accepted for publication in PNAS.

Conclusions

Collectively, our results show that the PA-LF_N binding interaction is more complex than originally described and consists of three sites within PA: the Φ clamp, the α clamp, and domain 1' (Figure 1A). Our results exemplify the power of SDSL-EPR as an adjunct to crystallography for defining interactions between oligomeric membrane-spanning proteins and their proteinaceous ligands.

Acknowledgements

This work was supported by NIH Grant AI022021 (to R.J.C.).

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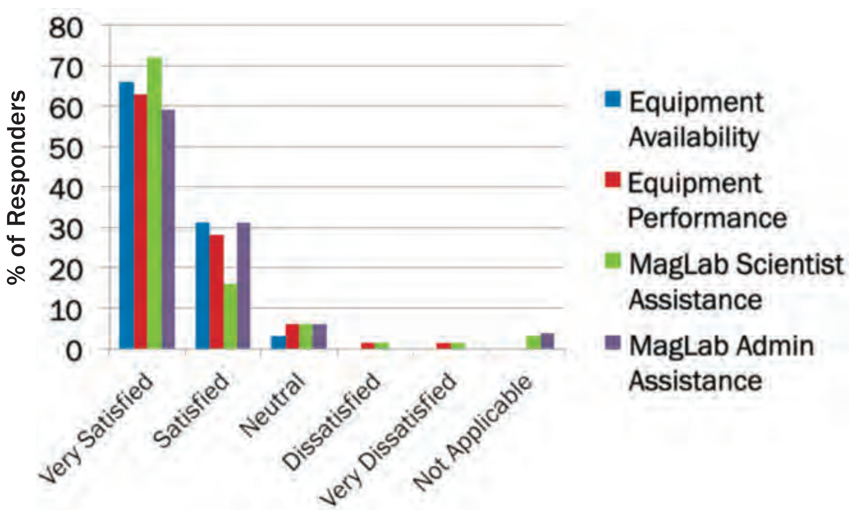
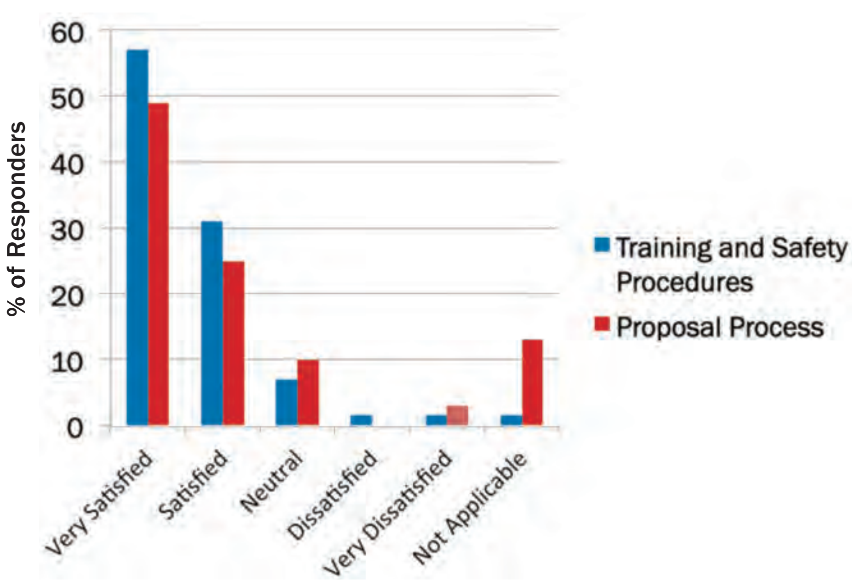
CHAPTER 3
User Programs

2010 NHMFL User Survey:
MagLab User Satisfaction with Equipment and MagLab Faculty and Staff



2010 NHMFL User Survey:
MagLab User Satisfaction with Processes



The strength of the user programs is built around the synergies of the highest field magnets, unique instrumentation, and exceptional support from highly qualified faculty and staff. In this chapter, each of the laboratory's user facilities—DC Field, Pulsed Field, High B/T, NMR, AMRIS, EMR, ICR, and the nascent Geochemistry program—presents information about its research capabilities, developments, plans, productivity, and efforts to build the user community.

Beginning January 4, 2010, *all* requests for magnet time were made through the same Web site, ***https://users.magnet.fsu.edu/***, in accordance with the User Proposal Policy. The *Unified User Portal* provides an easy-to-access, single point of entry for the seven user programs. In addition, it:

- standardizes policies across all facilities,
- institutes common practices in the content, review, and management of all proposals
- implements external review for proposals,
- supports user and facility needs for responsiveness and flexibility with regard to system offerings, samples (and possible safety-related issues), scheduling, and
- ensures transparency of the magnet time assignment process.

Program directors, staff scientists, and support staff are always looking for ways to improve user service, facilities, and instrumentation. Typically, they learn of user requests and suggestions during on-the-spot discussions, from follow-up emails, and from the NHMFL Users Executive Committee and the four User Advisory Committees: DC Field/PFF/High B/T; NMR/MRIS; EMR, and ICR. The User Portal opened new avenues for facilitating user-and-facility communications:

- The first annual all-facilities *Magnet Lab User Survey* was conducted in early fall. 460 principal investigators and on-site users were sent a brief 12-question survey and 68 responded (response rate of 15%). (See **charts**.) The survey will be repeated in June, so the results will be available for the 2011 meetings of the NHMFL External Advisory Committee, the NHMFL Users Executive Committee, and the next NSF Site Visit.

TABLE 1

Magnet Lab User Profile[1] Calendar Year 2010

	Total	Women	Minority	NHMFL Affiliated Users[2]	Local Users[2]	University Users[3,5]	Industry Users, U.S. [5]	National Lab Users, U.S. [3,4]	Non-U.S. Users[5]
Senior Investigators	594	70	34	135	80	362	18	62	152
Postdocs	161	33	15	41	52	94	1	27	39
Students	318	104	21	66	83	260	0	4	54
Technicians	54	8	2	14	20	35	4	2	13
TOTAL USERS	**1127**	**215**	**72**	**256**	**235**	**751**	**23**	**95**	**258**

1 The laboratory reports seven user facilities (DC Field, Pulsed Field, High B/T, NMR, AMRIS, ICR, EMR) and the Geochemistry Facility, which is affiliated. A user is a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. Consequently, a researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on Web site/directory], even if they travel to another site.
Local users are defined as any non-NHMFL-affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
3 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
4 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
5 Four columns of users (university, industry, national lab, non-U.S.) will equal the Total Number of Users.

TABLE 2

Magnet Lab Facility Usage Profile Calendar Year 2010

	Number of Magnet Days[1] Allocated	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	3,683	620	1,347	240	222	1,254
Local[2]	1,780	528	332	1	58	861
U.S. University	2,699	1,461	314	37	56	831
U.S. Govt. Lab.	161	79	72	4	6	0
U.S. Industry	38	0	31	7	0	0
Non-U.S.	1346	697	467	7	5	170
Test, Calibration, Set-up, maintenance[3]	718	59	139	150	250	120
Idle	632	0	0	0	0	0
TOTAL	**11,057**	**3,444**	**2,702**	**446**	**597**	**3,236**

1 User Units are defined as magnet days for four types of magnets. [This definition is used for Magnet Lab reporting to NSF for Government Performance & Reporting Act (GPRA) purposes]. One magnet day is 7 hours in a water cooled resistive or hybrid magnet in Tallahassee. One magnet day is 12 hours in any pulsed magnet in Los Alamos and 24 hours in superconducting magnets in Tallahassee, Los Alamos, and the High B/T system in Gainesville.
Magnet days for AMRIS instruments in Gainesville: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours (7 days/week);
Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours (5 days/week).
2 Use by NHMFL-Affiliated and Local users as defined in Table 1, footnote 2.
3 In 2007 and prior years, not all facilities captured this information. Beginning in 2008, all groups collected this data so it is now included in the summary table.

- *"Request for Feedback"* emails are sent immediately after magnet time in the DC Field and Pulsed Field Facilities and are sent quarterly to NMR, High B/T, and EMR users.

The Magnet Lab was extremely pleased to welcome 58 new principal investigators in 2010: 18 in the DC Field Facility; 1 in the Pulsed Field; 1 in the High B/T; 7 in NMR; 3 in AMRIS; 15 in EMR; 12 in ICR; and 1 in Geochemistry. Some "frequently-asked-for" lab-wide user statistics are presented in Tables 1 and 2; details for each facility are presented in Appendix A.

DC Field Facility

2010 statistics on DC Field users, proposals, and magnet usage are presented in Appendix A.

The DC Field Facility at the NHMFL's headquarters in Tallahassee continues to provide the user community with the highest and quietest slowly varying magnetic fields in the world. The magnets are coupled with state-of-the-art instrumentation resulting in a suite of powerful measurement environments for research. Expert experimental staff members provide users with scientific and technical support while using the DC facilities.

Facility Developments

During 2009, the DC facility implemented one of the biggest changes to how it has operated in many years. The change dubbed "FlexTime" essentially provided users with 33% more time but limited their electricity usage to the amount that they would have used under the old time limits. The electrical energy used by the DC program has long been the largest single item in the MagLab's annual budget. By giving users an energy budget, we are allowing them to decide how to use the energy to best meet their scientific agenda while encouraging them to use it efficiently. Users who are getting publishable data and can demonstrate a need to exceed their energy budget can have a budget extension granted. During 2010 our FlexTime policy continued to have positive feedback from users. Due to the stabilization of electric power rates and the implementation of FlexTime, *for the first time in the history of the NHMFL our electric bill was significantly reduced for a second year in a row.*

Another significant improvement implemented during 2010 was *a new sample prep room* that our users now enjoy. Walls between the old sample prep rooms were removed and the area was renovated

Florida-bitter and Hybrid Magnets

Field, Bore, (Homogeneity)	Power (MW)	Supported Research
45 T, 32 mm, (25 ppm/mm)	31.0	Magneto-optics – ultra-violet through far infrared; Magnetization; Specific heat; Transport – DC to microwaves; Magnetostriction; High pressure; Temperatures from 30 mK to 1500 K; Dependence of optical and transport properties on field, orientation, etc.; Materials processing; Wire, cable, and coil testing.
36 T, 32 mm	19.0	
35 T, 32 mm	19.2	
31 T, 32 mm to 50 mm[1]	18.4	
29 T, 32 mm (~5 ppm/mm)[2]	18.3	
20 T, 195	20.0	
25 T, 52 mm, (1 ppm/mm)[2]	18.6	Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.

Superconducting Magnets

Field (T), Bore (mm)	Sample Temperature	Supported Research
18/20 T, 52 mm	20 mK – 2 K	Magneto-optics – ultra-violet through far infrared; Magnetization; Specific heat; Transport – DC to microwaves; Magnetostriction; High pressure; Temperatures from 20 mK to 300 K; Dependence of optical and transport properties on field, orientation, etc. Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.
18/20 T, 52 mm	0.3 K – 300 K	
17.5 T, 47mm[3]	4 K – 300 K	
17.5 T, 34 mm, (50 ppm/cm)[2]	0.3 K – 300 K	

1 A coil for modulating the magnetic field and a coil for superimposing a gradient on the center portion of the main field are wound on 32 mm bore tubes.
2 Higher homogeneity magnet for magnetic resonance measurements.
3 Magnet system for optical measurements.

– resulting in a large open space with lab benches and high quality microscopes where users can mount samples for their experiments. The room also provides desk space and computers for users.

In recent years we upgraded our user cryogenics with two modern top-loading systems that provide lower and more stable temperatures, faster turnarounds when sample problems occur, and are much more reliable and easier to use than our old systems (which are still available). Users continue to request these new systems in ever-higher numbers as they discover the benefits. We have continued to improve these systems by designing new improved sample holders and refining their operating parameters to optimize their performance.

Finally, our Millikelvin users frequently need to cool a sample very slowly. Because of the complexity of the top-loading dilution refrigerators, we don't allow users to load their own probes. However, these slow cools can take a great deal of time for our technicians. *A second generation auto-loading device has been designed and fabricated that allows the probe to be lowered very slowly.* Not only does this save staff time, but since the rate at which the probe is lowered is determined by the sample temperature, the sample can be cooled at a much more precisely controlled rate. This device will be modified to fit our other top-loading systems and made available for users during the coming year.

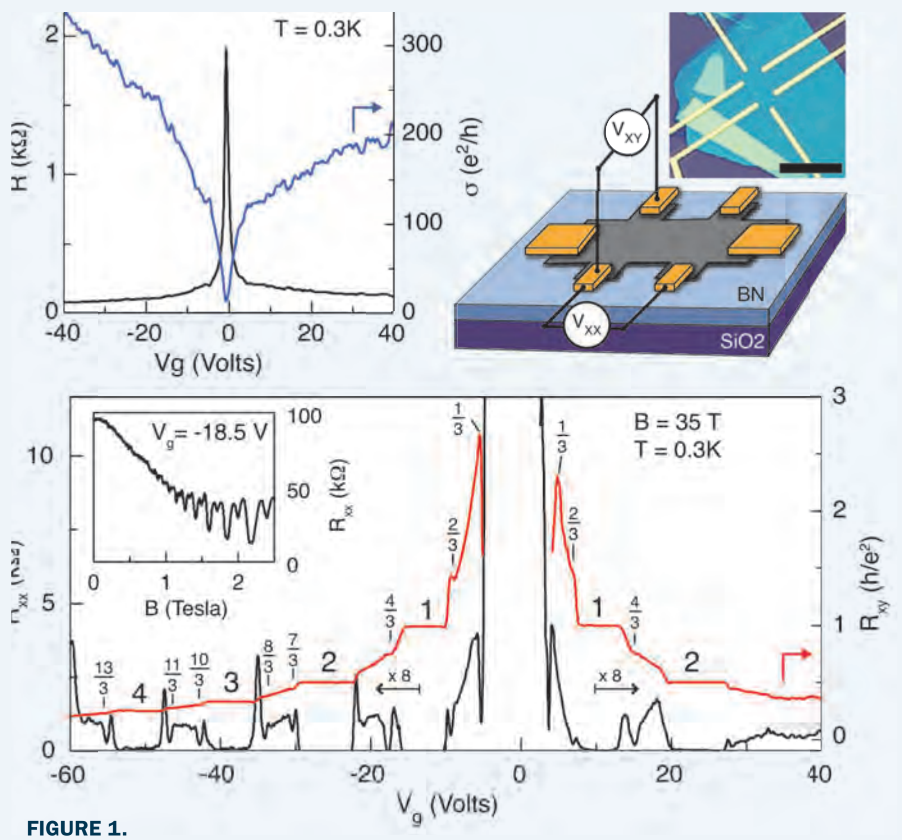


FIGURE 1.

Facility Plans

In addition to the advances that were made in the DC Facility, we spent a great deal of time preparing the way for major projects to be completed in the coming years. The first of these projects is *the new split bore magnet* that will provide fields up to 26 T with 4 large ports through the center of the magnet to allow access for optics. This magnet will be available with new improved optical equipment all designed to make optimal use of its unique characteristics. This is a multi-year effort that constitutes a significant investment in our optics program and infrastructure. New equipment includes a unique top-loading cryostat with direct optical access to samples in vacuum that will rest on non-magnetic optical tables surrounding the magnet.

To further optimize the productivity of scientists using the 45 T Hybrid magnet, *a new top-loading cryogenic system with a He-3 and a variable temperature insert (VTI)* has been purchased. This system will be similar to the cryostats currently in cells 12 and 9 and will provide users with improved temperature control, faster temperature changes and more reliability than our current cryogenic systems.

Finally we are in the midst of *a large multi-year effort to completely overhaul our helium liquefaction facilities*. We will be installing a large Linde turbine liquefier this summer and in following months a number of other items including a custom cold box to distribute the liquid helium to various magnets and dewars, a purifier to efficiently clean the recovered helium, and other equipment that will provide huge upgrades to our plant and allow more helium to be recovered with much higher reliability. This not only helps our users with their liquid helium allocation, but since it will also replace the liquefiers that keep the hybrid magnet cold, it will make hybrid operations more bulletproof.

Science Productivity

• Graphene

Research on graphene continued to draw users to the DC Facility and continued to break ground both scientifically and technically. The work by **C.R. Dean** (Columbia University) *et al.* on graphene layers on single crystal substrates of Boron Nitride showed beautiful fractional quantum Hall steps that convincingly demonstrate the high quality of the graphene **(Figure 1)**. Technically this is important since future devices utilizing graphene will need to be fabricated on substrates rather than as freestanding films.

• Topological Insulators

Another class of materials that is just beginning to be productive at the Magnet Lab is topological insulators. The bulk of these materials are insulating, but the

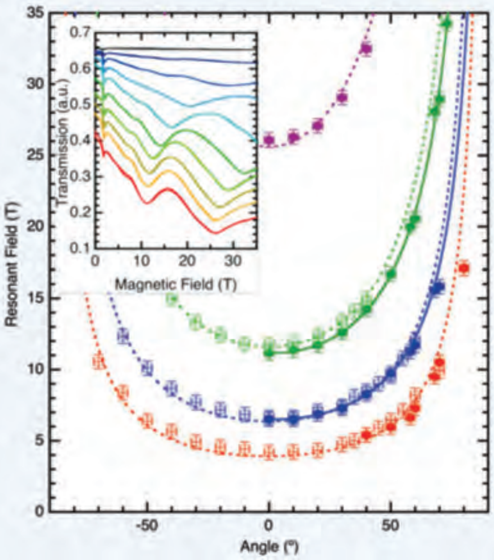


FIGURE 2.

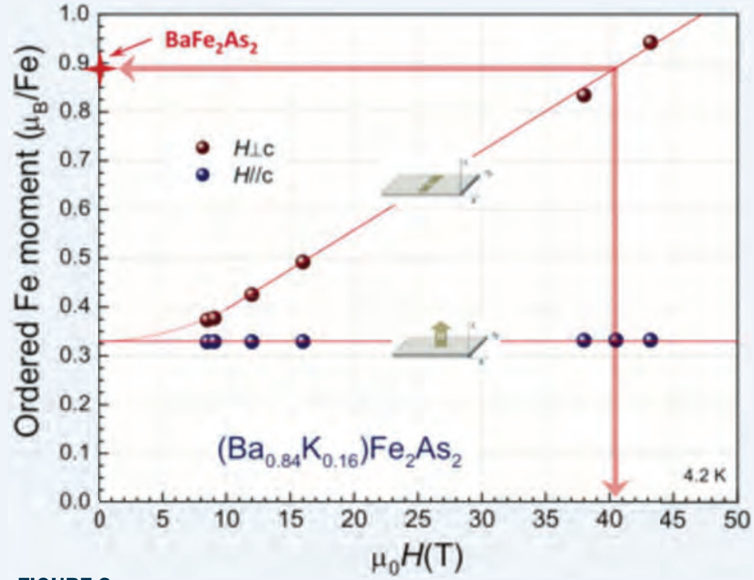


FIGURE 3.

surface conducts electricity because of the topological nature of its band structure. The surface then is another new unique laboratory to study two dimensional electron behavior. The work by **R.D. McDonald** on Bi_2Se_3 samples grown by the **I.R. Fisher group** at Stanford looks at microwave absorption as a function of angle and field. Plotting resonance peaks as a function of angle clearly shows the peaks vary as cosine demonstrating the behavior is two dimensional and associated with the surface states and not the bulk **(Figure 2).**

• **SC Materials in the Hybrid**

Finally we continue to have a number of experiments breaking rich new ground in studies of superconducting materials. The work of **R.R. Urbano** *et al.* utilized NMR to study the behavior of iron-based pnictides in the 45 T Hybrid magnet. In $Ba_{0.84}K_{0.16}Fe_2As_2$ surprisingly they found that the structural and magnetic phase transitions that had previously been reported as happening at the same temperature where not in fact concomitant, but the structural phase transitions happen at higher temperatures followed by the magnetic phase transition at lower temperatures **(Figure 3)**. The fact that material exhibits strong anisotropy depending on the direction of the magnetic field indicates that the magnetic fields themselves can be used to tune the material towards an antiferromagnetic state with the electrons becoming increasingly more localized.

In addition to the groundbreaking experiments above, the DC Field Facility has continued to support users making significant advances in other areas such as basic research on conventional and unconventional superconductors, heavy fermion materials, correlated behavior in magnetic materials, and wide range of other experiments in a variety of fields.

Progress on STEM and Building the User Community

In 2010 the *DC Field attracted 18 new principal investigators.* These PIs were from U.S. universities as varied as Tufts University, Grand Valley State University, Washington University, and the University of California Berkeley. They came too from government funded labs such as NIST and NREL, and foreign institutions such as Osaka University (Japan), Université Paris Diderot (France), and Ioffe Institute (Russia). The new PIs included three (3) women, one who had used Magnet Lab DC facilities in her Ph.D. work and based part of her initial research efforts as a new faculty member out of the laboratory. We often see young faculty members, who had used the DC Facility as students or postdocs, show enough confidence with our capabilities to use our facility for their own research program in the critical years that they seek tenure.

As one can see from our magnet usage tables in Appendix A, we continue to be oversubscribed. In spite of this oversubscription, however, the DC Facility makes bringing new investigators into the Magnet Lab a priority. In addition we are continuing our efforts to reach out wherever possible in order to expand our user program and to enable access for PIs from backgrounds that are underrepresented in the scientific community.

Pulsed Field Facility

2010 statistics on Pulsed Field users, proposals, and magnet usage are presented in Appendix A.

The Pulsed Field Facility (PFF) and the Los Alamos branch of the NHMFL are located in Los Alamos, New Mexico, at the Los Alamos National Laboratory (LANL). The pulsed field user program is designed to provide researchers with a balance of the highest research magnetic fields and robust scientific diagnostics specifically designed to operate in pulsed magnets. The connection with the DC Field Facility is strong and complementary in expertise. Although achieving the highest research magnetic fields possible is a fundamental competency at the PFF, we also strive to create the very best high-field research environment possible and to provide users with expertise from some of the world's leading experts in science conducted in pulsed magnets. All of the user support scientists are active researchers and collaborate with multiple users per year. A fully multiplexed and computer controlled, 6-position, 4.0 mega-Joule (32 mF @ 16 kV) capacitor bank system is at the heart of the pulsed field activities. Some 4000 shots are fired each year for the users program.

Capacitor-Bank-Driven Magnets

Field (T), Duration, Bore (mm)	Supported Research
Cell 1: 65 T Short Pulse, 25 msec, 15 mm	Magneto-optics (IR through UV), magnetization, and magneto-transport from 350 mK to 300 K. Pressure from 10 kbar typical, up to 100 kbar. GHz conductivity, MHz conductivity, Pulse Echo Ultra-sound spectroscopy. IR transmission in the Single Turn Magnet. Specific heat capability in 60 T Long Pulse. Dilatometry.
Cell 2: 65 T Short Pulse, 25 msec, 15 mm	
Cell 3: 65 T Short Pulse, 25 msec, 15 mm	
Cell 4: 65 T Short Pulse, 25 msec, 15 mm	
Cell 294: Development test cell	
60 T Long Pulse Magnet, ~3 sec, 32 mm	
85 T Multi-shot, 10 msec, 15 mm	
Single Turn (to 240 T so far), 0.06 msec, 10 mm	

Superconducting Magnets

Field (T), Bore (mm)	Supported Research
20 T magnet 52 mm bore (available 6/2011)	Same as pulsed fields, plus thermal-expansion, specific heat, and 20 mK to 600 K temperatures. Heat capacity, THz resistivity, and Magnetometry.
15/17 T magnet, 52 mm	
13/15 T magnet 52 mm	
14 T-PPMS magnet	

Facility Developments

In 2010 the PFF was focused on completing the second generation of inserts for the 100 T multi-shot magnet. Testing is expected to begin in spring 2011.

The second set of user experiments in the 85 T multi-shot magnet system was started in the summer of 2010. Six (6) proposals were selected for magnet time with 4 backup proposals also selected. This set of 85 T experiments is expected to be complete at the beginning of 2011.

The new 16 kV, 4 MJ user capacitor bank is now installed and currently running two (2) 65 T magnets in user cells 2 and 4. A new safety platform has been installed in cell 2 and is in the process of being evaluated before installation in all of the short pulse user cells.

A new 20 T superconducting magnet system with an actively cooled helium reservoir was purchased in 2010 and will be installed in 2011.

Facility Plans

Procurement of the conductor and contractor services for replacement coils for the 60 T long pulse and 100 T multi-shot magnet has begun. Also, the next generation 100 T multi-shot insert magnet is well underway and testing will begin in spring 2011.

Science Productivity

To date, 37 peer-reviewed publications and 47 presentations and posters

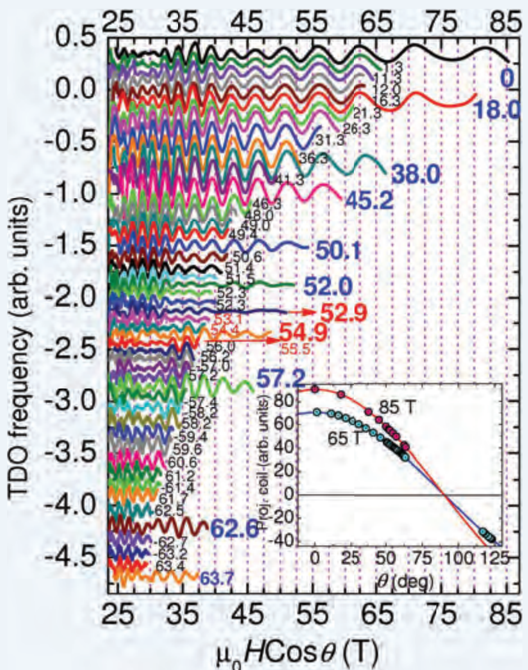


FIGURE 4.

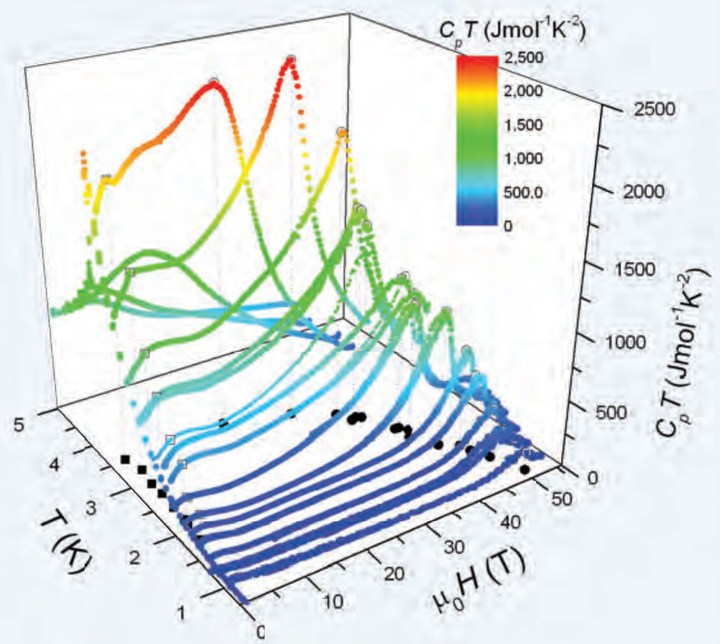


FIGURE 5.

have been reported for 2010.

• **Angular Dependence of Quantum Oscillations in Underdoped YBCO up to 85 T**

S. E. Sebastian, G. G. Lonzarich (University of Cambridge), **N. Harrison, M. A. Altarawneh, F. F. Balakirev** (NHMFL, Los Alamos), **Ruixing Liang, W. N. Hardy, D. A. Bonn** (University of British Columbia)

Quantum oscillations were measured as a function of angle in the 65 T and 85 T (angles labeled in blue) pulsed magnets. **(Figure 4)** The oscillations are seen to undergo a minimum in amplitude accompanied by an inversion in phase in the angular regime 53°56°. The phase remains uninverted in the remaining angular regime. Precise *in situ* calibration by means of a projection coil affixed under the sample is performed – the inset shows the pickup from the projection coil as a function of angle – dotted lines show the expected cosine form in 65 T and 85 T.

• **Specific Heat Measurements of $CeRhIn_5$ in Pulsed Fields Up to 55T**

H. Yuan, L. Jiao (Zhejiang University), **Y. Kohama, M. Jaime, T. Park, E. Bauer, J. Thompson** (Los Alamos National Laboratory).

CpT1 vs. Temperature vs. Magnetic Field plot when *H//ab* in $CeRhIn_5$. **(Figure 5)** The anomalies at low and high fields are incommensurate to commensurate [H. Hegger *et al., Phys. Rev. Lett.*, **84**, 4986 (2000)] and paramagnet to incommensurate transitions [A. L. Cornelius *et al., Phys. Rev. B*, **64** 144411 (2001)], respectively. The phase diagram measured by AC*Cp* measurement provides the first (*H,T*) phase diagram up to 55 T. We also find a difference in the shape of (*H,T*) phase diagram by applying different magnetic field direction. The magnetic field induced QCP seems to be located at about 60 T. *Cp(T)* at 55T changes linearly down to 850 mK and do not show specific temperature dependence on QCP which is $Cp/T \propto \ln(T)$. This is most probably originating from the lack of magnetic field.

Progress on STEM and Building the User Community

The NHMFL-PFF provided magnet time for 109 experiments in 2010, supporting 42 distinct PI's, one of whom is new.

The National Science Foundation REU program has given the PFF an excellent opportunity to extend the impact of the facility to underrepresented groups in the scientific community, particularly with students. Several students from underrepresented groups were involved in the program this year providing mutual benefits to the students and the PFF mentors.

Travel support may be granted to the new users, which has been helpful in growing the new user base considering the relatively remote location of the PFF in Los Alamos.

The staff members of the PFF continue to make considerable efforts toward outreach. In 2010, the second Magnet Lab User Summer School was organized by Albert Migliori. Held at the DC facility in Tallahassee, the school used lectures and hands-on experiences to help new users and students understand the complexity of conducting experiments in all NHMFL facilities. Many scientists from the NHMFL-PFF gave their time to teach at this event.

High B/T Facility

2010 statistics on High B/T users, proposals, and magnet usage are presented in Appendix A.

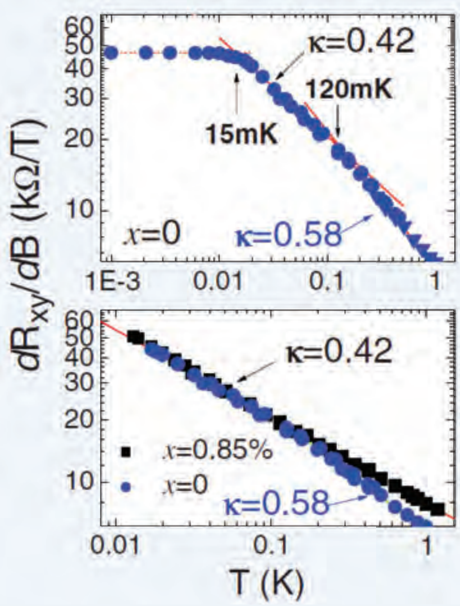


FIGURE 6. (TOP) The temperature scaling of the derivative $dR_{xy}dB$, showing three distinct regimes. The derivative saturates at very low temperatures (T<15 mK), has a power-law dependence with exponent κ=0.58 at very high temperatures, and a power law behavior with the universal exponent κ=0.42 for 15<T<120 mK. The bottom of the figure compares the crossover for x=0.85% with x=0%.

The High B/T facility provides specialized low temperature capabilities for users who need access to both very low temperatures (down to 0.04 mK) and high magnetic fields (up to 16 T) simultaneously. The facility also includes tempest quality electromagnetic enclosures and advanced vibration isolation techniques to provide an ultra-quiet environment for high sensitivity measurements. The facilities are housed in separate buildings at the University of Florida (a) the UF Microkelvin Laboratory, and (b) neighboring Williamson Hall. The Microkelvin Laboratory houses two nuclear demagnetization refrigerators: a PrNi5 cooling refrigerator for high cooling power down to 0.4 mK and for fields up to 16 T; and a Cu cooling refrigerator capable of reaching temperatures as low as 0.04 mK and for fields up to 8 T. In Williamson Hall a fast-turn-around facility for pre-testing samples and experimental cell designs down to 10 mK and up to 10 T is available to experimenters before using the nuclear refrigerators.

Facility Developments

In order to provide high sensitivity for nuclear magnetic resonance studies the staff at the High B/T Facility has developed broad band radio-frequency amplifiers that can operate in magnetic fields and down to 0.4 K. The amplifiers use pseudomorphic field effect devices that are oriented parallel to the applied magnetic fields to minimize Hall effects.

Facility Plans

Faculty members of the High B/T facility are exploring methods for extending accessible parameter space at low temperatures and high magnetic fields to moderately high pressures. This effort responds to user inquiries about studying systems such as low dimensional frustrated magnets at GPa pressures at very low temperatures.

Science Productivity

The High B/T facility reported 12 peer reviewed publications for 2010, including three significant publications, and there were 11 research reports for a total of 9 independent experiments in 2010. Two examples of exceptional science include:

• **Crossover from the Non-universal Scaling Regime to the Universal Scaling Regime in Quantum Hall Plateau Transitions**
W. Pan (Sandia National Laboratories), **W. Li, D.C. Tsui, L.N. Pfeiffer, and K. W. West** (Princeton University), **C. Vicente** (University of Puerto Rico), **J. S. Xia, N. S. Sullivan** (UF, Physics and NHMFL).
Publication: *Phys. Rev. B*, **81**, 033305 (2010).

Measurements of the quantum Hall plateau-to-plateau transition were carried out in an optimal-window sample of $Al_xGa_{1-x}As/Al_{0.32}Ga_{0.68}As$ heterostructure with x=0.85% down to a new low temperature regime, to 1 mK, in the nuclear demagnetization refrigerator of the High B/T facility. **(Figure 6)** A perfect scaling of the Hall resistance, dRxy/dB ~ $T^{-\kappa}$ with exponent κ = 0.42, was observed through two full decades of temperature from 1.2 K to 12 mK. At high temperature a crossover to a scaling with exponent κ= 0.58 was observed for two different samples, for x=0% and x=0.21%. The crossover temperature increases with increasing x or short-ranged alloy disorder. This crossover behavior is attributed to a transition from thermionic emission process at high temperatures to a quantum percolation process at low temperatures, where the quantum phase coherence length becomes greater than the puddle size.

• NMR Studies of the Microscopic Dynamics of the Proposed "Supersolid" Phase of Solid ^{4}He
D. Candela (University of Massachusetts, Physics), **S.S. Kim, C. Huan, L. Yin, J.S. Xia** and **N.S. Sullivan** (UF, Physics)

NMR measurements are particularly useful for probing the dynamics of solids at low temperatures. As a result of the motions the nuclear spin-spin interactions become time dependent and the Fourier transform of these dipolar fluctuations known as the spectral density, determine the nuclear spin relaxation rates. The spectral densities at the Larmor frequency ω_L and at $2\omega_L$ determine the spin-lattice relaxation rate T_1^{-1}, while the component at zero frequency determines the spin-spin lattice relaxation rate T_2^{-1}. We used these properties to probe the local dynamics of very dilute ^{3}He impurities in solid ^{4}He in order test for changes in the quantum tunneling of the ^{3}He impurities near the temperatures for which the proposed supersolid state may have been detected through observations of anomalies in the measurements of the response of torsional oscillators and of the shear modulus.

The temperature dependence of the nuclear-spin-lattice relaxation times are shown in **Figure 7**. A pronounced peak in T_1 is observed at the same temperatures (~ 170 mK) as those for which anomalies in the NCRIFs and shear modulus are observed. After the peak in T_1 a sharp drop in T_1 is observed at about 90 mK corresponding to the phase separation in which the ^{3}He atoms form nanoscale droplets of Fermi liquid.

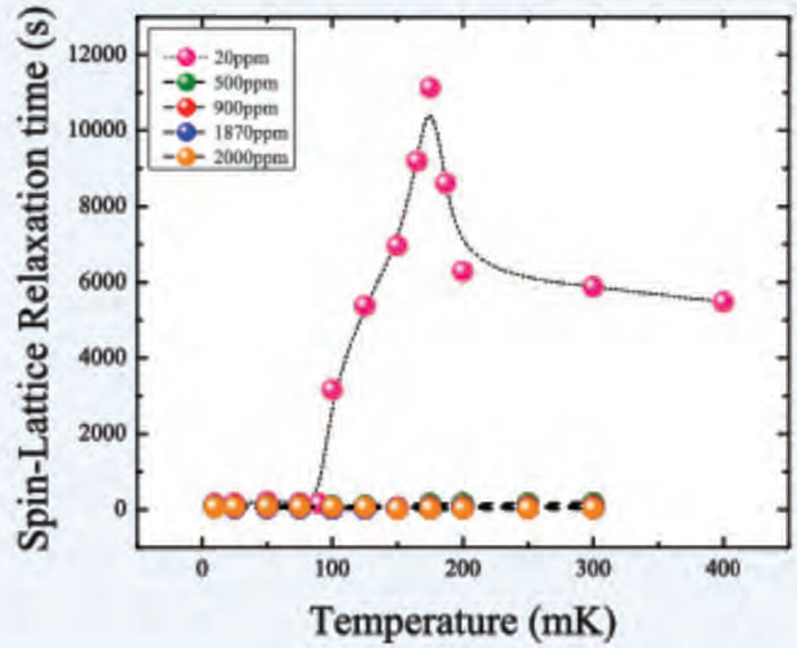


FIGURE 7. Temperature dependence of the nuclear spin-lattice relaxation time observed for ^{3}He impurities in solid ^{4}He.

These NMR studies show unequivocally that there is a pronounced change in the dynamics of solid ^{4}He in a narrow temperature range close to that for which torsional oscillator and shear modulus anomalies have been reported by other workers. The NMR study is the first non-invasive experiment to report on the dynamics of the solid ^{4}He at very low temperatures.

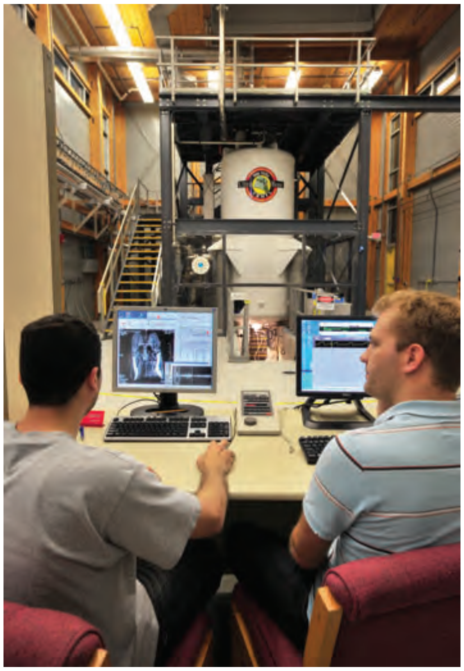
Progress on STEM and Building the User Community

A new international principal investigator, Dr. Bin Zhang (Chinese Academy of Sciences) and his colleagues have asked for experimental time to study a new problem, namely the search for a half-metallic state of the quasi-one dimensional magnet $Co(C_2O_4)(HO(CH_2)_3OH$. Up to the present such a state has not been reported for very low dimensional systems. Previous attempts to verify the half-metallic state have failed because of the inability to cool specimens to sufficiently low temperatures. The high cooling power and specialized thermalization techniques using liquid ^{3}He of the High B/T facility will be used to address this need. We are working with Dr. Zhang on designing a new experimental cell to meet his needs while he characterizes single crystal specimens.

The High B/T facility staff members hosted several visits from high school students and their teachers for guided tours of the Microkelvin Laboratory in 2010. In addition faculty members supervised three REU students for summer research programs and two undergraduate fellows supported by the UF Center for Condensed Matter Sciences.

NMR Spectroscopy & Imaging Facility

2010 statistics on NMR users, proposals, and magnet usage are presented in Appendix A.



The NMR and MRI User Program in Tallahassee has a mission to develop NMR technology and methodology at high fields and to develop the application science at the highest fields available for NMR spectroscopy and MR imaging. A broad range of fields are available to the users of the NMR and MRI Program to facilitate the application and technology developments through studies of the field dependence. In addition the range of fields provides an opportunity to evaluate what experiments should be performed at the highest possible fields. While the current flagship instrument continues to be the ultra-wide bore 900 MHz spectrometer, the NMR and MRI User Program is increasingly looking toward the completion of the 36 Tesla Series Connected Hybrid Magnet and the development of NMR and MRI technology for this unique magnet.

NMR & MRI Systems at the Magnet Lab in Tallahassee

NMR Frequency	Field (T), Bore (mm)	Homogeneity	Measurements
1.7 GHz	40, 32	10 ppm	Solid State NMR
1066 MHz	25, 52	1 ppm	Solid State / Solution NMR
900 MHz	21.1, 105	1 ppb	Solid State NMR, MRI
830 MHz	19.6, 31	100 ppb	Solid State NMR
800 MHz	18.7, 52	1 ppb	Solution NMR, Cryoprobe
720 MHz	16.9, 52	1 ppb	Solution NMR
600 MHz	14, 89	1 ppb	MRI and Solid State NMR
600 MHz	14, 89	1 ppb	Solid State NMR
600 MHz	14, 52	1 ppb	Solution NMR
500 MHz	11.75, 89	1 ppb	Solid State NMR
500 MHz	11.75, 52	1 ppb	Solution NMR, Cryoprobe
400 MHz	9.4, 89	1 ppb	Solid State NMR
300 MHz	7, 52	1 ppb	Developmental NMR
300 MHz	7, 89	1 ppb	Solid State NMR

Facility Developments and Plans

To maintain unique capabilities, the NMR and MRI User Program is constantly developing novel radio-frequency probes for specific experiments. In 2010 we were able to demonstrate a triple resonance (^{1}H, ^{13}C and ^{15}N) Magic Angle Spinning probe with more than 100 kHz of ^{1}H decoupling field. This probe has demonstrated more than a 50% improvement in sensitivity over the commercially available probes. This probe is currently in very high demand from the biological solid state NMR user community. This technology will be transferred to the ultra-wide bore 900 MHz magnet for even greater sensitivity and spectral resolution in 2011. While the Magnet Lab has been an international leader in the development of double resonance (^{1}H and ^{15}N) probes for aligned biological samples, 2011 will see the development of triple resonance (^{1}H, ^{13}C, and ^{15}N) aligned sample probes in collaboration with the UCSD NIH supported facility for Imaging Membrane Proteins directed by **S.J. Opella**.

This past year has also seen the development of very high temperature stability (+/- 0.2 K over a 24 hour period or longer) double resonance Magic Angle Spinning probes for materials research at temperatures to 120 K. In 2011 we look forward to extending this temperature range down to 100 K. While the Magnet Lab has been known for its very high sensitivity single resonance probes for quadrupolar spectroscopy, we are developing novel double resonance (^{1}H/X) probes that maintain the same sensitivity while providing ^{1}H decoupling of the quadrupolar nuclei.

This past year **W.W. Brey** and coworkers submitted a Major Research Instrumentation proposal to NSF for the development of an NMR console for the 36 Tesla Series Connected Hybrid magnet due to reach field in mid-2013. The proposal focused on quadrupolar nuclei for biological and materials systems, as

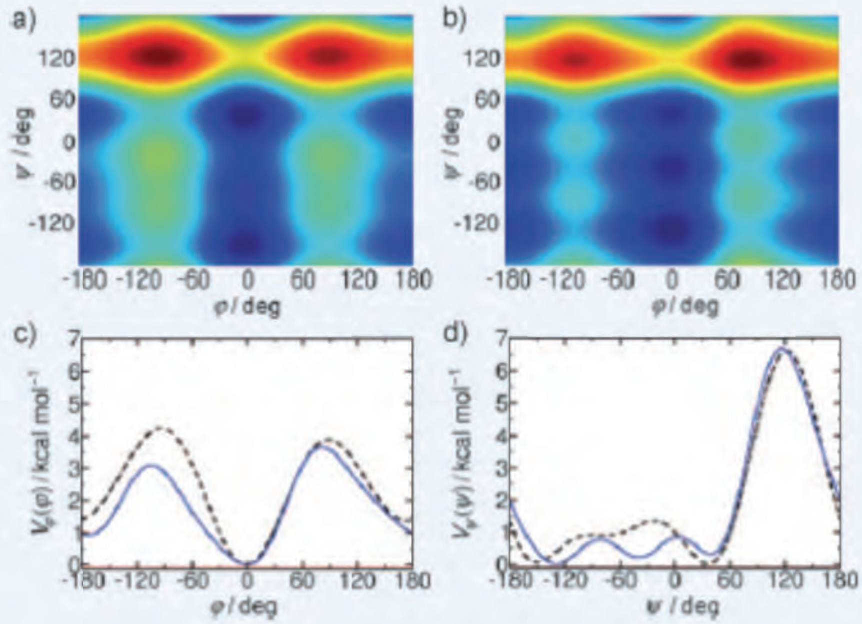


FIGURE 8. Comparison between the NMR-optimized potential for protein backbone dihedral angles refined by ff99SBnmr1 (b) and ff99SB (a). Two-dimensional maps (a,b) and one-dimensional projections along φ (c) and ψ (d) dihedral angles for ff99SBnmr1 (solid line) and ff99SB (dashed line).

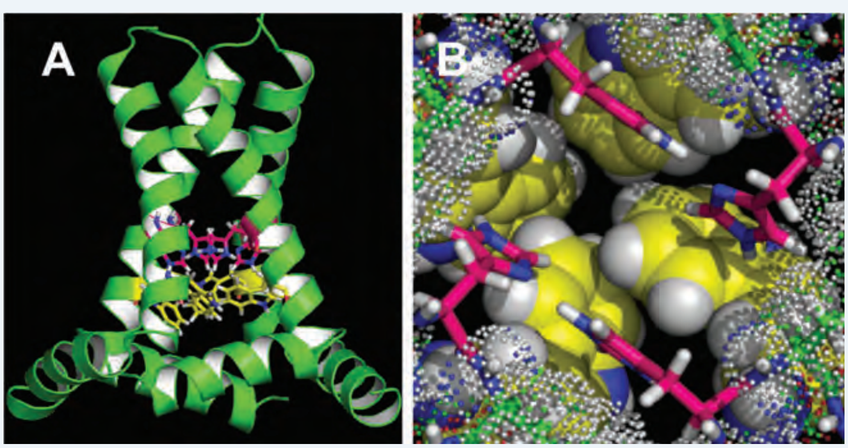


FIGURE 9. The M2 proton channel (A) is a tetramer of four M2 proteins each with a characteristic pair of Histidine (magenta) and Tryptophan (yellow) amino acid residues (B). Protons in the acid environs are transferred to the histidine residues and the tryptophan rings form the conductance gate.

well as the sensitivity gains that can be realized for spin ½ systems in biological samples. A broad range of solid state and solution NMR was proposed, as well as magnetic resonance imaging. A probe for ^{1}H detected solid state NMR will be developed through a collaboration with **K. Zilm** at Yale University and a cryo-probe for low-g nuclei will be developed by a research team at Pacific Northwest National Lab. An additional subcontract to **J. Schiano** at Penn State for field stabilization is planned to continue the excellent work that has been ongoing in the Keck Magnet. This proposal was funded by the NSF Division of Materials Research with support from Florida State University. Funding for additional probes is part of both the original Construction phase of the SCH magnet project and of this console grant. We will be working with the user community during 2011 to prioritize these probe development projects as well as moving ahead with the console development.

Science Productivity

41 peer-reviewed papers, 61 annual research reports, and 9 theses credited the NHMFL NMR Program in Tallahassee in 2010. Users of the NMR Program continue to publish in top-ranked scientific journals, such as *Science* (1), *Journal of the American Chemical Society* (3), *Angewandte Chemie Int. Ed.* (1), *FASEB J.* (1), as well as journals important for NMR technology development, such as *Journal of Magnetic Resonance* (3) and *Journal of Biomolecular NMR* (1). These publications credited 25 different corresponding authors, illustrating the breadth and depth of the NMR Program user base.

• **Protein Structures**

The computational refinement of protein structures is very important for achieving a functional understanding of proteins and for describing mechanisms by which the proteins function. **D.-W. Li** and **R. Brüschweiler** recently published [*Angew. Chem. Int. Ed.* **49**, 6778-6780 (2010)] a modification of the Amber ff99SB potential used for refining protein structure. Their modification incorporated the ^{13}C isotropic chemical shifts for the C_α, C_β, and C' carbon sites from protein structures. A comparison of calculated and observed ^{13}C chemical shifts suggests that there is considerable room for this improvement to the potential used for these refinements. Accurate values of these chemical shifts are available from the BioMagResBank (BMRB) for more than 5000 proteins. By using a sampling of 22 proteins, the authors showed a marked improvement in the force field performance as shown in **Figure 8**. This significant enhancement can be applied to

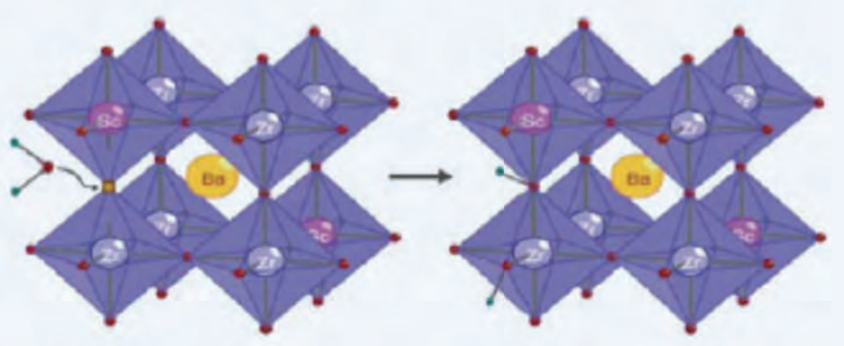


FIGURE 10. Hydration process of the $BaZr_{1-x}Sc_xO_{3-x/2}$ crystal structure. The Yellow, blue, red and green atoms respectively represent barium, zirconium, scandium, oxygen and hydrogen atoms.

the extensive BMRB database substantially enhancing our biological understanding of a great many proteins.

• **Influenza A**

The M2 proton channel from Influenza A is a drug target that has been extensively studied. **T.A. Cross** (FSU, Chemistry and Biochemistry), **H.-X. Zhou** (FSU, Physics) and **D. Busath** (Brigham Young Univ., Physiology and Dev. Biol.) have recently solved the structure of the conductance domain in a liquid-crystalline lipid bilayer environment [**M. Sharma** *et al., Science*, **330**, 509-512 (2010)]. **(Figure 9)** Previous (solution NMR and x-ray crystallographic) structures obtained from detergent based samples have been shown to be seriously distorted by the lack of a native-like sample environment. Uniquely, the Cross, Zhou and Busath team has characterized an atomic resolution mechanism for the transport of protons across the viral membrane. The novel chemistry involved in the mechanism suggests exciting prospects for drug development.

• **Fuel Cells**

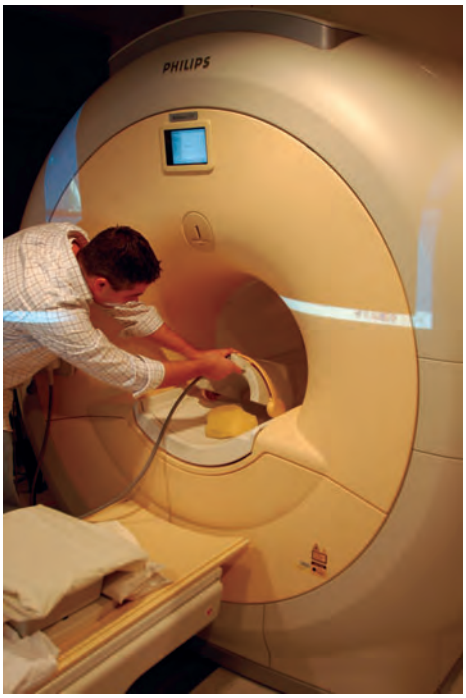
In fuel cell research **C. Grey** (SUNY-Stony Brook & Univ. of Cambridge) and **Z. Gan** have teamed up at the Magnet Lab to obtain magic Angle Spinning ^{45}Sc spectra of scandium-substituted $BaZrO_3$ [**L. Buannic** *et al., J. Mat. Chem.*, **20**, 6322-6332 (2010)]. The combination of high fields, optimized probes and optimized experimental protocols revealed the presence of both 5- and 6-coordinate scandium atoms with the 5-coordinate scandium arising from scandium nearby an oxygen vacancy. With proton decoupled ^{17}O spectroscopy obtained at the New York facility a description of three ^{17}O environments: Zr-O-Zr, Zr-O-Sc, and Sc-O-Sc was achieved. ^{1}H and ^{45}Sc NMR on hydrated samples revealed the presence of at least two different proton defects. From variable temperature spectroscopy two different proton environments were observed between which proton transfer occurs at ambient temperature. The reorientation of the protons around their hosting oxygen atoms may be hindered by the small expansion of the lattice parameter after scandium insertion and the presence of strong hydrogen bonds, thereby contributing an additional barrier to long-range conduction in the scandium-substituted $BaZrO_3$ systems.

Progress on STEM and Building the User Community

The NMR and MRI User Program in Tallahassee had 173 users this past year: 22% were female and 6% were minorities. Of the 91 senior investigators 7 were new principal investigators leading groups of researchers. In addition to the lead PI's there were 21 new senior investigators involved in this year's projects. This reflects on our major efforts at national and international meetings to recruit users to the NHMFL. All of these new principal investigators received magnet time.

Advanced Magnetic Resonance Imaging Spectroscopy Facility

2010 statistics on AMRIS users, proposals and magnet usage are presented in Appendix A.



The AMRIS facility at the University of Florida supports biological nuclear magnetic resonance studies of chemicals, biomolecular systems, tissues, small animals, large animals, and humans. We currently offer eight systems with different magnetic fields and configurations to users for magnetic resonance experiments. AMRIS has eight professional staff members to assist users, maintain instrumentation, build new coils and probes, and help with administration.

Several of the AMRIS instruments offer users unique capabilities: the 750 MHz wide bore provides outstanding high-field microimaging for excised tissues and live mice; the 11.1 T horizontal MRI is the largest field strength magnet in the world with a 400 mm bore; the 600 MHz 1-mm HTS cryoprobe is the most mass-sensitive NMR probe in the world and is ideal for natural products; the 3 T human whole body has 16 channels for rapid parallel imaging and is the only whole body instrument in the state of Florida dedicated to research. These systems support a broad range of users from natural product identification to solid-state membrane protein NMR to cardiac studies in animals and humans to tracking stem cells and gene therapy *in vivo* to functional MRI in humans.

Facility Developments

With funding from an NIH shared instrumentation grant and NSF ARRA funds to the NHMFL, in 2010 we were able to upgrade the console and gradients on our 11.1 T/40 cm imaging magnet and replace our 4.7 T/33 cm animal MRI system with a new console and gradients as well as an actively shielded magnet. These consoles replaced 12- to 15-year-old RF technology, allowing us to capitalize on state-of-the-art digital technology for pulse sequence generation and data acquisition. Both consoles have multitransmit and receive capabilities and a new gradient set for the 11.1 T system increases its usable bore size to 29 cm with integrated shims that improve the homogeneity of the active volume.

With the arrival of Dr. **Huadong Zeng**, an imaging scholar scientist for the AMRIS Facility, in December, 2009, we have been able to increase user support for animal imaging projects and attract new users to our facility. Dr. Zeng, along with our other AMRIS staff members, regularly offers training workshops for new users.

In March, 2010, we successfully applied for an NIH shared instrumentation grant to upgrade the gradients and console on the 14.1 T/5.2 cm system that is primarily utilized for microimaging and solid state NMR experiments that are integral to several NIH-funded individual investigator grants. The NHMFL is providing matching funds, which will allow us to concurrently upgrade the 11.7 T/5.2 cm NMR console. We anticipate these upgrades will be in place by fall, 2011, at which point we will have replaced all of the consoles that were installed in the AMRIS facility at its inception in 1998.

Two of the technology cores funded by the NHMFL, in HTS probe technology and microimaging, are now leveraged with NIH individual investigator grants. Art Edison received funding to develop the next generation HTS probe for natural products and metabolomics, which will be optimized for both ^{1}H and ^{13}C detection. We anticipate installation of the initial prototype for this design in spring, 2011. This grant also included funds to purchase a new 600 MHz NMR console; by partnering with the Chemistry Department at UF to purchase a new magnet for this console we were able to add an eighth instrument administered by the AMRIS Facility in fall, 2010, which is available through the NHMFL user program. **Steve Blackband** was initially funded by the NHMFL User Collaboration Grants Program (UCGP) to develop, in collaboration with Bruker Biospin, Inc., planar gradients and microcoils for ultra high resolution microimaging. He has now received NIH funding to continue developing this technology for microimaging of live tissue slices.

In September, 2010, Dr. **Tetsuo Ashizawa** assumed leadership of the McKnight Brain Institute at the University of Florida, which houses the AMRIS facility. Through generous support of human imaging initiatives by the MBI, the 3 T/90 cm imaging system will be upgraded to 32 receive channels in early 2011, and two 32-channel coils (for cardiac and fMRI studies) will be installed.

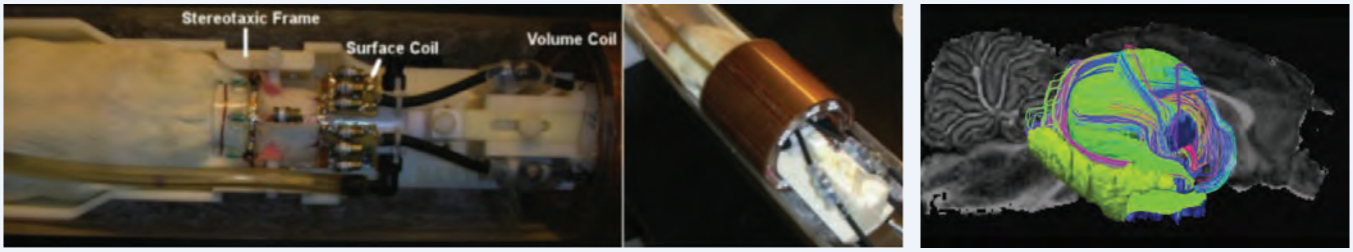


FIGURE 11. (Left) View of rat in MR compatible stereotaxic frame with volume coil removed. (Middle) Rat in stereotaxic frame with volume coil in position for MR imaging at 11.1 T. (A) DWI data measured on an excised rat brain using a diffusion-weighted multiple-slice, spin echo sequence on a 17.6T magnet system with an isotropic measurement resolution 0.190 mm.

Facility Plans

In spite of the challenging budgetary climate, our users have consistently and successfully pursued federal funding to support their research programs and assisted the AMRIS facility in writing proposals to upgrade instrumentation. The successful partnership of the NHMFL user program with individual investigator research grants also provides constant scientific motivation for our continued technology development, particularly for the three technology cores of the NHMFL in multimodal nanoparticles specifically designed for use at high magnetic fields, microimaging, and high sensitivity NMR. As we develop our science drivers and technology goals for the NHMFL renewal proposal to be submitted in late summer 2011, we continue to seek advice from our user community on new initiatives to pursue.

NMR & MRI Systems at the AMRIS Facility at UF

^{1}H Frequency	Field (T), Bore (mm)	Homogeneity	Measurements
750 MHz	17.6, 89	1 ppb	Solution/Solid State NMR & MRI
600 MHz	14, 52	1 ppb	Solution/Solid State NMR & MRI
600 MHz	14, 52	1 ppb	1-mm HTS Cryoprobe
600 MHz	14, 54	1 ppb	5-mm Cryoprobe
500 MHz	11.7, 52	1 ppb	Solution/Solid State NMR
470 MHz	11.1, 400[1]	0.1 ppm	MRI and NMR of animals
200 MHz	4.7, 330	0.1 ppm	MRI and NMR of animals
130 MHz	3, 900[2]	0.1 ppm	Whole body MRI and NMR of humans and large animals

1 290 mm useable bore
2 600 mm useable bore

Science Productivity

The AMRIS facility users reported 38 peer-reviewed publications for 2010. Some of the notable research highlights include:

• **Parekh, M.B.; Carney, P.R.; Sepulveda, H.; Norman, W.; King, M.; Mareci, T.H.**, "Early MR diffusion and relaxation changes in the parahippocampal gyrus precede the onset of spontaneous seizures in an animal model of chronic limbic epilepsy", *Experimental Neurology* **224**(1), SI258-270 (2010).

• **Cadotte, A.J.; DeMarse, T.B.; Mareci, T.H.; Parekh, M.B.; Talathi, S.S.; Hwang, D.U.; Ditto, W.L.; Ding, M.Z.; Carney, P.R.**, "Granger causality relationships between local field potentials in an animal model of temporal lobe epilepsy", *Journal of Neuroscience Methods* **189**(1), 121-129 (2010).

• **Astary, G.W.; Kantorovich, S.; Carney, P.R.; Mareci, T.H.; Sarntinoranont, M.,** "Regional convection-enhanced delivery of gadolinium-labeled albumin in the rat hippo-campus in vivo", *Journal of Neuroscience Methods* **187**(1), 129-137 (2010).

• **Kim, J.H.; Mareci, T.H.; Sarntinoranont, M.**, "A voxelized model of direct infusion into the corpus callosum and hippocampus of the rat brain: model development and parameter analysis", *Medical & Biological Engineering & Computing* **48**(3), 203-214 (2010).

Magnetic resonance imaging (MRI) is now a leading diagnostic technique, particularly for examining brain structure, due to its noninvasive nature. Using diffusion weighted imaging (DWI) structural connectivity between regions of the brain can be mapped and monitored with regard to specific disease states. (See **Figure 11**.) In particular, white matter (WM) fiber maps between regions of interest can estimate the strength of connections between limbic structures. In WM, water diffuses mainly along the direction of fiber bundles. With high angular resolution measurements, the direction and rate of water translational diffusion in each image voxel can be calculated and the estimated fiber tracks can be used to infer connectivity between regions of interest.

• **Menjoge, A.R.; Huang, Q.L.; Nohair, B.; Eic, M.; Shen, W.; Che, R.C.; Kaliaguine, S.; Vasenkov, S.,** "Combined Application of Tracer Zero Length Column Technique and Pulsed Field Gradient Nuclear Magnetic Resonance for Studies of Diffusion of Small Sorbate Molecules in Mesoporous Silica SBA-15", *Journal of Physical Chemistry C* **114**(39) 16298-16308 (2010).

• **Menjoge, A.; Bradley, S.A.; Galloway, D.B.; Low, J.J.; Prabhakar, S.; Vasenkov, S.**, "Observation of intraparticle transport barriers in FAU/EMT intergrowth by pulsed field gradient NMR", *Microporous and mesoporous materials* **135**(1-3) 30-36 (2010).

A major problem arising during catalytic applications of microporous and mesoporous materials is related to transport limitations caused by a slow rate of diffusion of guest molecules in pore systems of porous particles. As a result, diffusion may become a rate-determining, and even a selectivity-determining process in catalysis. Fundamental understanding of the relations between structural and transport properties of meso-\micro-porous materials on all relevant length scales is essential for applications of these materials in catalysis as well as in separations. Using pulsed field gradient (PFG) NMR with high (up to 30 T/m) gradient amplitudes, the self-diffusion rates of solute molecules in porous media can be measured. The temperatures and diffusion times used in the measurements are sufficiently small to allow diffusion studies for the length scales of sorbate displacements smaller than or comparable with the sizes of the individual particles or channels.

• **Waller, J.C.; Alvarez, S.; Naponelli, V.; Lara-Nuñez, A.; Blaby, I.K.; Da Silva, V.; Ziemak, M.J.; Vickers, T.J.; Beverley, S.M.; Edison, A.S.; Rocca, J.R.; Gregory, J.F.; de Crécy-Lagard, V.; Hanson, A.D.**, "A role for tetrahydrofolates in the metabolism of iron-sulfur clusters in all domains of life", *Proceedings of the National Academy of Sciences of the United States of America* **107**(23) 10412-10417 (2010).

Folic acid is necessary for proper cell division and DNA replication, and thus it is very important for mothers to take this during pregnancy. The major impact of this work biologically is that folic acid was discovered to be necessary to support the proper function of a family of proteins that protect against oxidative stress. In addition to a novel function, these proteins are important in every living thing, so this study shows a new significance to folic acid that was never known before. (See **Figure 12.**)

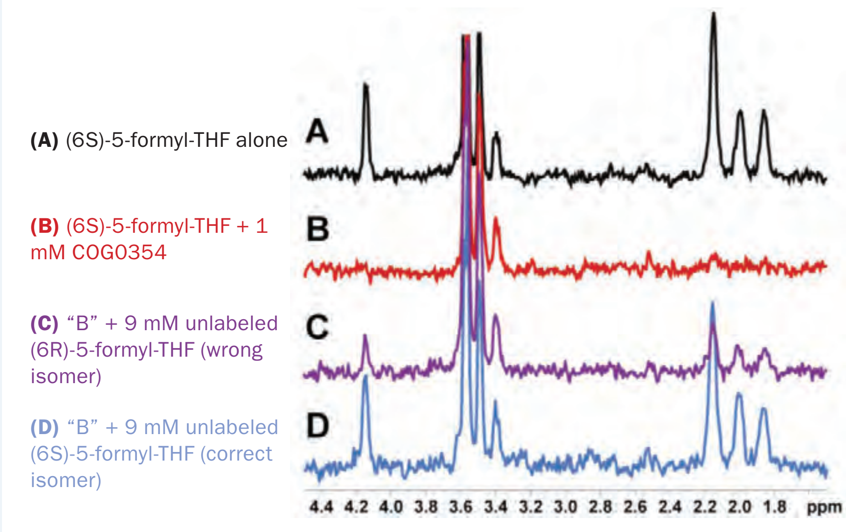


FIGURE 12. NMR evidence for folate binding by bacterial protein COG0354. Samples contained ^{13}C labeled 1 mM (6S)-5-formyl-THF. One-dimensional ^{13}C-HSQC experiments provided a filter to observe only ^{1}H resonances directly bonded to ^{13}C. The resonances from ~3.4-3.6 ppm are from the buffer.

Progress on STEM and Building the User Community

The AMRIS User Program had 3 new principal investigators in 2010.

Art Edison, professor and director of NHMFL Chemistry & Biology, travels to underrepresented colleges and universities as part of the NHMFL CO-WIN program. In 2010 he visited Claflin University in South Carolina. Dr. Edison also continues to run a weekly science club in Gainesville for disadvantaged children in grades 2-5, with 9-10 African American participants each week. With the assistance of 2 experts in education and 2-3 university student volunteers, this club provides tutoring, develops social skills, and offers group activities in science and math. **Steve Robinette**, an undergraduate researcher in Dr. Edison's laboratory, received both a Marshall Scholarship and an NSF graduate research fellowship to pursue graduate studies at Imperial College.

Electron Magnetic Resonance Facility

2010 statistics on the EMR users, proposals, and magnet usage are presented in Appendix A.

The Electron Magnetic Resonance (EMR) facilities at the NHMFL offer users several home built, high field and high frequency instruments providing continuous frequency coverage from 10 GHz to ~1 THz, with additional frequencies available up to 2.5 THz using a molecular gas laser. Several transmission probes are available for continuous-wave (c.w.) measurements that are compatible with a range of magnets at the lab, including the highest field 45 T hybrid magnet. Some of the probes can be configured with resonant cavities, providing enhanced sensitivity as well as options for *in-situ* rotation of samples in the magnetic field. Quasi-optical (QO) reflection spectrometers are also available in combination with dedicated high-resolution 12/17 T superconducting magnet systems; a simple QO spectrometer has also been developed for use in the resistive magnets (up to 45 T).

In addition to c.w. capabilities, the NHMFL EMR group boasts the highest frequency pulsed EPR spectrometer in the world, operating at 120, 240, and 336 GHz with 100 ns time resolution. A commercial Bruker Elexsys 680 operating at 9.7 and 95 GHz is available upon request. In the general science building, two superconducting magnets currently serve three spectrometers, as presented in the following table. EMR staff members also assist users in the DC Facility using broadband tunable homodyne and heterodyne spectrometers. The combination of instruments may be used for a large range of applications, including the study of optical conductivity, cyclotron resonance, paramagnetic impurities, molecular clusters, antiferromagnetic and ferromagnetic compounds and thin films, optically excited paramagnetic states, etc.

New in 2010:EMR instruments/ capabilities

A new scholar/scientist in the area of biochemistry/biophysics. After an exhaustive international search, **Dr. Likai Song** joined the group from the Dana Farber Cancer Institute at Harvard Medical School, where he served as Director of the Structural Biology Core. Likai will head the biological EPR users program and will assist users who wish to use the commercial (Bruker) W-band spectrometer. Likai's own research interests include structural studies of HIV and the anthrax toxin, as well as technique development related to distance measurements using pulsed EPR.

Acquisition of HiPER. The EMR group entered into an agreement with St. Andrews University in Scotland to acquire a copy of their recently developed high-power 95 GHz pulsed EPR spectrometer – HiPER. The Tallahassee version will initially operate at low powers, with the plan to obtain external funding for the amplifiers and switches needed to operate at high powers. Longer term plans involve extending capabilities to ~240 GHz. HiPER offers a step change in pulsed EPR spectroscopy, enabling 1 ns time resolution (and 1 ns deadtimes) and significantly enhanced sensitivity relative to commercial spectrometers. The low deadtime and exceptional isolation also makes Fourier transform EPR a reality, even at low powers. During the next year, and as part of the planning process for MagLab renewal funding, the EMR group will look to the Advisory Committee to develop a users program around this new instrument, which should be available to users in early 2013.

EMR Systems at the Magnet Lab in Tallahassee

Spectrometer	Frequency (GHz)	Field range (T)	c.w. – EPR	Pulsed	Time Resolved	ENDOR	Rotation	Absolute Sensitivity at 290 K (spins/mT)	Concentration Sensitivity[1] at 290 K (spins/cm³·mT)	Max. sample size (µl)
Transmission	23–660	0–17	✔					10^{13}	$5x10^{13}$	200
Homodyne QO	190–670	0–17	✔			✔		$5x10^{11}$	$2x10^{13}$	10
Heterodyne QO & Transmission	120, 240, 336	0–12.5	✔	✔	✔	✔	✔	10^9 (in cavity) $2x10^{11}$	$5x10^{13}$ $2x10^{12}$	0.1 100
DC Field[2] QO & Transmission	50–900	0–45	✔		✔		✔	10^9 (in cavity) 10^{13}	$5x10^{13}$	200
Bruker X-band	9.7	0–1.5	✔	✔		✔	✔	10^{11}	10^{12}	70
Bruker W-band	95	0–6	✔	✔		✔	✔	$5x10^8$	10^{12}	0.4

1 The Absolute sensitivity is the minimum number of detectable spins per mT linewidth and a 1Hz bandwidth at room temperature.
2 In combination with a far-infrared laser, select frequencies up to 2500 GHz are available.

High-resolution, high-field/frequency EPR. In collaboration with **Stefan Stoll** and **David Britt, Jurek Krzystek** recently revived capabilities for performing measurements in the resistive, high homogeneity 25 T Keck magnet. This facility provides enhanced g-anisotropy resolution relative to the spectrometers in the EMR lab that utilize superconducting magnets (see highlight below). After the initial work on photo-induced chlorophyll and carotenoid radicals in the late 1990s, the capability for performing this type of experiment at the NHMFL ceased. The source used in the current experiments was a backward-wave oscillator (BWO) operating at ~700 GHz. This, together with the capacity for measuring the source frequency very precisely by heterodyning with a vector network analyzer, and using appropriate standards, allowed determination of the g-factor anisotropy in biologically-relevant tryptophan radicals down to the 5th decimal digit.

EPR under pressure. With funding from the Chemistry Division at NSF, the Hill group has developed probes for performing cavity perturbation measurements in the 40 – 150 GHz range on samples subjected to hydrostatic pressures of up to 30 kbar (3 GPa). The probes are compatible with a split-pair 7 T superconducting magnet, thus enabling EPR studies of oriented crystals under significant pressures. This capability is now available to users.

Plans for 2011

EMR Summer/Winter Schools. Based on the success of the first EMR workshop in 2009, the group plans to hold similar events in coming years that will be open to members of the EMR community in the United States and overseas. The first of these events is tentatively planned for May 2011.

Construction of a frequency domain magnetic resonance spectrometer. A new instrument is being setup to cover a very broad frequency range (70-1500 GHz), initially for zero-field experiments and later for operation in a split-coil magnet.

Science Productivity

In 2010 a large number of research groups and projects were accommodated by the EMR group, resulting in the submission of 38 research reports. In addition, 25 peer-reviewed journal articles were reported by our users, as well as numerous presentations at conferences. Many publications appeared in high-impact journals including: *Science; Nature Materials; Angewandte Chemie;* 3 in the *Journal of the American Chemical Society;* 3 in *Physical Review B*; 5 in *Inorganic Chemistry*; and 3 in *Dalton Transactions in Chemistry.* Projects spanned a range of disciplines from applied materials research to studies of proteins. A few examples are given below.

• The Magnetic Structure of Tryptophan Radicals in Proteins

S. Stoll, R.D. Britt (University of California, Davis); **H.S. Shafaat, M.J. Tauber, J.E. Kim** (University of California, San Diego)

Tryptophan radicals are involved in many crucial single-electron processes in nature, serving as intermediaries in long-range electron transfer and as reagents in difficult redox transformations. The properties and reactivities of tryptophan radicals are controlled by their protein nanoenvironments, but little is known about the specific mechanisms of this control. In order to help gain insight into the underlying structure-function relationships, we determined the magnetic properties of two differently embedded photoinduced neutral tryptophan radicals in azurin [H. S. Shafaat, *et al., J. Am. Chem. Soc.* **132**, 9030-9039 (2010)] using EPR. The high magnetic fields and frequencies available at the NHMFL (25 T in the Keck Bitter magnet, 700 GHz) were necessary to resolve the very narrow EPR spectra, which reveal rhombic g tensors with very small anisotropies (see **Figure 13**). These g tensors are reporters on the nanoenvironments of the radicals, which tune their chemical properties. The two g tensors are clearly different, due to differences in the nanoenvironment of the radicals: one sits in a hydrophobic pocket, and the other one is partially surface-exposed, with a hydrogen bond to a water molecule. The recorded spectra constitute the first resolved tryptophan spectra and highest field/frequency EPR of organic radicals recorded to date. The work is being submitted for publication.

• Spintronics and Spin Quantum Computing

D.R. McCamey and **C. Boehme** (University of Utah); **G.W. Morley, M. Warner, A.M. Stoneham, P.T. Greenland, C.W.M. Kay, G. Aeppli,** (London Centre for Nanotechnology and University College London); **J. van Tol** (NHMFL)

In collaboration with groups at the University of Utah and the University College London, the properties of the spins of electrons trapped at shallow donors in silicon bound states were studied by Electrically Detected Magnetic Resonance at high frequencies. In previous years we have shown that, at high fields, the mechanism of spin-dependent

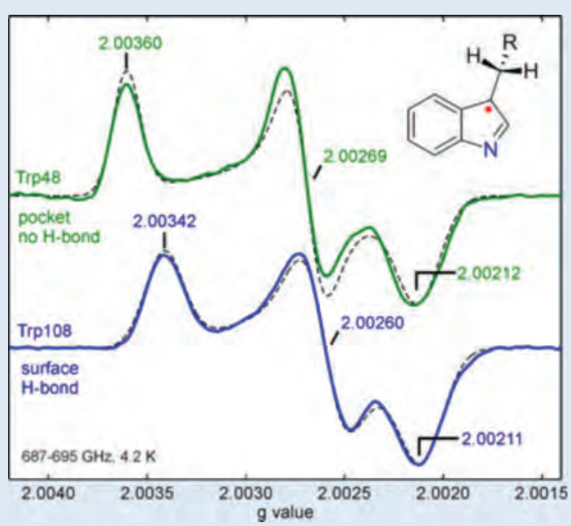


FIGURE 13. 700 GHz EPR spectra of two Trp radicals in azurin, including simulations and g values.

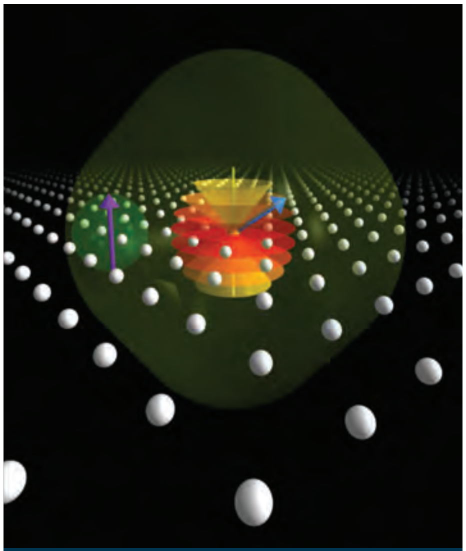


FIGURE 14.
A bismuth atom in one slice of a silicon crystal. The purple arrow is the electron spin while the blue arrow is the nuclear spin. *Artwork by Manuel Vögtli (LCN).*

recombination processes differs from the processes at low fields and that the magnitude of the spin dependent recombination process can be quite large at high fields. Furthermore we have shown that, at high fields, the electron spin state can be measured electrically while retaining the long (100 µs) spin coherence time, thus providing a possible readout mechanism for a silicon-based quantum computer. One of the disadvantages of electron spins is their relatively short lifetimes, which presents a problem for long-term storage of spin information. In 2010, we have shown that, at high fields, we can use the ^{31}P nuclear spin to store electron spin information for times as long as 100 s, and to read-out this information electrically [McCamey, D.R.; van Tol, J.; Morley, G.W. and Boehme, C., "Electronic Spin Storage in an Electrically Readable Nuclear Spin Memory with a Lifetime > 100 Seconds," *Science* **330**, 1652-1656 (2010)]. This provides an important new step toward the realization of a quantum computer. This work was highlighted on National Public Radio.

Also this year, we have investigated another shallow donor in silicon: Bismuth (**Figure 14**). While Bismuth is the heaviest stable element, the expected large spin-orbit coupling is effectively quenched in silicon, and it was found that g-values and linewidths are similar as those for the much lighter Phosphorus donor. Significantly though, the spin relaxation rates are as long or even longer than those in the Si:P system [Morley, G.W.; Warner, M.; Stoneham, A.M.; Greenland, P.T.; van Tol, J.; Kay, C.W.M. and Aeppli, G., "The initialization and manipulation of quantum information stored in silicon by bismuth dopants," *Nature Materials* **9**, 725-729 (2010)], making this a good candidate as a qubit system. What is very attractive for spin manipulation is the large nuclear spin (I=9/2) and the very large hyperfine splitting. This opens the avenue of individually addressing spins by tuning the hyperfine interaction electrically.

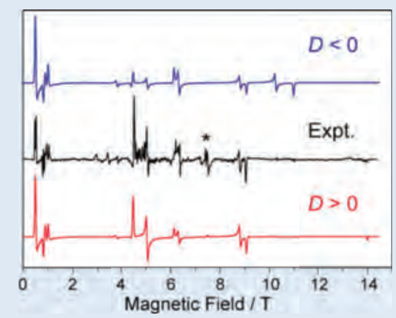


FIGURE 15.

• **Reactivity and Spectroscopic Studies of a "Masked" Three-Coordinate Vanadium(II) Complex**
B.L. Tran, M. Singhal, H. Park, M. Pink, D.J. Mindiola (Indiana University); **J. Telser** (Roosevelt University); **O.P. Lam, K. Meyer** (University Erlangen, Germany); **J. Krzystek, A. Ozarowski** (NHMFL)
Publication: B.L. Tran, *et al., Angew. Chem. Int. Ed.* **49**, 9871-9875 (2010)

This project was initiated in the Midiola group and has been directed toward the synthesis and characterization of a new type of complexes containing vanadium(II). In contrast to previous examples of V(II) compounds, in this case the V(II) ion is "masked" by a specially chosen set of ligands. In the structure, two coordination sites are taken up by each of the N atoms of the b-ketiminate ("NacNac")ligand, one by the N atom of a ditolylamide, and tolyl ring of that ligand "masks" the V(II) ion. The complex was further investigated by reactivity studies that showed removal of the mask and binding of a variety of small molecules, such as alkynes, to V(II).

The complex has an S = 3/2 ground spin state due to the $3d^3$ configuration of V(II). It was probed by both magnetometry and high-frequency and -field electron paramagnetic resonance (HFEPR). The EPR data on this low oxidation form of vanadium are scarce; ours is the first HFEPR investigation of V(II) to our best knowledge. The spin Hamiltonian parameters obtained from it, and magnetometry were in excellent agreement and pointed at an unusual electronic structure of the complex, relative to that of traditional V(II) complexes (**Figure 15**).

This project was supported by the Chemical Sciences, Geosciences and Biosciences Division, Office of Basic Energy Science, Office of Science, U.S. Department of Energy (Grant No. DE-FG02-07ER15893) and the NHMFL.

Progress on STEM and Building the User Community

In 2010, the EMR group received 15 applications for magnet time from first time principal investigators. 101 researchers visited the EMR facility in 2010, of which roughly a third were either female (19%) or minority (9%). In an effort to attract new users, the EMR group continues to provide up to $500 of financial support to first time visitors to the lab.

In addition, members of the EMR group made aggressive efforts to advertise the facility at international workshops and conferences. These efforts included attending conferences outside of our own immediate research areas. The group also organized several workshops and symposia and provided financial support in the form of student travel grants for the two main EPR conferences in the United States. We plan to continue this series of student workshops in the coming years as a means of outreach to the international EPR community. Finally, the EMR group has participated in several outreach activities, including the mentorship of summer REU students and local high-school interns.

Ion Cyclotron Resonance Facility

2010 statistics on ICR users, proposals, and magnet usage are presented in Appendix A.

During 2010, the Fourier Transform Ion Cyclotron Resonance (ICR) Mass Spectrometry program continued instrument and technique development as well as pursuing novel applications of FT-ICR mass spectrometry. These methods are made available to external users through the NSF National High-Field FT-ICR Mass Spectrometry Facility. The facility features five staff scientists who support instrumentation, software, biological applications, petrochemical and environmental applications, and user services as well as a machinist, technician, and several rotating postdocs who are available to collaborate and/or assist with projects.

Facility Developments

An actively-shielded 14.5 T, 104 mm bore system offers the highest mass measurement accuracy (<300 parts-per-billion rms error) and highest combination of scan rate and mass resolving power available in the world [*Protein Science*, **19**, 703-715 (2010)]. The spectrometer features electrospray, atmospheric pressure photoionization (APPI), atmospheric pressure chemical ionization sources (APCI), linear quadrupole trap for external ion storage, mass selection, and collisional dissociation (CAD); and automatic gain control (AGC) for accurate and precise control of charge delivered to the ICR cell. The combination of AGC and high magnetic field make sub-ppm mass accuracy routine without the need for an internal calibrant. Addition of new reagents enhances liquid chromatographic separation for intact proteins and increases the charge states of proteins up to 78 kDa [*Anal. Chem*. **82**, 7515-7519 (2010)]. Mass resolving power > 200,000 at m/z 400 is achieved at one scan per second, which is ideal for LC-MS [*Anal. Chem*. **82**, 6542-6548 (2010)] and facilitates automated data reduction for H/D exchange experiments [*J. Am. Soc. Mass Spectrom*. **21**, 550-558 (2010)]. Robotic sample handling allows unattended or remote operation. An additional pumping stage has been added to improve resolution of small molecules. Simultaneous infrared multiphoton (IRMPD) and electron capture dissociation (ECD) are under development.

The 9.4 T, 220 mm bore system offers a unique combination of mass resolving power ($m/\Delta m$ = 8,000,000 at mass 9,000 Da) and dynamic range (>10,000:1), as well as high mass range, mass accuracy, dual-electrospray source for accurate internal mass calibration, efficient tandem mass spectrometry (as high as MS^8), and long ion storage period. When combined with compositionally complex organic mixtures such as dissolved organic matter [*Org. Geochem*., **41**, 1177-1188, (2010)] and petroleum, mass spectrometer performance improves significantly, since these mixtures are comprised of mass "splits" which are readily separated and identified by FT-ICR MS. The magnet is passively shielded to allow proper function of all equipment and safety for users. The system features external mass selection prior to ion injection for further increase in dynamic range and rapid (~100 ms timescale) MS/MS [*Anal. Chem*. **75**, 3256-3262 (2003)]. Available dissociation techniques include collisional (CAD), photon-induced (IRMPD), and electron-induced (ECD). An APPI source can be used for analysis of nonpolar analytes and recently produced the first exhaustive compositional test of the Boduszynski model for heavy petroleum fractions [*Energy Fuels* **24**, 2929-2938 (2010); *Energy Fuels* **24**, 2939-2946 (2010)].

The 9.4 and 7 T actively shielded FT-ICR instruments are available for analysis of complex nonpolar mixtures and instrumentation development. The 9.4 T magnet is currently used for field desorption [*Anal. Chem*., **80**, 7379-7382 (2008)] and elemental cluster analysis. The 7 T magnet is optimized for volatile mixture analysis [*Rev. Sci. Instrum*. **77**, 025102 (2006)] and can be used to develop ion optics and ICR ion traps. Samples are volatilized in a heated glass inlet system (at 200-300 °C) and externally ionized by an electron beam (0-100 eV, 0.1-10 μA). The ions are collected in a linear multipole ion trap and injected into the FT-ICR cell. Mass resolving power ($m/\Delta m$) greater than 10^5 and mass accuracy within 1 ppm has been achieved with both systems.

Facility Plans

In 2010, NSF's Division of Chemistry awarded $17.5 M to NHMFL, matched by $1.4 M from Florida State University for **a four-year project to design and build the world's highest field (21 tesla) Fourier transform ion cyclotron resonance mass spectrometer.** The magnet has been ordered from Bruker Daltonics, with delivery scheduled for the first half of 2013, and the mass spectrometer will be integrated into the NHMFL ICR user program. Initial applications include top-down proteomics (with mass range extended to encompass most of the human proteome); mapping of protein binding surfaces for complexes too large (1 MDa or higher) for NMR and/or that have not been successfully crystallized for x-ray diffraction; and petroleum "heavy ends" analysis, for which components with up to 50,000 chemical formulas ($CcH_hN_nO_oS_s$) must be resolved (requiring >1 M resolving power) and identified (requiring better than 100 ppb mass measurement error) in a single mass spectrum.

Science Productivity

Automated broadband phase correction of FT-ICR data can in principle produce an absorption-mode spectrum with mass resolving power as much as a factor of 2 higher than conventional magnitude-mode display, an improvement otherwise requiring a more expensive increase in magnetic field strength. We have developed and implemented a robust and rapid automated method to enable accurate broadband phase correction for all peaks in the mass spectrum and present experimental FT-ICR absorption-mode mass spectra with at least 40% higher resolving power, increased number of resolved peaks, and higher mass accuracy relative to magnitude mode spectra and produce more complete and more reliable elemental composition assignments for complex organic mixtures such as petroleum [*Anal. Chem.*, **82**, 8807-8812 (2010)].

A novel "walking" calibration equation for complex petroleum mixtures divides the mass spectrum into dozens of adjoining segments and applies a separate calibration to each segment thereby eliminating systematic error with respect to *m/z* and increases the number of assigned peaks by as much as 25% while reducing the rms mass error by as much as 3-fold for significant improved confidence in the elemental composition assignment [Anal. Chem., 2011, Accepted Jan. 7, 2011].

ICR Systems at the Magnet Lab in Tallahassee

Field (T), Bore (mm)	Homogeneity	Measurements
14.5, 104	1 ppm	ESI, AP/LIAD-CI, APPI FT-ICR, Thermospray Ionization
9.4, 220	1 ppm	ESI, AP/LIAD-CI, APCI, APPI FT-ICR, Thermospray
9.4, 155	1 ppm	FD, LD FT-ICR
7, 155	1 ppm	EI, CI FT-ICR

Development of novel ionization techniques such as Atmospheric Pressure Laser-Induced Acoustic Desorption Chemical Ionization (AP/LIAD-CI) decouples analyte desorption from subsequent ionization and enables rapid and independent optimization and generates analyte ions that are efficiently thermalized by collisions with atmospheric gases thereby reducing fragmentation [*Anal. Chem.,* 2011, *Accepted Jan. 11, 2011*].

Biomolecular sequence verification continues to be in high demand. Protein and oligonucleotide masses can be determined with ppm accuracy [*Rapid Comm. Mass Spectrom.*, **24**, 2386-2392 (2010)]. Molecules can be fragmented (by collisions, photons, or electron capture by multiply-charged positive ions) to yield sequence-specific products. Sites and nature of post-translational modification (e.g., glycosylation, phosphorylation, etc.) are readily determined [*J. Proteome Research*, **9**, 2098-2108 (2010)]. In-house software has been developed for rapid data analysis. We devised a method to distinguish N-terminal from C-terminal peptides by use of electron capture dissociation MS/MS [Anal. Chem., 79, 7596-7602 (**2007**)], as well as the first large-scale characterization of hundreds of membrane lipids from cell cultures [*Anal. Chem.*, **79**, 8423-8430 (2007)].

Tertiary and quaternary structure can also be probed. Automated **hydrogen/deuterium exchange** has been improved by depletion of heavy isotopes ($^{13}C/^{15}N$) for protein subunits of a complex can greatly simplify the mass spectra, increase the signal-to-noise ratio of depleted fragment ions, and remove the ambiguity in assignment of m/z values to the correct isomeric peptides [*Anal. Chem.*, **82**, 3293-3299 (2010)]. Details of biomolecular conformation and surface contact between molecules in a noncovalent complex can be deduced. We also demonstrated that simultaneous quench/digestion/reduction following H/D exchange yields dramatically increased sequence coverage and localization of solvent-exposed segments for characterization of proteins containing disulfide bonds, which previously could not be reduced before or during the H/D exchange reaction without affecting protein higher-order structure [*Anal. Chem.*, **82**, 1450-1454 (2010)]. Changes in gene and polar lipid expression due to chemotherapy treatment in glioblastoma cells exposed significant changes in sulfonated glycolipids (sulfatides) and indicated post-transcriptional control of sulfatide synthesis [*Glycoconj. J.*, **27**, 27-38 (2010)].

The 7, 9.4, and 14.5 T instruments are primed for immediate impact in **environmental, petrochemical, and forensic analysis**, where intractably complex mixtures are common. The field of "petroleomics" has been developed largely due to the unique ability of high-field FT-ICR mass spectrometry to resolve and identify all the components in petroleum samples [*Eur. J. Mass Spectrom.* **16**, 367-371 (2010)].

Characterization of an unusual blue crude oil indicated an enhanced concentration of perylene, a polycyclic aromatic hydrocarbon known to fluoresce, was identified with various analytical techniques and confirmed with FT-ICR MS [*Energy Fuels* **25**, 172-182 (2011)]. Further, fossil fuel samples can be analyzed and components resolved without chromatographic separation. In a recent study more than 30,000 distinct chemical components were resolved and identified (elemental formulas) in a single atmospheric pressure photoionization FT-ICR mass spectrum of heavy crude oil [*Energy Fuels* **24**, 2939-2946 (2010)].

Progress on STEM and Building the User Community

The ICR program had 12 new principal investigations in 2010. The ICR program also enhanced its undergraduate research and outreach program for 5 female undergraduate scientists along with two female high school students. One high school student presented results at the 2010 ACS Spring Conference and was awarded the Student Poster Award from the Division of Petroleum Chemistry. The ICR program in 2010 supported the attendance of scholar-scientists, postdoctoral associates, graduate, undergraduate and high school students at numerous national conferences to present current results.

Geochemistry Facility

2010 statistics on Geochemistry users, proposals, and magnet usage are presented in Appendix A.

The geochemistry facility has six mass spectrometers of which four are available to outside users. One instrument is a multi collector thermal ionization instrument (Finnegan MAT 262/RPQ) that is used for measurements of isotopes of elements with low first ionization potential. The second instrument is a single collector inductively coupled plasma mass spectrometer (ICP-MS), ELEMENT, which is used for trace metal abundance determinations. A separate laser ablation system can be interfaced for *in-situ* trace element analyses on solid materials. The third instrument is a multi collector inductively coupled plasma mass spectrometer (NEPTUNE) that is used for determination of isotopic abundances of metals. The fourth instrument is a mass spectrometer designed for the measurement of the light stable isotopes (C, N O, S).

The facility is run via external grants and in the last year individual PIs had funding from NSF (several divisions of the GEO directorate), NASA, NOAA, and EPRI (Electrical Power Research Institute).

Facility Developments

Facility developments involved mostly the now 16-year-old Finnegan MAT 262/RPQ thermal ionization mass spectrometer. We have gradually shifted most of the measurement routines from this old mass spectrometer to the NEPTUNE ICP-MS. This can now be noted in the decrease in instrument time on the 262. Next year we will not report on this instrument anymore.

We have solved our technical position and were able to hire a new technician for the mass spectrometry facility. We submitted a successful proposal to NSF to replace our 14-year-old ICP-MS (ELEMENT1).

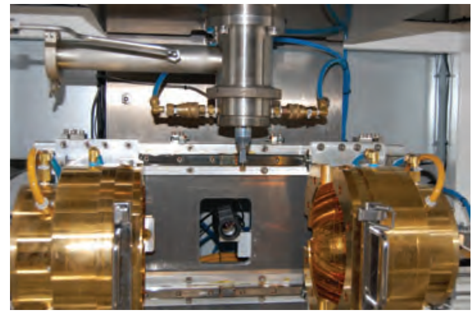
Facility Plans

Parts for the ELEMENT 1 are very hard to find, so we will disassemble the instrument. We will also be streamlining the Ar-gas distribution and switch to micro bulk gas instead of dewars.

Science Productivity

This year there are significant achievements in the area of high temperature geochemistry. Basalts of ocean islands, like Hawai'i, are thought to find their source from a plume that rises from the core-mantle boundary. The interaction of this plume with the matrix it is rising through has long been a point of debate. The research report "Plume Asthenosphere Interaction; New Evidence from Hafnium and Neodymium Isotopes" (Research Report #298, available online at **http://www.magnet.fsu.edu/usershub/publications/researchreportsonline.aspx**) provides conclusive data that the plume material indeed assimilates some of the matrix on its way to the surface. A second report, #297, "Domains of Ultra Depleted Mantle; New Evidence from Hafnium and Neodymium Isotopes" discusses the data that allows the conclusion that the mantle is poorly mixed with respect to the presence of an ultra depleted component as domains up to 1200 km in size are observed with a constant amount of this depleted component present. The existence of such a component has been debated; its ubiquitous presence can now be shown for the Indian and Atlantic Ocean basin, while ridge basalts from the Pacific basin show limited involvement of this component.

In 2010 we published 25 peer-reviewed publications and made 18 presentations at international meetings. In addition three students defended their Ph.D., while two students received MSc degrees. We have broadened our funding with an NSF grant from the atmospheric sciences program. The new ICP-MS instrument is supported by three NSF programs: Chemical Oceanography, Marine Geology and Geophysics in Ocean Sciences, and Instrumentation and Facilities in Earth Sciences.



Progress on STEM and Building the User Community

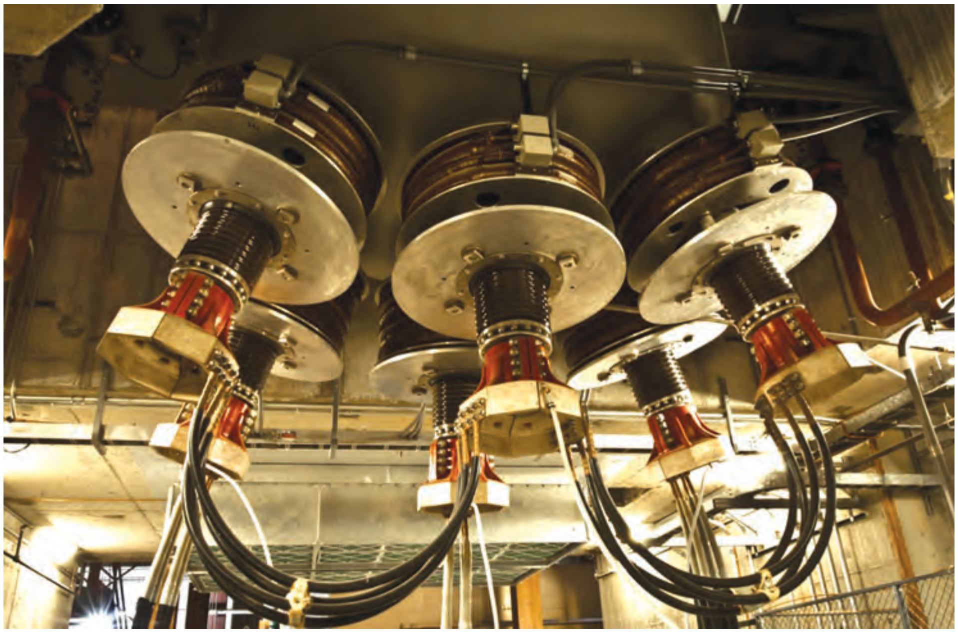
Geochemistry had one new principal investigator this year, Brian Stapleton (FSU Institute of Molecular Biophysics, Department of Chemistry and Biochemistry). Again this year, we saw an increase in the number of new students from the FSU Department of Chemistry and Biochemistry.

The facility is open to users of all kind and we have a long-time collaboration with the USGS Volcano Monitoring Program.

As our facilities are mainly supported through external grants, external users have to be able to contribute to the cost of the lab use. However, we continue to help people get preliminary data for use in proposals etc. free of charge. Also, training of new users on the instruments is done free of charge.

We participated in the annual open house in February 2010, and during the summer, we hosted two undergraduate students from the REU program.

CHAPTER 4
Magnets & Magnet Materials



ABOVE The 85 T multi-pulse magnet at LANL holds the world record, 88.9 T, for a non-destructive pulsed magnet.

Introduction

A central feature of the NHMFL's mission is the provision of unique high-performance magnet systems for our users that exploit the latest materials and magnet design developments. As we move forward, pursuing ever higher fields while controlling costs, balancing developments of both resistive and superconducting magnet development is built in to our program. The balance of ongoing magnet construction with the materials and technology development needed to make sure that we stay at the forefront is of critical importance. Collaborations with other leading industrial, academic and government groups that develop these new magnet technologies are built in to many of these thrusts. While the Cuprate HTS materials were discovered over 20 years ago, it is only in the past 3-4 years that dramatic improvements in both YBCO tape and Bi2212 round wire have been realized which show their tremendous potential to enable revolutionary magnet systems. 2010 saw the MagLab leading the way to these higher field magnets with major contributions in superconducting materials technology, as well as magnet technology.

The most immediate impact to the user community in 2010 was the development in **pulsed magnets** at the Los Alamos branch. *The world-record 85 T pulsed magnet is presently being upgraded and we anticipate it returning to service in March 2011 at a still higher field of 95 T. Further upgrades to 100 T are being considered.*

In the **resistive magnet program**, 2010 saw the fabrication of most of the components of a *novel split resistive magnet that will provide a world-record magnetic field (25 T vs. 18 T elsewhere) along with uniquely large mid-plane ports for scattering experiments!* Assembly of the components of this magnet is underway at the MagLab and the system should be ready for user service in mid-2011.

The NHMFL is one of the world's leading institutions in the design and fabrication of magnets using **cable-in-conduit conductor** (CICC). Presently we are constructing new hybrid magnets for the NHMFL and for the Helmholtz Center Berlin (HZB), Germany. The NHMFL magnet will be used for NMR experiments in addition to more traditional high field experiments, and the HZB magnet will be used for neutron-scattering experiments. *2010 brought many milestones, principally*: (1) the delivery of the last of the Nb_3Sn strand required for the HZB and NHMFL magnets, (2) fabrication of 7 of the 10 lengths of cable, (3) completion of jacketing the first CICC's, (4) purchase of the refrigerators for both the MagLab and HZB, (5) completion of design of the cold-masses for both magnets (6) completion of the design of the cryostat for the MagLab. The NHMFL and HZB systems are expected to be complete in 2013.

In late 2009 we received funding from the NSF's Major Research Instrumentation program to design and build an all-superconducting magnet to provide **32 T** to the scientific community. While superconducting demonstration coils have been built that provide as much as 33.8 T, the highest all-superconducting-field available worldwide today in a user facility is 23.5 T in Lyon, France. Achieving a 36% increase in field for a superconducting user magnet requires development of numerous scalable technologies such as: uniformity of YBCO tape properties, ultrathin insulation systems, quench detection and protection algorithms, high-strength joints, reinforcement procedures, coil winding equipment, etc. 2010 saw tremendous progress on all these fronts and we anticipate ordering the Nb-based outer coils and YBCO tape for the inner coils in mid-2011 with the system operational in early 2013. This magnet will not only serve as a unique user facility at the NHMFL but will also serve as a stepping stone in the development of a 30 T NMR magnet as advocated by the Committee on Opportunities for High Magnetic Field Science report (2005), which laid out ambitious 10 – 15 year goals for magnet technology.

Present magnet designs for pulsed, resistive, and superconducting systems are limited by either the critical current density, strength, stiffness, or fatigue life of the available **materials**. For many years we have been nurturing high temperature superconductors (HTS) as the route to a transformational magnet technology that is bringing superconducting magnets closer to the field limits that can be achieved by DC resistive technology. Cuprate HTS materials have been developed as conductors for electric utility use since the late 1980's, but it is only in the last 3-4 years that they have emerged into viable consideration for making high field magnets that extend beyond Nb_3Sn. In 2009 we started, consistent with COHMAG's recommendation for greater inter-institutional collaboration in new magnet technologies, a new collaboration of 6 institutions, Very High Field Superconducting Magnet Collaboration (VHFSMC), jointly led from the NHMFL and Fermilab, to evaluate round wire Bi-2212 for high field superconducting magnets suitable for High Energy Physics applications. This work has demonstrated paths to much higher conductor critical current density and makes a good case for round wire Bi-2212 as a viable new HTS conductor technology for high field magnets.

Despite 2011 being the 50th anniversary of the discovery of Nb_3Sn as a high-field superconductor, the behavior of filamentary Nb_3Sn conductors particularly in the transposed, open-space environment of CICC conductors has needed detailed exploration, both for the series-connected hybrid and for the International Thermonuclear Experimental Reactor (ITER) magnet systems. Understanding the mechanical and cracking performance of filaments has been one facet of our work for ITER this year, as has been an understanding of the low temperature crystallographic state.

The vortex pinning mechanisms that determine the upper limit to J_c, as well as the current-limiting mechanisms that degrade this limit, were studied for industrial $YBa_2Cu_3O_{7-x}$ (or more generally, their rare-earth variants REBCO) and Bi-2212 conductors at fields up to 31 T. The potential of the low anisotropy and still very high upper critical field (well over 50 T) ferropnictide superconductors remain under study as potential future conductors. Mechanisms affecting the strength and conductivity of high-strength copper alloys for resistive and pulsed magnets were discovered. Work studying the conductors needed to understand fatigue and embrittlement of stainless steels for the CICC magnets of ITER continued. Theories and experiments to understand the huge variability of superconducting RF cavity performance were developed.

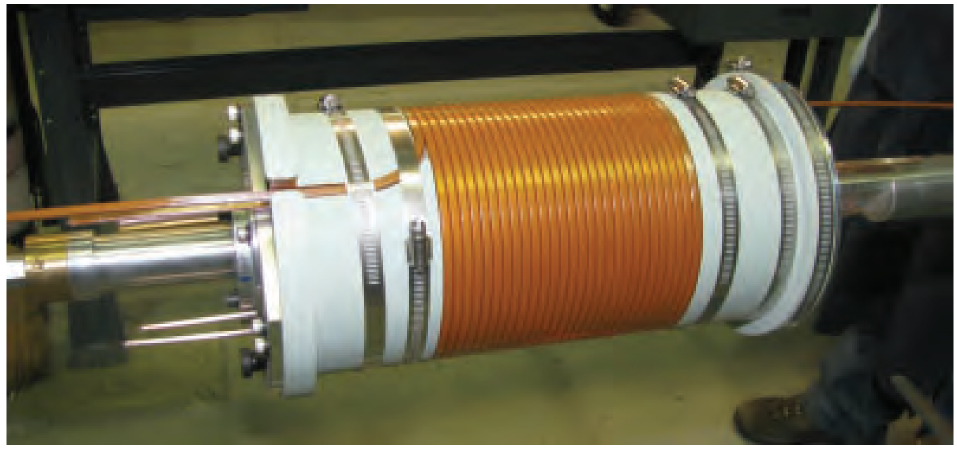


FIGURE 1. Photo of layer 7 of the 95 T insert after winding at LANL.

Pulsed Magnets

The NHMFL pulsed magnet group is responsible for development and operation of both generator-driven and capacitor-driven pulsed magnet systems. The mission is in direct response to the NSF charges to provide the highest fields for science, and develop new magnet technology. Work in 2010 primarily focused on: (1) refining 85 T operations and diagnostics procedures for generator magnet operations, (2) the final design and production of the insert magnet upgrade to reach 95 T to 100 T, (3) production of user magnets for the NSF Pulsed Field Facility, and (4) further refining the next-generation duplex-magnet technology.

85 T Multi-Pulse Magnet System and Planned Insert Upgrade to Allow 95 T to 100 T Operations.

The 85 T Multi-Pulse Magnet System is a long-term partnership jointly funded by the U. S. Department of Energy - Office of Basic Energy Science, and the National Science Foundation - Division of Materials Research. *This magnet holds the world-record field for a non-destructive coil, 88.9 T, and the record for continuous non-destructive pulsed operations, >215 pulses.* The magnet is a unique unmatched resource for high field scientific research. The year 2010 saw the continued successful demonstration of 85 T operations in support of user science. 100 T magnet operations are maturing in both definition and predictability. We have implemented a systematic diagnostic monitoring of coil resistances to ensure more reliable operations and to monitor the state of the nanocomposite conductor in the insert magnet assembly. The 100 T magnet systems are designed such that the inner insert magnets are replaceable. In December 2010 an insert magnet experienced an electrical fault at full field. No damage to the outsert magnet system was observed. Post-fault inspection of the insert magnet indicated possible deficiencies in the design of axial support system for the insert magnet, and the need for improved magnetic centering between the insert and outsert magnets during installation and training. The insert magnet's axial support interface has been modified. We have also implemented improved magnet centering procedures to be used during magnet installation, commissioning, and operations. These structural and procedural improvements are critical to the success of the planned operation of the insert magnet upgrade in March 2011.

The next insert magnet upgrade is designed to reach magnetic fields between

95 T and 100 T in a 10 mm bore. The design of the upgraded insert was finalized during late 2009. Construction of two upgraded insert magnet assemblies began on schedule in August of 2010. The critical issue that will determine the maximum attainable field is the feasibility of extending the outsert magnet's field from 37 T to 42 T. Analysis activities in 2010 entailed a detailed review of the outsert design and projected performance after the 2008 upgrade to determine the risks associated with increasing field production from the outsert. The 2008 installation of upgraded coils #1 and #2 has enabled 42 T operation of the outsert. 95 T operations are planned in 2011 for the generator powered outsert and the capacitor-driven insert magnet system. 100 T operations will be considered based upon magnet performance and the results of extensive materials testing.

NSF User Magnet Production.

The pulsed magnet group supports the operation of five scientific user stations and inserts for 85 T operations. The 2010 work for the NSF Science Program entailed the delivery of six 65 T pulsed magnet assemblies and one insert magnet.

Duplex Magnet Development for the Next Generation of User Magnets.

The NHMFL has designed a first generation of duplex magnets for operation with the new 4 MJ capacitor bank at the LANL facility. Duplex magnet development was postponed in 2010 to allow development of the 100 T Insert Magnet Upgrade.

Resistive Magnets

Split 25 T Magnet.

A novel split magnet is being developed for photon scattering experiments at the Magnet Lab that will provide world record magnetic field (25 T vs. 18 T available elsewhere) along with uniquely large mid-plane ports for scattering (four ports providing 0.5 steradians of solid angle). See **Figure 2**. In addition, the magnet housing includes a special mounting structure to allow the whole magnet system to be tilted to allow operation with the field either vertical or horizontal. The magnet consists of 4 coils electrically in series. The innermost coil consists, in turn, of two sub-coils electrically in parallel. In a split solenoid, the magnet must accommodate numerous conflicting constraints; over half the mid-plane must be devoted to vacuum space. The remainder must include (1) sufficient structure to support ~500 tons of force between the two halves of the magnet, (2) sufficient conductor to carry 160 kA between the two halves, and (3) sufficient free space to carry 220 liters per second of cooling water. To address these constraints, a new magnet technology, the Split Florida-Helix, has been developed and patented and is employed at the mid-plane of the innermost coils. A detailed design of all magnet components was completed and a final design review was held in January 2010. Purchase orders were placed for the conductor materials and stamping dies. The full drawing package needed for fabrication and assembly of the total magnet system was completed in May 2010 and procurement started. In June 2010 the users requested the magnet be installed in cell 5 instead of cell 2, which required extensive modification of the magnet housing and plumbing. Currently, fabrication of all parts and components (including assembly tooling) is nearing completion. Important completed milestones include the successful pressure tests of the vacuum chamber (10-6 torr) and hydro-testing the split magnet housing (40 bar), as well as completion of the 4 split Florida Helix parts (fabricated in house by complicated 5-axis wire EDM). Finally, the NHMFL has started the assembly and test of the various components of the magnet system. We expect to have the complete system serving users in mid-2011.

Maintenance and Upgrades.

During 2010 the MagLab tested an improved stacking methodology for Florida-Bitter magnets that shows promise to result in still higher efficiency in resistive magnets. In late 2009 a 35 T, 32 mm bore magnet was upgraded to 36 T. This is not only the highest field resistive magnet worldwide, but it is also more efficient than previous high-field systems. Spare coils are now being assembled using this approach. We anticipate routinely operating at 36 T in the 32 mm bore magnets and 32 T in the 50 mm bore magnets. In 2010, the internal structure and the stacking pattern of the large bore magnet were modified to improve reliability. At the present time, the magnet seems to be operating reliably.

High Strength Materials

The high strength material program continues to play an important role in developing and characterizing materials for high-field magnets.

Conductors: In 2009 we began characterization of a new Ag-bearing copper alloy for use in high-field pulsed magnets. Cu-Ag0.085wt% (C107) was chosen as it has higher Ag content than previously used materials, which we expect will result in higher strength. Thermodynamic calculations indicated this material should

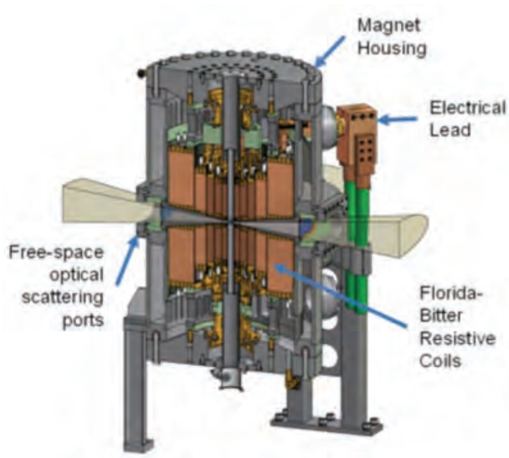


FIGURE 2. 3D CAD model (left) and actual housing installation (right) of Split magnet.

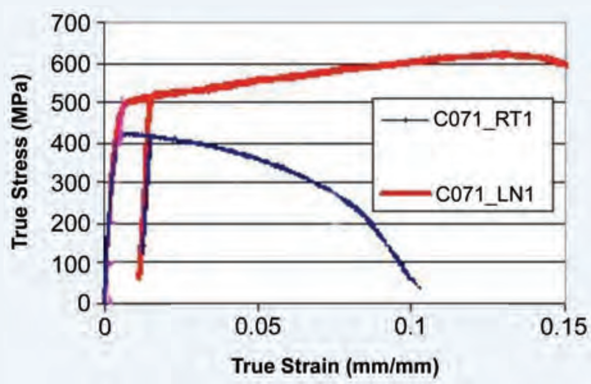


FIGURE 3. A comparison of stress-strain curves of reduced cross-section samples tested at 77 K (thick line (red if read online), sample C071_LN1) and room temperatures (thin dark line, sample C071_RT1).

have two phases at 295 K: Cu with Ag precipitates. TEM indicates the as-drawn material has dislocation cells and Ag precipitates up to 20 nm in size indicating the material has two strengthening mechanisms: strain and precipitation hardening.

This material is known to have suitable ductility for magnet applications, but the strain-hardening rate was not previously reported. The blue curve in **Figure 3** shows the room-temperature stress-strain curve for this material. We see that the strain-hardening rate, $d\sigma/d\varepsilon$, is negative, i.e. unstable and unsuitable for magnet design. When materials have a strong ability to accumulate dislocations, the materials usually have a high $d\sigma/d\varepsilon$ and high strength. The accumulation of dislocations by deformation is an effective approach to increase yield-strength in conductors. However, the storage of dislocations at room temperature is limited by dynamic recovery, i.e. dislocation /defect annihilation, and hence the strength reaches a saturated value at a certain imposed strain.

At 77 K, the dynamic recovery in Cu is suppressed and more defects can be accumulated. The defects accumulated at cryogenic temperatures are dislocations and possibly twins/stacking faults. The dislocations can be divided into two categories. The first category is retainable defects (d-ret), which contribute to the strain hardening, and they remain in the crystal after materials are warmed to room temperature during magnet pulses or between user runs. The second category, vacancy dipoles, is not retained at room temperature. The red curve in **Figure 3** is stress-strain curve at 77 K; we see that $d\sigma/d\varepsilon > 0$. Post-test analysis implied that the dislocations generated at 77 K were retained at room-temperature. Further tests will be performed to verify this.

Pulsed magnets not only operate at high tensile strain, but they are cycled and experience stress reversal due to the external reinforcement remaining elastic while the conductors exceed yield. Consequently tensile-compressive fatigue testing is performed for potential conductors in both stress-controlled and strain-controlled modes. Design tensile and compressive stresses at 77 K are 495 and -443 MPa. **Figure 4** shows a stress-controlled fatigue test using these values. Additional strain-controlled tested were performed using the peak strain of the first tensile load (2.3%) and the strain at the end of the first compressive load (1.4%) as set-points. The actual coil behavior is somewhere between the stress-controlled nad strain-controlled modes.

Post-test analysis of fatigued samples revealed higher densities of dislocations than in as-drawn samples. The dislocations were formed within the dislocation cells and most of them were the d-ret type. The high density of dislocations was formed in the Cu matrix due to the fact that the materials were cyclically deformed at cryogenic temperatures and the dynamic recovery was partially reduced. Nevertheless, neither the dislocation in Ag particles nor deformation twins in the matrix were observed after the fatigue tests. Therefore, the positive $d\sigma/d\varepsilon$ is mainly related to the high density dislocations accumulated in Cu matrix. The results of this work were reported in one of our papers [Han, K.; Toplosky, V.; Xin, Y.; Sims, J.R. and Swenson, C.A., Fatigue Property Examinations of Conductors for Pulsed Magnets, *IEEE Trans. Appl. Supercond.* **20** (3), 1463-1466 (2010)] and are considered to be essential for pulsed magnet design with this conductor.

The other high strength normal conductors we have been working on are the Cu with high densities of twins and Cu-Nb composites.

High Temperature Superconductors.

The external stress limits the performance of not only the normal conductors, but also the superconductors. For example, the critical current densities of both the Nb_3Sn and YBCO superconductors are affected by the applied external strain or stress. To support the 32 T all-superconducting magnet project we characterized the mechanical and physical properties of a high-strength YBCO composite superconductor. Since YBCO is superconducting at 77 K, economical qualification tests at 77 K in self-field can be performed. Axial tensile tests were per-

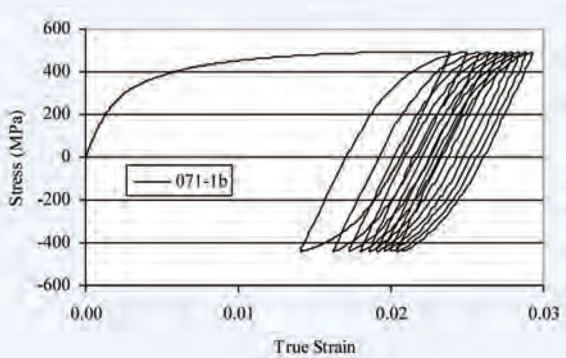


FIGURE 4. Stress-strain curve of sample C107 tested at 77 K for the first 10 cycles. The prescribed maximum stress is 495 MPa and minimum stress is -443 MPa. The figure shows that plastic deformation occurs at every cycle.

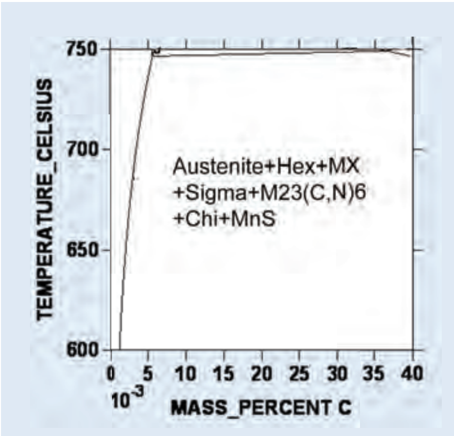


FIGURE 5. A calculated phase diagram with a chemistry (17.14wt%Cr, 1.56wt%Mn, 2.09 wt%Mo, 0.15wt%N, 0.11wt%Nb, 13.05wt%Ni, 0.019wt%P, 0.01 wt%S, 0.34wt%Si with balance of Fe) of modified 316 LN.

formed in conjunction with 4-point critical current (I_c) measurements to measure the strain dependence of I_c. A specialized test fixture was designed that enabled reproducible test conditions and allowed for rapid qualification of multiple specimens for the 32 T insert coils. In addition, the specialized tensile fixture was used to test the electrical lap joints for evaluation of the joint performance under stress. Transverse stress is also a major concern for coated YBCO conductors and was addressed in our laboratory with a unique pull cable design to apply normal stress to the face of the conductor while performing in-situ I_c measurements. This work significantly bolsters the available data for the safe design and operation of the 32T all superconducting magnet program.

Structural Materials.

High-field Cable-in-Conduit Conductor (CICC) magnet systems typically employ modified versions of 316LN that have reduced C content than standard the standard alloy to reduce sensitization during the Nb_3Sn reaction. Recent efforts at the MagLab were focused on the effects of modification of the chemistry on the phase constitutions, microstructure and mechanical properties after the modified 316 LN was heat-treated in the temperature range between 640 °C to 700 °C for up to 100 hours. The calculated phase diagrams in **Figure 5** of M316LN (where M stands for modified) provide an insight into what phases are possible with every element (trace elements included) being considered in the steels. The calculated results indicate that 0.01 wt % C is slightly above the solubility limit of $(Cr,Mn,Mo,Fe)_{23}(C,N)_6$, which may form an undesirable grain boundary carbide and is a major player in making the stainless steel sensitive to heat treatment. It is conceivable that the $M_{23}C_6$ will not form in the designed materials if the aging time is not sufficiently long (e.g. less than 50 hours). Detailed examination of the heat treated steels showed no grain boundary $M_{23}C_6$ in steels with the chemistry as shown in **Figure 5**. Based on our extensive examination, the chemistry for modified 316 LN was proposed and adopted for use for the construction of the Series-Connected Hybrid (CICC) magnets.

Insulation.

The insulation technology is critically important for very high field magnets. However, finding a reliable insulation system is very challenging due to the required minimal thickness, the extreme working environment and potentially high voltage in addition to high mechanical strength. We have experimented with the UV-cured polymer coating, oxide physical vapor deposition, and oxide sol gel coating techniques. The initial results of these processes have shown great potential for high quality and practical insulation for high field magnets, such as the 32 T superconducting magnet.

A production UV-cured epoxy coating system has been set up at the NHMFL. This reel-to-reel system is capable of insulating conductor tapes with a speed of about 30 m/h. A suitable epoxy has been identified. The unique double metering-rods applicator developed in-house ensures 10 μm uniform coating. No cracking or delamination occured at 77 K under tensile strain up to 1%. The breakdown voltage of the coating is about 400 V in air at room temperature. Using this system, 500 meters of tape has been insulated and some has been successfully used in a YBCO test coil. Meanwhile, we have set up an experimental sol-gel oxide coating system. The oxide coating by a sol-gel process is a step forward from the UV polymer coating, because it has better thermal contraction matching with the HTS superconductors and is thinner. The initial experiments on the Zr-Mg oxide films coated by the sol-gel process have produced very promising results.

32 T All-Superconducting Magnet for the Magnet Lab

High field solenoid magnets, for operation at fields much greater than about 20 Tesla, have historically been resistive magnets, or have contained a resistive inner coil. To date, superconducting magnets have been limited in field primarily due to performance limitations of available superconductors. High Temperature Superconductors (HTS), when operated at the low temperature of liquid helium, also have the characteristic of being extraordinary High Field Superconductors. HTS conductors presently being developed have the potential to radically alter the technology of very high field magnets, extending superconducting magnets to much higher fields, eventually to 40 to 50 Tesla.

As a first major program for application of YBCO coated conductors to high field magnets, an all-superconducting 32 Tesla magnet system is being developed for installation in the millikelvin user facility at the MagLab. The 32 T magnet shown in **Figure 6** is a combination of YBCO inner coils producing 17 Tesla in the bore of a Low Temperature Superconductor outer magnet based on Nb_3Sn and Nb-Ti superconductors and producing a 15 Tesla background field. The cold bore of the combined magnet is 32 mm, selected to allow an eventual dilution refrigerator with 25 mm sample space. The field uniformity of this first significant YBCO application magnet was selected to be 5x10-4 in a 1 cm-Diameter Spherical Volume with the objective of keeping the magnet configuration relatively simple while providing enough field uniformity for a range of experiments. The magnet system has a stored energy of 9.7 MJ. The design employs separate power supplies for the inner and outer magnets, which provides flexibility for the development of the inner YBCO coils and allows independent procurement of the outer Nb-Ti/Nb_3Sn magnet.

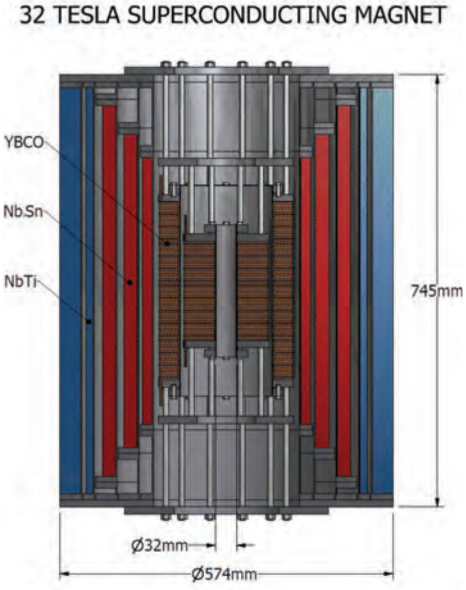


FIGURE 6. Vertical section of 32 T all-superconducting magnet.

High field magnet technology is being reinvented to accommodate the unique characteristics of YBCO coated conductors. The design and fabrication procedures suitable for YBCO are being developed for the 32 T magnet project. YBCO conductor is a tape or ribbon of high aspect ratio, being approximately 4 mm wide by 0.15 mm thick. Historically, tape conductors have been pancake-wound into flat spiral disks that are stacked and connected to form the magnet windings. While this configuration is familiar, the resulting construction requires a large number of individual parts and components, and involves many solder joint connections of the superconductor. An alternative construction that is unconventional with tape conductor is layer-winding. This configuration in principle involves fewer separate components and the potential for fewer joints. But the realization of a winding configuration is related to other aspects of the technology.

A suitable insulation for high field magnet application is not provided by the conductor suppliers. This situation has led to insulation studies as part of the 32 T magnet development. The present approach to the windings is to incorporate co-wound stainless steel reinforcement. Until a more suitable insulation is developed, the turn insulation will be achieved by an epoxy insulation coating on the co-wound steel, and not on the actual superconductor. This insulation approach favors pancake winding, as layer winding requires edge insulation of the conductor. To date, progress has been slow in the availability of significantly longer lengths of YBCO conductor from the commercial suppliers. Again, the potential advantage of long lengths in a layer-wound construction is not presently realized.

A major aspect of HTS magnet technology in general is providing for quench protection. The high critical temperature of HTS conductors is manifest in a very low rate of normal zone propagation. Since quench propagation is at the core of conventional quench protection methods for LTS coils, a significant development of technology is required for quench protection of the 32 T magnet. A method of densely distributed heaters that is being developed is more readily applied to pancake coil construction. For these various reasons, then, pancake coil construction with insulated co-wound steel reinforcement is adopted for the 32 T magnet.

The critical current characteristics of YBCO conductor lead to unusual aspects of the coil design. The critical current of YBCO has been extensively characterized in the DC Field facility. The critical current of YBCO is strongly dependent on field orientation; being strongly reduced by a component normal to the tape surface. This results in the unusual situation where the lowest critical current margin is at the end of the YBCO coils, at moderate field values, and not at the high field point in the bore. The result is a large margin throughout most of the volume of the coil, representing an under-utilization of the conductor and creating additional problems for protection. This aspect of YBCO coil technology may be improved with future conductors that show less field-orientation dependence. It also provides an opportunity to use graded conductor.

The 32 T magnet project is in the process of making test coils to establish component designs and processes. A recent test coil provided essential data on quench heater performance, showing the possibility of driving the YBCO conductor normal in the time interval required for coil protection. Additional coils are planned leading to larger prototype coils that will provide the basis to proceed with the full scale design and fabrication of the 32 T magnet. See **Figure 7**.

Other YBCO/ReBCO Coil Development

Layer-Wound Coils.

YBCO (or more generally, Rare-Earth Barium-Copper-Oxide, or ReBCO) coated conductors are among the materials of great interest to be used in a new generation of high field magnets to reach magnetic fields beyond 30 T. In addition to the 32 T magnet project described above, efforts are underway to develop technologies suitable for other magnet systems such as NMR magnets, large bore magnets, etc. One of the R&D test beds is that of small coils that are being tested under various conditions. In previous work a pancake type coil with several resistive joints was successfully tested in 31 T background field. Its performance, however, was limited by conductor degradation at the coil terminals and severe He-gas trapping at high fields. To reduce the amount of resistive joints and reach the

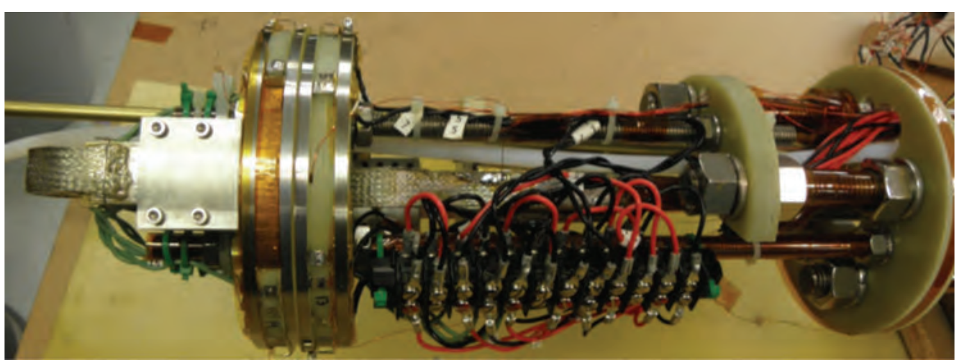


FIGURE 7. YBCO test coil equipped with quench protection and prepared for testing in the MagLab 20 T Large Bore Resistive Magnet.

FIGURE 8. Layer wound coil with silk paper inter-layer insulation and glass fiber thread turn to turn insulation.

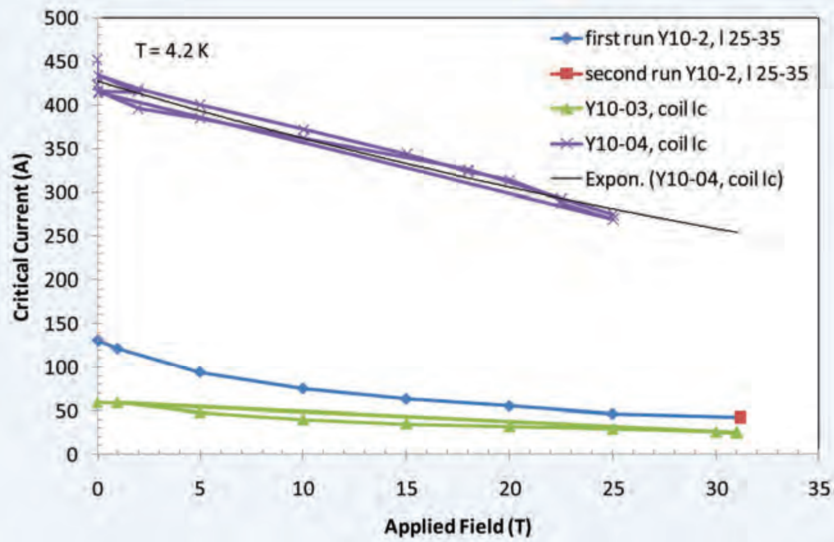


FIGURE 9. $I_c(B)$ curves of the three most recent layer-wound ReBCO test coils Y10-02, Y10-03, and Y10-04.

highest field increments possible we are now taking the layer winding approach. Two coils (Y10-02, Y10-03) were wound at the NHMFL using 4 mm wide ReBCO tape, made by SuperPower, and tested in the 31 T resistive magnet. These coils were wet wound using an epoxy-saturated silk paper as inter-layer insulation and a glass fiber string as turn-to-turn insulation. Both coils were 100 mm high, with an inner diameter (ID) of 14.3 mm and an outer diameter (OD) of 38 mm using a total of close to 120 m of conductor, one such coil is shown in **Figure 8**.

Both coils degraded severely in various layers throughout the winding pack caused by weak transverse mechanical properties of the conductor, that is the conductive layer delaminated due to differential thermal contractions of the fully epoxy impregnated winding pack. A shorter, 20 mm high, coil (Y10-04) has been wound and recently tested successfully. $I_c(B)$ data of all tested coils are shown in **Figure 9**. This coil incorporates a novel approach to interlayer insulation which avoided almost all of the earlier problems. A comparison of self field coil data with short samples clearly reproduced the same transport results. It also showed that the coil was limited by the radial field component of I_c due to the rapid drop of I_c away from the B parallel to the tape plane condition.

The work on layer wound ReBCO coils continues and longer test coils are now in preparation as well as larger diameter coils that are geared towards NMR applications.

AC-loss Initiated Quench in ReBCO Coils.

As ReBCO tapes are implemented into large magnets however, quench protection becomes an issue. These conductors have low quench propagation velocities on the order of 10 mm/s (as opposed to m/s for Low Temperature Superconductors (LTS)). This makes it potentially difficult to protect HTS magnets, as hot spots can develop inside the magnet that may not be able to dissipate fast enough. The conventional technology for quench protection relies on a large number of resistive heaters to heat a certain volume section of a coil. While this method proves to be satisfactory for pancake coils, we are investigating a new approach utilizing AC-losses to initiate controlled quenches in HTS coils, which should be particularly suitable for layer-wound coils. In our setup AC-losses are generated in an HTS coil either by an external magnet briefly running in AC-mode or by an AC-current of short duration superimposed on the DC-transport current running in the test coil. The test coil is a wet-layer-wound coil with epoxy-saturated silk paper as inter-layer insulation and a glass fiber thread as turn-to-turn insulation. The coil has an inner diameter of 48 mm, an outer diameter of 68 mm, and uses a ReBCO 4 mm wide tape manufactured by SuperPower. The tests are performed at 77 K at the Center for Advanced Power Systems (CAPS) using a helical magnet setup to generate an AC-field up to 100 mT, and up to 10 kHz, perpendicular to its axis and parallel to the axis of the HTS insert coil (**Figures 10 and 11**). The coil is instrumented to monitor the propagation of the quench among the different layers along the coil radius and azimuthally along the middle layer. Preliminary experiments with the AC-magnetic field setup have shown promising results: multiple quenches were generated without apparent degradation of the coil. The quenches were homogeneous throughout the coil, which means the quench was initiated in all layers at the same time. Work is

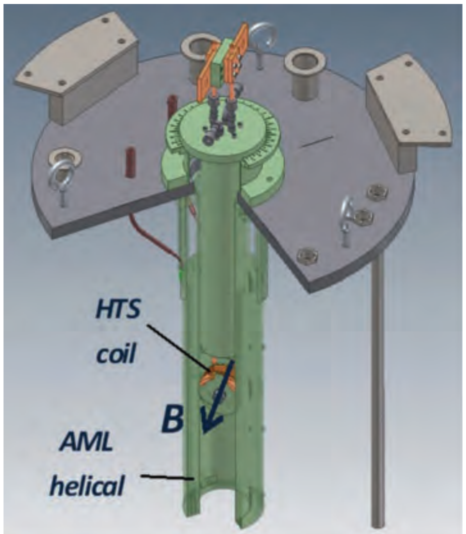


FIGURE 10. Schematic of the AC-quench setup. The HTS coil is shown inserted into the helical magnet at CAPS. The arrow indicates the direction of the external field.

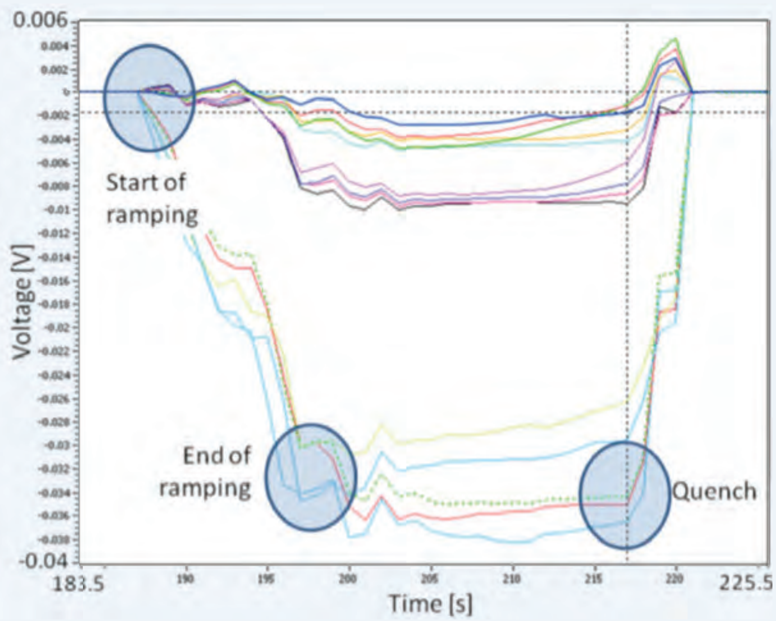


FIGURE 11. Detail of a typical AC-magnetic field quench test run. The voltage signals are recorded across the multiple voltage taps distributed throughout the HTS test coil. External field amplitude set to 21 mT at a frequency of 100 Hz. Test coil DC current is set to 27 A = 0.75 x I_c.

continuing to improve the data acquisition system and adapt it to the AC-noise affected environment. The AC-current quench experiments will soon follow.

BiSCCO Coil Development

Though Bi2212 round wire, like ReBCO tape, is still a developmental superconductor it is gaining significant interest within the high field magnet community, particularly driven by potential applications in the high energy physics area. This is largely due to its unique properties that, in contrast to ReBCO coated conductor, Bi2212 does not show any electromagnetic anisotropy and can easily be cabled due to its round wire geometry. A major difference in the processing of ReBCO and Bi2212 is that Bi2212 has to undergo a heat treatment at close to 900° C to carry a substantial transport current. This is preferably done after coil winding in a "wind-and-react" approach as opposed to a "react-and-wind" approach in which the bending strain on the fully reacted conductor may degrade coil performance. Conductor and coil processing issues, however, are not yet fully understood and a major goal of the ongoing R&D is to push conductor and coil technology forward to make Bi2212 fully applicable for high field magnet systems.

Several coils have been built and tested under various conditions in high background fields. Two of these are shown in **Figures 12 and 13**. In several of the previous test coils, a pattern of transport inconsistencies, particularly on the innermost coil layers, was noticed and analyzed by deconstructing these coils and extracting short sample pieces from various layers looking at a wide range of properties. It was shown that the Ni-base alloy, chosen as structural material for mandrels and flanges showed chemical and mechanical incompatibilities with the Bi2212 wire and winding pack. As a result a bore-tube-free coil was manufactured. This coil was wound around on a collapsible mandrel that was removed before the heat treatment. After heat treatment this coil was instrumented with various voltage taps to monitor layer voltages throughout the coil and tested in the Cell 4 Large Bore Resistive Magnet (LBRM). Bi2212 conductor uses Ag and AgMg alloy as electrical stabilizer. Though chemically and electrically a very suitable material, the Ag is not very strong. To characterize the mechanical properties of a coil exposed to high Lorentz forces, a coil with a large OD was built and tested in high background fields. The coil was epoxy impregnated and instrumented with several strain gauges and an array of voltage taps to measure potential degradation at fields up to 20 T.

The bore-tube-free test coil showed no apparent degradation of any of the innermost layers and the layer voltages showed homogeneous performance of the coil throughout all of its layers. These results make bore-tube-free coils a suitable test bed for further coil optimization work. With little modification it is possible to adapt this approach to larger winding packs. In the large OD coil a stress level of >100 MPa was reached without any signs of coil degradation. Also, the stress-strain data showed an increased elastic range of the coil compared with data on short single samples measured in a tensile tester. It is believed that load-sharing between the strands that are mechanically coupled by the epoxy impregnation contributes to this observation. A larger OD coil will be built to determine the critical stress level of epoxy impregnated winding packs made with Bi2212 round wire conductor.

Superconducting Materials Development Bi-2212 Conductor.

In 2009 we focused on through-process quench studies to understand

FIGURE 12. Small bore-tube-free coil tested successfully in the NHMFL 20 T Large Bore Resistive Magnet.

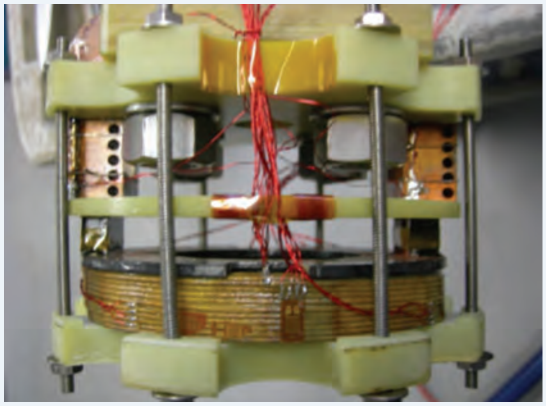


FIGURE 13. Large diameter coil (ID = 92.5 mm, OD = 118.5 mm, 10 layers, 10 turns) using 1.03 mm diameter Bi2212 round wire fully instrumented with voltage taps and strain gauges. It was tested in the NHMFL 20 T Large Bore Resistive Magnet.

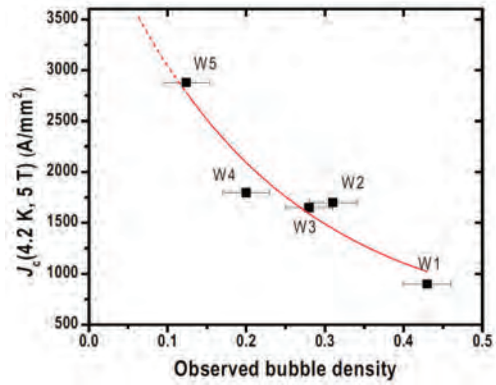


FIGURE 14. J_c in fully-processed 2212 round wire as a function of bubble density in wire samples quenched from T_{max} in the heat treatment.

how the Bi-2212 microstructure and superconducting properties developed during the heat treatment. In 2010 we continued these quench studies and have investigated 9 different 2212 green wires we received from industry as part of the Very High Field Superconducting Magnet Collaboration. The wires had a wide range of Jc performance and we noticed that the samples we quenched from the highest temperature during the heat treatment appeared to have different amounts of porosity (bubbles) in the filaments. **Figure 14** shows Jc in fully-processed wire decreases as a function of increasing bubble density in the quenched wire. We did additional quench experiments on a 2212 round wire that had been built with a sparse filament density, which allowed us to extract single filaments. **Figure 15** shows SEM images of extracted filaments from this wire. The presence of the bubbles in the individual filaments is a striking feature in Figure 15. These bubbles segment the filaments into regions that contain melt and regions that contain gas. The bubbles do not disappear from the filament during cooling and the 2212 grains that form and grow on cooling can bridge the bubbles, but they do not fill in the bubbles. The fully-processed wire has a high degree of remnant porosity from these bubbles that formed on melting. We believe that eliminating the bubbles is key to increasing Jc in the 2212 conductors. A major effort in 2011 will be to understand how to prevent bubbles from forming when the 2212 melts, or how to remove them once they have formed after the 2212 melts. It is our view that these bubbles are the major factor limiting the current density of all commercial 2212 conductors at present.

Nb_3Sn Work.

(a) Attaining a deeper understanding of High J_c Internal Tin-Nb_3Sn conductors: Previously we reported on our collaboration with FNAL and BNL on strand degradation produced by Rutherford cabling. The focus has turned most recently to the strain sensitivity of high performance strands in collaboration with Arup Ghosh at BNL and Najib Cheggour and Loren Goodrich at NIST (Boulder). The most notable result from that study (presented by Najib Cheggour at ASC'10) is that strands made by the RRP® process have dramatically improved resilience to axial tensile strain when alloyed with Ti as compared to Ta. The Ta-alloyed Nb_3Sn in RRP wires showed permanent damage to I_c when tensioned beyond an intrinsic strain as small as 0.04%, whereas Ti-doped Nb_3Sn in similar RRP strands exhibited a remarkable reversibility up to a tensile strain of about 0.25%, conceivably making Ti-doped RRP wires more suitable for high-field magnets. We provided microstructural support for this work. Somewhat to our surprise we found a negligible difference in the grain size for the Ti and Ta strands. Some of this work was presented at ASC'10 however the main publication will come after our analysis of the chemistry of the conductors in the new TEM/STEM as described in this proposal.

(b) Development of a full understanding of Hc_2 in variable composition Nb_3Sn samples of high chemical homogeneity in the pure binary state, as well as with Cu and the classical additions of Ti and Ta: Last year, we established essential methods to fabricate bulk Nb_3Sn samples of high homogeneity using ball milling of Sn, Nb and other elemental additions (Cu, Ti, Ta etc) and then reacting them at temperatures up to 1800° C in our HIP. We used techniques such as specific heat and reversible magnetization which are sensitive to volumetric average properties, as well as the more usually applied transport measurements which can often be biased by transitions of the best bits of inhomogeneous samples to evaluate their structure, homogeneity, and superconducting properties. We supplemented them by X-ray diffraction (XRD), SEM, EDS, SQUID to get a true knowledge of sample homogeneity and found that T_c and H_{c2} of our nominal 17 at %, 25 at% and 27 at% Sn samples fell into 2 zones, Sn-rich (T_c ~18 K and H_{c2} ~29 T) and Sn-poor (T_c ~6 K and H_{c2} ~8 T). As a result, we believe that our samples, though not yet completely homogeneous, are almost certainly more homogeneous than samples in the literature.

Based on the last year's results and using the fabrication method and techniques we established, we are making intermediate Sn binary A15 Nb18-25Sn so as to give an entire view of H_{c2} as a function of Sn composition and advancing to the study of the effects of Cu, Ti and Ta additions to A15 samples for optimizing Nb_3Sn conductor performance. The progress is reported below.

Homogeneous intermediate compositions have not been easy to obtain. The nominal 19at% and 23at% samples which were heat treated at 1800° C for 24hr or 1800° C for 72hr after the Nb_3Sn formation at 1200° C 72hr are still inhomogeneous (see **Figures 16 and 17**). Although the 72hr at 1800° C heat treatment, rather than just 24 hours, significantly increases the homogeneity for both 19 at% Sn and 23 at% Sn, 72hr is not enough to achieve sharp T_c transitions for them. However, previous 17at%Sn, 25at%Sn and 27at% Sn show very sharp transition after 1800° C for 24hr (see **Figure 18**).

We annealed 27 at% Sn at 1200° C for 30 days after 1200° C for 3 days and then 1800° C for 24hr and found that this long time annealed sample has the sharp transition with T_c at 17.9 K and a reduced H_{c2} (0.3 K) = 27.6 T (see **Figure 19**). Moreover, the high RRR value of 9.5 indicates that this sample is very likely in the clean limit, in agreement with thin films made by Orlando *et al.*, which show that clean limit films have lower H_{c2} than dirty limit samples.

Our preliminary results on ternary Nb_3Sn show that Cu depresses H_{c2} of A15 Nb_3Sn and Ta or Ti slightly increases H_{c2} of A15 Nb_3Sn. All the samples shown in **Figures 21 and 22** were heat treated at 1200° C for 160 hr or 72 hr. **Figure 20** displays that H_{c2} of 1 at% Cu sample is more than 1T lower than binary Nb_3Sn. Moreover, **Figures 20 and 22** demonstrate

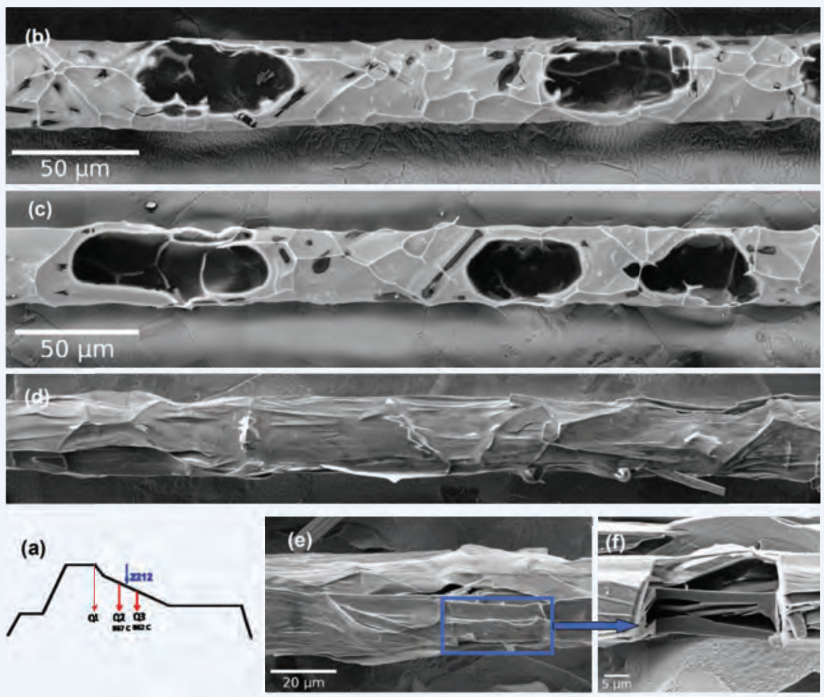


FIGURE 15. SEM images of individual filaments from 2212 round wire with a sparse filament structure. (a) shows the where in the heat treatment process wires (b-d) were quenched relative to the formation of 2212 during cooling. (b and c) show filaments from wires quenched at Q1 and Q2 respectively, which are before 2212 forms on cooling. These filaments contain bubbles (the large black regions) that are several 10s of µm long and are nearly the same diameter as the filament. (d) shows a filament from wire quenched after 2212 started to form. The length scale in (d) is the same in (b) and (c). No bubbles are visible in (d) and in fully-processed wire (e). However, cutting the filament from the fully-processed wire with a FIB SEM, shows that the bubbles are still present in the filament.

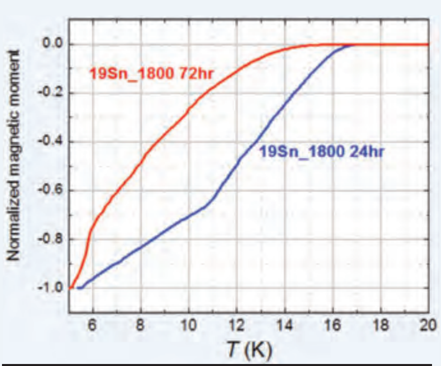


FIGURE 16. SQUID T_c of 19 at.% Sn HT'ed at 1800° C for 24 and 72 hrs.

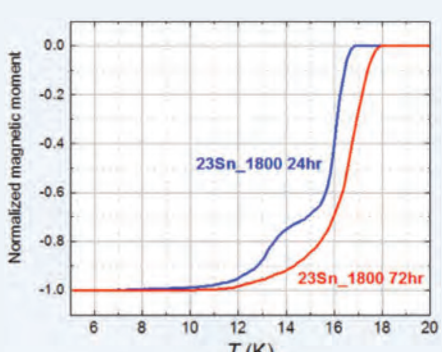


FIGURE 17. SQUID T_c of 23 at.% Sn HT'ed at 1800° C for 24 and 72 hrs.

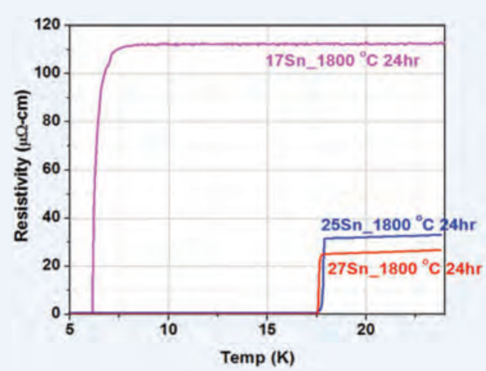


FIGURE 18. Resistivity T_c transitions of 17, 25 and 27 at% Sn after 1800° C 24hr heat treatments. Compositions are global ones.

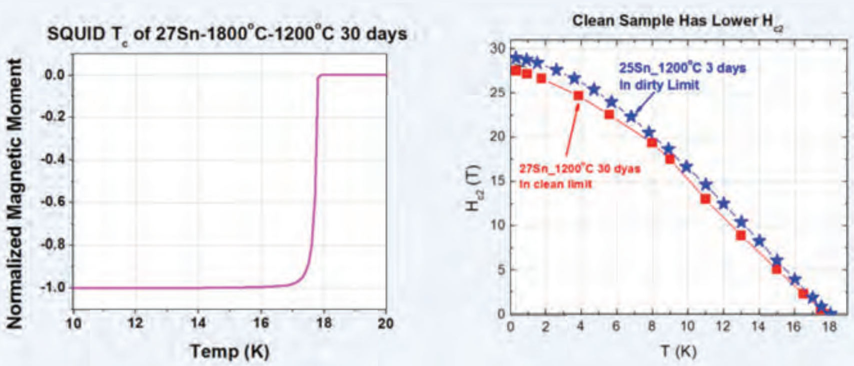


FIGURE 19. T_c and H_{c2} plots of long time annealed 27 at% Sn sample. The left plot is T_c and right plot is the H_{c2} comparison between the samples in clean limits, this sample and in dirty limit.

that Ta or Ti ternary Nb_3Sn has slightly higher H_{c2}, less than 0.5 T, than binary Nb_3Sn. So Ta or Ti does not show significant effect on Nb_3Sn H_{c2} after 1200° C heat treatment.

Ti ternary Nb_3Sn shows that T_c decreases as nominal Ti at% increase and ΔT_c increases as nominal Ti at% increases (see **Figure 21**). But Ta ternary Nb_3Sn does not shows the clear tendency between T_c and Ta content (see **Figure 22**). It may contribute to the sample inhomogeneity. One point is clear that 10 at% Ta sample shows the lowest T_c among all Ta samples whose nominal compositions are 1 at%, 2 at%, 4 at% and 10 at% Ta, respectively.

Magnets Using Cable-In-Conduit Conductor

Two large-scale hybrid magnet projects are presently under construction at the Magnet Lab. These Series-Connected Hybrid (SCH) magnets utilize cable-in-conduit conductor (CICC) in the windings of the superconducting coil (outsert) which is connected in series with an inner set of resistive Florida-Bitter coils (insert). One SCH, shown in **Figure 23**, is funded by the NSF and will be located in Cell 14 of the DC field facility at the MagLab. It is a 36 T, high homogeneity magnet at 1 ppm uniformity in a 40 mm cylindrical warm bore for low-resolution NMR and condensed-matter research. The other SCH is funded by the German government for the Helmholtz Zentrum Berlin (HZB). It is a 25 T magnet with a conical bore in a horizontal orientation for neutron scattering experiments. The systems have the same outsert designs and are similar in concept; however the differences in the insert coils and cryostat orientation require separate designs for many of the subsystems. Several milestones have been met in all aspects of the projects over the past year.

CICC and Outsert Coil Fabrication:

Fabrication of the CICC is a long, complex process and takes place over thousands of miles. As the name implies, the CICC is a cable, composed of superconducting Nb_3Sn and pure copper strands, housed in a stainless steel conduit that is compacted to securely restrain the brittle superconductor and shaped into a rectangular cross-section to facilitate coil winding and improve the current density.

At the start is the Nb_3Sn strand, which was manufactured by Oxford Superconducting Technologies in Carteret, NJ. From there the strand travels to Lisbon, NH where the superconductor and copper strands are twisted into cables by New England Wire Technologies. At the same time, the conduit was being manufactured by Salzgitter Mannesmann Stainless Tubes in Costa Volpino, Italy. Fabrication of the last 10% of Nb_3Sn strand, 9 of 10 cables, and all of the conduit were completed in 2010. The cables and conduit meet and are joined together in the northwest of Italy, in Chivasso, where a cryogenic systems manufacturing company (Criotec Impianti) in collaboration with an Italian fusion research association, ENEA, perform the jacketing. The end of 2010 saw the completion of a major milestone; the completion and delivery of the high-field CICC for both the NHMFL and HZB, shown in **Figure 24**.

Cryostat and Cryogenics:

The primary component of the cryo-

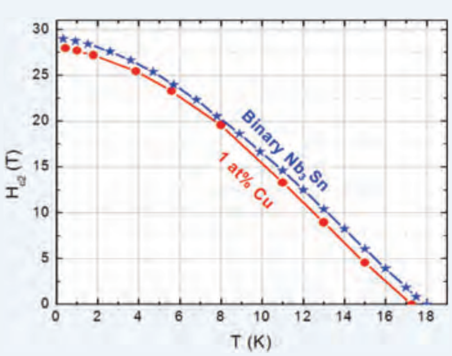


FIGURE 20. Cu-added Nb_3Sn shows the H_{c2} depression (1800° C Final HT).

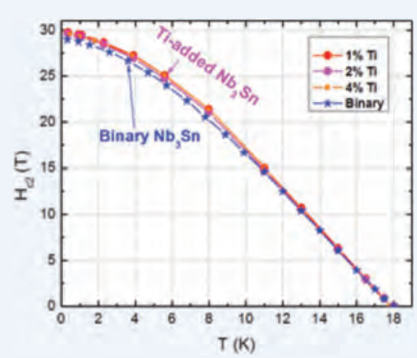


FIGURE 21. Ti-added Nb_3Sn shows a slight increase in H_{c2}.

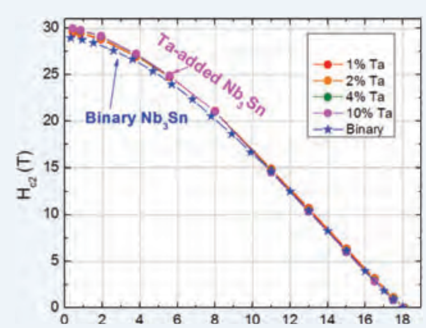


FIGURE 22. Ta-added to binary Nb_3Sn shows only a slight increase H_{c2}.

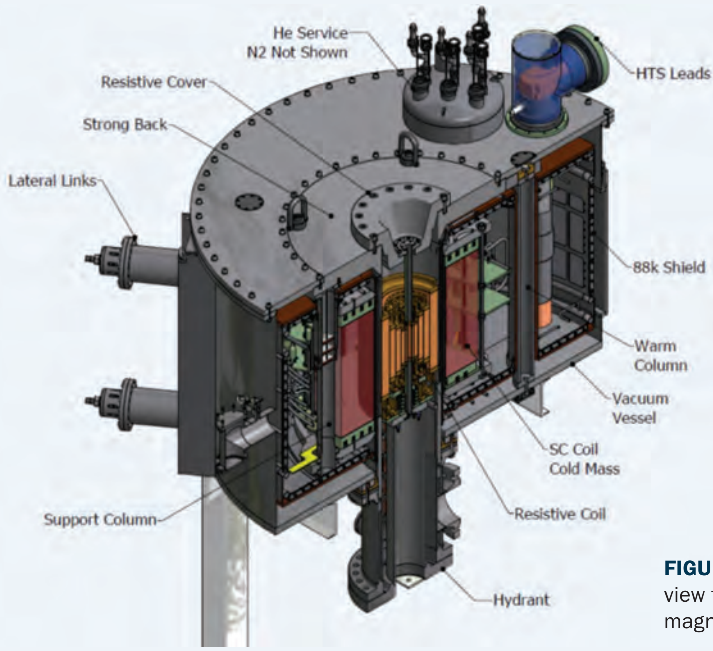


FIGURE 23. Sectional view the NHMFL SCH magnet system.

FIGURE 24. Completed high field CICC at the NHMFL.

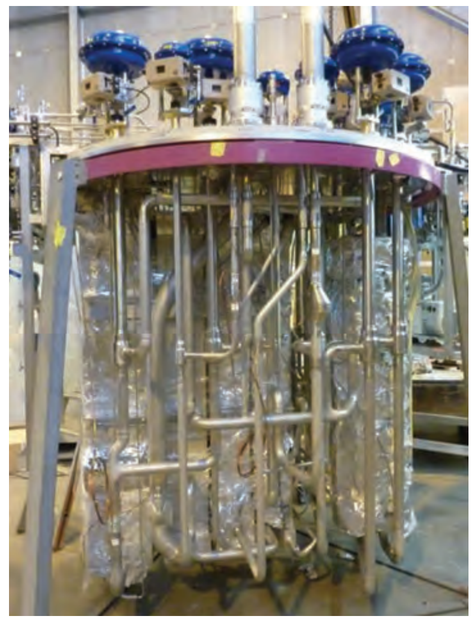


FIGURE 25. Fabricated cold-box of the NHMFL refrigerator, Courtesy Linde Cryogenics.

genic circuits for the HZB and NHMFL is the helium refrigerator that is used to flow and recycle helium through the CICC coils. The HZB refrigerator will be dedicated to delivering supercritical helium to the SCH alone. The NHMFL refrigerator will supply supercritical helium not only to the SCH but directly to the 45 T Hybrid and Oxford Split magnets, and supply liquid for the 900 MHz NMR magnet and user experiments. To accomplish this, the NHMFL SCH magnet system will have a cryogenic distribution box to interface between the refrigerator and magnets/dewars. Fabrication of the refrigerators for NHMFL and HZB commenced in 2010 by Linde and will be completed in 2011. Construction of the central distribution box has also begun and will be delivered in fall 2011. **Figure 25** shows a major component of the refrigerator, the cold box, being assembled at the factory.

The analysis and manufacturing design package for the NHMFL cryostat, shown in **Figure 23**, is now finished and the procurement activity has begun. Late in 2010, HZB placed a contract with a vendor for cryostat fabrication. The NHMFL has started transfer the HZB cryostat design package to the vendor for manufacture.

Magnet Power and Facility:

A readiness review of the major infrastructure upgrades for tying the magnet into the DC facility electrical system was performed in December 2010. This marked the completion of the system and component designs and specifications. The major components include the dump resistors (which have been ordered), breakers, diode stacks for the outsert and insert, 20 kA contactors for reverse switching, and water cooled bus lines. With this, a full experimental cell layout has been generated for positioning of the equipment, utilities, and NMR console, as displayed in **Figure 26**.

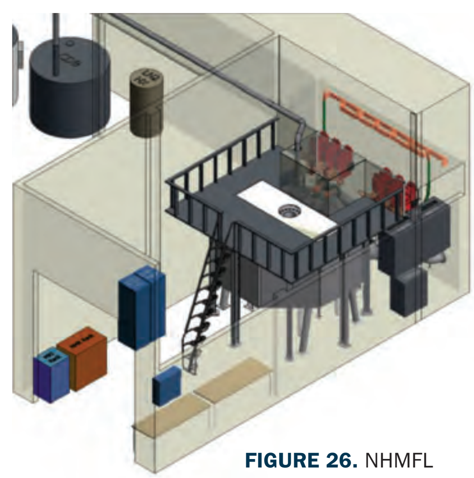


FIGURE 26. NHMFL SCH magnet site plan.

CHAPTER 5

User Collaboration Grants Program

The National Science Foundation charged the National High Magnetic Field Laboratory (NHMFL) with developing an internal grants program that utilizes the NHMFL facilities to carry out high quality research at the forefront of science and engineering and advances the facilities and their scientific and technical capabilities. The User Collaboration Grants Program (UCGP), established in 1996, stimulates magnet and facility development and provides intellectual leadership for experimental and theoretical research in magnetic materials and phenomena.

The UCGP seeks to achieve these objectives by funding research projects of normally one- to two-year duration in the following categories:

- small, seeded collaborations between internal and/or external investigators that utilize their complementary expertise;
- bold but risky efforts that hold significant potential to extend the range and type of experiments; and
- seed support for new faculty and research staff, targeted to magnet laboratory enhancements.

The UCGP strongly encourages collaboration across host-institutional boundaries; between internal and external investigators in academia, national laboratories, and industry; and interaction between theory and experiment. Some projects are also supported to drive new or unique research, that is, to serve as seed money to develop initial data leading to external funding of a larger program. In accord with NSF policies, the NHMFL cannot fund clinical studies.

Fifteen (15) UCGP solicitations have now been completed with a total of 455 pre-proposals being submitted for review. Of the 455 proposals, 231 were selected to advance to the second phase of review, and 100 were funded (21.98% of the total number of submitted proposals).

TABLE 1

UCGP Proposal Solicitation Results 2010

Research Area	Pre-Proposals Submitted	Pre-Proposals Proceeding to Full Proposal	Projects Funded
Condensed Matter Science	8	4	1
Biological & Chemical Sciences	8	6	3
Magnet & Magnet Materials Technology	2	2	1
TOTAL	**18**	**12**	**5**

TABLE 2

UCGP Funded Projects from 2010 Solicitation

Head P.I.	NHMFL Institution	Project Title	Funding
Yasu Takano	UF	Capacitive Force Magnetometers for Precise Low-Temperature Magnetization Measurements in High Magnetic Fields	$178,847
Likai Song	FSU	Multi-frequency EPR Study of HIV gp41 at the Membrane Interface	$179,863
Peter Gor'kov	FSU	Efficient Low-G Solid State NMR Probes for Energy and Material Chemistry Applications	$133,376
Sam Grant	FSU	MR Imaging in the Far Field: Holographic Interferometry & Spatial Encoding at High Field	$180,000
Jan Jaroszynski	FSU	Construction of a Vector Vibrating Sample Magnetometer (VVSM) with Especial Application for Contact-free Studies of the Angular Critical Current Density in Superconducting Films	$172,211

2010 Solicitation and Awards

The NHMFL UCGP has been highly successful as a mechanism for supporting outstanding projects in the various areas of research pursued at the laboratory. Since 2001, proposal submission and proposal review (including two review stages) have been handled by means of a web-based system.

Of the 18 pre-proposals received during the 2010 solicitation, the committee recommended that 12 pre-proposals be

TABLE 3

Facility Enhancements Reported from 2005-2010 UCGP Solicitations

Enhancement, Available Date	Users*
Free Space Raman measurement capability to 10 T, 4/10	3
Ball bonder, 1/10	1
EPR field standard using lines of the H-atom entrapped in octa-isobutyl-silsesquioxane, 4/10	1
Resonant ultrasound uniaxial pressure probe, 1/10	2
Silicon micromechanical Faraday balance for absolute magnetization measurements, 1/06	3
Temperature control of ^{3}He rotator probe for superconductor measurements, 12/06	8
Time-resolved reflection, photoluminescence and Kerr effect spectroscopy, in 17 T and 31 T magnets, 10/07	6
Time-domain spectroscopy 200 GHz-1 THz, 5/09	2
Photoluminescence probe with fiber-free light retrieval, 1/09	1
Dilatometer with AFM cantilever tip as active element; 9/09	2
Low temperature HEMT based NMR preamp, for high B/T facility, 5/08	1
Mössbauer facility, 2/07	5
Probe and coils for in vivo NMR with 900 MHz and 600 MHz magnets, 1/09	3
900 MHz high B1 homogeneity dielectric resonator for NMR, 5/09	1
Sample current supply for magnetic resonance electrical impedance tomography (MREIT), 11/10	1
Quadrupolar Carr-Purcell Meiboom-Gill Magnetic resonance technique for Keck Magnet, 8/08	1
Triple resonance 600 MHz “low E” probe, 3/10	1
NMR pulse sequence for improved broadband sideband separation, resolution enhancement,6/10	1
Microscope-based setup for room temperature Raman spectroscopy, 8/09	3
Custom Network analyzer, 50-75 GHz, 6/07	1

* Number of external users (PI’s only) reported to have used the enhancements.

moved to the full proposal stage. Of the 12 full proposals, 5 grants were awarded. A breakdown of the review results is presented in **Tables 1 and 2**.

2011 Solicitation

The 2011 Solicitation Announcement will be released about May 19, 2011. Awards will be announced by the end of the year.

Results Reporting

To assess the success of the UCGP, reports were requested in February 2011, on grants issued from the solicitations held in the years 2005 through 2010, which had start dates respectively near the beginnings of years 2006 through 2010. At the time of the reporting, some of these grants were in progress, and some had been completed. For this “retrospective” reporting, PIs were asked to include external grants, NHMFL facilities enhancements and publications that were generated by the UCGP. Since UCGP grants are intended to seed new research through high risk initial study or facility enhancements, PIs were allowed and encouraged to report results that their UCGP grant had made possible, even if these were obtained after the term of the UCGP grant was complete. Reports were submitted for a total of 29 grants.

Tables 3 and 4 summarize the results. The success of the program is evident from the wide-ranging enhancements produced and from the production of peer-reviewed publications, many in high impact journals. These include 4 articles in *Nature*, 18 in *Physical Review Letters*, and 7 in the *Journal of the American Chemical Society*. A significant positive impact on education is also evident from the reporting, since almost all grants were reported to have supported one or more students, at least partially or through supplies.

TABLE 4

Publications Reported, 2005-2010 UCGP Solicitations

Adv. in Cryogenic Engineering	1
App. Phys. Lett.	6
Biochemistry	2
Chem. Acta	1
Chem. Commun.	1
Chem. Int. Ed.	1
Chem. Sci.	1
Euro. Biophys. J.	1
Euro. Phys. Lett.	1
Inorg. Biochem.	1
Inorg. Chem.	7
Int. J. Mass Spectrometry	1
Inst. of Phys. Conf. Series	13
J. App. Phys.	6
J. Biomol. NMR	1
J. Low Temp. Phys.	4
J. Membrane Sci.	1
J. of American Chemical Society	7
J. of Magnetic Resonance	4
J. of Physical Chemistry	3
J. Phys.	2
J. Phys. Chem. Lett.	2
J. Phys. Condens. Mat.	6
Langmuir	1
Magnetic Reson. Chem.	1
Magnetic Reson. Imaging	2
Magnetic Reson. Med.	1
Nature	4
Nature Materials	2
Neuro Image	1
Phi. Mag.	1
Phys. Rev. B	28
Phys. Rev. Lett	18
Physica B	1
Physica C	2
Polyhedron	1
Rev. Sci. Instrument	1
Solid State NMR	1
Superconductor Sci. Technology	7
Neurology	1
Ultrafast Phenomena	1

NOTE: Publications (including accepted for publication) as of December 2010, reported from UCGP grants.

CHAPTER 6
Education

Introduction

The Center for Integrating Research and Learning (CIRL) continues to identify ways to engage students, teachers, and the general public in science – the process of science, the nature of science, and the scientific endeavor. Translating the research conducted at the Magnet Lab includes encouraging K12 students, undergraduates, and graduate students to pursue careers in science, technology, engineering and mathematics (STEM) fields. CIRL provides a wide range of activities from traditional outreach and REU and RET programs, to **Science Café** programs. **Roxanne Hughes**, postdoctoral researcher in CIRL, along with **Susan Ray**, Director of Public Affairs, facilitated the Science Café initiative from the Magnet Lab. Started in October 2010, the series of "scientific conversations" has reached a new segment of the local population and has been standing room only on the first Tuesday of each month. Speakers included **Scott Hannahs**, director, DC Facilities and Instrumentation, on "Exploring America's Energy Future"; **Ryan Rodgers**, associate scholar/scientist, and **Amy McKenna**, assistant scholar/scientist, both in the ICR Program, on "Deconstructing Deepwater Horizon: Catastrophe and Cleanup in the Gulf of Mexico"; and **Susanne Cappendijk**, FSU assistant professor, NMR Program, on "Unlocking the Mysteries of the Brain Through MRI."

ABOVE REU Class of 2010.

Science Nights at local schools typically attract over 250 parents and students who experience activities designed to arouse curiosity about various concepts. It is also an opportunity for Magnet Lab graduate students to become involved in outreach. For example, **Ernesto Bosque**, graduate research assistant in cryogenics, provided content-rich demonstrations at the same time modeling for students what it is like to be a graduate student in science. Monthly **MagLab Nights at Barnes & Noble** provide yet another venue for engaging the general public. Through demonstrations and hands-on activities, **Carlos Villa**, CIRL Outreach Coordinator, portrays the excitement of complex science concepts. Quarterly science outreach at **Chick-Fil-A Family Nights** provides yet another opportunity to reach families.

Research Experiences for Undergraduates

The 2010 REU class consisted of 22 students; 17 at FSU, 3 at UF, 2 at LANL. Altogether 19 mentors from three sites provided experiences for undergraduates (see REU table). Three of the students in that group, Justin Mincey (Bethune Cookman), Michelle Sokoll (FSU), and Jane Anstey (FSU), presented research conducted at the Magnet Lab at the 2010 STEM Undergraduate Symposium at Florida State University.

Brandon Nzekwe, graduate researcher continues to gather data on our past REU participants. The "Where Are They Now?" REU study has established an ongoing and ever-growing social network for former participants to communicate with each other as well as with CIRL. Currently, we are working on a study that will not only gather the evaluative and academic/professional status information of former REU participants, but will focus on understanding how participants develop their identity as a researcher/scientist by assuming these role-identities in a situated learning context. The goal of the new study is to develop a survey instrument that we can use across multiple REU programs for evaluation and comparison.

Research Experiences for Teachers

Fourteen (14) teachers participated in the 2010 RET program representing elementary, middle, and high schools in Florida and Arizona. Teachers participated in seminars and lectures designed to enhance their understanding of the process of science, nature of science, experimental design, communicating in science, and scientific inquiry. In addition, teachers are provided with new strategies

Research Experiences for Undergraduates – 2010 Participants

REU Participant	School	Research Area	Mentor
Jane Anstey	Florida State University	Localization of Targeting Fusions with a mKate2.7 Fluorescent Protein	Michael Davidson
Roman Ciapurin	University of Central Florida	Transport Properties of Underdoped $La_2Sr_xCuO_4$ Superconductors	Dragana Popovic
Michael Cole	Morehouse College	Nanostructured Materials in CuAg by Cyclic Cold Rolling	Ke Han
Fenner Colson	Minnesota State University-Moorhead	Heat Transfer In Helium Injected Liquid Nitrogen	Steve Van Sciver
Akshita Dutta	University of California, Berkeley	Solar Panels as a Source of Noise-free Power	Irinel Chiorescu
Mary Gruak	University of Texas, Dallas	Magnetoelectric Coupling in Chromium Triangles	Ross McDonald, at Pulsed Field Facility, LANL
Joe Kedrowski	Grand Valley State University	Temporal Dependency on YBCO Joint Soldering Procedure with a Solder Temperature of 195°C	Denis Markiewicz
James McClain	Haverford College	Thermo-Mechanical Finite Element Analysis of an HTS Current Lead by Means of ANSYS	Andy Gavrilin
Luis Medina	University of Puerto Rico-Mayaguez	An Approach to the Free Radical Organic BDPA Using Electron Paramagnetic Resonance	Steven HIll
Justin Mincey	Bethune Cookman University	Microstructure Characterization of Current Blocking Defects in YBCO Coated Semiconductors for Potential Magnet Applications	Yan Xin
Rana Mohammed	Ohio Wesleyan University	Properties of UV Cured Epoxy for YBCO Insulation of the 32T Superconducting Magnet	Jun Lu
Valerie Pezzullo	Florida State University	Elastic Response of a Superconductor Between 17 and 340 K by Resonant Ultrasound Spectroscopy	Victor Fanelli, at Pulsed Field Facility, LANL
Alexander Ruiz	Gulf Coast University	High Field, High Resolution MR Imaging of Atherosclerotic Lesion Development & Regression in the Post-Menopausal Hamster Brain	Sam Grant
Natalie Schmitt	University of Puerto Rico-Mayaguez	Characterization of Co-doped $BaFe_2As_2$ Thin Film	Eric Hellstrom
Aaron Shepard	Claflin University	Pheromone Analysis of C. Elegans Using NMR Spectroscopy	Art Edison, at the University of Florida
Alex Sincore	University of Florida	Differential Hall Element Magnetometer for Room Temperature Magnetization Measurements	Mark Meisel, at the University of Florida
Michelle Sokoll	Florida State University	Intracellular Delivery of Gadolinium in CHO Cells using Pyrenebutyrate	Sam Grant
Brandon Strange	Florida State University	The Structure and Magnetism of Single Crystal $DyFe_1MnO_3$	Haidong Zhou
Donovan Thompson	University of Florida	The Low Temperature Magnetic Properties of Bulk and Nanoparticle DPPH	Mark Meisel, at the University of Florida
Francisco Valle	University of Puerto Rico-Mayaguez	Electroplating Bi-2212 Wire to Improve Superconducting Properties	Eric Hellstrom
William Ware	Lamar University	Using Femtosecond Electron Diffraction to Study Dynamical Structures and Transient States	Jim Cao
Yer Yang	Columbus State University	An Investigation of Factors that Affect the Mass Range of Atmospheric Pressure Laser Induced Acoustic Desorption Chemical Ionzation (AP/LIAD-CI)	Leonard Nyadong

for delivering science instruction. Many teachers maintain contact throughout the school year with both CIRL staff and with their mentors.

Both the REU and RET programs are facilitated by **Jose Sanchez**, Assistant Director of CIRL, who ensures that students and teachers are supported outside of the laboratory exploring the vibrant educational, cultural, and historical sites in the area. In addition, he oversees seminars and colloquia that provide REU and RET participants that provide overviews of current research, graduate school options, undergraduate research publication opportunities, and content related to magnet research.

ABOVE RET Class of 2010.

Outreach

The Center for Integrating Research and Learning's outreach program continues to be busy in the classrooms of the surrounding counties. In addition to the established science activities on the topics of electricity and magnetism, new programs include showing students the scientific method, an introduction to scientific inquiry, and a popular activity about the nature of science.

In March **Carlos R. Villa** presented twice at the National Science Teachers Association national conference in Philadelphia, PA; and in November at the Florida Association of Science Teachers (FAST) state conference in St Augustine, Florida. In 2010, outreach was conducted for 9,099 students from 11 counties in North Florida and South Georgia; 970 students came to the Magnet Lab for field trips and tours.

SciGirls I and II camps for middle and high school girls with a keen interest in science and engineering completed its fifth year in summer 2010, hosting 32 young women. Activities ranged from hands-on activities at the Magnet Lab to assisting with surgery at the local animal shelter. This popular program is very competitive—receiving far more applications than available spots. This highly successful collaboration between the Magnet Lab, WFSU-TV, the local public television station, and local engineering firms, provides role models for young women and points out the importance of community engagement and partnerships.

Middle School Mentorship

Thirteen (13) middle school students from a local charter school participated in laboratory experiences at the lab during spring semester 2010. Teams of students developed research projects with their mentors that culminated in a presentation to an audience of parents, teachers, scientists, and other students.

High School Internships

In 2010 eight (8) high school students worked with seven mentors honing their laboratory skills and learning about science research in a real-world setting.

Professional Development

CIRL educators continued to support area teachers in science education by providing after-school workshops at three area schools: Ruediger Elementary School (Title I), Riversink Elementary School (area center), and Springwood Elementary School. We continue our partnership with Leon County Schools by providing expertise and workshop facilitation for their STEM initiative.

Partnerships

Through a number of organizations, CIRL maintains active and enthusiastic partnerships with other outreach groups

ABOVE Sci Girls Class of 2010.

ABOVE Carlos Villa at Chick-Fil-A

and outreach professionals. In addition, CIRL works with departments and centers on the campus of Florida State University to provide the widest range of activities possible to students and teachers. CIRL staff participated in *Origins 2010, Super Why Family Day, Senior Days*, and *Flying Circus of Physics*.

CIRL is also a partner with the Center for Advanced Power Systems, FAMU-FSU College of Engineering, and North Carolina State University in the **Engineer-**

Research Experiences for Teachers – 2010 Participants

RET Participant	Home Town	Research Area	Mentor
Kathy Gibbons-Adams	Lake View Elementary	Using Solid State NMR to Understand the Molecular Structure of Designer Self-Assembling Proteins MAX8 and RADA16	Anant Paravastu
Jason Burdick	Sail High School	Atomic Force Microscopy (AFM) Analysis of Surface Structures	Maitri Warusawithana
Althea Carling	Gilbert Classical Academy	The Mystery of the Copper Free Grains in Bi-2212	Eric Hellstrom
Megan Crombie	Riversink Elementary	Using Solid State NMR to Understand the Molecular Structure of Designer Self-Assembling Proteins MAX8 and RADA16	Jim Cao
Patricia Gruhn	Stanton College Prep	Atomic Force Microscopy (AFM) Analysis of Surface Structures	Maitri Warusawithana
Stephen Kufrovich	Maitland Middle	Scanning Electron Microscopy (SEM) of Twin Bands	Bob Goddard
Chad Linville	Riversprings Middle	Superconducting Boat	David Larbalestier
Jodie Martin	Medart Elementary	Solar Panels as a Source of Noise-Free Power	Irinel Chiorescu
Rasheeda Mohamed	Holmes Elementary	Crystal Growth and the Characterization of Micro-structures	Yan Xin
Emily Morris	West Elementary	Scanning Electron Microscopy (SEM) of Twin Bands	Bob Goddard
Kerry O'Connor	Montford Middle School	Using Bernoulli's Principle to Achieve Ultrasonic Levitation	Alexey Souslov
Beverly Ransom	Holley-Navarre Primary	The Mystery of the Copper Free Grains in Bi-2212	Eric Hellstrom
Amon Rwito	Apalachee Elementary	Using Bernoulli's Principle to Achieve Ultrasonic Levitation	Alexey Suslov
Erin Smidt	Deerlake Middle	Crystal Growth and the Characterization of Micro-structures	Yan Xin

Middle School Mentorships – Class of 2010

Students	Research Area	Mentors
Francis Bass & Mel Kochanowsky	Fluorescent Proteins	Mike Davidson & Ericka Ramko
Rora Haskins & Haley Madkour	Dissipation and Capacitance	James Brooks & Ade Kismarahardja
Maya Manciagli & Ashley Moore	Time Fountain	Dmitry Smirnov
Riley Carson	Frequency and Resonance	Lloyd Engel
Aleigha Brown & Tadge Haskins	Metal in Plant Growth	Afi Sachi-Kocher, Nicole Tibbetts & Soumen Mallick
Olivia Merkhofer & Joseph Portillo	When O-Rings Go Bad	Vince Toplosk & Bob Walsh
Nancy Engel & Zola Hoehn	Determining the Ratio of Carbon Isotopes in Lake Sediments	Yang Wang & Yingfeng Xu

High School Mentorships – Class of 2010

Students	High School	Mentors
Eta Atolia	Rickards High School	Ryan Rodgers
Payal Patel	Rickards High School	Maitri Warusawithana
David Stupski	Maclay School	Maitri Warusawithana
Marhsall Jiang	Chiles High School	Jingping Chen
Sel Celik	Rickards High School	David Hilton
Carissa Redmon	Chiles High School	Steve Van Sciver
Mayon Hight	Lincoln High School	Iain Dixon
Hannah Karimipour	Chiles High School	Afi Sachi-Kocher

ing Research Center for Renewable Electric Energy Delivery and Management Systems (ERC FREEDM). Working with The Science House and the ERC FREEDM Center at NCSU, CIRL facilitates the pre-college education program through summer camps, Young Scholars high school internship programs, and Research Experiences for Teachers. In addition, one full-time graduate student coordinates assessment at all locations participating in the FREEDM grant.

Research

In 2010, the Center for Integrating Research and Learning, under the leadership of **Roxanne Hughes**, post-doctoral researcher, **Kristen Molyneaux**, ERC FREEDM assessment coordinator, and Brandon Nzekwe, graduate research assistant, conducted research on the following programs: **SciGirls Summer Camp, ERC-FREEDM Summer Camp**, and **ERC-FREEDM Young Scholars**. We found that the camps were particularly effective in improving students' views of science and engineering careers, and the students indicated that they learned about new careers and broadened their interest in science and engineering career options. The research indicated that the female participants had the most significant change in their views of scientists.

For all three programs, interviews were conducted with participants to gain a better understanding of the program effects. Interviews focused on students' views of science/scientists and their identity formation. Research on the informal science summer programs conducted through CIRL indicate that our office and the NHMFL are having a positive impact on young students' views of science careers, which is a step in the right direction toward increasing the number of women and minorities in the STEM pipeline. In addition to the 2010 summer programs, we are working toward contacting past SciGirls who are currently upperclassmen in high school or in their first years of college to determine what effect (if any) the camp had on their science interests.

One article on the 2009 RET research was written, revised, and re-submitted for publication: Hughes, R., Dixon, P., & Molyneaux, K., "The role of scientist mentors on teacher perceptions of the community of science during a summer research experience" Research in Science Education. The article focuses on the effects of scientist mentor relationships on science teachers' understanding of science.

Four CIRL educational researchers — **Pat Dixon**, Director CIRL, **Roxanne Hughes**, Post Doctoral Researcher, **Kristen Molyneaux**, Graduate Research Assistant, and **Brandon Nzekwe**, Gradu-

ABOVE Elementary students participate in hands-on activities.

ABOVE Megan Crombie and Kathy Gibbons-Adams with the NMR magnet they used to analyze the RADA-16 Protein with mentor Anant Paravastu.

ate Research Assistant — participated in presentation of research at the regional and national conferences. The research agenda, including program evaluation for all CIRL-administered programs, is an important element of CIRL's participation in the national and international informal science education community.

- January 2010, Association of Science Teacher Education Sacramento, CA
- February 2010, Eastern Educational Research Association, Savannah, GA
- March 2010, National Association for Research in Science Teaching, Philadelphia, PA
- April 2010. American Educational Research Association, Denver, CO
- October 2010, Annual Research on Women and Education Conference, Philadelphia, PA
- November 2010, Florida Educational Research Association, Orlando, FL.

Program Evaluation

In 2010, the Center of Integrating Research and Learning conducted program evaluation on the following programs: educational outreach, SciGirls, ERC-FREEDM camp and young scholars, and teacher workshops. Program evaluation efforts included pre and post surveys that measured expectations/goals for program and the effects the program had on science interest and understanding. All of these programs received positive evaluations, with participants citing examples of the positive effects on their science interest and understanding. Every teacher that receives educational outreach is required to provide feedback through surveys sent after the outreach is conducted. Data indicate overwhelmingly positive responses to the value of classroom visits.

CHAPTER 7

Industrial Partners & Collaborations

Magnet Lab researchers and staff develop partnerships and collaborations with the private sector, federal agencies, and institutions and international organizations, resulting in a wide variety of magnet-related technologies and advancing other projects that bring technologies closer to the marketplace.

Engaging in such research and development activities is part of the National Science Foundation's charge to the Magnet Lab.

Magnet Lab-U.S. Private Sector Activities

89 North, Burlington, VT

Scientists at the Magnet Lab are working with applications specialists at 89 North to develop light-emitting diode technology for fluorescence microscopy. This collaboration involves testing the power output and usability of new high-power LED technology in the emission region between 490 and 590 nanometers, a spectral region that is central to microscopy investigations.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Abbott, Abbott Park, Chicago, IL

This collaboration is with Shaun McLaughlin, senior research physical chemist at Abbott Pharmaceuticals. McLaughlin is collaborating with the ICR program on epitope mapping of specific antibodies toward the NoGo protein using Hydrogen-deuterium exchange at 14.5 tesla. The NoGo protein is involved in neurite growth inhibition. Specific inhibition of NoGo would be a useful tool to aid repair of spinal cord injuries. NoGo inhibitors have also been targeted for treatment of brain damage after stroke.
(Magnet Lab contact: Mark R. Emmett, ICR)

Advanced Magnet Lab, Inc., Palm Bay, FL

Engineers from the NHMFL are collaborating with Advanced Magnet Lab, Inc. to produce the innovative field-correction shims required to decrease spatial and temporal field disturbances in the Series-Connected Hybrid (SCH). Advanced Magnet Lab has provided the precision fabrication processes required to produce these innovative shims for the first-of-a-kind SCH magnet system that will produce 1 ppm field homogeneity at 36 T.
(Magnet Lab contact: Tom Painter, MS&T)

Agilent Technologies, Santa Clara, CA

Agilent Technologies is entering the imaging arena with a new "Monolithic" laser combiner featuring acousto-optic-tunable filter (AOTF) control. The Magnet Lab is collaborating with Agilent to prototype the laser system for use in super-resolution imaging.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Allele Biotech, San Diego, CA

Allele is a manufacturer and distributor of fluorescent protein constructs made by Robert Campbell and Nathan Shaner. The Magnet Lab is collaborating with Allele to develop fusion vectors of selected fluorescent proteins.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

AnaSpec Eurogentec Group, Fremont, CA

An upstart supplier of fluorophores for confocal and wide-field microscopy, AnaSpec is collaborating with the Magnet Lab to develop educational tutorials on the use of fluorescent probes in optical microscopy.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

B&B Microscopes, Pittsburgh, PA

Scientists in the Optical Microscopy facility at the Magnet Lab are working with B&B engineers to develop new live-cell imaging techniques using the wide array of products offered by the company. Eventually, an educational Web site is planned.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Bioptechs, Butler, PA

The Magnet Lab is involved with Bioptechs of Pennsylvania to develop live-cell imaging techniques using the company's advanced culture chambers. The collaboration involves time-lapse imaging of living cells over periods of 36-72 hours using techniques such as differential interference contrast, fluorescence, and phase contrast.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Chroma, Rockingham, VT

A major supplier of Interference filters for fluorescence microscopy and spectroscopy applications, Chroma is collaborating with the Magnet Lab to build educational tutorials targeted at fluorescence microscopy. Working in conjunction with Nikon, engineers from Chroma and scientists from the Magnet Lab are examining the characteristics of a variety of filter combinations.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

The Cooke Corp., Romulus, MI

Scientists at the Magnet Lab are working with applications specialists at Cooke to field test the company's cooled and electron-multiplied scientific CCD camera systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.

(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Covance Research Products, Berkeley, CA

Covance is a biopharmaceutical company involved with research and diagnostic antibody production. Magnet Lab scientists are working with Covance researchers to examine immunofluorescence staining patterns in rat and mouse brain thin and thick sections using a wide spectrum of antibodies.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Diagnostic Instruments, Sterling Heights, MI

Scientists at the Magnet Lab are working with applications specialists at Diagnostics to field test the company's new line of cooled scientific CCD systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Foveon, Santa Clara, CA

A corporation exploring true color "complementary metal-oxide semiconductor" (CMOS) image sensor technology, Foveon is involved with developing educational tutorials with the Magnet Lab that explain its cutting-edge technology in image-sensor design.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

General Electric Global Research, Niskayuna, NY

In the continuing effort to explore the utility of heavy oils, the FT-ICR MS facility has joined a collaborative research project with GE to provide a detailed inventory of heavy petroleum species. Of specific interest are metal-containing species (porphyrins) that are corrosive upon combustion. The project resulted in the first direct determination of metal (Ni and V) porphyrin species in unfractionated heavy crude oil.
(Magnet Lab contact: Ryan Rodgers, ICR)

Hamamatsu Photonics, Bridgewater, NJ

Scientists at the Magnet Lab are working with applications specialists at Hamamatsu to field test the company's cooled and electron-multiplied scientific CCD camera systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Lumencor Inc., Beaverton, OR

The Magnet Lab is collaborating with Lumencor to examine the spectra and output power of various illumination sources for microscopy including metal halide lamps, light engines, LEDs, and the LiFi illumination system.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

MBL International, Woburn, MA

Scientists at the Magnet Lab are collaborating with MBL to develop new fluorescent proteins for live-cell imaging applications. These include both optical highlighters and fluorescence resonance energy transfer (FRET) biosensors.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Media Cybernetics, Silver Spring, MD

Programmers at the Magnet Lab are collaborating with Media Cybernetics to develop imaging software for time-lapse optical microscopy. In addition, the Optical Microscopy group is working to add new interactive tutorials dealing with fundamental aspects of image processing and analysis of data obtained with the microscope.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Molecular Probes/Invitrogen, Eugene, OR

A major supplier of fluorophores for confocal and wide-field microscopy, Molecular Probes is collaborating with the Magnet Lab to develop educational tutorials on the use of fluorescent probes in optical microscopy.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Nalco, Sugarland, TX

Deposits formed in petroleum production equipment pose major obstacles to safe, economical production of heavy oils in both terrestrial and deep offshore production environments. With the help of Nalco, the FT-ICR group has provided detailed compositional analysis for emerging production deposits for new and late production oil reserves all over the globe. The compositional information is vital to the design of the next generation of chemical dispersants and inhibitors to reduce deposition in the transport of heavy petroleum reserves. Another concern is that many species in oil that are soluble under reservoir conditions (high temperature and pressure) become unstable when oil production starts. Their precipitation poses significant problems. The FT-ICR facility has begun the compositional analysis of pressure-induced and temperature-induced precipitants from live oil samples in collaboration with Chevron. The results show that specific classes (chemical functionality) preferably precipitate when either the temperature or pressure is dropped from reservoir conditions.
(Magnet Lab contact: Ryan Rodgers, ICR)

Nikon USA, Melville, NY

The Magnet Lab maintains close ties with Nikon on the development of an educational and technical support microscopy Web site, including the latest innovations in digital-imaging technology. As part of the collaboration, the Magnet Lab is field-testing new Nikon equipment and developing new methods of fluorescence microscopy.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Olympus America, Melville, NY

The Magnet Lab is developing an education/technical Web site centered on Olympus products and will be collaborating with the firm on the development of a new tissue culture facility at the Magnet Lab in Tallahassee. This activity will involve biologists at the Magnet Lab and will feature Total Internal Reflection Fluorescence microscopy.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Omega Optical, Brattleboro, VT

The Magnet Lab is involved in collaboration with Omega to develop interactive tutorials targeted at education in fluorescence filter combinations for optical microscopy. Engineers at Omega work with Magnet Lab microscopists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Pfizer Global Research & Development, San Diego, CA

Dr. Michael Greig at Pfizer is collaborating with the ICR program in a novel application of supercritical fluid chromatography to separate peptides following hydrogen-deuterium exchange experiments, thereby essentially eliminating deuterium-hydrogen back-exchange that has been the primary drawback to such analyses. This idea was a specific aim of the recently funded National Institutes of Health project for which Greig is a contributor.
(Magnet Lab contact: Mark Emmett, ICR)

Photometrics (Roper Scientific Inc.), Tucson, AZ

The microscopy research team at the Magnet Lab is exploring single molecule fluorescence microscopy using electron-multiplying CCD camera systems developed by Photometrics. In addition, the team is conducting routine fixed-cell imaging with multiple fluorophores to gauge camera performance.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Photonics Instruments, Pittsfield, MA

The microscopy research team at the Magnet Lab is collaborating with engineers at Photonics Instruments to develop photoactivation techniques for wide-field and spinning disk confocal microscopy. This collaboration involves live-cell imaging techniques.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Prior Scientific Inc., Rockland MA

Prior is a major manufacturer of illumination sources and filter wheels for fluorescence microscopy. The Magnet Lab team is collaborating with Prior to develop new illumination sources and mechanical stages for all forms of microscopy.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Revolution NMR, Fort Collins, CO

The Magnet Lab's NMR instrumentation program and Revolution NMR collaborate on the development of stators for magic angle spinning NMR and on sample chambers for static solid-state NMR.
(Magnet Lab contact: Peter Gor'kov, NMR)

Semrock, Rochester, NY

The Magnet Lab Optical Microscopy group is collaborating with Semrock to develop interactive tutorials targeted at education in fluorescence filter combinations for optical microscopy. Engineers and support personnel at Semrock work with Magnet Lab microscopists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission. In addition, Magnet Lab scientists produce images of living cells with Semrock filter combinations.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Shell Global Solutions, Houston TX

The FT-ICR group has an ongoing collaboration with Shell, USA to explore new mass spectrometric ionization techniques for characterization of petroleum crude oil and its products. Current efforts involve application of atmospheric pressure photoionization (APPI) to provide access to non-polar components (e.g., hydrocarbons, thiophenes, etc.) not accessible by conventional electrospray ionization. Fundamental research in APPI determines relative ionization efficiencies of chemical types known to exist in crude oil.
(Magnet Lab contact: Ryan Rodgers, ICR)

Sierra Analytics, Modesto, CA

The lab's ICR research team maintains a licensing agreement with Sierra, a company that provides mass spectrometry software to petroleum companies. The software contains high level algorithms for identification of thousands of compounds in petroleum mass spectra, obtained through the lab's pioneering Fourier transform ICR technique development. Lab researchers and Sierra Analytics continue to share updated information, enabling both to stay atop the petroleomics field.
(Magnet Lab contact: Chris Hendrickson, ICR)

Sutter Instrument, Novato, CA

The Magnet Lab is collaborating with Sutter to examine the spectra and output power of various illumination sources for microscopy including metal halide lamps and the LiFi illumination system.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Technique Materials Inc., Lincoln, RI

Technique Materials Inc. is a company specializing in fabrication of materials via glading, plating, and coating. The company and the laboratory have undertaken a joint research project on fabrication of high strength conductors for next-generation magnets. Because of the high efficiency of the fabrication approach, nanostructured conductors can be fabricated in a reasonable time.
(Magnet Lab contact: Ke Han, MS&T)

Varian, Inc., Palo Alto, CA

AMRIS and Magnet Lab's NMR instrumentation program collaborate with Varian, Inc. on an NIH-funded project to develop improved superconductive cryoprobes for solution NMR.
(Magnet Lab contacts: William Brey, NMR and Art Edison, AMRIS)

Zeiss Micro Imaging, Thornwood, NY

The Optical Microscopy group at the Magnet Lab is negotiating a contract with Zeiss on the development of an educational and technical support microscopy Web site, including the latest innovations in digital imaging technology. As part of the collaboration, microscopists are field-testing new Zeiss equipment and developing new methods of fluorescence microscopy.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Inter-Agency and Inter-Institutional Activities

Columbia University, Stanford University, University of California Santa Barbara, University of Rhode Island

The Center for Integrating Research & Learning continues its collaboration with other institutions that conduct educational outreach with teachers. Through the Research Experiences for Teachers (RET) Network, the Center maintains a national presence among other laboratories, centers, and universities that conduct RET and other teacher enhancement programs. Current projects include expansion of the current RET Network Web site to include input from additional sites and an interactive component to share best practices. In addition, the RET Network will be a comprehensive site that compiles lists of RET programs across the country.
(Magnet Lab contact: Pat Dixon, Educational Programs)

Falk Center for Molecular Therapeutics, Northwestern University, Evanston, IL

Joseph R. Moskal and Roger A. Kroes are collaborating with the FT-ICR group on the inhibition of invasion of glioblastoma brain tumors through gene therapy. Drs. Moskal and Kroes bring their unique glyco-gene array technology and expertise in the field of glycomics to the collaboration, which permits a systems biology approach (proteomics, lipidomics, glycomics, transcriptomics and phenotypic response) to the search for therapeutic targets for treatment of glioblastoma brain tumors.
(Magnet Lab contact: Mark R. Emmett, ICR)

Lawrence Berkeley Lab, Accelerator & Fusion Research, Berkeley, CA

The NHMFL collaborated with the Lawrence Berkeley National Laboratory (LBNL) on the development on a 35 kA superconducting DC transformer with accurate measurement and regulation of the secondary current. This current source can be used in combination with the NHMFL 12 T Superconducting Split magnet in Cell 16 to power Nb_3Sn and Bi-2212 Rutherford cables, as well as small dipole magnets at LBNL in the stand-alone configuration. The transformer was successfully used to energize prototype (LHC Accelerator Research Program) LARP Nb_3Sn cables in magnetic field and under transverse pressure in Cell 16 at the NHMFL.
(Magnet Lab contact: Huub Weijers, MS&T)

Leon County Schools, Tallahassee, FL

The Center for Integrating Research & Learning facilitates science workshops and summer institutes for Leon County Schools. With high stakes testing in science now part of school accountability, the Center has responded to the call of teachers and schools to provide quality professional development. The Center currently maintains formal partnerships with two elementary schools, three middle schools, and two high schools.
(Magnet Lab contact: Pat Dixon, Educational Programs)

M.D. Anderson Cancer Center, Houston, TX

This collaboration with Charles A. Conrad, M.D., associate professor of neuro-oncology and medical director of the Anne C. Brooks Neuro Center, involves the study of a protein (galectin-1) as a therapeutic target in the progression of glioblastoma multiforme brain tumors. The galectin target was discovered in previous collaborations between Conrad, Carol L. Nilsson (then of Goteborg University), and Mark R. Emmett of the FT-ICR program. The initial collaboration was primarily funded by a Swedish STINT grant. Recently, Mike Davidson, director of the Magnet Lab's Optical Microscopy group, joined the collaboration to provide high-resolution fluorescent photomicroscopy of the live glioblastoma cell lines.
(Magnet Lab contacts: Mark Emmett, ICR, and Mike Davidson, Optical Microscopy)

North Carolina State University, Raleigh, NC

In partnership with the Center for Advanced Power Systems and the FAMU-FSU College of Engineering, the Center for Integrating Research & Learning supports ERC FREEDM educational and assessment activities. Working with The Science House and the ERC FREEDM Center at North Carolina State University, we facilitate the pre-college education program through summer camps, Young Scholars high school internship programs, and Research Experiences for Teachers. In addition, one full-time graduate student coordinates assessment at all locations participating in the FREEDM grant.
(Magnet Lab Contact: Pat Dixon, Educational Programs)

Penn State University, University Park, PA

In collaboration with Jonathan Matthews at Penn State University, we recently provided detailed compositional analysis of pyridine soluble coal species to aide in the construction of a detailed model of coal behavior. The Penn State model contains tens of thousands of individual molecules and is the most detailed model constructed to date. The FT-ICR MS data was used to validate the model through comparison with compositional data afforded by the FT-ICR Mass Spectrometers in the NSF-funded High Field FT-ICR MS facility.
(Magnet Lab contact: Ryan Rodgers, ICR)

Spallation Neutron Source, Oak Ridge, TN

In late 2006, the National Science Foundation awarded funding to a team (which included researchers at Johns Hopkins University, the Magnet Lab, the Spallation Neutron Source (SNS), and MIT) for a conceptual engineering design of a conical Series Connected Hybrid magnet suitable for neutron scattering at the SNS. The five-year study includes development of a conical resistive magnet. A conceptual magnet design has been developed. Members of the potential user community at the SNS discussed the beamline concepts in April 2008. Design reviews of the magnet were held in November 2007 and January 2009. In the coming year, we expect to be developing cables using high-temperature superconductors that would be used in an all-superconducting 25-30 T magnet for neutron scattering.
(Magnet Lab contact: Mark D. Bird, MS&T)

Training Solutions Interactive Inc., I4 Learning, Atlanta, GA & Tallahassee, FL

TSI and the Center for Integrating Research & Learning have been collaborating since 1998 to bring "Science, Tobacco & You" to more than 20 states. TSI specializes in the implementation

of programs, systems, and strategies to improve efficiency and productivity in business, industry and education. Because of the overwhelming success of "Science, Tobacco & You," TSI and the Center continue to maintain an active business relationship.
(Magnet Lab contact: Pat Dixon, Educational Programs)

Wakulla County Schools, Crawfordville, FL

After-school workshops are conducted by the Center for Integrating Research and Learning staff each month. Located at Riversink Elementary School in Crawfordville, FL, teachers from the entire district are invited to attend workshops. The school district facilitates workshop registration and coordinates the ongoing partnership.
(Magnet Lab contact: Jose Sanchez, Educational Programs)

WFSU-TV, Tallahassee, FL

The Center for Integrating Research & Learning partners with WFSU-TV, the area's public television station, to administer SciGirls, a 2-week camp for middle- and high-school girls with an interest in science. The collaboration between the Magnet Lab and WFSU-TV has resulted in a successful 6-year camp that has engaged the larger community. In addition, WFSU-TV and the Center partner to provide summer physics experiences for students entering high school.
(Magnet Lab contact: Pat Dixon, Educational Programs)

International Activities

Andor-Tech, Belfast, Northern Ireland

Andor-Tech is an imaging specialist involved with development of CCD camera systems designed to produce images at extremely low light levels. The Magnet Lab is collaborating with Andor-Tech to produce interactive tutorials describing electron multiplying CCD (EMCCD) technology and will work with the company to test new camera products in live-cell imaging.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

CoolLed Ltd., Andover, Hampshire, United Kingdom

Scientists at the Magnet Lab are working with applications specialists at CoolLed to develop light-emitting diode technology for fluorescence microscopy. This collaboration involves testing the power output and usability of new LED technology in the emission region between 490 and 590 nanometers, a spectral region that is central to microscopy investigations.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Criotec Impianti, Piedmont, Italy; ENEA, Rome, Italy

The Magnet Lab is collaborating with Criotec Imianti, an Italian cryogenic systems manufacturing company, and ENEA, an Italian Fusion Energy Research Organization, to jacket the cable-in-conduit superconductor for the outsert coils of the series-connected hybrid magnets. This work includes the welding and inspection of the stainless steel conduit, insertion of the cabled superconductor strands into the conduit, and compaction of the assembled conductor to a rectangular cross-section.
(Magnet Lab contact: Iain Dixon, MS&T)

Evrogen, Moscow, Russia

Evrogen is a manufacturer and distributor of fluorescent protein constructs made by Dmitriy Chudakov and Vladislav Verkhusha. The Magnet Lab is collaborating with Evrogen to develop fusion vectors of selected fluorescent proteins.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

EXFO, Mississauga, Ontario, Canada

The Magnet Lab is collaborating with EXFO to examine the spectra and output power of various illumination sources for microscopy including metal halide lamps, light engines, LEDs, and the LiFi illumination system.
(Magnet Lab contact: Mike Davidson, Optical Microscopy)

Faculty of Material Science and Engineering, Kunming University of Science and Technology, China

The collaboration between the Kunming University and the Magnet Lab is related to the magnetic field impact on phase transformation in steels. A professor from Kunming University will come to the Magnet Lab as a visiting scientist for one year to do the research.
(Magnet Lab contact: Ke Han, MS&T)

HZB, Berlin, Germany

In March 2007, HZB (formerly the Hahn-Meitner Institute) signed an agreement with Florida State University Magnet Research and Development to develop a Series-Connected Hybrid magnet suitable for neutron scattering experiments and to install it at HZB. The magnet is intended to provide 25 T on-axis using 4 megawatts of DC power and have upstream and downstream scattering angles of 30 degrees. An international panel of experts reviewed the design of the superconducting magnet and cryogenic system at the Magnet Lab in November 2007, January 2009, January 2010, and February 2011. Fabrication of the magnet is underway: superconducting strand has been delivered and cabled, the first conductor has been jacketed, the cryostat has been ordered.
(Magnet Lab contact: Mark D. Bird, MS&T)

IFP, Lyon, France

Asphaltenes are one of the most problematic fractions of crude oil. Defined by their insolubility in n-heptane and solubility in toluene, they are the heaviest, most polar fractions of oil. Because world oil markets are moving toward heavier, more viscous fluids, they represent an ever-growing fraction of the whole crude. Asphaltenes are chemically complex, so complex that detailed speciation of individual components is not available outside high-resolution FT-ICR mass spectrometry. The High Field FT-ICR MS facility has an ongoing collaboration with IFP to look at the compositional changes in asphaltenes in thermal treatment processes aimed at the conversion of the heavy, viscous materials to light, less complex usable materials.
(Magnet Lab contact: Ryan Rodgers, ICR)

Institute of Metal Research, Chinese Academy of Sciences, Shenyang, China

The collaboration between the Institute of Metal Research and the Magnet Lab is related to the characterization of stainless steels and other structural materials for high field magnets. The materials are mainly stainless steel 316LN and maraging steels with high mechanical strength. *(Magnet Lab contact: Ke Han, MS&T)*

Linkam, Surrey, United Kingdom

Scientists at the Magnet Lab collaborate with Linkam engineers to design heating and cooling stages for observation of liquid-crystalline phase transitions in the optical microscope. In addition, microscopists are assisting Linkam in introducing a new heating stage for live-cell imaging in fluorescence microscopy. *(Magnet Lab contact: Mike Davidson, Optical Microscopy)*

Olympus Corp., Tokyo, Japan

Investigators at the Magnet Lab have been involved in a collaboration with engineers at Olympus to develop and test new optical microscopy systems for education and research. In addition to pacing the microscope prototypes through basic protocols, the Optical Microscopy group is developing technical support and educational websites as part of the partnership. *(Magnet Lab contact: Mike Davidson, Optical Microscopy)*

Qimaging, Burnaby, British Columbia, Canada

High-resolution optical imaging is the focus of the Magnet Lab collaboration with Qimaging, a Canadian corporation that specializes in CCD digital cameras for applications in quantitative image analysis and high-resolution images for publication. Target applications are interactive tutorials and image galleries that will be displayed on the Internet. *(Magnet Lab contact: Mike Davidson, Optical Microscopy)*

Scientific Magnetics, Abingdon, England

Scientific Magnetics is a designer and manufacturer of superconducting magnets and cryogenic equipment based in Abingdon near Oxford, England. The Magnet Lab is collaborating with Scientific Magnetics for the mechanical designing and manufacturing of the Central Distribution Box based on the specification and P&ID provided by NHMFL. The design and fabrication of the CDB will be finished in 2011, when the collaboration will have lasted for one and half years. *(Magnet Lab contact: Hongyu Bai, MS&T)*

University of Science and Technology Beijing, Department of Materials Science and Engineering, Beijing, China

The collaboration between the University of Science and Technology Beijing and the Magnet Lab is related to the thermodynamic calculations of the multi-elements and multiphase systems. Currently, efforts are focused on understanding interstitial elements impact on the precipitation in steels for high field magnets. *(Magnet Lab contact: Ke Han, MS&T)*

CHAPTER 8
Conferences & Workshops

2010 Series-Connected Hybrid Design Review

January 13-14, 2010
Tallahassee, Florida – NHMFL
Review Organizer: Mark D. Bird

The SCH design review has been held nearly each year since 2005. For the past four years it has brought together magnet designers, engineers, and scientists from the United States and Europe to discuss the development of cable-in-conduit conductor magnets for the Magnet Lab, as well as the Helmholtz Zentrum Berlin and the Spallation Neutron Source. The review provides an opportunity for the latest developments at ITER, EDIPO (European Dipole Superconducting magnet), and JT-60 (Japan Torus-60) to be incorporated into the plans for the magnets being developed by the Magnet Lab. Fourteen in-house faculty and staff members and three external contributors presented the work completed over the past year. Thirteen external reviewers and representatives of HZB and SNS attended.

From Quantum Hall Effect to Quantum Computation

(held in concert with Steve Girvin's 60th Birthday Celebration)
April 1-2, 2010
Tallahassee, Florida – NHMFL
Organizers: Greg Boebinger, Sankar Das Sarma, Matthew Fisher and Kun Yang

This MagLab-hosted workshop featured invited presentations from 14 global experts in condensed matter science; guests also feted fractional Quantum Hall effect pioneer and Yale Eugene Higgins Professor of Physics Steve Girvin. The workshop was also supported by the Office of the Vice President for Research at Florida State University.

Magnet Lab User Summer School

May 17-22, 2010
Tallahassee, Florida – NHMFL
Workshop Chair: Albert Migliori

Twenty-six advanced graduate students, postdoctoral associates, and early career investigators looking to gain practical measurement experience attended the second annual User Summer School. The program is designed to help users develop skills applicable to their own and other user institutions. The next User Summer School will be held May 16-20, 2011.

Rocky Mountain Conference on Analytical Chemistry

August 1-5, 2010
Snowmass, Colorado – Silvertree Hotel
Conference Chair: Kurt Zilm, Yale University

The 52nd annual meeting of the Rocky Mountain Conference on Analytical Chemistry featured, as always, symposia on both Solid State NMR and EPR. The NHMFL was a partial sponsor of the event. The Magnet Lab's Zhehong Gan was a member of the Solid State NMR Symposium's scientific committee, and University of Florida's Gail Fanucci, Alex Angerhofer, both Mag Lab affiliates, served as EPR co-chairs.

Applied Superconductivity Conference

August 1-6, 2010
Washington, DC – Omni Shoreham Hotel

This five-day conference brought together leaders in the commercial, military, research, university, and industrial communities from around the world to discuss progress and challenges in the field of applied superconductivity. There were several plenary sessions focused on overviews and the broad prospectus of the field, exhibitors from major superconducting and cryogenic companies, and daily technical discussions from 1400 attendees from 70 countries. Magnet Lab staff involved in the conference included Peter Lee, Eric Hellstrom, Ulf Trociewitz, and Tom Painter.

Low Temperature / High Field Superconductor Workshop

November 8-10, 2010
Monterey, California – Monterey Plaza Hotel
Workshop Chair: David Larbalestier

About a hundred guests attended this workshop, which featured a variety of presentations from both academic and industrial participants. LTSW/HFSW made significant changes for 2010, as the new joint title suggests. One driver for this was the emergence of plans for Muon accelerators into project status as the Muon Accelerator Project (MAP), which received its first formal review in August 2010. This has many challenges for magnets, some of which must be made out of high temperature superconductors. Independent of MAP, three significant 30T class YBCO magnets have now been funded, a 32 T user magnet for the NHMFL, two stand-alone but nestable ~10 T solenoids which prototype a 30T+ MC high field cooling magnet (PBL Inc), and a 3 MJ, 20-30T SMES magnet (ABB/BNL/SuperPower). Very High Field Superconducting Magnet Collaboration (VHFSMC) has been going for about 12 months and has made significant advances in understanding Bi-2212. The U.S. Large Hadron Collider Accelerator Research Program (LARP) has continued to make major advances in Nb_3Sn, feeding in options for the Large Hadron

Collider luminosity and energy upgrades. A broad SBIR program is nurturing many types of conductor development activities. LTSW/HFSW2010 provided a venue for discussion and forward planning for our community.

50 Years of the Gor'kov Equation: A Celebration of the Distinguished Career of Dr. Lev Gor'kov

December 2-3, 2010
Tallahassee, Florida – Horizon Conference Center at the Hotel Duval
Symposium Chair: Vladimir Dobrosavljevic

On December 3, 2010, the day before the start of PPHMF-VII, over 100 friends, colleagues, and former students of Lev P. Gor'kov met at the Hotel Duval in downtown Tallahassee for a day-long symposium to honor Lev's remarkable career in science. The theme of the symposium was "50 Years of the Gor'kov Equation," a reference to Lev's seminal work on the theory of superconductivity that provided the theoretical framework used for essentially all modern microscopic superconductivity calculations. The symposium began with welcoming remarks from Kirby Kemper (FSU Vice President for Research) and Joe Travis (FSU Dean of Arts and Sciences), followed by a series of nine talks by some of the today's top condensed matter theorists and experimentalists. These talks ran throughout the day, covering a wide range of topics in current condensed matter physics, reflecting the broad impact of Lev's work.

In the evening, these more formal talks gave way to a series of less formal presentations by a number of Lev's former students and colleagues who took the opportunity to tell stories about Lev, recalling in particular his time at the Landau Institute and the enormous influence he had on a generation of Russian scientists. After the symposium banquet, which was capped off by a short musical performance, David Pines gave an after-dinner talk on "Some Reflections of Lev: From 1963-2010". This was followed by more warm reminiscences about Lev from the conference participants and closing comments by Lev himself. All in all it was a day (and evening) to remember for all who participated.

Videos of the proceedings of the symposium, as well as a list of speakers and participants, can be found on the conference website: **http://www.magnet.fsu.edu/mediacenter/seminars/gorkovsymposium.**

ABOVE Several scientists gathered at the Turnbull Conference Center in Tallahassee during the PPHMF-VII conference in December.

Physical Phenomena at High Magnetic Fields VII

December 4-8, 2010
Tallahassee, Florida – Florida State University Turnbull Conference Center
Conference Chair: Dragana Popović

PPHMF-VII brought together more than 150 experts from 17 countries for discussions on a wide range of topics in condensed matter science and technology in which magnetic fields play an important role. The program consisted of 80 invited and contributed talks, and about 40 posters presented in two poster sessions. The choice of topics was driven largely by recent Magnet Lab user research and by the abstracts submitted by conference participants. New topics at PPHMF-VII included excellent presentations of the latest results on graphene, topological insulators, and pnictides, a new class of high-temperature superconductors.

A special session was devoted to the presentation of several experimental techniques adapted for use in high magnetic fields. In another session, brief talks were given by representatives of the world's leading high magnetic field laboratories to describe their facilities and experimental techniques, and to introduce conference participants to the highlights of their poster presentations. Compared to previous conferences in this series, PPHMF-VII featured greater balance between experimental and theoretical talks to encourage discussions of the most recent experimental findings in the context of the latest theoretical ideas.

The PPHMF series started in 1991, when the first conference was held to celebrate the award of the National High Magnetic Field Laboratory to Florida State University, the University of Florida, and Los Alamos National Laboratory. The inaugural conference was held in Tallahassee, with subsequent meetings held in 1995 and 1998 in Tallahassee; in 2001 in Santa Fe, New Mexico, with an Anniversary Symposium honoring J. Robert Schrieffer; in 2005 in Tallahassee; and in 2008 in Tallinn, Estonia. PPHMF-VII was chaired by Magnet Lab/FSU scientist Dragana Popović, and it was preceded by a symposium honoring Lev P. Gor'kov. In addition to the Magnet Lab and FSU, conference sponsors included LakeShore Cryotronics, Inc., Linde Cryogenics and Oxford Instruments. More details about the conference can be found at **http://pphmf2010.magnet.fsu.edu.**

The next meeting in this series, PPHMF-VIII, is planned for December 2013.

CHAPTER 9

Management & Administration

The Florida State University, the University of Florida, and Los Alamos National Laboratory (with user programs at each of those locations) jointly operate the National High Magnetic Field Laboratory for the National Science Foundation under a cooperative agreement that establishes the lab's goals and objectives. FSU, as the signatory of the agreement, is responsible for establishing and maintaining administrative and financial oversight of the lab, and ensuring that the operations are in line with the objectives outlined in the cooperative agreement.

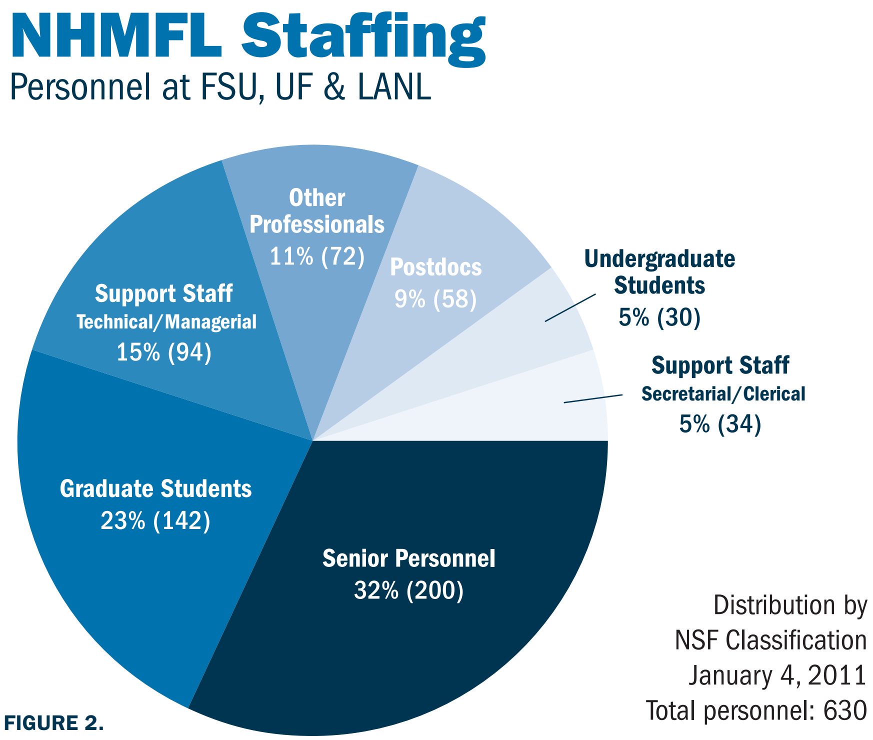


FIGURE 2.

Management

The NHMFL Organizational Chart (**Figure 1**) shows the detailed interfaces between internal and external organizations.

Gregory Boebinger serves as director and principal investigator of the Magnet Lab. He oversees the seven user programs, magnet science and technology, the activities of the Applied Superconductivity Center, and the associate lab director.

Brian Fairhurst serves as associate lab director and he has the primary responsibility for Management and Administration. He oversees budgeting and finance, human resources, facilities, health and safety, education, web outreach and applications, computer support, information technology, and other administrative functions.

The Magnet Lab has five co-principal investigators on the NSF grant. They are:

- **Tim Cross** (FSU), Nuclear Magnetic Resonance program director
- **Arthur Edison** (UF), Chem/Bio director
- **Alan Marshall** (FSU), Ion Cyclotron Resonance program director
- **Charles Mielke**, Pulsed Magnet Facility director
- **Neil Sullivan** (UF), High B/T program director.

The lab's scientific direction is overseen by the Science Council, a multidisciplinary group of distinguished faculty from all three sites, that serves as a think tank to consider and help guide the lab's scientific mission. Members are: **Albert Migliori** (co-chair), **Art Edison** (co-chair), **Gail Fanucci, Zhehong Gan, Lev Gor'kov, Stephen Hill, Jurek Krzystek, David Larbalestier, Dragana Popović, Ryan Rodgers, Theo Siegrist, Glenn Walter**, and **Huub Weijers**.

Two external committees meet regularly to provide critical advice on important issues. Reflecting the broad range of scientists who conduct research at the lab, the Users Committee provides guidance on the development and use of facilities and services in support of the work of those scientists. The External Advisory Committee, made up of representatives from academia, government and industry, offers advice on matters critical to the successful management of the lab.

Personnel and Staffing

Six hundred thirty people worked for or were affiliated with the Magnet Lab at its three sites in 2010 compared to 588 in 2009. Of that number, "senior personnel" represent the largest group at 32 percent, followed by graduate students at 23 percent and support staff technical/managerial at 15 percent. The total distribution by NSF classification appears in **Figure 2**.

Of the science and engineering staff, senior personnel make up 50 percent, followed by graduate students at 36 percent

Magnet Lab Organization October 2010

External Advisory Committee

Bill Halperin, Chair
Jan Musfeldt, Chair Users Cmte., ex officio

Meigan Aronson
David Awschalom
Dimitri Basov
Paul Chaikin
Jack Freed
Jean Futrell
Stephen Gourlay
Robert Griffin
Phil Heitzenroeder
Barabara Jones
Stephen Julian
Alex Lacerda
Peter Littlewood
Alex Malozemoff
Cynthia McIntyre
Tadeusz Molinski
Carol Nilsson
Stanley Opella
Doug Osheroff
Philip Phillips
James Prestegard
Ravinder Reddy
Mansour Shayegan
Alex Smimov
Andrew Webb
Paul Wood
Nai-Chang Yeh

Institutional Oversight Committee

Eric J. Barron, President, FSU, Chair
J.B. Machen, President, UF
M. Anastasio, Director, LANL

Institutional Representatives

K. Kemper, FSU VP for Research
W. Phillips, UF VP for Research
T. Wallace, Jr., LANL Principal Assoc. Director for Science, Technology and Engineering

Users Executive Committee

Jan Musfeldt, Chair
Roy Goodrich, Vice Chair, General Field Facilities
Tatyana Polenova, Vice Chair, Resonance Facilities

DC/Pulse/High B/T Advisory Cmte.
NMR/MRIs Advisory Cmte.
Ion Cyclotron Resonance Advisory Cmte.
Electron Magnetic Resonance Advisory Cmte.

Principal Investigator and Lab Director

Greg Boebinger, FSU/UF

Associate Lab DIrector

Brian Fairhurst, FSU

Co-Principal Investigators

Tim Cross, FSU
Art Edison, UF
Chuck Mielke, LANL
Alan Marshall, FSU
Neil Sullivan, UF

Chief Scientist for Chemistry & Biology

(vacant)

Chief Materials Scientist

David Larbalestier

Co-Principal Investigators

Albert Migliori, CMS co-chair
Art Edison, Chemistry/Biology co-chair

User & Science Programs

User Programs

DC Field Facility, FSU
Pulsed Field Facility, FSU
High B/T Facility, UF
AMRIS Facility, UF
NMR Facility, FSU/UF
EMR Facility, FSU
ICR Facility, FSU

Affiliated Science Programs

Condensed Matter
– Physics, FSU/UF/LANL
Materials Science, FSU/UF/LANL
Mechanical Engineering, FSU
Cryogenics, FSU/UF
Chemistry/Biology, FSU/UF
Biophysics, FSU
Geochemistry, FSU

User Services

User Collaboration Grants Program
Visiting Scientist Program

Magnets & Conductors

Applied Superconductivity Center
Magnet Science & Technology
Pulsed Magnet Engineering at LANL

Administration & Education

Management & Administration
– Business & Financial Services
– Center for Integrating Research & Learning
– Facilities
– Health & Safety
– Human Resources
– Technology Services
Public Affairs
Diversity Program

FIGURE 1.

and postdoctoral associates at 14 percent.

Diversity

Since the adoption of the formal diversity plan in 2004, the Magnet Lab has pursued a multitude of activities and efforts to increase the participation of underrepresented groups in science, engineering and mathematics.

The Magnet Lab aspires to become a nationally recognized leader in the diversity of its scientific, technical and engineering staff, much the same way it is already recognized for its education and outreach programs. With this goal in mind, the lab in 2010 conducted the following activities:

• It continued its recruiting policies of including at least one member of the Magnet Lab Diversity Committee on each STEM-related search committee for scientific staff, and advertised job openings in venues that target women and minorities. Recruitment was limited in 2010, however, due to FSU's hiring freeze.

List of STEM-related positions advertised and filled

Assistant Scholar/Scientist – (Asian, Male) AM
Assistant Scholar/Scientist – (White, Female) WF
Program Director – WF
Visiting Assistant Scholar/Scientist – AM
Visiting Assistant in Research – WM

Positions filled, but not advertised
Visiting Assistant Scholar/Scientist – WM
Visiting Assistant Scholar/Scientist – AM
Visiting Assistant Scholar – WM
Visiting Assistant Scholar/Scientist – WM
Visiting Assistant in Research – AM

Positions open, but not filled
Assistant Scholar/Scientist – CMS
Chief Scientist Chem/Bio
Assistant Scholar/Scientist – ASC
Assistant Scholar/Scientist – ICR
Assistant Scholar/Scientist – Director's Office/CMS

• Following the recommendation from the 2008 NSF Site Visit report, the Diversity Committee developed the Dependent Care Travel Grant Program (DCTGP), which seeks to assist and advance the careers of underrepresented groups including women by providing grants for travel-related expenses for dependents. The DCTGP was approved by the FSU administration in July, and it was first announced at the User Committee meeting in October. The information and the application form have been posted on the User Portal and on the Diversity webpage. The program announcement also appeared in the winter 2010 issue of MagLab Reports.

• **Bettina Roberson** and **Dragana Popović** attended workshops on Faculty Recruitment and on Mentorship, organized by the Alliance for the Advancement of Florida's Academic Women in Chemistry and Engineering (AAFAWCE). Popović and Roberson will work with the AAFAWCE team and the restructured Diversity Advisory Committee to determine how to provide STRIDE training (**http://sitemaker.umich.edu/advance/recruitment__stride_**) to the Magnet Lab search committees.

The lab strives to provide an environment for success for members of underrepresented groups by providing mentors and opportunities to network within and beyond the Magnet Lab. For example, partial travel support was provided to **Suzanne Farver**, a graduate student at UF, and to **Mika Kano**, a postdoc in DC Field CMS, to present their research at professional conferences. Farver attended the International Conference on Magnetic Resonance in Biological Systems in Australia, August 2010; Kano traveled to the conference on Strongly Correlated Electron Systems (SCES) in New Mexico, June 2010, and to the International Conference on Science and Technology of Synthetic Metals in Japan, July 2010.

The lab continued its efforts to develop and cultivate individually crafted early career opportunities for members of underrepresented groups at the undergraduate level and above. For example, a very successful conclusion to a multi-year individually crafted career mentoring and support at the postdoctoral and scientist level to **Frank Hunte** was his hire in a tenure-track assistant professor position at North Carolina State University. Other, similar efforts in 2010 included the following:

• A continuation of the successful "College Outreach – Workforce Initiative Program" (CO-WIN), where Magnet Lab scientists, engineers, and members of CIRL regularly travel to publicize NHMFL science and recruit REU students from women's colleges, historically black and minority-serving colleges and universities. A complete list of past trips and lectures is available at **http://www.magnet.fsu.edu/about/howwework/diversity/outreach.aspx.**

• As an ongoing relationship with Claflin initiated by a 2009 CO-WIN lecture, **Art Edison** is providing NMR training to Claflin faculty and students on their new 700 MHz spectrometer. A Claflin student **Aaron Shepard** was given an REU position and scholarship to attend an NMR metabolomics workshop at UF. As a part of another collaboration initiated by a 2007 CO-WIN lecture, **Christian Pascal**, an undergraduate student from Peru, also attended the same workshop.

• The Diversity Program provided support to two 2010 REU students: **Natalie Schmitt** and **Luis Medina**. Both students came from the University of Puerto Rico Mayaguez.

• Prof. **James Dickerson** from Vanderbilt spent his sabbatical at the NHMFL during fall 2009 – spring 2010. He received support from the Visiting Scientist Program.

• Travel support was provided to **Victoria Crawford**, an undergraduate WIMSE (FSU Women in Math, Science and Engineering) program student, to go to LANL for one week to learn sample growth and characterization techniques.

• Partial support was provided to four graduate students: **Suzanne Farver** (UF), **Anna Kuznetsova** (UF), **Shermane Benjamin** (FSU), and **Farzana Nasreen** (New Mexico State University).

• Matching funds were awarded to three postdoctoral research associates: **Rongmei Niu** (MS&T); **Mika Kano** (DC Field CMS), and **Ping Lin** (DC Field CMS).

• Support was provided to two early career scientists/students, **Tatiana Brinzari** and **Qi Sun** (both from U. of Tennessee) to attend the 2010 Users Summer School.

• **Vivien Zapf** served on the SCES (June 2010) organizing committee and **Dragana Popović** chaired the PPHMF-VII (conference on Physical Phenomena at High Magnetic Fields – VII, December 2010) organizing committee; they helped to increase the diversity among invited and contributed speakers.

One of the lab's goals is to aim educational outreach for K-12 and the general public to broad and diverse groups. This is accomplished through miscellaneous efforts by the Magnet Lab scientists and staff as well as by a variety of activities run by CIRL. In 2010, those efforts included the following:

• Judging at science fairs and mentorships at local schools that are labeled Title I or have a majority of underserved students. For example, **Art Edison** continued to run a weekly science club in Gainesville for economically disadvantaged, African-American children in grades 2-5. The number of participating children has increased over the last couple of years from 6-10 to 10-15 each week. They usually have 6-10 adult volunteers each week, who come from Edison's lab, other labs at UF, and the education department at UF. They provide tutoring, development of social skills, and group activities doing science and math. They also take a few field trips to UF or other places, such as the Florida Museum of Natural History. They feed the children sandwiches and fruit at the start of each session. NHMFL/UF staff also hosted a tour of the facilities from a spring break camp.

• CIRL continued after-school workshops at Title I schools to encourage teachers to model real-world science processes in classrooms to excite and encourage students to learn more about STEM fields. A rural county was added to the workshop schedule to provide services to teachers of underserved students.

• CIRL provided STEM activities for 32 middle and high school girls through the SciGirls program, including providing scholarships for students from Title I schools.

• CIRL conducted Science Fair Workshop for Spanish-speaking parents and ESOL students for a Title I elementary school.

• CIRL supported the ERC FREEDM grant by providing opportunities for 28 middle school students from a Title I middle school to attend an engineering camp, providing pre-college activities for 7 young women to participate in a 5-week engineering internship, and providing a 4-week engineering internship to four teachers from schools with large underserved population.

• CIRL continued to give preference to Title I and underserved schools when scheduling outreach. This increased the number of outreach activities to after school groups from underserved areas and to community groups that target at-risk students. As a consequence, outreach was conducted for over 200 students in Gadsden County (a rural, underserved community) in the first semester of academic year 2010-2011.

• CIRL staff visited Morehouse College, Spelman College, Clark Atlanta University, and Columbus State University to recruit REU students.

• 2010 RET program hosted 17 teachers, 4 from Title I schools, 6 from rural communities, all of whom teach science to underserved students. Of the total number of REU participants, there were 8 females and 14 males, 5 African American, 4 Hispanic, 1 Native American; 3 male students represented HBCU's. REU and RET programs have been registered with the Institute for Broadening Participation (**http://www.pathwaystoscience.org/Institution.asp**).

• CIRL continued presentations to general public at a local bookstore, local schools, a radio station, and a food establishment.

• The Public Affairs Office made a special outreach to minority-serving, after-school programs, Boys & Girls Clubs, and community centers to promote the annual open house. They also regularly feature a diverse mix of people in *Flux* (a Magnet Lab publication) to show that anyone can be a scientist and cultivate an interest in science.

• **Albert Migliori** gave a series of public lectures about energy storage research.

• NHMFL/FSU staff attended the Career Fair at a local high school serving mostly minority students encouraging them to pursue an education in one of the STEM programs.

NHMFL continues to publicize among NHMFL staff and user programs that diversity matters, via labwide meetings, the NHMFL diversity website, and the dissemination of NHMFL and national statistics on diversity. Diversity presentations and discussions are regular agenda items at meetings of the NHMFL Executive Committee, External Advisory Committee, User Committee, and NSF

TABLE 1

NHMFL NSF 5-Year Budget

with indirect cost distributed to programs

Division / Program	2008-2012 5-Year NSF Summary	% of Budget
Director's Office	3,377,953	2.18%
Associate Director/Management & Administration	13,730,600	8.84%
DC Field Facility	18,050,648	11.63%
Magnet Science & Technology	18,820,778	12.12%
Condensed Matter Science	5,375,854	3.46%
CIMAR - NMR	4,745,995	3.06%
CIMAR - ICR	7,570,645	4.88%
CIMAR - EMR	1,965,073	1.27%
CIRL & REU	1,416,111	0.91%
ASC	3,949,609	2.54%
Electricity & Gases	35,175,488	22.66%
LANL	29,864,823	19.24%
UF - High B/T	1,738,032	1.12%
UF- AMRIS	3,898,083	2.51%
Diversity	599,826	0.39%
User Collaboration Grants Program[6]	4,970,482	3.20%
TOTAL NSF COOPERATIVE AGREEMENT	**$155,250,000**	**100.00%**

1 FY 2008 included award of $26,500,000 plus supplement of $1,250,000 for a total award of $27,750,000.
2 FY 2009 included award of $22,525,000 plus supplement of $3,975,000 for a total award of $26,500,000. Supplement ARRA funding of $5,000,000 is not included in the financial data reported in this budget section.
3 FY 2010 award was $26,500,000 plus August 2010 supplement funding of $6,500,000 for a total award of $33,000,000.
4 Supplement funding of $5,000,000 was received in Septemb UCGP (User Collaboration Grants Program) for FSU/NHMFL, LANL and UF reported as one line item. er 2010 as an advance of FY 2011 funding and is not included in the above financial data.
5 The National Science Foundation (National Science Board) approved funding of up to $162,000,000 for 2008-2012.
6 UCGP (User Collaboration Grants Program) for FSU/NHMFL, LANL and UF reported as one line item.

TABLE 2

NHMFL NSF Budget by Program with indirect cost separate from programs

Division/Program	2008	2009	2010	2011	2012	Total Budget
Director's Office	578,614	-453,866	2,051,017	114,925	113,361	2,404,051
Associate Director/ Management & Administration	1,554,740	1,676,171	1,688,772	2,278,394	2,315,820	9,513,897
DC Field Facility	2,286,768	2,168,960	2,180,666	2,754,017	2,802,336	12,192,747
Magnet Science & Technology	2,340,153	2,250,915	2,653,109	3,413,637	2,432,915	13,090,729
Condensed Matter Science	500,894	953,785	974,190	548,454	559,423	3,536,746
CIMAR - NMR	587,040	623,469	650,256	717,293	728,843	3,306,901
CIMAR - ICR	961,673	1,053,252	1,119,366	1,074,149	1,093,167	5,301,607
CIMAR - EMR	131,519	133,475	998,930	172,002	175,042	1,610,968
CIRL & REU[3]	187,807	216,087	258,735	205,043	209,146	1,076,818
ASC	447,101	490,014	1,233,965	290,938	296,921	2,758,939
Electricity & Gases	5,791,897	4,779,676	4,918,789	7,985,682	9,066,735	32,542,779
LANL	2,895,534	3,065,568	3,218,243	2,545,810	2,593,488	14,318,643
UF - High B/T	212,483	273,940	272,036	239,991	243,928	1,242,378
UF - AMRIS	500,159	562,705	556,443	605,862	614,980	2,840,149
Diversity	64,073	64,001	64,642	106,067	108,811	407,594
User Collaboration Grants Program[5]	897,225	911,400	1,208,143	967,185	986,529	4,970,482
Indirect Cost	7,812,320	7,730,448	8,952,698	9,980,551	9,658,555	44,134,572
TOTAL	**$27,750,000**	**$26,500,000**	**$33,000,000**	**$34,000,000**	**$34,000,000**	**$155,250,000**

1 Year 2008 includes supplement funding of $1,250,000.
2 Year 2009 award was $31,500,000 including ARRA funding of $5,000,000. As noted from the previous table, ARRA funds are being reported separately. The 2009 award was funded in three increments: $22,525,000, $3,975,000 and ARRA funds of $5,000,000
3 CIRL & REU includes RET funding of $70,357 for 2008, $95,357 for 2009, and $95,358 in 2010.
4 Supplement funding of $5,000,000 was received in September 2010 as an advance of FY 2011 funding and is not included in the above financial data.
5 UCGP (User Collaboration Grants Program)funding is reported as total research funds for FSU/NHMFL, UF and LANL.

Site Visits. For example, the September meeting of the NHMFL Executive Committee was devoted to diversity. As a result of the 2010 Site Visit, LANL staff initiated an outreach program to teachers in the Hispanic and Native American communities in New Mexico. This program will be modeled after the very successful outreach programs launched by the Magnet Lab in Tallahassee.

A diverse slate of candidates for new members to the NHMFL DC/Pulsed/High B/T Advisory Committee was presented to the users for their vote. One of the three elected members was female.

Budget

The National High Magnetic Field Laboratory operates with funding provided by federal, institutional, and industry sources. In addition, the Magnet Lab faculty and staff have been very successful in securing individual research funding for specific areas of research from a variety of sources, including federal and private sectors. Although the lab receives funding from numerous sources, the National Science Foundation (NSF) is its primary funding source for operations.

NSF Facilities Budget

The National Science Foundation Division/Directorate approved the National High Magnetic Field Laboratory's facilities renewal award on December 12, 2007 with an effective date of January 1, 2008. **Table 1** provides a view of the current 5-Year award. **Table 2** presents the annual NSF budgets for the 5-Year award period. **Table 3** summarizes the Magnet Lab's budget position as of December 31, 2010. The budget balance represents deferred capital and expense items, such as resistive magnets maintenance and upgrade, split magnet equipment purchases and other miscellaneous equipment.

Matching Commitment

The NSF award includes a matching commitment by the State of Florida through Florida State University which is 10% of the annual award. In addition, the State of Florida also provides institutional funds to the laboratory above the NSF matching requirement. The Magnet Lab utilizes these additional state resources as cost-sharing funds for other funding

TABLE 3

NSF Budget & Expenses Fiscal Year 2010

Expense Classification	Budget	Spent and Encumbered	Balance (12/31/2010)
Salaries and Fringe	7,578,276	8,118,244	-539,968
Subawards	7,675,002	7,306,473	368,529
Capital Equipment	3,348,929	3,598,344	-249,415
Other Direct Cost	8,908,525	5,743,994	3,164,531
Subtotal	27,510,732	24,646,886	2,863,846
Indirect	5,302,759	5,509,768	-207,009
Total before Indirect on Encumbrances	**$32,813,490**	**$30,156,654**	**- $2,656,836**
Estimated Indirect on Encumbrances	186,510	186,510	0
Adjusted Total	**$33,000,000**	**$30,343,163**	**$ 2,656,836**
Program Income	0	0	0

1 The negative budget balance in salaries results from a one-time salary bonus for FSU faculty and staff and the unbudgeted hiring of additional staff.
2 The negative budget balance in equipment results from encumbered funds for large, long lead-time equipment purchases.
3 Residual direct expense funds are being used to reconcile the deficit in the salary and equipment categories.

TABLE 4

Fiscal Year 2010/2011 State of Florida Matching and Contribution

	State Matching	State Contribution	Total State Funding
State of Florida Recurring Funds Cost-Sharing	3,300,000	5,894,104	9,194,104
Indirect Costs (52%)	1,716,000	3,064,934	4,780,934
TOTAL	**$5,016,000**	**$8,959,038**	**$13,975,038**

opportunities, as well as supporting other NSF activities. **Table 4** presents the State of Florida matching requirements and contribution provided through FSU.

American Recovery and Reinvestment Act (ARRA) Funding

In 2009, the laboratory received a $5,000,000 ARRA award from the NSF that provided the flexibility for the lab to up-grade systems, magnets and purchase upgrades for imaging and spectroscopy consoles.

ARRA funds are being used during 2009, 2010 and 2011 to mitigate prior budget reductions. Cumulative underfunding of the 5-Year NSF award led to the deferment of equipment replacement, preventive maintenance, projects and a reduction in DC magnet operations. The receipt of ARRA funds provides the National High Magnetic Field Laboratory (NHMFL) the ability to reinstate many of the deferred items.

A helium liquefier system is being purchased and installed to replace unreliable equipment that is 18-20 years old. This system will upgrade the cryogenics plant enabling the lab to maintain a state of the art facility for users. A magnet cooling pump has been purchased and installed to support the helium purification needs associated with the upgrade. The Florida State University has provided supplementary funds in the amount of $1.9 million dollars to support this enhancement.

The system components include a *liquefier* that will be used to recover helium gas via a lab-wide recovery system, purify and liquefy helium for re-use as coolant for superconducting magnets and for use with samples during scientific experiments.

A Central *Helium Distribution Box*, comprising valves, heat exchangers, and helium sub coolers, is being purchased to supply liquid helium for the 45 tesla hybrid magnet system and for the cryogenic shields. This is an interface between the output of the 750 W turbine helium liquefier and the current cooling system of the 45 tesla magnet. The system is also designed for future expansion and the next generation of hybrid magnets.

Vacuum jacketed transfer lines are a necessity for coupling the Central Distribution Box to the 45 tesla hybrid. These transfer lines will enable the cost-effective (and environmentally friendly) transfer of liquid helium.

The NHMFL is committing $475,270 from other non-federal funding sources to support the *purchase of a new Magnet Cooling Pump System.* The total cost of the project is $575,270 which includes $350,000 for a pump. ARRA funds in the amount of $100,000 will be applied to the purchase of a pump. The magnet cooling pump will provide increased cooling efficiency and the ability to operate longer magnet "run times" during Users' research projects.

Equipment purchases at the Los Alamos National Laboratory (LANL), via a sub-award, includes $639,000 to purchase emergency replacement parts for the 60T and 100T Long Pulse Magnet Systems. The *NHMFL Renewal Proposal for 2008-2012, Section 2.2: Realizing the Science, Page 31 clearly stated "…pulsed magnets are essentially "applied metal fatigue"; the consumption of 100T (and 60T) insert coils is a new and ongoing cost to the pulsed magnet program."* Without these replacement parts, any magnet failure will require immediate suspension of the respective Pulsed Magnet User Program.

Also, a *cryostat has been purchased and installed* at LANL - $71,013. Low loss cryostats decrease the consumption of liquid helium for magnet systems that are used in the User Program. The improved efficiency is required to offset the increasing costs of liquid helium.

Equipment purchases for the Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) Program at the University of Florida, via a sub-award, includes $200,000 to *purchase upgrades* for imaging and spectroscopy consoles. Four of the current consoles are over ten years old and nearing the end of their useful lives. Frequent component breakdowns are negatively impacting the NHMFL user program. However, commercial NMR instrument manufacturers have made great strides in digital technology over the last decade and *modernizing the AMRIS consoles* would yield gains in sensitivity, dynamics range, and pulse sequence programming that would further leverage the already impressive performance of our high magnetic fields and radiofrequency coils. These upgrades are necessary to support cutting-edge imaging and in-vivo spectroscopy experiments that are required by NHMFL external users.

NSF Business System Review

As a result of a successful NSF Business System Review in 2008-2009, The Associate Lab Director (ALD) was invited to present and discuss *NHMFL Best Practices at the 2009 and 2010 NSF Large Facilities Operations Workshop and to be Co-Chair of the 2011 NSF Large Facilities Workshop*. At the request of NSF, the ALD served as a management reviewer of two NSF-funded Large Facilities in 2010 and will serve as a reviewer of a third NSF-funded Large Facility in January 2011.

CHAPTER 10

Science & Research Productivity

The laboratory continued its strong record of publishing, giving presentations at conferences, and advising and training students who earn Master degrees and Ph.D.s. **Table 1** summarizes these activities, and the listings follows. For additional information, refer to the Magnet Lab's Web site: ***www.magnet.fsu.edu*** (/search/publications/search.aspx), where you can search the publications database and link to many articles online. Grant information, received from Florida State University and the University of Florida's respective offices of sponsored research, is also presented in this chapter, beginning on page 147.

Of the over 390 publications reported by Magnet Lab faculty and users, 212 (53%) appeared in some of the most prominent science and major disciplinary journals (**Table 2**).

TABLE 1

2010 Magnet Lab Activities Summary

	Number Reported	Page Number for Citations
Publications in Peer-Reviewed Journals	390	114
Presentations, Posters & Other Publications	312	130
Books, Book Chapters, Other One-time Publications	9	143
Internet Disseminations	6	143
Patents and Other Products	7	143
Awards	36	144
Dissertations, Ph.D.	47	145
Theses, Master	6	147

TABLE 2

2010 Prominent Journal Articles

Acta Materialia	1
Analytical Chemistry	6
Angewandte Chemie International Edition	2
Applied Physics Letters	6
Biochemistry	2
Biochimica et Biophysica Acta	1
Biophysical Journal	2
Chemistry of Materials	3
Cryogenics	1
Energy & Fuels	4
Environmental Science & Technology	5
IEEE Transactions on Applied Superconductivity	10
Inorganic Chemistry	7
International Journal of Mass Spectrometry	2
Journal of Applied Physics	5
Journal of Biomolecular NMR	2
Journal of Magnetic Resonance	4
Journal of Mass Spectrometry	1
Journal of Molecular Biology	1
Journal of Neuroscience	1
Journal of Physical Chemistry B	1
Journal of Physics-Condensed Matter	4
Journal of Proteome Research	1
Journal of the American Chemical Society	9
Journal of the American Society for Mass Spectrometry	2
Magnetic Resonance Imaging	1
Magnetic Resonance in Medicine	3
Nature	1
Nature Materials	5
Nature Physics	5
NeuroImage	3
Physical Review B	59
Physical Review B Rapid Communications	4
Physical Review Letters	23
Proceedings of the National Academy of Sciences of the United States of America	3
Protein Science	1
Rapid Communications in Mass Spectrometry	6
Science	4
Solid State Nuclear Magnetic Resonance	1
Superconductor Science and Technology	10
TOTAL	**212**

Peer-Reviewed Publications

This section lists over 390 articles that appeared in print in referred journals and conference proceedings in 2010. Journal titles appearing in **red boldface** are regarded by the laboratory as prominent or major disciplinary publications. To read a publication noted as [read online], go the "pubs database": ***http://www.magnet.fsu.edu/search/publications/search.aspx***

Abou Hamad, I.; Israels, B.; Rikvold, P.A. and Poroseva, S.V., *Spectral Matrix Methods for Partitioning Power Grids: Applications to the Italian and Floridian High-voltage Networks*, Physics Procedia, **4**, 125-129 (2010) [read online]

Abou Hamad, I.; Novotny, M.; Wipf, D.O. and Rikvold, P.A., *A new battery-charging method suggested by molecular dynamics simulations*, Phys. Chem. Chem. Phys., **12**, 2740-2743 (2010) [read online]

Althaus, E.; Canzar, S.; Ehrler, C.; Emmett, M.R.; Karrenbauer, A.; Marshall, A.G.; Meyer-Baese, A.; Tipton, J.D. and Zhang, H.-M., *Computing H/D-Exchange Rates of Single Residues from Data of Proteolytic Fragments*, BMC Bioinformatics, **11**, 424-436 (2010)

Amaricci, A.; Camjayi, A.; Haule, K.; Kotliar, G.; Tanaskovic, D. and Dobrosavljevic, V., *Extended Hubbard model: Charge ordering and Wigner-Mott transition*, **Phys. Rev. B**, **82**, 155102 (2010) [read online]

Analytis, J.G.; Chu, J.H.; Chen, Y.L.; Corredor, F.; McDonald, R.D.; et al., *Bulk Fermi surface coexistence with Dirac surface state in Bi_2Se_3: A comparison of photoemission and Shubnikov-de Haas measurements*, **Phys. Rev. B**, **81** (20), 205407 (2010)

Analytis, J.G.; Chu, J.H.; McDonald, R.D.; Riggs, S.C. and Fisher, I.R., *Enhanced Fermi-Surface Nesting in Superconducting $BaFe_2(As_{1-x}P_x)_2$ Revealed by the de Haas-van Alphen Effect*, **Phys. Rev. Lett.**, **105** (20), 207004 (2010) [read online]

Analytis, J.S.; McDonald, R.D.; Riggs, S.C.; Chu, J.-H; Boebinger, G.S. and Fisher, I.R., *Two-dimensional surface state in the quantum limit of a topological insulator*, **Nature Physics**, **DOI: 10.1038** (NPHYS1861), 1-4 (2010)

Andino, J.G.; Kilgore, U.J.; Pink, M.; Ozarowski, A.; Krzystek, J.; Telser, J.; Baik, M.-H. and Mindiola, D., *Intermolecular C–H bond activation of benzene and pyridines by a vanadium(III) alkylidene including a stepwise conversion of benzene to a vanadium-benzyne complex*, Chem. Sci., **1**, 351-356 (2010) [read online]

Andrade, E. C.; Miranda, E. and Dobrosavljevic, V., *Quantum ripples in strongly correlated metals*, **Phys. Rev. Lett.**, **104** (23), 236401 (2010) [read online]

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Zhou, H.D.; Choi, E.S.; Jo, Y.J.; Balicas, L.; Lu, J.; Lumata, L.L.; Urbano, R.R.; Kuhns, P.L.; Reyes, A.P.; Brooks, J.S.; Stillwell, R.; Tozer, S.W.; Wiebe, C.R.; Whalen, J. and Siegrist, T., *Metamagnetic transition in single-crystal $Bi_4Cu_3V_2O_{14}$*, **Phys. Rev. B**, **82**, 054435 (2010) [read online]

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Zhou, H.D.; Wiebe, C.R.; Janik, J.A.; Vogt, B.; Harter, A.; Dalal, N.S. and Gardner, J.S., *Spin glass transitions in the absence of chemical disorder for the pyrochlores $A_2Sb_2O_7$ (A=Mn, Co, Ni)*, J. Solid State Chem., **183**, 890 (2010)

Zhu, Y.; Hunte, F.; Baily, S.A.; Balakirev, F.F.; Zhuang, C.G.; Feng, Q.R.; Gan, Z.Z.; Xi, X.X.; Larbalestier, D.C. and Voyles, P.M., Corrigendum, *MgO platelets and high critical field in MgB_2 thin films doped with carbon from methane, 2009 Supercond. Sci. Technol.* 22, 125001, **Superconductor Science and Technology**, **23**, 049801 (2010) [read online]

Zhu, Y.; Pogrebnyakov, A.V.; Wilke, R.H.; Chen, K.; Xi, X.X.; Redwing, J.M.; Zhuang, C.G.; Feng, Q.R.; Gan, Z.Z.; Singh, R.K.; Shen, Y.; Newman, N.; Rowell, J.M.; Hunte, F.; Jaroszynski, J.; Larbalestier, D.C.; Baily, S.A.; Balakirev, F.F. and Voyles, P.M., *Nanoscale disorder in pure and doped MgB_2 thin films*, **Superconductor Science and Technology**, **23**, 095008 (2010) [read online]

Presentations, Posters & Abstracts

This section lists invited and contributed talks and papers at conferences; papers in conference proceedings that were not peer-reviewed; posters; abstracts; and presentations at universities and public forums in 2010. More than 300 activities were reported this year.

Abou Hamad, I.; Israels, B.; Rikvold, P.A. and Poroseva, S.V., Spectral Matrix Methods for Partitioning Power Grids: Applications to the Italian and Floridian High-voltage Networks, 23rd Workshop on Recent Developments in Computer Simulation, Athens, GA, February 22-26 (2010); Published in Physics Procedia, **4**, 125-129 (2010) [read online]

Abou Hamad, I.; Novotny, M.A.; Wipf, D.O. and Rikvold, P.A., *Charging Time Dependence of a New Charging Method on the Direction of an Additional Oscillating Field*, 218th Meeting of the Electrochemical Society, Las Vegas, NV, October 10-15 (2010)

Abou Hamad, I.; Poroseva, S.V.; Israels, B. and Rikvold, P.A., *Optimization of a Power-grid Islanding Algorithm Using Monte Carlo Simulations*, Annual Meeting of the Four Corners Section of the APS, Ogden, UT, October 15-16 (2010)

Abraimov, D.; Li, P.; Feenstra, R.; Li, X.; Rupich, M.; Kametani, F.; Lee, S.; Eom, C.; Jiang, J.; Weiss, J.; Hellstrom, E. and Larbalestier, D.C., *Comparison of current limiting defects in $YBa_2Cu_3O_{7-x}$ and $Ba(Fe_{1-x}Co_x)As_2$ films*, Applied Superconductivity Conf. 2010, Washington D.C., August 1-6 (2010) [read online]

Abraimov, D.; Li, P.; Jiang, J.; Weiss, J.; Hellstrom, E.; Larbalestier, D.C.; Feenstra, R.; Li, X.; Rupich, M.; Lee, S. and Eom, C.-B., *Current limiting defects in $Ba(Fe_{1-x}Co_x)_2As_2$ and $YBa_2Cu_3O_{7-x}$ films* (invited talk), Materials Science & Technology 2010, Houston, TX, October 17-21 (2010) [read online]

Altarawneh, M.M.; Mielke, C.H.; McDonald, R.D.; Mitchell, J.N.; Ronning, F.; Kennison, J.A. and Bauer, E.D., *Superconductivity in $PuCoGa_5$*, SCES 2010, Santa Fe, NM, June 28-July 2 (2010)

Arevalo-Hidalgo, A.G. and Hernandez-Maldonado, A.J., *Separation of CO_2 from Light Gas Mixtures using Nanoporous Silicoaluminophosphate Sorbents*, 2010 American Chemical Society National Meeting, San Francisco, CA, March 21-25 (2010) [read online]

Atolia, E.; McKenna, A.M.; Rodgers, R.P.; Reddy, C.M.; Nelson, R.K. and Marshall, A.G., *3D Graphical Analysis of Ultrahigh-Resolution FT-ICR Mass Spectrometry Data. Comparison of a Crude Oil and Associated Production Deposit*, Symp. on Heavy Oil Production and Fouling, 239th Amer. Chem. Soc. Natl. Mtg., San Francisco, CA, March 21-25 (2010)

Bai, H.; Adkins, T.; Bole, S.; Dixon, I.; Marks, L.; Miller, G.; Noyes, P.; Painter, T.A.; Stanton, R.; Weijers, H.W. and Xu, T., *Joint Design and Test for the SCH*, Applied Superconductivity Conf., Washington, D.C., August 1-6 (2010) [read online]

Balicas, L., *Torque magnetometry in single-layer oxypnictide single-crystals*, University of Maryland, Physics Dept., College Park, MD, November (2010)

Bebout, B.; Taxaz, A.; Kelley, C.A.; Poole, J.A.; Davila, A. and Chanton, J., *Methane as a biomarker in the search for extraterrestrial life: Lessons learned from Mars analog hypersaline environments*, AGU, San Francisco, CA, December 13-17 (2010); Published in Accounts of Chemical Research (0)

Beck, B.L., *RF Prototyping Techniques*, Engineering Workshop, Int. Society of Magnetic Resonance in Medicine, Stockholm, Sweden, May 1-2 (2010) [read online]

Besara, T.; Kim, Y.H.; Kaur, N.; Kuhns, P.L.; Reyes, A.P.; Dalal, N.S. and Takano, Y., *Study of the Quantum Phase Transition in Cr(dien)$(O_2)_2 \cdot H_2O$ by means of ^1H NMR*, American Physical Society March Meeting, Portland, OR, March 15-19 (2010) [read online]

Beu, S.C.; Hendrickson, C.L. and Marshall, A.G., *Design Considerations for External Ion Injection FT-ICR MS at 21 Tesla,* 58th Amer. Soc. for Mass Spectrom. Annual Conf. on Mass Spectrometry & Allied Topics, Salt Lake City, UT, May 23-27 (2010)

Bird, M.D.; Adkins, T.; Bai, H.; Bole, S.; Cantrell, K.; Chen, J.P.; Dixon, I.R.; Han, K.; Lu, J.; Miller, J.R.; Painter, T.A.; Walsh, R.; Weijers, H.W.; Ehmler, H. and Smeibidl, P., *Status of the NHMFL CICC Magnet Program*, Applied Superconductivity Conf., Washington, D.C., August 1-6 (2010)

Bogner, J.E.; Spokas, K. and Chanton, J., *A field-valided model for landfill methane emissions inclusive of seasonal methane oxidation,* AGU, San Francisco, CA, December 13-17 (2010)

Bollinger, R.K.; White, B.D.; Neumeier, J.J.; Suzuki, Y.; Betts, J.B.; Migliori, A.; Sandim, H.R. and Dos Santos, C., *Anomalous Properties of Single Crystal Niobium*, American Physical Society March Meeting, Portland, OR, March 15-19 (2010)

Bonesteel, N.E., *Entanglement and Bond Fluctuations in Random Singlet Phases (Invited Talk),* Quantum Information Concepts for Condensed Matter Problems, MPIPKS Dresden, Germany, June 14-25 (2010)

Bonesteel, N.E., *Lectures on Topological Quantum Computation (Series of 4 lectures)*, 10th Canadian Summer School on Quantum Information, Pacific Institute for the Mathematical Sciences, Vancouver, Canada, July 28-29 (2010) [read online]

Bonesteel, N.E., *Quantum Computing with Braids*, Colloquium, University of North Carolina, Chapel Hill, Physics Department, January 11 (2010)

Bonesteel, N.E.; Cipri, R. and Zeuch, D., *Pulse Sequences for Exchange-Based Quantum Computation (Contributed Talk)*, American Physical Society March Meeting, Portland, OR, March 15-19 (2010) [read online]

Bou-Assaf, G.M.; Chamoun, J.E.; Fajer, P.G.; Emmett, M.R. and Marshall, A.G., *Calcium-induced conformational changes in the cardiac isoform of the troponin complex monitored by hydrogen/deuterium exchange and Fourier transform ion cyclotron resonance mass spectrometry*, 54th Biophysical Society Annual Meeting, San Francisco, CA, February 20-24 (2010)

Brinzari, T.; Xu, X.S.; Zhou, H.D.; Wiebe, C.R.; McGill, S.A. and Musfeldt, J.L., *Absence of Spin-Liquid Behavior: Magneto-optical Study of* $Nd_3Ga_5SiO_{14}$, American Physical Society March Meeting, Portland, OR, March 15-19 (2010)

Burch, K.; Chen, F.; Azad, A.; O'Hara, J.; Mack, S.; Dttelbaum, A.M.; Montano, G.; Zapf, V.S.; Awschalom, D.D.; Averitt, R.D. and Taylor, A.J., *Ultra-fast Creation and Destruction of Ferromagnetic Nanowires*, American Physical Society March Meeting, Portland, OR, March 15-19 (2010)

Bythell, B.; Molesworth, S.; Young, S.; Hendrickson, C.L.; Marshall, A.G.; Van Stipdonk, M.J. and Paizs, B., *Fragmentation Chemistry of Phosphorylated and De-phosphorylated, Protonated Peptides*, 58th Amer. Soc. for Mass Spectrom. Annual Conf. on Mass Spectrometry & Allied Topics, Salt Lake City, UT, May 23-27 (2010)

Cao, H.; Miotkowski, I.; Shen, T. and Chen, Y.P., *Magneto-transport and quantum oscillation in Bi2Se3*, Physical Phenomena at High Magnetic Fields – VII, Tallahassee, FL, December 5 (2010) [read online]

Chanton, J.; Corbett, J.; Burdige, D.J.; Gaser, P.H.; Cooper, W.T. and Tfaily, M.M., *Partitioning peat respiration with stable carbon isotopes*, AGU, San Francisco, CA, December 13-17 (2010)

Cheesman, A.W., *Phosphorus Composition of Wetland Soils: Application of* ^{31}*P NMR Spectroscopy*, Invited Presentation, Cranfield University. UK, June (2010)

Cheesman, A.W.; Turner, B.L. and Reddy, K.R., *Phosphorus composition in Palustrine Wetlands: a* ^{31}*P NMR study*, Soil Science Society of America Conf., Long Beach, CA, November (2010)

Cherian, J.; Zhou, H.D.; Brooks, J. and McGill, S.A., *Second Harmonic Generation in* $MnTiO_3$, American Physical Society March Meeting, Portland, OR, March 15-19 (2010)

Civale, L.; Baily, S. and Maiorov, B., *Comparative study of flux creep in superconductors over a broad spectrum of pinning properties*, 2010 American Physical Society March Meeting, Portland, OR, USA, 15-19-MAR (2010)

Cole, M. and Han, K., *Nanostructured Materials in CuAg by Cyclic Cold Rolling*, 2010 Annual Biomedical Research Conference for Minority Students (ABRCMS), November 13 (2010)

Cooper, W.T.; Podgorski, D.C.; Osborne, D.M.; Corbett, J. and Chanton, J., *Indetification of Reactive and Refractory Components of Dissolved Organic Nitrogen by FT-ICR Mass Spectrometry*, AGU, San Francisco, CA, December 13-17 (2010)

Cotten, M.; Fu, R.; Sharma, M.; Wieczorek, W.; Baxter, M.K.; McGavin, J.A.; Dao, A.E.; Smajic, N.; De Angelis, A.A.; Seckute, J.; Sudheendra, U.S.; Pastor, R.W.; Venable, R.M.; Nicholson, L. and Opella, S.J., *High Resolution Solid-State NMR Structural Studies of Two Piscidin Isoforms in Aligned Lipid Bilayers: Implications for Membrane Activity*, 12th Annual Upstate NY NMR Symposium, Albany, NY, November 29 (2010) [read online]

Crooker, S.A., *Imaging electron spin transport in semiconductor spintronic devices,* Materials Capability Review, LANL, Los Alamos, NM, May 5 (2010)

Crooker, S.A., *Imaging spin injection and spin transport in semiconductors*, DPG Physics School on Nano-Spintronics, Bad Honnef, Germany, September 15 (2010)

Crooker, S.A., *Listening to the spin noise of electrons and holes in semiconductors,* Condensed Matter Seminar, University of California - San Diego, CA, February 3 (2010)

Crooker, S.A., *Listening to the spin noise of electrons and holes in semiconductors*, DPG Physics School on Nano-Spintronics, Bad Honnef, Germany, September 16 (2010)

Crooker, S.A., *Listening to the spin noise of electrons and holes in semiconductors,* High Magnetic Field Laboratory, Grenoble, France, September 22 (2010)

Crooker, S.A., *Listening to the spin noise of electrons and holes in semiconductors*, Laboratoire National des Champs Magnétiques Intenses, Toulouse, France, September 20 (2010)

Crooker, S.A., *Listening to the spin noise of electrons and holes in semiconductors*, PASPS-VI, Tokyo, Japan, August 1-4 (2010)

Crooker, S.A., *Listening to the spin noise of electrons and holes in semiconductors*, University of Buffalo, Department of Physics, Buffalo, NY, October 7 (2010)

Crooker, S.A., *Listening to the spin noise of electrons and holes in semiconductors,* University of Rochester, Department of Electrical Engineering, Rochester NY, October 6 (2010)

Crooker, S.A., *Spin physics and exciton fine structure in semiconductor nanocrystals*, Center for Advanced Solar Photophysics, LANL, Los Alamos, NM, March 8 (2010)

Crooker, S.A., *Tunable coupling between electronic and magnetic degrees of freedom in colloidal semiconductor nanocrystals*, MRS Fall Meeting, Boston, MA, November 28-December 3 (2010)

Crooker, S.A.; Brandt, J.; Sandfort, C.; Yakovlev, D.R.; Bayer, M.; Reuter, D. and Wieck, A., *Spin noise of electrons and holes in self-assembled InGaAs quantum dots,* American Physical Society March Meeting, Portland, OR, March 15-19 (2010)

Crooker, S.A.; Schaller, R.D.; Bussian, D.; Pietryga, J. and Klimov, V.I., *Dark Excitons in PbSe Nanocrystals*, American Physical Society March Meeting, Portland, OR, March 15-19 (2010)

Cross, T.A., *From PISA Wheels to High Resolution Membrane Protein Structure,* Biological Solid State NMR Winter School, Stowe, VT, January (2010)

Cross, T.A., *Membrane Protein: Expression, Purification, Reconstitution, and Sample Preparation*, Biological Solid State NMR Winter School, Stowe, VT, January (2010)

Cross, T.A., *Sorting Structural Reality from Among the Artifacts: The M2 Proton Channel*, Biological Solid State NMR Winter School, Stowe, VT, January (2010)

Cross, T.A.; Sharma, M.; Busath, D. and Zhou, H.-Z., *Sorting Structural Reality from the Artifacts: In Search of Membrane Protein*

Functional Understanding, 93rd Canadian Chemistry Conf. and Exhibition, Toronto, Canada, May (2010)

Cross, T.A.; Sharma, M.; Busath, D. and Zhou, H.-Z., *Sorting Structural Reality from the Artifacts: In Search of Membrane Protein Functional Understanding*, Int. Conf. on Magnetic Resonance in Biological Systems, Cains, Australia, August (2010)

Cross, T.A.; Sharma, M.; Busath, D. and Zhou, H.-Z., *Sorting Structural Reality from the Artifacts: In Search of Membrane Protein Functional Understanding*, Int. Society for Magnetic Resonance, Florence, Italy, July (2010)

Curtis, J.; Moore, J.; Tokumoto, T.; Cherian, J.; Kono, J.; Belyanin, A.; McGill, S.A. and Hilton, D.J., *The Terahertz Frequency Hall Conductivity of a High-Mobility Two-Dimensional Electron Gas*, American Physical Society March Meeting, Portland, OR, March 15-19 (2010)

Dalban-Canassy, M.; Trociewitz, U.P.; Noyes, P.; Viouchkov, Y. and Pamidi, S., Quench *Initiation in YBCO Layer-wound Coils Using AC Current or AC Magnetic Field*, Applied Superconductivity Conf., Washington, D.C., August 1-6 (2010)

Davis, F.A.; Hirschmann, M.M.; Humayun, M. and Cooper, R.S., *Experimental investigation of properties of low degree partial melts of garnet peridotite and their role in OIB genesis*, AGU, San Francisco, CA, December 13-17 (2010)

Delis, F.; Grant, S.; Wang, G.; Volkow, N. and Thanos, P., *Three months of daily methamphetamine exposure increase the volume of the rat striatum*, Proc. 2010 Society for Neuroscience, San Diego, CA, November 13-17 (2010)

Dobrosavljevic, V., *Quantum-Critical Transport Near Interaction-Driven Metal-Insulator Transitions*, invited talk at the "2010 Gordon Research Conference on Strongly Correlated Electrons", Mt. Holyoke College. South Hadley, MA, June 12-14 (2010) [read online]

Dobrosavljevic, V., *Quantum-Critical Transport Near Interaction-Driven Metal-Insulator Transitions*, invited talk at the "Workshop on Complex Oxides", Santorini, Greece, June 15-18 (2010) [read online]

Drichko, I.L.; Smirnov, I.Yu.; Suslov, A.V.; Mironov, O.A. and Leadley, D.R., *Magnetoresistance in Dilute p-Si/SiGe with Anisotropic g*-factor in Tilted Magnetic Field*, Int. Conf. "Physical Phenomena at High Magnetic Fields-VII" (PPHMF-VII), Tallahassee, FL, December 4-8 (2010); Published in Conference program, 136 (2010)

Drichko, I.L.; Smirnov, I.Yu.; Suslov, A.V.; Mironov, O.A. and Leadley, D.R., *Magnetoresistivity and Acoustoelectronic Effects in a Tilted Magnetic Field in p-Si/SiGe/Si Structures with an Anisotropic g Factor*, XVIII Ural International Winter School on the Physics of Semiconductors February 15-20 (2010), Ekatirenburg-Novouralsk, Russia, February 15-20 (2010); Published in Book of Abstracts, 61 (2010)

Drichko, I.L.; Smirnov, I.Yu.; Suslov, A.V.; Mironov, M.; Mironov, O.A. and Leadley, D.R., *Ferromagnetic-paramagnetic transition in p-Si/SiGe / Si with an anisotropic g-factor in a tilted magnetic field*, The XIV Annual Symposium of "Nanophysics and Nanoelectronics", Nizhny Novgorod, March 15-19 (2010); Published in Book of Abstracts, **1**, 121 (2010)

Dugar, S.; Fu, R. and Dalal, N.S., *Resolution Enhancement in ^{13}C CP-MAS NMR using Single Crystals: Studies on Metal Octaethyl Porphyrins*, Rocky Mountain Conf. on Solid State NMR, Aspen, CO, August 1-5 (2010)

Dugar, S.; Fu, R.; Kitchen, J.; Gor'kov, P.; Brey, W.W. and Dalal, N.S., *Unusual Splitting of ^{31}P Peaks in the CP-MAS of Single Crystals of Ferroelectric RbH_2PO_4 at 900 MHz*, 51st Experimental Nuclear Magnetic Resonance Conf., Daytona, FL, April 18-23 (2010) [read online]

Edison, A.S., *High Sensitivity NMR Probes for Natural Products and Metabolomics,* LabAutomation 2010, Palm Springs, CA, January 25-27 (2010)

Edison, A.S., *New Advanced NMR Methodology for Natural Products and Drug Discovery: Applications to Nematodes*, 1st Workshop on Metabolomics in the Context of Systems Biology: A Rational Approach to Search for Lead Molecules from Nature., São Paulo city, State of São Paulo, February 25-26 (2010)

Edison, A.S., *New Approaches to Natural Products and Metabolomics: Applications to Nematode Chemical Ecology*, Latin American Association of Chemical Ecology (ALAEQ), Colonia del Sacramento, Uruguay, October 17-20 (2010)

Edison, A.S., *The Merging of Metabolomics and Natural Products: Applications in Chemical Communication of Nematodes*, Invited Speaker EUROMAR 2010 and 17th Int. Society of Magnetic Resonance Conference, Florence, Italy, July 5-9 (2010)

Ehrmann, B.M.; Robbins, W.K.; Rodgers, R.P. and Marshall, A.G., *Asphaltene Co-Precipitate Molecular Progression as a Function of Soxhlet Extraction Period, Illuminated by Negative ESI FT-ICR MS*, 58th Amer. Soc. for Mass Spectrom. Annual Conf. on Mass Spectrometry & Allied Topics, Salt Lake City, UT, May 23-27 (2010)

Emmett, M.R.; He, H.; Nilsson, C.L.; Kroes, R.A.; Moskal, J.R.; Groves, M. and Conrad, C.A., *Lipid Profiling in a Systems Biology Approach to Cancer Research: Response, Targets and Biomarkers*, 7th Annual Ardgour Symposium, Edinburgh, Scotland, September 27 (2010)

Emmett, M.R.; Tipton, J.D.; Nilsson, C.L.; Sheng, X.; Conrad, C.A. and Marshall, A.G., *Secretion Vesicle Proteomics: Glioblastoma Exosome and Modulation by Wild-Type p53 Gene Therapy*, 58th Amer. Soc. for Mass Spectrom. Annual Conf. on Mass Spectrometry & Allied Topics, Salt Lake City, UT, May 23-27 (2010)

Emmett, M.R.; Wang, X.; Marshall, A.G.; Fokt, I.; Skora, S.; Conrad, C.A. and Priebe, W., *Characterization of the Effects of 2-Deoxyglucose on Global N-Glycosylation in Glioblastoma-Derived Cancer Stem Cells,* 2010 Soc. for NeuroOncology Annual Mtg., Montreal, Canada, November 18-21 (2010)

Fanelli, V.R.; Migliori, A.; Suzuki, Y. and Betts, J.B., *Elastic moduli, Debye Waller and electron localization in plutonium, Plutonium Futures*, The Science 2010 Meeting, Keystone, CO, September 19-23 (2010)

Fanelli, V.R.; Riggs, S.C.; Shekhter, A.; Suzuki, Y.; Betts, J.B.; Migliori, A.; Boebinger, G.S.;

Bonn, D.; Hardy, W. and Liang, R., *Resonant Ultrasound Spectroscopy signatures of $YBa_2Cu_3O_{6.56}$ Phase Diagram in the range 20 K - 310 K,* Int. Conf. on Strongly Correlated Electron Systems, Santa Fe, NM, June 27-July 2 (2010)

Foroutan, P.; Cappendijk, S.L.T. and Grant, S.C., *Contrast Enhancement in Preserved Tissue Utilizing Low Temperatures at High Magnetic Fields*, 18th Joint Annual Int. Society for Magnetic Resonance in Medicine and European Society for Magnetic Resonance in Medicine and Biology Conf., Stockholm, Sweden, May 1-7 (2010)

Foroutan, P.; Schweitzer, K.J.; Dickson, D.W.; Broderick, D.F.; Klose, U.; Berg, D.; Wszolek, Z.K. and Grant, S.C., *High Resolution ^1H MRI of Postmortem Human Brain Sections Performed at 21.1 T,* 18th Joint Annual Int. Society for Magnetic Resonance in Medicine and European Society for Magnetic Resonance in Medicine and Biology Conf., Stockholm, Sweden, May 1-7 (2010)

Franco, A. Jr.; Machado, F.A.; Zapf, V.S. and Wolff-Fabris, F., *Enhanced magnetic properties of Bi-substituted cobalt ferrites,* Magnetism and Magnetic Materials Conf., Atlanta, GA, November 15-19 (2010)

Fu, R., *Dynamics of Cross-Polarization Mediated Spin Diffusion in NMR of Aligned Sample,* 39th Southeastern Magnetic Resonance Conf. (SEMRC), Gainesville, FL, October 22-24 (2010)

Fu, R., *High Field Solid-State NMR and Applications to Materials Science*, Department of Chemical Engineering, University of Puerto Rico – Mayaguez, March 15-17 (2010)

Fu, R., *Studies of Phase Transition in Model Compounds by High Resolution Solid-State NMR at High Fields*, Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui Province, China, July 14 (2010)

Fu, R.; Gunaydin-Sen, O. and Dalal, N.S., *CPMAS with Crystals at 900 MHz: First Detection of Pretransitional Clusters above a Paraelectric-Antiferroelectric Phase Transition*, 51st Experimental Nuclear Magnetic Resonance Conf. (ENC), Daytona Beach, FL, April 18-23 (2010)

Fu, R.; Truong, M.; Hibbard, D.J.; Wieczorek, W.; Gordon, E.D. and Cotten, M., *Enhanced Resolution Using Dipolar-Encoded HETCOR Spectroscopy at Ultra-High Field: A Critical Advantage for Structural Determination of Peptides in Aligned Bilayers*, 51st Experimental Nuclear Magnetic Resonance Conf. (ENC), Daytona Beach, FL, April 18-23 (2010)

Gavrilin, A.V. and Markiewicz, W.D., *Analysis of the Performance of Quench Protection Heaters for YBCO Coils of Very High Field Superconducting Magnets,* Applied Superconductivity Conf., Washington, D.C., August 1-6 (2010)

Gebre, T.; Balicas, L.; Xin, Y.; Whalen, J. and Siegrist, T., *Physical properties of $FeSe_{1-x}Te_x$ single crystals,* American Physical Society March Meeting, Portland, OR, March (2010)

Goddard, R.E.; Padelford, J.; Han, K. and Lu, J., *EBSD Investigation of Twinned Copper,* Microscopy and Microanalysis 2010, Portland, OR, August 1-5 (2010); Published in Microscopy and Microanalysis, **16** (1) (2010)

Gor'kov, L.P. and Teitel'baum, G.B., *Inherent Inhomogeneity of the Superconducting Iron Pnictides,* PPHMF-VII, Tallahassee, FL, December 4-7 (2010)

Gor'kov, L.P. and Teitel'baum, G.B., *On the Formation of the Soliton Phase in Iron Pnictides,* Conference on Strongly Correlated Electron Systems, SCES 2010, Santa Fe, NM, June 27-July 2 (2010)

Gor'kov, P.L.; Hung, I.; Qian, C., Kitchen, J.A., Hou, G., Han, Y., Polenova, T. and Brey, W.W., *Efficient triple-resonant $^1H/X/Y$ low-E MAS probe for biological applications*, ENC, Daytona Beach, FL, April 18-23 (2010)

Görke, R.; Meyer-Bäse, A.; Wagner, D.; He, H.; Emmett, M.R.; Marshall, A.G. and Conrad, C.A., *Determining and Interpreting Correlations in Lipidomic Networks Found in Glioblastoma Cells*, SPIE Evolutionary and Bio-Inspired Computation: Theory and Applications IV, Orlando, FL, April 7-8 (2010)

Graber, L.; Infante, D., Steurer, M. and Brey, W.W., *Validation of Cable Models for Simulation of Transients in Shipboard Power Systems*, Int. Conf. on High Voltage Engineering and Application, New Orleans, LA, October 11-14 (2010) [read online]

Graf, D., Stillwell, R., Park, J.-H., Murphy, T., Palm, E.C., Kato, R., Cui, H.B., and Tozer, S.W., *Fermi Surface Study of Valence Bond Solid EtMe3P[Pd(dmit)2]2 Under Pressure*, Gordon Research Conf., Holderness, NH, June 27-July 2 (2010)

Granroth, G.E.; Savici, A.T.; Bird, M.D.; Santodonato, L.; Lee, Y. and Broholm, C.L., *Zeemans: A High Magnetic Field Beamline for the SNS*, 19th Meeting on Collaboration of Advanced Neutron Sources, Grindelwald, Switzerland, March 8-12 (2010)

Guenster, Ch.; Molodov, D.A. and Gottstein, G. (Guenter), *Magnetically induced motion of grain boundaries in Zn bicrystals, Recrystallization and Grain Growth*, Sheffield, UK, July 6 (2010)

Guenster, Ch.; Molodov, D.A. and Gottstein, G., *Magnetically induced motion of grain boundaries in Zn bicrystals*, MAP4, Atlanta, GA, May 12 (2010)

Gurevich, A., *Effect of defects on the physics of SRF*, 6th Materials SRF Workshop, NHMFL, Tallahassee, FL, February 19-20 (2010)

Gurevich, A., *Ferropnictides at high magnetic fields: the role of pairing symmetry and impurity scattering*, American Physical Society March Meeting, Portland, OR, March 16 (2010)

Gurevich, A., *Impurity effects and current transport in oxypnictides at high magnetic fields*, Int. Conf. of Superconductivity and Magnetism, Antalya, Turkey, April 25-30 (2010)

Gurevich, A., *Nonlinear Meissner Effect and Enhancement of the Field Onset of Penetration of Vortices in Dirty Nb Films Under RF and DC Fields*, 6-th Thin Film SRF Workshop, Padova, Italy, October 4-6 (2010)

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Zapf, V.S., *Bose-Einstein Condensation in an S = 1 Organic Quantum Magnet*, American Physical Society March Meeting, Portland, OR, March (2010)

Zapf, V.S., *Frustration-induced multiferroic behavior in organo-metallics*, Strongly Correlated Electron Systems, Santa Fe, NM, June (2010)

Zapf, V.S., *Multiferroic behavior and boson masses in organic quantum magnets*, Invited talk, Calorimetry Conf., Colorado Springs, CO, July 18-23 (2010)

Zapf, V.S., *Power and pitfalls of high magnetic fields*, Center for Nonlinear Studies, Los Alamos National Lab, May (2010)

Zapf, V.S., *Quantum Magnetism in* $NiCl_{2-4}SC(NH_2)_2$, Stanford University, February (2010)

Zapf, V.S., *Thermal Conductivity and the Boson Mass in the Bose-Einstein Condensate compound* $NiCl_{2-4}SC(NH_2)_2$, American Physical Society March Meeting, Portland, OR, March (2010)

Zapf, V.S.; Batista, C.D.; Sengupta, P.; Kenzelmann, M.; Wolff-Fabris, F.; Balakirev, F.; Jaime, M. and Paduan-Filho, A., *Multiferroic behavior in organo-metallic quantum magnets*, Physical Phenomena in High Magnetic Fields VII, Tallahasse, FL, December 4-8 (2010)

Zhang, H.-M.; Guo, M.; Yang, X.-L.; Schimmel, P.; Zhang, Q.; Emmett, M.R. and Marshall, A.G., *Contact Surface Mapping of LysRS in its Multi-Functional States by Solution-Phase Hydrogen/Deuterium Exchange Monitored by FT-ICR Mass Spectrometry*, 24th Protein Soc. Ann. Symp., San Diego, CA, August 24 (2010)

Zhang, H.-M.; Yu, X.; Greig, M.J.; Gajiwala, K.S.; Wu, J.C.; Diehl, W.; Lunney, E.A.; Emmett, M.R. and Marshall, A.G., Conformational *Basis for the Drug Inhibition and Resistance Mechanism of KIT Tyrosine Kinase, Determined by H/D Exchange FT-ICR MS*, 58th Amer. Soc. for Mass Spectrom. Annual Conf. on Mass Spectrometry & Allied Topics, Salt Lake City, UT, May 23-27 (2010)

Zhang, Q.; Blakney, G.T.; Emmett, M.R.; Zhang, H.-M.; Maddox, K.; Stagg, S.M. and Marshall, A.G., *Front-End Automation for Solution-Phase H/D Exchange FT-ICR Mass Spectrometry*, 58th Amer. Soc. for Mass Spectrom. Annual Conf. on Mass Spectrometry & Allied Topics, Salt Lake City, UT, May 23-27 (2010)

Zhou, J.; Jo, Y.; Sung, Z.; Lee, P.J. and Larbalestier, D., *Compositional and structural dependence of Hc2 in pure and alloyed* Nb_3Sn, Low Temperature High Field Superconductivity Workshop 2010, Monterey, CA, November 8-12 (2010)

Zhou, J.; Jo, Y.; Sung, Z.; Lee, P.J. and Larbalestier, D., *Does Tetragonal* Nb_3Sn *Really Have Lower Hc2 Than Cubic* Nb_3Sn*?*, 2010 Applied Superconductivity Conf., Washington D.C., August 1-6 (2010)

Zou, G.; Luo, H.; Baily, S.; Zhang, Y.; Xiong, J.; Zhai, J. and Bauer, E., *Enhanced Irreversibility Field and Critical Current Density in Superconducting NbC Integrated With Aligned Carbon Nanotubes*, 2010 Materials Research Society Spring Meeting, San Francisco, CA, April 7 (2010)

Zudov, M.A., *Emergent nonlinear transport phenomena in very high Landau levels*, 19th Int. Conf. on High Magnetic Fields in Semiconductor Physics (HMF-19), Fukuoka, Japan, August 1-6 (2010)

Zudov, M.A., *Nonlinear transport in very high Landau levels*, Advanced Research Workshop: Fundamentals of electronic nanosystems, Saint Petersburg, Russia, June 26-July 2 (2010)

Zudov, M.A.: Hatke, A.T.; Chiang, H.-S.; Pfeiffer, L.N. and West, K.W., *Emergent nonlinear transport phenomena in very high Landau levels*, 30th Int. Conf. on the Physics of Semiconductors (ICPS-30), Seoul, Korea, July 25-30 (2010)

Zudov, M.A.; Hatke, A.T.; Chiang, H.-S.; Pfeiffer, L.N. and West, K.W., *States with zero differential resistance in high mobility quantum Hall systems driven by dc electric fields*, 18th Int. Symposium NANOSTRUCTURES: Physics and Technology, Saint Petersburg, Russia, June 21-26 (2010)

Books, Chapters, Reviews, and Other One-Time Publications

Campbell, R.E. and Davidson, M.W., "Fluorescent Protein Reporters", Molecular Imaging with Reporter, Genes, 3-40, 2010.

Cross, T.A., "The Origins of Membrane Proteins Structural Characterization in Lipid Bilayers", Encyclopedia Magn. Reson, Eds. R.K. Harris & R.E. Wasylishen, 2010.

Edison, A.S. and Schroeder, F.C., "Modern Methods in Natural Product Chemistry - Characterization Methodologies: (I) NMR Spectroscopy of Small Molecules and Analysis of Complex Mixtures", Comprehensive Natural Products II Chemistry and Biology, 9, 169-196, 2010.

Gor'kov, L.P., "Developing BCS Ideas In The Soviet Union", " BCS: 50 Years" (L N Coper & D. Feldman, eds.), Singapore: World Scientific Publishers ., 107-126, 2010.

Gor'kov, L.P., "Notes on Microscopic Theory of Superconductivity", Superconductivity in New Materials, Elsevier; Z. Fisk and H. R. Ott eds, 16-49, 2010.

Gor'kov, P.L.; Brey, W.W. and Long, J.R., "Probe Development for Biosolids NMR Spectroscopy", Solid-State NMR Studies of Biopolymers, eds. A.E. McDermott and T. Polenova, John Wiley & Sons Ltd, UK, 141-158, 2010.

Manning, T.J.; Abadi, G.; Bishop, K.; McLeod, K.; Bullock, G.; Kean, G.; Anderson, S.; Cooper-White, K.; Sermons, S.; Patel, O.; Phillips, D.; Potter, T.; Nienow, J.; Klausmeyer, P. and Newman, D., "Production of ET743, Bryostatin, and Taxol Using a Mineral Based Microbial Amplification System", Recent Progress in Medicinal Plants Drug Plants III, ed. J. N. Govil & V. K. Singh (Studium Press LLC, USA), 29, 21, 2010.

Migliori, A.; Suzuki, Y.; Betts, J.B. and Fanelli, V.R., "Digital Ultrasonics for Materials Science", McGraw Hill 2010 Yearbook of Science & Technology, 2010.

Rizzo, M.A.; Davidson, M.W. and Piston, D.W., "Fluorescent Protein Tracking and Detection", Live-Cell Imaging: A Laboratory Manual, 2, 3-29, 2010.

Internet Disseminations

Atkinson, N. (Nancy), Faster-Than-Light Pulsar Phenomena, http://www.universetoday.com/49646/faster-than-light-pulsar-phenomena/, (2010)

Moskowitz, C. (Clara), Cosmic currents may move faster than light, http://www.msnbc.msn.com/id/34938302/ns/technology_and_science-space/, (2010)

Moskowitz, C. (Clara), What's Faster Than Light?, http://www.foxnews.com/sci-tech/2010/01/19/whats-faster-light/, (2010)

Musser, G. (George), Faster-than-light electric currents could well explain pulsars, http://www.scientificamerican.com/blog/post.cfm?id=faster-than-light-electric-currents-2010-06-18, (2010)

Singleton, J. and Schmidt, A.C., Lawbreakers? faster-than-light Polarization Currents, The Electromagnetic "Boom" and Pulsar Observational Data, http://www.spaceref.com/news/viewpr.html?pid=29949, (2010)

Singleton, J., Faster-than-light-electric-currents-could-explain-pulsars, http://www.kurzweilai.net/forums/topic/faster-than-light-electric-currents-could-explain-pulsars, (2010)

Patents & Other Products

Bird, M.D. and Toth, J., "Conical Magnet", U.S. Patent No. 7,825,760, dated November 2, 2010 (2010)

Bruschweiler, R. and Zhang, F., "Robust Deconvolution of Complex Mixtures by Covariance Spectroscopy", U.S. Patent No. 7,835,872 (2010)

Cross, T.A.; Brey, W.W.; Smirnov, A. and Chekmenev, E.Y., "Solid State NMR Method for Screening Cell Membrane Protein Binding Drug Candidates", U.S. Patent 7,678,546 (2010)

Cross, T.A.; Brey, W.W.; Smirnov, A. and Chekmenev, E.Y., "Solid-State NMR Method for Screening Cell Membrane Protein Binding Drug Candidates", U.S. Patent No. 7,674,595 (2010)

Cui, B.Z. and Han, K., "Method of Producing Cobalt-Platinum Magnetic Alloys with Improved Magnetic Properties", U.S. Patent No. 7,819,988 (2010)

Mao, P.; Han, K. and Xin, Y., "Age-Hardening Process Featuring Anomalous Aging Time", Provisional Patent (2010)

Markiewicz, W.D., "Quench Protection of HTS Superconducting Magnets", U.S. Patent No. 7,649,720, January 19, 2010 (2010)

Awards, Honors & Service

Bird, M. (Mark), Florida State University's Distinguished University Scholar Award (2010)

Boebinger, G.S. (Gregory), Member, Editorial Board: Annual Review of Condensed Matter Physics (2010)

Brooks, J. (James), Member, Editorial Board: Journal of Low Temperature Physics (2010)

Crooker, S. (Scott), American Physical Society Fellow (2010)

Cross, T.A. (Timothy), 2010 Florida Award, Florida Local Section of the American Chemical Society (2010)

Cross, T.A. (Timothy), Member, Editorial Board: Journal of Magnetic Resonance (2010)

Dalal, N. (Naresh), 2010 Silver Medal for Physics/Materials Science from the International Electron Paramagnetic Resonance Society (2010)

Dalal, N. (Naresh), Fellow of the American Chemical Society (2010)

Davidson, M. (Michael), Member, Editorial Board: Microscopy Today (2010)

Dobrosavljevic, V. (Vlad), American Physical Society Fellow (2010)

Engel, L. (Lloyd), American Physical Society Fellow (2010)

Fajer, P. (Peter), Member, Editorial Board: The Open Structural Biology Journal (2010)

Gurevich, A. (Alex), Member, Editorial Board: Superconductor Science and Technology (2010)

Hamaed, H. (Hiyam), Governor General's Gold Medal (2010) for top Ph.D. thesis at University of Windsor

Hendrickson, C.L. (Christopher), FSU Distinguished University Scholar (2010-2011)

Lee, P. (Peter), Member, Editorial Board: IEEE Transactions in Applied Superconductivity (2010)

Marshall, A. (Alan), Member, Editorial Board: Annual Review Analytical Chemistry (2010)

Marshall, A. (Alan), Member, Editorial Board: International Journal of Mass Spectrometry (2010)

Marshall, A. (Alan), Member, Editorial Board: Journal of the American Society of Mass Spectrometry (2010)

Marshall, A. (Alan), Member, Editorial Board: Mass Spectrometry Reviews (2010)

Marshall, A. (Alan), Member, Editorial Board: Rapid Communications in Mass Spectrometry (2010)

Marshall, A.G. (Alan), Pittcon 2010 Plenary Lecturer (2010)

McKenna, A.M. (Amy), Richard A. Glenn Award for the best paper presented before the Division of Fuel Chemistry at the 237th American Chemical Society National Meeting (2010)

Meisel, M. (Mark), Honorary degree, "Doctor honoris causa", from Pavol Jozef Šafárik University in Košice, Slovakia (2010)

Odom, L. (Leroy), Member, Editorial Board: Geoscience Frontiers (2010)

Rikvold, P.A., FSU Distinguished Research Professor Award (2010)

Rodgers, R.P. (Ryan), Member, Editorial Board: Journal of Dispersion Science and Technology (2010)

Rodgers, R.P. (Ryan), Member, Editorial Board: American Society for Mass Spectrometry Abstracts (2010)

Singleton, J. (John) and **Schmidt, A. (Andrea)**, Universe Today - Top 10 Story of 2010 (2010)

Singleton, J. (John), Business Weekly - Who's Who in Technology Honoree (2010)

Singleton, J. (John), Federal Laboratory Consortium for Technology Transfer Notable Technology Development Award for Superluminal Radar System (2010)

Singleton, J. (John), Los Alamos National Laboratory - Top 10 Science and Technology Development of 2010 (2010)

Van Sciver, S. (Steven), Mendelssohn Award from International Cryogenic Engineering Society (2010)

Vasenkov, S. (Sergey), NSF CAREER: Fundamentals of the relationship between pore structure and transport of light gases in materials with a hierarchy of pore sizes (2010)

Zapf, V. (Vivien), 2010 Lee-Osheroff-Richardson Prize (2010)

Zhou, H.-X. (Huan-Xiang), American Physical Society Fellow (2010)

Ph.D. Dissertations

Forty-seven (47) Ph.Ds were reported for 2010: 22 were awarded to users / students at FSU, UF, or FAMU; 25 were awarded to users at other academic institutions.

Ph.Ds. awarded by FSU, UF, or FAMU to "local" users/students

Boyd, G.R., "*Thermodynamic and Transport Properties of Unconventional Superconductors and Multiferroics*", University of Florida, Physics, advisor: Hirschfeld, P.J. (Peter) (2010)

Bryant, N. (Nathan), "*Noninvasive Characterization of Skeletal Muscle Damage and Repair in Murine Models of Muscular [dystrophy]*", University of Florida, advisor: Walter, G. (Glenn) (2010)

Cheesman, A.W., "*Biogenic Phosphorus in Palustrine Wetlands: Sources and Stabilization*", University of Florida. Soil and Water Science Department, advisor: Reddy, K.R. (2010)

Dalban-Canassy, M. (Matthieu), "*Counterflow Heat Transfer in He II Contained in Porous Media*", Florida State University, FAMU-FSU College of Engineering, Mechanical Engineering, advisor: Van Sciver, S.W. (Steven) (2010)

Davy, C.A. (Charney), "*A Study of Nanostructured Cu-Ag Composites*", Florida State University, FAMU-FSU College of Engineering, advisors: Kalu, P.N. (Peter) and Han, K. (Ke) (2010)

Fan, Y. (Ye), "*Impact of Viral Mediated Insulin-like Growth factor I on Skeletal Muscle Following Cast Immobilization*", University of Florida, Rehabilitation Science, advisor: Vandenborne, K. (Krista H Elvire) (2010)

Henning, P. (Paul), "*HMB as a Novel Nutritional Intervention to Attenuate the Loss of Lean Body Mass and Muscle Regeneration in Soldiers under a Catabolic State*", Florida State University, College of Medicine, advisor: Kim, J.-S. (Jeong-Su) (2010)

Kaur, N. (Narpinder), "*Magnetic and Thermodynamic Studies on Spin 1 Compounds*", Florida State University, Chemistry and Biochemistry, advisor: Dalal, N. (Naresh) (2010)

Kemper, A.F., "*Computational Studies of Correlated Electronic Systems*", University of Florida, Physics, advisors: Hirschfeld, P.J. (Peter) and Cheng, H.-P. (Hai Ping) (2010)

Kismarahardja, A. (Ade), "*Dielectric and Transport Studies of Materials*", Florida State University, Physics, advisor: Brooks, J. (James) (2010)

Menjoge, A., "*Relationship Between Diffusion and Structure in Selected Nanostructured Systems by NMR*", University of Florida, Chemical Engineering, advisor: Vasenkov, S. (Sergey) (2010)

Misra, S. (Sambuddha), "*Lithium Isotope Evolution of Cenozoic Seawater*", Florida State University, Department of Oceanography, advisor: Froelich, P.N. (Phillip Nissen) (2010) [read online]

Nguyen, D. (Doan), "*Alternating Current Loss Characteristics in $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ and $YBa_2Cu_3O_7$ Superconducting Tapes*", Florida State University, Physics, advisor: Boebinger, G.S. (Gregory) (2010)

Pajerowski, D.M., "*Photoinduced Magnetism in Nanostructures of Prussian Blue Analogues*", University of Florida, Physics, advisor: Meisel, M.W. (Mark) (2010)

Parekh, M.B., (Mansi), "*Enhanced Magnetic Resonance Imaging of a Rat Model of Temporal Lobe Epilepsy*", University of Florida, Neuroscience, advisor: Mareci, T.H. (Thomas) (2010)

Riggs, S. (Scott), "*Thermodynamics of the Magnetic-Field-Induced "Normal" State in an Underdoped High-Tc Superconductor*", Florida State University, Physics, advisor: Boebinger, G.S. (Gregory) (2010)

Sharma, M. (Mukesh), "*Solution and Solid State NMR Spectroscopy of Alpha-Helical Membrane Proteins*", Florida State University, Chemistry and Biochemistry, advisor: Cross, T.A. (Timothy) (2010)

Shen, T.M. (Teng Ming), "*Processing, Microstructure, and Critical Current Density of Ag-Sheathed $Bi_2Sr_2CaCu_2O_x$ Multifilamentary Round Wire*", Florida State University, Electrical and Computer Engineering, advisor: Hellstrom, E. (Eric) (2010)

Song, H. (Honghai), "*Microscopic Observations of Quenching and the Underlying Causes of Degradation in $YBa_2Cu_3O_{7-\delta}$ Coated Conductor*", Florida State University, Electrical and Computer Engineering, advisor: Schwartz, J. (Justin) (2010)

Tran, H. (Huan), "*Entanglement and Bond Fluctuations in Random Singlet Phases*", Florida State University, Physics, advisor: Bonesteel, N.E. (2010)

Truong, M.L. (Milton), "*Determination and Application of the Proton Chemical Shift Tensor by Solid State Nuclear Magnetic Resonance Spectroscopy*", Florida State University, Chemistry and Biochemistry, advisor: Cross, T (Timothy) (2010)

Wilson, J. (Jacob), "*Sacropenia as a Factor of Inactivity and Anabolic Resistance: Possible Mechanical and Amino Acid Based Interventions*", Florida State University, College of Medicine, advisor: Kim, J.-S. (Jeong-Su) (2010)

Ph.Ds. awarded by other academic institutions to external users/students:

Aczel, A. (Adam), "*Studies of Bose-Einstein Condensates in Magnetic Insulators*", McMaster University, Physics and Astronomy, advisor: Luke, G. (Graeme) (2010)

Beedle, C.C. (Christopher), "*Quantum Dynamics and Magneto-Structural Correlations in Molecule Based Magnets*", University of California, San Diego, Chemistry and Biochemistry, advisor: Hendrickson, D.N. (David) (2010)
Checkelsky, J. (Joseph), "*Transport Experiments with Dirac Electrons*", Princeton University, Physics, advisor: Ong, N.P. (N. Phuan) (2010)

Hamaed, H. (Hiyam), "*Solid-State NMR Spectroscopy of Unreceptive Nuclei in Inorganic and Organic Systems*", University of Windsor, Chemistry and Biochemistry, advisor: Schurko, R.W. (Robert) (2010)

Harris, D.T. (David), "*Directed Assembly of Single-Molecule and Single-Chain Magnets: From Mononuclear High-Spin Iron(II) Complexes to Cyano-Bridged Chain Compounds*", University of California, Berkeley, Chemistry, advisor: Long, J.R. (Jeffrey) (2010)

Hasan, S.A. (Saad), "*Nanoparticles as the Sole Building Blocks of Macroscopic Solids*", Vanderbilt University, Interdisciplinary Graduate Program in Materials Science, advisor: Dickerson, J.H. (James) (2010)

Heroux, K.J. (Katie), "*Modulation of Intermolecular Interactions in Single-Molecule Magnets*", University of California, San Diego, Chemistry and Biochemistry, advisor: Hendrickson, D.N. (David) (2010)

Ishmael, S.A. (Sasha Anissa), "*Three-Dimensional Design Applied to a Double-Helix Wound Superconducting Synchronous Condenser*", Florida Institute of Technology, Melbourne, FL, advisor: Sullivan, R.L. (Robert) (2010)

Kim, J.W. (Jae Wook), "*Studies on Critical Phenomena in Multiferroic Materials Under High Magnetic Fields*", Seoul National University, School of Physics, advisor: Kim, K.H. (Kee Hoon) (2010)

Koutroulakis, G. (Georgios), "*Unraveling the Mysteries of Unconventional Superconductivity with NMR: The Curious Case of* $CeCoIn_5$", Brown University, Physics, advisor: Mitrovic, V. (Vesna) (2010)

Li, W., "*Quantitative Magnetization Transfer Imagingin Ultra-high Magnetic Field*", University of Illinois at Chicago, advisor: Magin, R. (2010)

Ling, P. (Peng), "*Nonlinear Effects in NMR: Radiation Damping and Intermolecular Multiple Quantum Coherences*", Xiamen University in China, Chemistry, advisor: Chen, Z. (Zhong) (2010)

Mahajan, S.V. (Sameer), "*Ultra-Small Rare-Earth Oxide Nanocrystals: Development, Assembly, Optical and Dielectric Studies*", Vanderbilt University, Interdisciplinary Graduate Program in Materials Science, advisor: Dickerson, J.H. (James) (2010)

Mun, E.D. (Eun Deok), "*Yb-Based Heavy Fermion Compounds and Field Tuned Quantum Criticallity*", Iowa State University, Physics and Astronomy, advisor: Canfield, P.C. (Paul) (2010)

O'Farrell, E. (Eoin), "*Magnetic Field Tuned Quantum Criticality in beta-*$YbAlB_4$ *and* $Sr_3Ru_2O_7$*: An Experimental Investigation*", Cambridge University, Physics, advisor: Sutherland, M. (Michael) (2010)

Oh, Y.S. (Yoon Seok), "*Studies on Magnetic Field Induced Phase Transitions in Heavy Fermion and Multiferroic Materials*", Seoul National University, School of Physics, advisor: Kim, K.H. (Kee Hoon) (2010)

Parashar, N. (Nidhi), "*Ferromagnetism in Manganese Doped Indium Antimonide Semiconductor Thin Films Grown by Metal-organic Vapor Phase Epitaxy*", Northwestern University, Materials Science and Engineering, advisor: Wessels, B. (Bruce) (2010)

Pregelj, M. (Matej), "*Magnetic Properties of Two-dimensional Systems of Magnetic Clusters with Triangular Geometry*", University of Ljubljana, Slovenia, advisor: Arcon, D. (Denis) (2010)

Samulon, E. (Eric), "*Magnetic Phases of the Frustrated Spin Dimer Compound* $Ba_3Mn_2O_8$", Stanford University, Applied Physics, advisor: Fisher, I. (Ian) (2010)

Semenaka, V.V. (Valentina), "*Direct Synthesis of Heterometallic Complexes of Cr(III) with N,O-donor Ligands in the Presence of Reinecke's Salt*", National Taras Shevchenko University, Chemistry (Kiev, Ukraine), advisor: Kokozay, V. (Vladimir) (2010)

Shabani, J. (Javad), "*Fractional Quantum Hall Effect in Wide Quantum Wells*", Princeton University, Electrical Engineering, advisor: Shayegan, M. (Mansour) (2010)

Somarajan, S. (Suseela), "*Lanthanide Nanocrystals: A Platform for the Study of Optics and Magnetism in Nanomaterials*", Vanderbilt University, Department of Physics and Astronomy, advisor: Dickerson, J.H. (James) (2010)

Sung, Z.H. (Zu Hawn), "*The Influence of Grain Boundaries on the Properties of Superconducting Radio Frequency Cavity Niobium*", University of Wisconsin, Madison, Engineering, advisor: Larbalestier, D.C. (David) (2010)

Wang, Q. (Qiang), "*Dipolar Recoupling in Solid State MAS NMR*", Université des Sciences et Technologies de Lille, Chemistry, advisor: Amoureux, J.-P. (Jean-Paul) (2010)

Zeng, B. (Birong), "*Spectroscopic and Density Functional Theoretical Study on the Peroxovanadium Compounds and the Interactions with Small Ligands*", Xiamen University in China, Chemistry, advisor: Chen, Z. (Zhong) (2010)

Master Theses

Bazil, C. (Craig), "*Adaptive Multi-resolution Modulation for Multimedia Wireless Communication*", Prairie View A&M University, Electrical Engineering, advisor: Storr, K. (Kevin), on thesis committee (2010)

Gurbuz, B. (Burcu), "*An Isotopic Record of Late Cenozoic Diet, Habitat and Climate Change from Northern China*", Florida State University, Geological Sciences Department, advisor: Wang, Y. (Yang) (2010)

Harrison-Akita, K. (Katrina), "*Interdisciplinary Study of the Intermetallic Heavy Fermion Superconductor CeCoIn5*", Prairie View A&M University, Chemistry, advisor: Storr, K. (Kevin) (2010)

Pfaff, D.A. (Danielle), "*Structural Characterization of Cytoskeleton Regulating Protein Villin and its C-terminal Modular Domains*", Western Washington University, Chemistry, advisor: Smirnov, S.L. (Sergey) (2010)

Prévost, B. (Bobby), "*Études des aimants quantiques et supraconducteurs non conventionnels*", Université de Montréal, Département de physique, advisor: Bianchi, A. (Andrea) (2010)

Tremaine, D. (Darrel), "*Speleothem Paleoclimatology and Modern Speleochemistry Proxies: Calcite Farming in a Continuously Monitored Cave*", Florida State University, Oceanography, advisor: Froelich, P.N. (Philip) (2010) [read online]

Grants Awarded to NHMFL-Affiliated Faculty at Florida State University

As reported by the FSU Office of Sponsored Research for calendar year 2010
Note: Individual investigator grants awarded to faculty is a measure of scientific productivity, similar to publications, presentations, and patents. The information below is presented in this context. Because individual awards are administered differently (by different agencies; under different terms), this information should not be aggregated.

PI: Alamo, Rufina G.
Grant Title: EH Branching Microstructure
Agency: Exxon Chemical Company
Project Dates: 10/1/06 - 12/31/13
Award: $55,000

PI: Alamo, Rufina G.
Grant Title: FRG:GOALI: Collaborative Research: The Role of Polymer...
Agency: National Science Foundation
Project Dates: 7/15/07 - 6/30/11
Award: $90,000

PI: Balicas, Luis Molinuevo
Grant Title: SISGR - High Magnetic Fields as a Probe to Unveil...
Agency: U. S. Department of Energy
Project Dates: 9/15/09 - 9/14/11
Award: $150,000

PI: Balicas, Luis Molinuevo
Grant Title: SISGR - High Magnetic Fields as a Probe to Unveil...
Agency: U. S. Department of Energy
Project Dates: 9/15/09 - 9/14/11
Award: $150,000

PI: Boebinger, Gregory S.
Grant Title: National High Magnetic Field Laboratory Renewal Proposal
Agency: National Science Foundation
Project Dates: 1/1/08 - 12/31/12
Award: $26,500,000

PI: Boebinger, Gregory S.
Grant Title: National High Magnetic Field Laboratory Renewal Proposal
Agency: National Science Foundation
Project Dates: 1/1/08 - 12/31/12
Award: $6,500,000

PI: Boebinger, Gregory S.
Grant Title: National High Magnetic Field Laboratory Renewal Proposal
Agency: National Science Foundation
Project Dates: 1/1/08 - 12/31/12
Award: $5,000,000

PI: Bonesteel, Nicholas E.
Grant Title: Correlated Electrons in Reduced Dimensions
Agency: U. S. Department of Energy
Project Dates: 6/1/97 - 7/31/11
Award: $70,000

PI: Brey, William W.
Grant Title: Improved NMR Technology for Natural Products...
Agency: University of Florida
Project Dates: 8/1/09 - 6/30/11
Award: $224,097

PI: Brey, William W.
Grant Title: Improved NMR Technology for Natural Products...
Agency: University of Florida
Project Dates: 8/1/09 - 6/30/11
Award: $154,489

PI: Brey, William W.
Grant Title: MRI: Development of an NMR Console for the 36 T Series
Agency: National Science Foundation
Project Dates: 10/1/10 - 9/30/14
Award: $1,300,000

PI: Brooks, James S.
Grant Title: Electronic, Magnetic, and Spectroscopic Properties of...
Agency: National Science Foundation
Project Dates: 9/1/10 - 8/31/11
Award: $86,000

PI: Bruschweiler, Rafael
Grant Title: Functional Dynamics During Induced-Fit...
Agency: Oregon Health Sciences University

Project Dates: 2/1/07 - 1/31/11
Award: $65,473

PI: Bruschweiler, Rafael
Grant Title: Covariance-Based NMR of Proteins and Complex Metabolite
Agency: National Institute of General Medical Sciences
Project Dates: 5/1/09 - 4/30/11
Award: $255,885

PI: Chanton, Jeffrey
Grant Title: Coupling of Continuous
Agency: University of Mississippi
Project Dates: 7/1/06 - 7/31/11
Award: $80,781

PI: Chanton, Jeffrey
Grant Title: Constraining the Effects of Secondary Porosity...
Agency: Environmental Research and Education Fdn.
Project Dates: 1/25/10 - 3/31/11
Award: $100,000

PI: Chanton, Jeffrey
Grant Title: Resolving Chemical Properties and Extent of Crude Oil...
Agency: University of South Florida
Project Dates: 8/13/10 - 8/12/12
Award: $266,250

PI: Chanton, Jeffrey
Grant Title: Tracing the Intrusion of the GOM-2010 Oil Spill on Coastal...
Agency: University of Florida
Project Dates: 8/1/10 - 7/31/11
Award: $10,000

PI: Chiorescu, Irinel
Grant Title: Quantum Optics with Magnetic Molecular Spins
Agency: National Science Foundation
Project Dates: 2/15/07 - 1/31/12
Award: $100,000

PI: Chiorescu, Irinel
Grant Title: Quantum Optics with Magnetic Molecular Spins
Agency: National Science Foundation
Project Dates: 2/15/07 - 1/31/12
Award: $100,000

PI: Cross, Timothy A.
Grant Title: Four Mtb Membrane Proteins: Structure and Function
Agency: National Institute of Allergy and Infectious Diseases
Project Dates: 12/1/07 - 11/30/11
Award: $37,141

PI: Cross, Timothy A.
Grant Title: Four Mtb Membrane Proteins: Structure and Function
Agency: National Institute of Allergy and Infectious Diseases
Project Dates: 12/1/07 - 11/30/11
Award: $367,262

PI: Cross, Timothy A.
Grant Title: M Tuberculosis Membrane Protein Pharmaceutical Targets
Agency: National Institute of Allergy and Infectious Diseases
Project Dates: 8/20/09 - 7/31/11
Award: $1,713,056

PI: Dixon, Patricia
Grant Title: QuarkNet
Agency: University of Notre Dame
Project Dates: 9/1/08 - 8/31/10
Award: $1,500

PI: Dobrosavljevic, Vladimir
Grant Title: Complex Behavior Near the Metal-Insulator Transition...
Agency: National Science Foundation
Project Dates: 9/15/10 - 8/31/11
Award: $115,000

PI: Engel, Lloyd W.
Grant Title: Microwave/Rf Spectroscopy of 2D Solids/Stripes
Agency: U. S. Department of Energy
Project Dates: 7/1/05 - 6/30/11
Award: $102,000

PI: Englander, Ongi
Grant Title: NUE: NanoCORE II (Nanotechnology Concepts, Opportunities
Agency: National Science Foundation
Project Dates: 1/1/11 - 12/31/12
Award: $200,000

PI: Froelich JR, Philip N.
Grant Title: Cave Ventilation and Dripwater Geochemistry: Modern Time...
Agency: National Science Foundation
Project Dates: 9/1/10 - 8/31/13
Award: $726,955

PI: Gaffney, Betty
Grant Title: Reactive Intermediates in Lipoxygenase Pathways
Agency: National Institute of General Medical Sciences
Project Dates: 1/1/09 - 12/31/11
Award: $18,355

PI: Gaffney, Betty
Grant Title: Reactive Intermediates in Lipoxygenase Pathways
Agency: National Institute of General Medical Sciences
Project Dates: 1/1/09 - 12/31/11
Award: $181,383

PI: Gor'kov, Petr L.
Grant Title: Fabricate An 800 Mhz WB Static 15N-1H Solid State NMR...
Agency: University of Oxford
Project Dates: 1/1/10 - 6/30/11
Award: $27,175.78

PI: Gor'kov, Petr L.
Grant Title: Fabricate Low-Gamma MAS Probe for 800 MHz 1H/X...
Agency: Lille University of Science and Technology
Project Dates: 6/1/10 - 5/31/11
Award: $40,528

PI: Gurevich, Alexander
Grant Title: Exploring the Limits of Critical Currents in High Temperature...
Agency: UT-Battelle LLC
Project Dates: 6/11/08 - 3/31/11
Award: $144,420

PI: Gurevich, Alexander
Grant Title: Atomic Layer Deposition for Superconducting RF Cavities
Agency: Argonne National Laboratory
Project Dates: 5/1/10 - 5/1/11
Award: $53,296.77

PI: Gurevich, Alexander
Grant Title: Atomic Layer Deposition for Superconducting RF Cavities
Agency: Argonne National Laboratory
Project Dates: 5/1/10 - 5/1/11
Award: $100,000

PI: Hellstrom, Eric E.
Grant Title: Investigation of Phase Relations and Reaction Pathways
Agency: National Science Foundation

Project Dates: 7/1/10 - 6/30/11
Award: $125,750

PI: Hill, Stephen Olof
Grant Title: Magnetic Resonance Investigations of Symmetries...
Agency: National Science Foundation
Project Dates: 11/1/08 - 2/29/12
Award: $145,000

PI: Hill, Stephen Olof
Grant Title: International Collaboration in Chemistry: EPR Characterization...
Agency: National Science Foundation
Project Dates: 9/1/09 - 8/31/11
Award: $160,000

PI: Humayun, Munir
Grant Title: Siderophile Element Constraints on Solar System Process
Agency: National Aeronautics & Space Administration
Project Dates: 8/1/10 - 7/31/13
Award: $115,000

PI: Kim, Jeong-Su
Grant Title: Research Enhancement
Agency: Korea Express
Project Dates: 1/18/10 - 12/31/11
Award: $10,000

PI: Landing, William M.
Grant Title: Mercury Isotopes in the Pensacola Bay Watershed
Agency: Electric Power Research Institute
Project Dates: 3/1/10 - 3/31/11
Award: $159,613.31

PI: Landing, William M.
Grant Title: Collaborative Research: Global Ocean Survey of Dissolved...
Agency: National Science Foundation
Project Dates: 2/15/10 - 1/31/14
Award: $490,222

PI: Landing, William M.
Grant Title: Collaborative Research: A Novel Tracer Approach to Estimate...
Agency: National Science Foundation
Project Dates: 1/1/11 - 12/31/13
Award: $221,186

PI: Landing, William M.
Grant Title: FSU Southeastern Atmospheric Mercury Research Consortium
Agency: National Oceanic and Atmospheric Administration
Project Dates: 9/1/10 - 2/28/12
Award: $487,500

PI: Larbalestier, David C.
Grant Title: High Field Superconductor Development and Understanding
Agency: U. S. Department of Energy
Project Dates: 4/1/07 - 3/31/11
Award: $610,000

PI: Larbalestier, David C.
Grant Title: Buffer Layer Growth and the Thickness Dependence
Agency: U. S. Department of Energy
Project Dates: 6/30/08 - 7/1/11
Award: $348,055.37

PI: Larbalestier, David C.
Grant Title: High Field Superconductor Development and Understanding
Agency: U. S. Department of Energy
Project Dates: 4/1/10 - 3/31/11
Award: $273,762

PI: Larbalestier, David C.
Grant Title: Electro-Mechanical Characterization and Understanding of...
Agency: Fermi National Accelerator Lab
Project Dates: 9/1/09 - 6/30/11
Award: $753,377

PI: Larbalestier, David C.
Grant Title: Collaborations Between CNR-INFM And ASC-NHMFL
Agency: Consiglio Nazionale Delle Ricerche (CNR)
Project Dates: 1/1/10 - 12/31/11
Award: $7,000.13

PI: Lee, Peter
Grant Title: Understanding & Development of High Field SCS for Fusion
Agency: U. S. Department of Energy
Project Dates: 7/1/06 - 6/30/11
Award: $90,000

PI: Lee, Peter
Grant Title: Investigate and Gain and Understanding of the Origins of...
Agency: Fermi National Accelerator Lab
Project Dates: 2/2/10 - 12/31/10
Award: $125,000

PI: Lee, Peter
Grant Title: Support of Conductor Qualification Program
Agency: ITER (Int'l Fusion Energy Org) Org.
Project Dates: 4/1/09 - 3/31/12
Award: $7,000

PI: Liang, Zhiyong
Grant Title: Feasiblitiy Study for Potential Acoustic Device Applications
Agency: NEOS Music and Cinema Inc
Project Dates: 10/1/10 - 12/31/10
Award: $8,500

PI: Marshall, Alan G.
Grant Title: Classification Analysis of Organic Carbon Natural Storage...
Agency: U. S. Civilian Research & Deve
Project Dates: 12/1/09 - 11/30/11
Award: $16,000

PI: Marshall, Alan G.
Grant Title: Development of a 21 Tesla Fourier Transform ICR Magnet
Agency: National Science Foundation
Project Dates: 12/1/09 - 11/30/13
Award: $15,000,000

PI: Marshall, Alan G.
Grant Title: Development of a 21 Tesla Fourier Transform ICR Magnet
Agency: National Science Foundation
Project Dates: 7/1/10 - 6/30/14
Award: $2,528,837

PI: McKenna, Amy Marilyn
Grant Title: Rapid: Molecular Level Characterization and Archive...
Agency: National Science Foundation
Project Dates: 9/1/10 - 8/31/11
Award: $198,790

PI: Oates, William
Grant Title: Development and Implementation of Piezoelectric Microjet
Agency: U. S. Army Research Office
Project Dates: 5/1/08 - 12/31/10
Award: $77,797

PI: Oates, William
Grant Title: Field Coupled Mechanics and Nonlinear Control of Photo-R...
Agency: Space and Naval Warfare Systems Center
Project Dates: 9/23/09 - 9/22/11
Award: $147,918

PI: Oates, William
Grant Title: Light Interactions of Azobenzene

Elastomer Networks
Agency: Azimuth Corporation
Project Dates: 3/1/10 - 4/30/11
Award: $24,161.52

PI: Oates, William
Grant Title: Light Interactions of Azobenzene Elastomer Networks
Agency: Azimuth Corporation
Project Dates: 3/1/10 - 4/30/11
Award: $24,161.52

PI: Odom, A Leroy
Grant Title: Geological Sciences Coordinator of Alumni Affairs
Agency: FSU Foundation
Project Dates: 12/10/09 - 6/30/10
Award: $13,529

PI: Odom, A Leroy
Grant Title: Geological Sciences Coordinator of Alumni Affairs
Agency: FSU Foundation
Project Dates: 12/10/09 - 6/30/10
Award: $23,000

PI: Pamidi, Sastry V.
Grant Title: Magnetic Shielding with High Temperature Superconductors
Agency: Office of Naval Research
Project Dates: 1/15/08 - 9/30/13
Award: $31,250

PI: Pamidi, Sastry V.
Grant Title: STTR: Fabrication of Higher Temperature Semiconductor
Agency: Tai Yang Research Corp
Project Dates: 6/1/10 - 7/31/11
Award: $30,060

PI: Pamidi, Sastry V.
Grant Title: Fabricating and Testing of a 30 Meter Long Coxial Super
Agency: Office of Naval Research
Project Dates: 8/17/10 - 9/30/12
Award: $3,075,000

PI: Paravastu, Anant K.
Grant Title: NMR Characterization of Prefibrillar Amyloid-Beta Aggreg...
Agency: Alzheimer's Association
Project Dates: 9/1/10 - 8/31/12
Award: $80,000

PI: Rikvold, Per A
Grant Title: Computational Studies of Non-equilibrium Processes
Agency: National Science Foundation
Project Dates: 9/15/08 - 8/31/11
Award: $95,000

PI: Rikvold, Per A
Grant Title: Confirmation and Development of a Fast-Charging Method...
Agency: Mississippi State University
Project Dates: 12/11/09 - 12/7/10
Award: $11,700

PI: Schlottmann, Pedro
Grant Title: Strongly Correlated Electron Systems
Agency: U. S. Department of Energy
Project Dates: 8/15/98 - 2/14/12
Award: $55,000

PI: Shatruk, Mykhailo
Grant Title: CAREER: Magnetostructural Correlations in Rare Earth-Tra...
Agency: National Science Foundation
Project Dates: 5/1/10 - 4/30/11
Award: $100,000

PI: Shatruk, Mykhailo
Grant Title: CAREER: Magnetostructural Correlations in Rare Earth-Tra...
Agency: National Science Foundation
Project Dates: 5/1/10 - 4/30/11
Award: $5,000

PI: Tozer, Stanley W.
Grant Title: Electron Interactions in Actinides and Related Systems
Agency: U. S. Department of Energy
Project Dates: 1/11/10 - 4/10/11
Award: $470,000

PI: Vafek, Oskar
Grant Title: CAREER: Theoretical Approach to Dirac and Related...
Agency: National Science Foundation
Project Dates: 7/1/10 - 6/30/11
Award: $84,000

PI: Van Sciver, Steven W.
Grant Title: Liquid Helium Fluid Dynamics Studies
Agency: U. S. Department of Energy
Project Dates: 1/1/96 - 5/1/11
Award: $212,000

PI: Van Sciver, Steven W.
Grant Title: Mechanical, Thermal, and Hydroscopic Properties of Solid...
Agency: University of Central Florida
Project Dates: 10/1/08 - 5/31/10
Award: $10,000

PI: Van Sciver, Steven W.
Grant Title: Recovery Act Enhancement to Infrastructure of the Cryog...
Agency: U. S. Department of Energy
Project Dates: 12/8/09 - 1/31/11
Award: $100,000

PI: Van Sciver, Steven W.
Grant Title: GE Collaboration on MLI Testing
Agency: GE Healthcare
Project Dates: 12/15/10 - 12/15/11
Award: $50,000

PI: Walsh, Robert P.
Grant Title: ITER-NHMFL 2007 Materials Characterization Program
Agency: UT-Battelle LLC
Project Dates: 6/1/07 - 12/31/10
Award: $2,108

PI: Wang, Yang
Grant Title: Technician Support for the Stable Isotope Laboratory
Agency: National Science Foundation
Project Dates: 4/1/09 - 3/31/11
Award: $39,865

PI: Wang, Yang
Grant Title: Collaborative Research: Late Cenozoic Vertebrate Paleon...
Agency: National Science Foundation
Project Dates: 5/1/10 - 4/30/13
Award: $107,018

PI: Weijers, Hubertus W.
Grant Title: High-Current Conductor
Agency: Lawrence Berkeley Laboratory
Project Dates: 5/21/09 - 9/30/10
Award: $20,125

PI: Yang, Kun
Grant Title: Unconventional Phases and Phase Transitions in Electronic...
Agency: National Science Foundation
Project Dates: 10/1/10 - 9/30/11
Award: $90,000

PI: Zhou, Huan-Xiang
Grant Title: Theory of Protein-Protein Association
Agency: National Institute of General
Project Dates: 4/1/08 - 3/31/11
Award: $252,835

PI: Zhou, Huan-Xiang
Grant Title: Modeling Crowding & Confinement of Cellular Environments
Agency: National Institute of General
Project Dates: 8/1/10 - 7/31/11
Award: $253,159

PI: Zhu, Lei
Grant Title: Development of Sensitive Fluorescent Probes
Agency: Florida Department of Health
Project Dates: 7/1/08 - 6/30/11
Award: $95,000

PI: Zhu, Lei
Grant Title: Development of Sensitive Flouresent Probes
Agency: National Institute of General
Project Dates: 1/1/10 - 11/30/11
Award: $263,917

Grants Awarded to NHMFL-Affiliated Faculty at University of Florida

As reported by the UF Office of Sponsored Research for calendar year 2010
Note: Individual investigator grants awarded to faculty is a measure of scientific productivity, similar to publications, presentations, and patents. The information below is presented in this context. Because individual awards are administered differently (by different agencies; under different terms), this information should not be aggregated.

PI: Andraka, B.
Grant Title: Investigation of Novel Strongly Corelated Electron States with the Emphasis on Pr-Based Systems
Agency: U.S. Department of Energy
Project Dates: 2/1/99 - 1/31/11
Award: $102,000

PI: Angerhofer, A.
Grant Title: National High Magnetic Field Laboratory- User Collaboration Grants Programs
Agency: Florida State University
Project Dates: 4/1/09 - 3/31/11
Award: $70,761

PI: Angerhofer, A.
Grant Title: The Catalytic Mechanism Of Oxalate Decarboxylase Studied By Advanced Epr Experiments
Agency: National Science Foundation
Project Dates: 7/1/08 - 6/30/11
Award: $130,000

PI: Angerhofer, A.
Grant Title: Ex Vivo Analysis of Irradiated Finger/Toe Nails by EPR as a Biodosimeter System
Agency: Dartmouth College
Project Dates: 8/15/10 - 7/31/11
Award: $6,736

PI: Biswas, A.
Grant Title: The Effect of Strain on the Phase Separation and Magnetoelectric Coupling in Manganites
Agency: National Science Foundation
Project Dates: 8/1/08 - 7/31/11
Award: $100,000

PI: Blackband, S. J.
Grant Title: Mr Microscopy At The Cellular Level Using Microsurface Rf Coils
Agency: Florida State University
Project Dates: 2/1/10 - 1/31/12
Award: $97,158

PI: Blackband, S. J.
Grant Title: Development of MR Microscopy at the Cellular Level
Agency: National Institutes of Health
Project Dates: 9/30/10 - 8/31/14
Award: $480,935

PI: Bowers, C. R.
Grant Title: Inducing Molecular Single File Diffusion by Co-Adsorption in One Dimensional Channels for Gas Separations and Catalysis
Agency: National Science Foundation
Project Dates: 6/22/10 - 8/31/12
Award: $106,343

PI: Christou, G.
Grant Title: Collaborative Research: Molecular Spintronics with Single-Molecule Magnets
Agency: National Science Foundation
Project Dates: 5/1/10 - 4/30/13
Award: $65,621

PI: Christou, G.
Grant Title: Transition Metal Clusters as Single-Molecule Magnets
Agency: National Science Foundation
Project Dates: 9/1/09 - 8/31/11
Award: $174,000

PI: Edison, A.S.
Grant Title: An Integrated Chemical Platform To Elucidate Eukaryotic Sensing Of Bacterial Crosstalk
Agency: Ben-Gurion Univ Of The Negev
Project Dates: 5/1/10 - 4/30/12
Award: $83,640

PI: Edison, A.S.
Grant Title: National High Magnetic Field Laboratory (NHMFL) Project
Agency: Florida State University
Project Dates: 1/1/08 - 12/31/12
Award: $768,689

PI: Edison, A.S.
Grant Title: Comparative Behavioral Metabolomies in Nematodes
Agency: National Institutes of Health
Project Dates: 5/1/09 - 2/28/13
Award: $295,321

PI: Edison, A.S.
Grant Title: Varian 600 MHz NMR Spectrometer
Agency: Florida State University
Project Dates: 3/25/10 - 12/31/10
Award: $100,000

PI: Edison, A.S.
Grant Title: Metabolomics Workshop at the University of Florida
Agency: National Science Foundation
Project Dates: 7/1/10 - 6/30/11
Award: $10,000

PI: Edison, A.S.
Grant Title: Metabolomics Workshop at UF
Agency: Florida State University
Project Dates: 5/5/10 - 5/4/11
Award: $10,000

PI: Edison, A.S.
Grant Title: Improved NMR Technology for Natural Products and Metabolomics
Agency: National Institutes of Health
Project Dates: 8/1/09 - 6/30/13
Award: $471,609

PI: Edison, A.S.
Grant Title: Miscellaneous Donors
Agency: Miscellaneous Donors
Project Dates: 6/28/06 - 6/27/11
Award: $1,300

PI: Edison, A.S.
Grant Title: Endogenous G-Protein Coupled Receptor Antagonists
Agency: National Institutes of Health
Project Dates: 4/1/03 - 7/31/13
Award: $19,587

PI: Edison, A.S.
Grant Title: Miscellaneous Donors
Agency: Miscellaneous Donors
Project Dates: 6/28/06 - 6/27/11
Award: $500

PI: Fanucci, G.E.
Grant Title: Membrane Binding Properties of the Gm2 Activator Protein
Agency: National Institutes of Health
Project Dates: 5/5/06 - 4/30/11
Award: $237,195

PI: Fanucci, G.E.
Grant Title: Career: Site-Directed Spin Labeling EPR Applications in Intrinsically Unstructured Proteins (Participant Support)
Agency: National Science Foundation
Project Dates: 8/1/08 - 7/31/11
Award: $12,000

PI: Fanucci, G.E.
Grant Title: Career: Site-Directed Spin Labeling EPR Applications in Intrinsically Unstructured Proteins
Agency: National Science Foundation
Project Dates: 8/1/08 - 7/31/11
Award: $106,250

PI: Forder, J.R.
Grant Title: Automated Assessment of Structural Changes & Functional Recovery Post Spinal Injury Using Diffusion Weighted MRI
Agency: National Institutes of Health
Project Dates: 4/1/10 - 3/31/15
Award: $111,435

PI: Hebard, A.F.
Grant Title: Physics of Proximate Metallic and Insulating Phases
Agency: National Science Foundation
Project Dates: 9/1/10 - 8/31/11
Award: $130,000

PI: Hirschfeld, P.J.
Grant Title: Disorder and Emergence of Inhomogeneous Phases in Strongly Correlated Electron Systems
Agency: National Science Foundation
Project Dates: 9/16/10 - 9/30/13
Award: $90,000

PI: Hirschfeld, P.J.
Grant Title: Grains, Wires and Interfaces of Cuprate Superconductors
Agency: U.S. Department of Energy
Project Dates: 9/1/05 - 8/31/11
Award: $105,000

PI: Ingersent, K.
Grant Title: Materials World Network - Collaborative Research: Decoherence, Correlations and Spin Effects in Nanostructured Materials
Agency: National Science Foundation
Project Dates: 9/1/07 - 8/31/11
Award: $91,000

PI: Liu, Y.
Grant Title: Diffusion Tensor Imaging of OCD
Agency: Obsessive Compulsive Fou
Project Dates: 7/1/06 - 4/1/11
Award: $48,193

PI: Long, J.R.
Grant Title: Creation of a Highly Stable Pulmonary Surfactant Replacement
Agency: Gates Foundation, Bill & Melinda
Project Dates: 11/1/10 - 4/30/12
Award: $100,000

PI: Long, J.R.
Grant Title: Miscellaneous Donors
Agency: Miscellaneous Donors
Project Dates: 7/1/10 - 6/30/15
Award: $13,203

PI: Luesch, H.
Grant Title: Chemistry and Biology of Apratoxins
Agency: Florida Department of Health
Project Dates: 7/1/10 - 6/30/15
Award: $272,666

PI: Luesch, H.
Grant Title: Chemistry and Biology of Largazoles
Agency: National Institutes of Health
Project Dates: 7/1/09 - 6/30/11
Award: $297,946

PI: Mareci, T.H.
Grant Title: Selective Wirelessly-Adjustable Multiple-Frequency Probe (Swamp) Coil for MRI/S
Agency: National Institutes of Health
Project Dates: 4/1/09 - 3/31/11
Award: $98,620

PI: Mareci, T.H.
Grant Title: Neuroimage Processing for Rehabilitation Research for Neuroimaging Core
Agency: U.S. Department of Veterans Affairs
Project Dates: 6/16/10 - 6/15/11
Award: $10,000

PI: Mareci, T.H.
Grant Title: Computational Transport Models for Convection-Enhanced CNS Delivery
Agency: National Institutes of Health
Project Dates: 7/1/08 - 7/31/13
Award: $104,541

PI: Mareci, T.H.
Grant Title: A Study of Model B-Cells in Diabetes Treatment
Agency: National Institutes of Health
Project Dates: 5/15/02 - 8/31/11
Award: $13,871

PI: Maslov, D.
Grant Title: Materials World Network: Control of the Electron Nuclear Interaction in Nanoelectronic Devices
Agency: National Science Foundation
Project Dates: 8/1/09 - 7/31/13
Award: $85,000

PI: Merz, K.M.
Grant Title: Mettalloenzyme Structure/Function
Agency: National Institutes of Health
Project Dates: 2/1/07 - 1/31/12
Award: $234,775

PI: Pearton, S. J.
Grant Title: Wide Bandgap Semiconductor Nanowires for Electronic, Photonic and Sensing Devices
Agency: U.S. Army

Project Dates: 8/1/07 - 7/31/10
Award: $42,860

PI: Pearton, S. J.
Grant Title: A 21st Century Approach to Electronic Device Reliability
Agency: U.S. Air Force
Project Dates: 5/15/08 - 5/14/13
Award: $130,923

PI: Pearton, S. J.
Grant Title: Proton Irradiation Effects on Ain/Gan High Electron Mobility Transitors
Agency: Svt Associates Inc
Project Dates: 6/19/10 - 3/18/11
Award: $15,000

PI: Pearton, S. J.
Grant Title: A 21st Century Approach to Electronic Device Reliability
Agency: U.S. Air Force
Project Dates: 5/15/08 - 5/14/13
Award: $92,809

PI: Pearton, S. J.
Grant Title: Terahertz Sensing and Imaging Technology
Agency: Intl. Technology Corp
Project Dates: 9/29/10 - 3/30/12
Award: $65,762

PI: Pearton, S. J.
Grant Title: Revenue for Alumni / Endowed Professorship
Agency: University of Florida Foundation
Project Dates: 9/1/05 - 6/30/15
Award: $17,436

PI: Stanton, C. J.
Grant Title: Coherent Phonon Dynamics in Semiconductor Nanostructures and Nanotubes
Agency: National Science Foundation
Project Dates: 12/15/07 - 11/30/12
Award: $90,000

PI: Sullivan, N. S.
Grant Title: National High Magnetic Field Laboratory--High B/T Facility
Agency: Florida State University
Project Dates: 1/1/08 - 12/31/12
Award: $387,372

PI: Talham, D. R.
Grant Title: Metal Phosphonate Interfaces for Phosphopeptide Enrichment
Agency: National Science Foundation
Project Dates: 7/1/10 - 6/30/13
Award: $392,500

PI: Talham, D. R.
Grant Title: Magnetic and Photomagnetic Coordination Polymer Heterostructures
Agency: National Science Foundation
Project Dates: 7/1/10 - 6/30/13
Award: $130,000

PI: Talham, D. R.
Grant Title: MRI: Acquisition of a Maldi Tof-Tof Mass Spectrometer
Agency: National Science Foundation
Project Dates: 10/1/10 - 9/30/13
Award: $273,827

PI: Talham, D. R.
Grant Title: ACS Hach Scientific Foundation Scholarship 2010
Agency: American Chemical Society
Project Dates: 5/1/10 - 4/30/11
Award: $12,000

PI: Talham, D. R.
Grant Title: Eastman Fellowship for Matthew J Andrus
Agency: Eastman Chemical Co.
Project Dates: 5/16/10 - 8/15/10
Award: $8,300

PI: Talham, D. R.
Grant Title: Miscellaneous Donors
Agency: Miscellaneous Donors
Project Dates: 7/1/85 - 6/30/15
Award: $8,682

PI: Talham, D. R.
Grant Title: Acquisition of an FTIR Spectrometer for Biochemical and Materials Research and Education
Agency: National Science Foundation
Project Dates: 12/15/10 - 11/30/13
Award: $219,272

PI: Talham, D. R.
Grant Title: Miscellaneous Donors
Agency: Miscellaneous Donors
Project Dates: 7/1/85 - 6/30/15
Award: $11,440

PI: Talham, D. R.
Grant Title: Carbon Nanotube-Based Transparent Electrodes for Polymer Emittin, Electro...
Agency: Nradiance
Project Dates: 7/15/05 - 8/31/11
Award: $14,307

PI: Tanner, D. B.
Grant Title: Time-Resolved Far-Infrared Experiments: Implications For Nanotechnology
Agency: U.S. Department of Energy
Project Dates: 5/15/02 - 5/14/11
Award: $165,000

PI: Tanner, D. B.
Grant Title: Task N: Research in High Energy Phsyics (Experimental and Therotical) Together with Quarknet Educational Outreach
Agency: U.S. Department of Energy
Project Dates: 3/1/10 - 6/30/11
Award: $23,206

PI: Vandenborne, K. H.
Grant Title: Magnetic Resonance Imaging and Biomarkers for Muscular Dystrophy
Agency: National Institutes of Health
Project Dates: 5/5/10 - 4/30/15
Award: $1,172,416

PI: Vandenborne, K. H.
Grant Title: MRI Assessment of Cardiac Structure and Function in Muscular Dystrophies
Agency: American Heart Association
Project Dates: 7/1/10 - 6/30/12
Award: $47,428

PI: Vandenborne, K. H.
Grant Title: Magnetic Resonance Imaging and Biomarkers for Muscular Dystrophy
Agency: Parent Project Muscular Dystrophy
Project Dates: 2/9/09 - 4/30/10
Award: $4,900

PI: Vandenborne, K. H.
Grant Title: MR Monitoring of PTC124 Treatment in DMD
Agency: National Institutes of Health
Project Dates: 9/30/09 - 8/31/11
Award: $385,014

PI: Vasenkov, S.
Grant Title: Career: Fundamentals of the Relationship between Pore Structure and Transport of Light Gases in Materials with a Hierarchy
Agency: National Science Foundation
Project Dates: 4/15/10 - 3/31/15
Award: $400,000

PI: Vasenkov, S.
Grant Title: Collaborative Research: Molecular

Modeling and Experimental Investigation of the Structure and Dynamics of Confined...
Agency: National Science Foundation
Project Dates: 7/1/10 - 6/30/13
Award: $55,418

PI: Vasenkov, S.
Grant Title: Inducing Molecular Single File Diffusion by Co-Adsorption In One-Dimensional Channels for Gas Separations and Catalysis
Agency: National Science Foundation
Project Dates: 9/1/10 - 8/31/12
Award: $34,570

PI: Walter, G.A.
Grant Title: Magnetic Resonance Imaging and Biomarkers for Muscular Dystrophy
Agency: National Institutes of Health
Project Dates: 5/5/10 - 4/30/15
Award: $35,637

PI: Walter, G.A.
Grant Title: MR Monitoring of PTC124 Treatment in DMD
Agency: National Institutes of Health
Project Dates: 9/30/09 - 8/31/11
Award: $16,773

PI: Walter, G.A.
Grant Title: Therapeutic Strategies to Augment Muscle Rehabilitation
Agency: National Institutes of Health
Project Dates: 9/30/09 - 8/31/11
Award: $142,949

2010 USER FACILITY STATISTICS

DC Field Facility

Users, Requests & Operations

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users. All user numbers reflect distinct individuals, i.e. if a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once.

TABLE 1

DC Field Facility: User Demographics

	Users	Female	Minority[1]	On-Site[2] Users[6]	Remote Users [3,6]	Users Sending Sample [4,6]
Senior Investigators, U.S.	171	11	6	171	0	0
Senior Investigators, non-U.S.	43	5	5	43	0	0
Postdocs, U.S.	40	6	4	40	0	0
Postdocs, non-U.S.	6	0	0	6	0	0
Students[5], U.S.	107	26	3	107	0	0
Students[5], non-U.S.	16	2	0	16	0	0
Technician, U.S.	6	1	1	6	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**389**	**51**	**19**	**389**	**0**	**0**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 Users at the Magnet Lab facility operating the magnet. Not all users on the proposal must physically come to the lab; if one or more come, then all members of the group are counted in this category.
3 Users conducting the experiment remotely.
4 Experiments in which the sample was sent by an external PI and the experiment was conducted by in-house user support personnel in service mode. No member of the group comes to the lab, and all are counted in this category.
5 "Students" generally refers to graduate students, but may include a few undergraduate students.
6 The total of on-site users, remote users, and users sending samples will equal the total number of users.

TABLE 2

DC Field Facility: User Affiliations

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	171	58	9	136	6	29
Senior Investigators, non-U.S.	43	0	0	28	0	15
Postdocs, U.S.	40	11	8	28	0	12
Postdocs, non-U.S.	6	0	0	4	0	2
Students, U.S.	107	13	12	104	0	3
Students, non-U.S.	16	0	0	15	0	1
Technician, non-U.S.	6	3	2	4	0	2
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**389**	**85**	**31**	**319**	**6**	**64**

1 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
2 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
3 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
4 The total of university, industry, and national lab users will equal the total number of users.

TABLE 3

DC Field Facility: Users by Discipline

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	171	67	11	7	14	72
Senior Investigators, non-U.S.	43	32	2	0	0	9
Postdocs, U.S.	40	29	2	0	2	7
Postdocs, non-U.S.	6	3	0	1	0	2
Students, U.S.	107	55	9	8	11	24
Students, non-U.S.	16	14	0	1	0	1
Technician, non-U.S.	6	1	0	0	1	4
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**389**	**201**	**24**	**17**	**28**	**119**

TABLE 4

DC Field Facility: Experimental Requests[1] for Magnet Time

Weeks Requested	Weeks Granted	Weeks Declined
320	295 (72.48%)	112 (27.52%)

1. Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

DC Field Facility: Research Proposals[1] Profile with Magnet Time

	Number of Proposals
Condensed Matter Physics	102
Chemistry, Geochemistry	5
Engineering	3
Magnets, Materials, Testing, Instruments	13
Biology, Biochemistry, Biophysics	39
TOTAL	**162**

	Number of Proposals
Minority[2]	3
Female[3]	12

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

TABLE 6

DC Field Facility: Operations Statistics Number of Magnet Days[1]

	Resistive Magnets & Hybrid	Superconducting Magnets	Total Days Allocated /User Affiliated	Percentage Allocated /User Affiliated
NHMFL-Affiliated[2]	191.39	115.52	306.91	18.92%
Local[2]	35.72	113.00	148.72	9.17%
U.S. University	406.47	462.00	868.47	53.54%
U.S. Govt. Lab.	39.32	42.00	81.32	5.01%
U.S. Industry	0.00	0.00	0.00	0.00%
Non-U.S.	101.54	112.00	213.54	13.16%
Test, Calibration, Set-up, Maintenance	3.13	0.00	3.13	0.19%
Idle	0.00	0.00	0.00	0.00%
TOTAL	**777.57**	**844.52**	**1622.09**	**100.00%**

1 User Units are defined as magnet days. For the DC Field Facility, one magnet day is defined as 7 hours in a water-cooled resistive or hybrid magnet. Using this definition, a typical 24-hour day in the DC Field Facility contains three or four "magnet days." For experiments in the superconducting magnets, one "magnet day" is defined as 24 hours of use.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

TABLE 7

DC Field Facility: Operations by Discipline Number of Magnet Days[1]

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	306.91	257.19	0.00	1.98	44.80	2.94
Local[2]	148.72	82.94	62.00	0.00	3.24	0.54
U.S. University	868.47	784.56	27.91	0.00	20.33	35.67
U.S. Govt. Lab.	81.32	67.53	3.74	4.47	5.59	0.00
U.S. Industry	0.00	0.00	0.00	0.00	0.00	0.00
Non-U.S.	213.54	206.32	0.00	7.23	0.00	0.00
Test, Calibration, Set-up, Maintenance	3.13	0.00	0.00	0.00	1.79	1.34
Idle	0.00	n/a[3]	n/a	n/a	n/a	n/a
TOTAL	**1622.09**	**1398.54**	**93.65**	**13.67**	**75.75**	**40.49**

1 User Units are defined as magnet days. For the DC Field Facility, one magnet day is defined as 7 hours in a water-cooled resistive or hybrid magnet. Using this definition, a typical 24-hour day in the DC Field Facility contains three or four "magnet days". For experiments in the superconducting magnets, one "magnet day" is defined as 24 hours of use.

2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

3 n/a means not applicable.

2010 USER FACILITY STATISTICS

Pulsed Field Facility

Users, Requests & Operations

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users. All user numbers reflect distinct individuals, i.e. if a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once.

TABLE 1

Pulsed Field Facility: User Demographics

	Users	Female	Minority[1]	On-Site[2] Users[6]	Remote Users [3,6]	Users Sending Sample [4,6]
Senior Investigators, U.S.	42	3	5	42	0	0
Senior Investigators, non-U.S.	20	2	2	20	0	0
Postdocs, U.S.	18	4	2	18	0	0
Postdocs, non-U.S.	2	0	0	2	0	0
Students[5], U.S.	6	3	0	6	0	0
Students[5], non-U.S.	2	0	0	2	0	0
Technician, U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**90**	**12**	**9**	**90**	**0**	**0**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 Users at the Magnet Lab facility operating the magnet. Not all users on the project must physically come to the lab; if one or more come, then all members of the group are counted in this category.
3 Users conducting the experiment remotely.
4 Experiments in which the sample was sent by an external PI and the experiment was conducted by in-house user support personnel in service mode. No member of the group comes to the lab, and all are counted in this category.
5 "Students" generally refers to graduate students, but may include a few undergraduate students.
6 The total of on-site users, remote users, and users sending samples will equal the total number of users.

TABLE 2

Pulsed Field Facility: User Affiliations

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	42	18	9	21	0	21
Senior Investigators, non-U.S.	20	0	0	19	0	1
Postdocs, U.S.	18	6	7	6	0	12
Postdocs, non-U.S.	2	0	0	1	0	1
Students, U.S.	6	3	1	5	0	1
Students, non-U.S.	2	0	0	2	0	0
Technician, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**90**	**27**	**17**	**54**	**0**	**36**

1 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
2 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
3 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
4 The total of university, industry, and national lab users will equal the total number of users.

TABLE 3

Pulsed Field Facility: Users by Discipline

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	42	21	4	1	0	16
Senior Investigators, non-U.S.	20	14	2	0	0	4
Postdocs, U.S.	18	12	3	0	2	1
Postdocs, non-U.S.	2	2	0	0	0	0
Students, U.S.	6	3	0	2	0	1
Students, non-U.S.	2	2	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**90**	**54**	**9**	**3**	**2**	**22**

TABLE 4

Pulsed Field Facility: Experimental Requests[1] for Magnet Time

Experiment Requests	Experiment Requests Granted	Experiment Requests Declined
171	109 (63.74%)	62 (36.26%)

1. Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

Pulsed Field Facility: Research Proposals[1] Profile with Magnet Time

	Number of Proposals
Condensed Matter Physics	42
Chemistry, Geochemistry	3
Engineering	1
Magnets, Materials, Testing, Instruments	3
Biology, Biochemistry, Biophysics	0
TOTAL	**49**

	Number of Proposals
Minority[2]	5
Female[3]	6

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

TABLE 6

Pulsed Field Facility: Operations Statistics Number of Magnet Days[1]

	Super-cond.	Short Pulse	Mid Pulse	Long Pulse	100T	Single Turn	Total Days Allocated /User Affiliated	Percentage Allocated / User Affiliated
NHMFL-Affiliated[2]	193	120	41	0	0	14	368	29.63%
Local[2]	223	9	5	0	3	0	240	19.32%
U.S. University	115	88	25	0	13	26	267	21.50%
U.S. Govt. Lab.	0	12	0	0	0	0	12	.97%
U.S. Industry	0	0	0	0	0	0	0	0.00%
Non-U.S.	119	152	52	7	5	10	345	27.78%
Test, Calibration, Set-up, Maintenance	5	0	0	0	5	0	10	.81%
Idle	0	0	0	0	0	0	0	0.00%
TOTAL	**655**	**381**	**123**	**7**	**26**	**50**	**1,242**	**100.00%**

1 User Units are defined as magnet days. For the Pulsed Field Facility, one magnet day is defined as 12 hours in any pulsed magnet system. For experiments in the superconducting magnets, one "magnet day" is defined as 24 hours of use.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

TABLE 7

Pulsed Field Facility: Operations by Discipline Number of Magnet Days[1]

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL[2]	368	363	0	0	5	0
Local[2]	240	187	0	0	53	0
U.S. University	267	222	17	2	26	0
U.S. Govt. Lab.	12	12	0	0	0	0
U.S. Industry	0	0	0	0	0	0
Non-U.S.	345	340	0	0	5	0
Test, Calibration, Set-up, Maintenance	10	5	0	0	5	0
Idle	0	n/a	n/a	n/a	n/a	n/a
TOTAL	**1,242**	**1,129**	**17**	**2**	**94**	**0**

1 User Units are defined as magnet days. For the Pulsed Field Facility, one magnet day is defined as 12 hours in any pulsed magnet system . For experiments in the superconducting magnets, one "magnet day" is defined as 24 hours of use.

2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

2010 USER FACILITY STATISTICS

High B/T Facility

Users, Requests & Operations

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users. All user numbers reflect distinct individuals, i.e. if a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once.

TABLE 1

High B/T Facility: User Demographics

	Users	Female	Minority[1]	On-Site[2] Users[6]	Remote Users [3,6]	Users Sending Sample [4,6]
Senior Investigators, U.S.	7	1	0	7	0	0
Senior Investigators, non-U.S.	4	1	1	4	0	0
Postdocs, U.S.	2	0	0	2	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students[5], U.S.	0	0	0	0	0	0
Students[5], non-U.S.	0	0	0	0	0	0
Technician, U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**13**	**2**	**1**	**13**	**0**	**0**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 Users at the Magnet Lab facility operating the magnet. Not all users on the project must physically come to the lab; if one or more come, then all members of the group are counted in this category.
3 Users conducting the experiment remotely.
4 Experiments in which the sample was sent by an external PI and the experiment was conducted by in-house user support personnel in service mode. No member of the group comes to the lab, and all are counted in this category.
5 "Students" generally refers to graduate students, but may include a few undergraduate students.
6 The total of on-site users, remote users, and users sending samples will equal the total number of users.

TABLE 2

High B/T Facility: User Affiliations

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	7	5	0	6	0	1
Senior Investigators, non-U.S.	4	0	0	3	0	1
Postdocs, U.S.	2	2	0	2	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	0	0	0	0	0	0
Students, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**13**	**7**	**0**	**11**	**0**	**2**

1 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
2 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
3 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
4 The total of university, industry, and national lab users will equal the total number of users.

TABLE 3

High B/T Facility: Users by Discipline

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	7	5	0	0	0	2
Senior Investigators, non-U.S.	4	2	0	0	0	2
Postdocs, U.S.	2	2	0	0	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	0	0	0	0	0	0
Students, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**13**	**9**	**0**	**0**	**0**	**4**

TABLE 4

High B/T Facility: Experimental Requests[1] for Magnet Time

Experiment Requests	Experiment Requests Granted	Experiment Requests Declined
9	9 (69.23%)	4 (30.77%)

1. Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

High B/T Facility: Research Proposals[1] Profile with Magnet Time

	Number of Proposals
Condensed Matter Physics	6
Chemistry, Geochemistry	0
Engineering	0
Magnets, Materials, Testing, Instruments	0
Biology, Biochemistry, Biophysics	1
TOTAL	**7**

	Number of Proposals
Minority[2]	0
Female[3]	0

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

TABLE 6

High B/T Facility: Operations Statistics Number of Magnet Days[1]

	Total Days Allocated /User Affiliated	Percentage Allocated /User Affiliated
NHMFL-Affiliated[2]	0	0.00%
Local[2]	439	46.50%
U.S. University	405	42.90%
U.S. Govt. Lab.	0	0.00%
U.S. Industry	0	0.00%
Non-U.S.	46	4.87%
Test, Calibration, Set-up, Maintenance	54	5.72%
Idle	0	0.00%
TOTAL	**944**	**100.00%**

1 User Units are defined as magnet days. For the High B/T Facility, one magnet day is defined 24 hours in the superconducting magnets.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

TABLE 7

High B/T Facility: Operations by Discipline Number of Magnet Days[1]

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL[2]	0	0	0	0	0	0
Local[2]	439	258	0	0	0	181
U.S. University	405	405	0	0	0	0
U.S. Govt. Lab.	0	0	0	0	0	0
U.S. Industry	0	0	0	0	0	0
Non-U.S.	46	46	0	0	0	0
Test, Calibration, Set-up, Maintenance	54	54	0	0	0	0
Idle	0	n/a	n/a	n/a	n/a	n/a
TOTAL	**944**	**763**	**0**	**0**	**0**	**181**

1 User Units are defined as magnet days. For the High B/T Facility, one magnet day is defined 24 hours in the superconducting magnets.

2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

2010 USER FACILITY STATISTICS

NMR Facility

Users, Requests & Operations

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users. All user numbers reflect distinct individuals, i.e. if a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once.

TABLE 1

NMR Facility: User Demographics

	Users	Female	Minority[1]	On-Site[2] Users[6]	Remote Users [3,6]	Users Sending Sample [4,6]
Senior Investigators, U.S.	71	11	4	63	4	4
Senior Investigators, non-U.S.	20	0	0	16	0	4
Postdocs, U.S.	22	3	2	19	0	3
Postdocs, non-U.S.	0	0	0	0	0	0
Students[5], U.S.	48	20	4	43	2	3
Students[5], non-U.S.	4	1	0	1	0	3
Technician, U.S.	8	3	1	7	0	1
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**173**	**38**	**11**	**149**	**6**	**18**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 Users at the Magnet Lab facility operating the magnet. Not all users on the proposal must physically come to the lab; if one or more come, then all members of the group are counted in this category.
3 Users conducting the experiment remotely.
4 Experiments in which the sample was sent by an external PI and the experiment was conducted by in-house user support personnel in service mode. No member of the group comes to the lab, and all are counted in this category.
5 "Students" generally refers to graduate students, but may include a few undergraduate students.
6 The total of on-site users, remote users, and users sending samples will equal the total number of users.

TABLE 2

NMR Facility: User Affiliations

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	71	22	9	67	2	2
Senior Investigators, non-U.S.	20	0	0	18	1	1
Postdocs, U.S.	22	7	8	19	1	2
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	48	21	11	48	0	0
Students, non-U.S.	4	0	0	4	0	0
Technician, non-U.S.	8	5	2	8	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**173**	**55**	**30**	**164**	**4**	**5**

1 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
2 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
3 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
4 The total of university, industry, and national lab users will equal the total number of users.

TABLE 3

NMR Facility: Users by Discipline

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	71	3	5	9	1	53
Senior Investigators, non-U.S.	20	0	8	2	0	10
Postdocs, U.S.	22	1	2	1	0	18
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	48	0	7	10	2	29
Students, non-U.S.	4	0	3	0	0	1
Technician, non-U.S.	8	0	0	1	1	6
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**173**	**4**	**25**	**23**	**4**	**117**

TABLE 4

NMR Facility: Experimental Requests[1] for Magnet Time

Experiment Requests	Experiment Requests Granted	Experiment Requests Declined
2,958	2,749 (84.98%)	486 (15.02%)

1. Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

NMR Facility: Research Proposals[1] Profile with Magnet Time

	Number of Proposals
Condensed Matter Physics	1
Chemistry, Geochemistry	22
Engineering	7
Magnets, Materials, Testing, Instruments	7
Biology, Biochemistry, Biophysics	42
TOTAL	**79**

	Number of Proposals
Minority[2]	6
Female[3]	11

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

TABLE 6

NMR Facility: Operations Statistics Number of Magnet Days[1]

	900	830	800	720	600	600 WB	600 WB2	500	Total Days Allocated/ User Affiliated	Percentage Allocated / User Affiliated
NHMFL-Affiliated[2]	175	105	351	12	72	75	157	322	1,269	46.16%
Local[2]	94	0	0	95	0	225	125	0	539	19.61%
U.S. University	52	104	0	251	254	29	55	0	745	27.10%
U.S. Govt. Lab.	0	0	0	0	0	0	0	0	0	0.00%
U.S. Industry	7	0	0	0	0	0	0	0	7	0.25%
Non-U.S.	14	89	0	0	0	0	0	0	103	3.75%
Test, Calibration, Set-up, Maintenance	0	0	14	6	18	0	5	43	86	3.13%
Idle	0	0	0	0	0	0	0	0	0	0.00%
TOTAL	**342**	**298**	**365**	**364**	**344**	**329**	**342**	**365**	**2,749**	**100%**

1 User Units are defined as magnet days. For the NMR Facility in Tallahassee, one magnet day is 24 hours in the superconducting magnets.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

TABLE 7

NMR Facility: Operations by Discipline Number of Magnet Days[1]

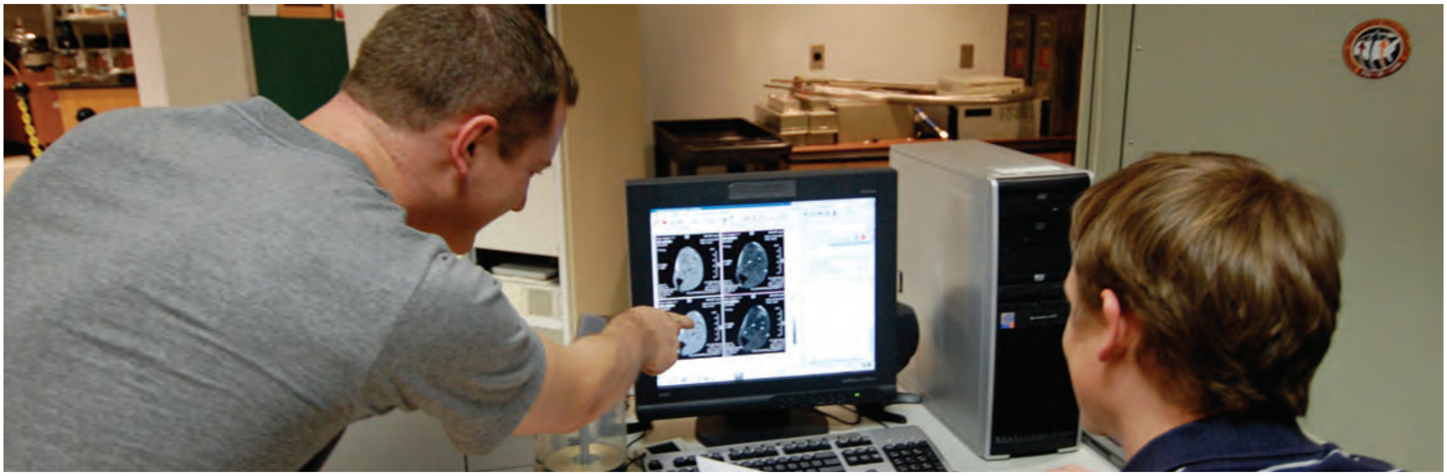
	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL[2]	1,269	0	523	38	53	655
Local[2]	539	0	42	1	0	496
U.S. University	745	10	71	35	10	619
U.S. Govt. Lab.	0	0	0	0	0	0
U.S. Industry	7	0	0	7	0	0
Non-U.S.	103	0	99	0	0	4
Test, Calibration, Set-up, Maintenance	86	0	43	0	24	19
Idle	0	n/a	n/a	n/a	n/a	n/a
TOTAL	**2,749**	**10**	**778**	**81**	**87**	**1,793**

1 User Units are defined as magnet days. For the NMR Facility in Tallahassee, one magnet day is 24 hours in the superconducting magnets.

2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

2010 USER FACILITY STATISTICS

AMRIS Facility



Users, Requests & Operations

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users. All user numbers reflect distinct individuals, i.e. if a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once.

TABLE 1

AMRIS Facility: User Demographics

	Users	Female	Minority[1]	On-Site[2] Users[6]	Remote Users [3,6]	Users Sending Sample [4,6]
Senior Investigators, U.S.	68	16	4	45	2	21
Senior Investigators, non-U.S.	22	2	1	8	4	10
Postdocs, U.S.	15	5	2	11	1	3
Postdocs, non-U.S.	22	6	2	16	3	3
Students[5], U.S.	36	11	3	26	0	10
Students[5], non-U.S.	27	5	5	22	1	4
Technician, U.S.	21	2	0	14	0	7
Technician, non-U.S.	13	1	0	5	2	6
TOTAL	**224**	**48**	**17**	**147**	**13**	**64**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 Users at the Magnet Lab facility operating the magnet. Not all users on the proposal must physically come to the lab; if one or more come, then all members of the group are counted in this category.
3 Users conducting the experiment remotely.
4 Experiments in which the sample was sent by an external PI and the experiment was conducted by in-house user support personnel in service mode. No member of the group comes to the lab, and all are counted in this category.
5 "Students" generally refers to graduate students, but may include a few undergraduate students.
6 The total of on-site users, remote users, and users sending samples will equal the total number of users.

TABLE 2

AMRIS Facility: User Affiliations

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	68	10	32	65	0	3
Senior Investigators, non-U.S.	22	2	6	20	1	1
Postdocs, U.S.	15	0	9	14	0	1
Postdocs, non-U.S.	22	0	16	22	0	0
Students, U.S.	36	0	24	36	0	0
Students, non-U.S.	27	0	20	27	0	0
Technician, non-U.S.	21	4	11	18	3	0
Technician, non-U.S.	13	0	4	10	3	0
TOTAL	**224**	**16**	**122**	**212**	**7**	**5**

1 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
2 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
3 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
4 The total of university, industry, and national lab users will equal the total number of users.

TABLE 3

AMRIS Facility: Users by Discipline

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	68	0	9	5	0	54
Senior Investigators, non-U.S.	22	0	7	1	0	14
Postdocs, U.S.	15	0	2	0	0	13
Postdocs, non-U.S.	22	0	4	1	0	17
Students, U.S.	36	0	12	3	0	21
Students, non-U.S.	27	0	6	4	0	17
Technician, non-U.S.	21	0	1	3	0	17
Technician, non-U.S.	13	0	2	3	0	8
TOTAL	**224**	**0**	**43**	**20**	**0**	**161**

TABLE 4

AMRIS Facility: Experimental Requests[1] for Magnet Time

Experiment Requests	Experiment Requests Granted	Experiment Requests Declined
>400	>400	1

1. Requests which are deferred in a given month but then honored in a future month or which are granted, but with less time than originally requested, are counted as granted.

TABLE 5

AMRIS Facility: Research Proposals[1] Profile with Magnet Time

	Number of Proposals
Condensed Matter Physics	0
Chemistry, Geochemistry	9
Engineering	2
Magnets, Materials, Testing, Instruments	0
Biology, Biochemistry, Biophysics	38
TOTAL	**49**

	Number of Proposals
Minority[2]	4
Female[3]	17

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

TABLE 6

AMRIS Facility: Operations Statistics Number of Magnet Days[1]

	500 MHz NMR	600 MHz NMR/ MRI	600 MHz cryo	750 MHz WB	4.7 T /33cm	11.1 T / 40cm	3T whole body	Total Days Allocated/ User Affiliated	Percentage Allocated/ User Affiliated
NHMFL-Affiliated[2]	38	256	122	210	57	152	30	865	38%
Local[2]	11	3	14	2	10	36	99	175	7%
UF Pilot Study[3]	0	0	0	0	0	0	0	0	0%
U.S. University	41	6	40	58	.5	38	0	183.5	8%
U.S. Govt. Lab.	0	0	1	0	0	0	0	1	0%
U.S. Industry	0	0	0	0	0	0	0	0	0%
Non-U.S.	94	0	29	15	1	107	0	246	11%
Development[4]	21	57	39	50	33	6	0	206	9%
Test, Calibration, Set-up, Maintenance[5]	51	25	51	20	45	18	35	245	11%
Idle	101	10	61	2	108.5	0	91	373.5	16%
TOTAL	**357**	**357**	**357**	**357**	**255**	**357**	**255**	**2,295**	**100%**

1 User Units are defined as magnet days. Magnet-day definitions for AMRIS instruments: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours (7 days/week). Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours (5 days/week). This accounts for the difficulty in running animal or human studies overnight. There is an annual 7 day holiday shutdown at UF so total days are based on a 51 week calendar. Magnet days were calculated by adding the total number of real hours used for each instrument and dividing by 24 (vertical) or 8 (horizontal).
NOTE: Due to the nature of the 4.7 T, 11 T and 3 T studies, almost all studies with external users were collaborative with UF investigators.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."
NOTE: All of the use in this category was paid by individual investigator grants and not the NHMFL.
3 Pilot studies are awarded to UF investigators from NHMFL funds. **For merging with other NHMFL user tables it will be added to the NHMFL-Affiliated category.**
4 Development was used for several purposes, primarily for establishing new capabilities such as building and testing coils, implementing new pulse sequences, and developing new protocols. **For merging with other NHMFL user tables, Development data will be added to Test, Calibration, Set-up, Maintenance.**
5 Note that each instrument has approximately the same number of hours for maintenance/testing and days are different due to definitions of magnet days on the different instruments.

TABLE 7

AMRIS Facility: Operations by Discipline Number of Magnet Days[1]

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL[2]	865	0	265	200	0	400
Local[2]	175	0	75	0	0	100
UF Pilot Study[3]	0	0	0	0	0	0
U.S. University	183.5	0	83.5	0	0	100
U.S. Govt. Lab.	1	0	1	0	0	0
U.S. Industry	0	0	0	0	0	0
Non-U.S.	246	0	96	0	0	150
Development[4]	206	0	6	100	50	50
Test, Calibration, Set-up, Maintenance[5]	245	0	0	50	145	50
Idle	373.5	n/a	n/a	n/a	n/a	n/a
TOTAL	**2,295**	**0**	**526.5**	**350**	**195**	**850**

1 User Units are defined as magnet days. Magnet-day definitions for AMRIS instruments: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours (7 days/week).Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours (5 days/week). This accounts for the difficulty in running animal or human studies overnight. There is an annual 7 day holiday shutdown at UF so total days are based on a 51 week calendar. Magnet days were calculated by adding the total number of real hours used for each instrument and dividing by 24 (vertical) or 8 (horizontal).

NOTE: Due to the nature of the 4.7 T, 11 T and 3 T studies, almost all studies with external users were collaborative with UF investigators.

2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."
NOTE: All of the use in this category was paid by individual investigator grants and not the NHMFL.

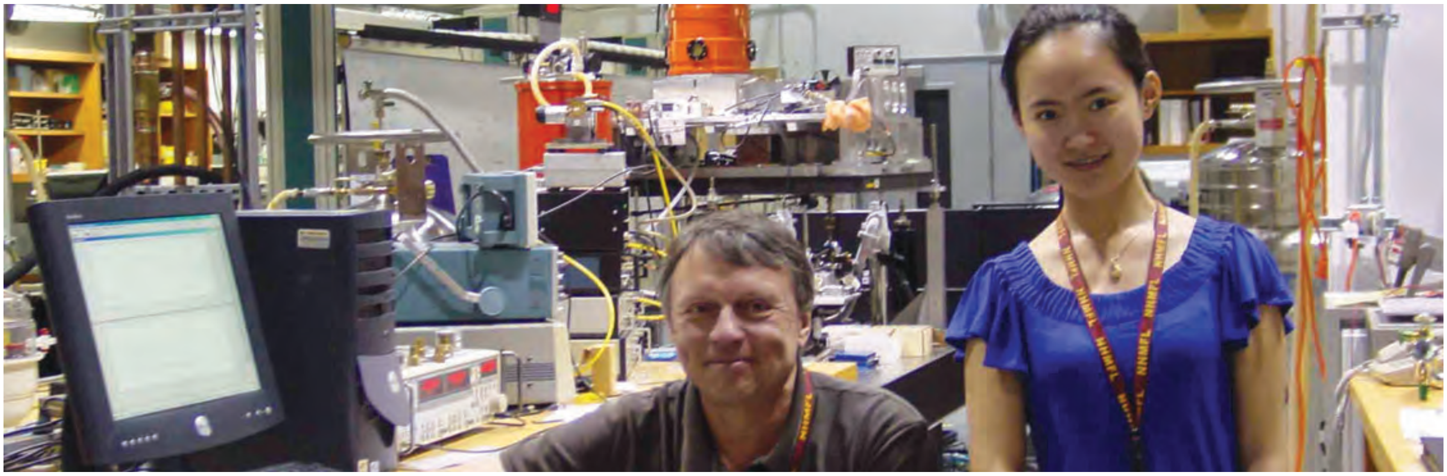
3 Pilot studies are awarded to UF investigators from NHMFL funds. **For merging with other NHMFL user tables it will be added to the NHMFL-Affiliated category.**

4 Development was used for several purposes, primarily for establishing new capabilities such as building and testing coils, implementing new pulse sequences, and developing new protocols. **For merging with other NHMFL user tables, Development data will be added to Test, Calibration, Set-up, Maintenance.**

5 Note that each instrument has approximately the same number of hours for maintenance/testing and days are different due to definitions of magnet days on the different instruments.

2010 USER FACILITY STATISTICS

EMR Facility



Users, Requests & Operations

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users. All user numbers reflect distinct individuals, i.e. if a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once.

TABLE 1

EMR Facility: User Demographics

	Users	Female	Minority[1]	On-Site[2] Users[6]	Remote Users [3,6]	Users Sending Sample [4,6]
Senior Investigators, U.S.	28	2	2	28	0	0
Senior Investigators, non-U.S.	34	4	2	34	0	0
Postdocs, U.S.	8	1	0	8	0	0
Postdocs, non-U.S.	9	3	2	9	0	0
Students[5], U.S.	17	5	3	17	0	0
Students[5], non-U.S.	5	1	0	5	0	0
Technician, U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**101**	**16**	**9**	**101**	**0**	**0**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 Users at the Magnet Lab facility operating the magnet. Not all users on the proposal must physically come to the lab; if one or more come, then all members of the group are counted in this category.
3 Users conducting the experiment remotely.
4 Experiments in which the sample was sent by an external PI and the experiment was conducted by in-house user support personnel in service mode. No member of the group comes to the lab, and all are counted in this category.
5 "Students" generally refers to graduate students, but may include a few undergraduate students.
6 The total of on-site users, remote users, and users sending samples will equal the total number of users.

TABLE 2

EMR Facility: User Affiliations

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	28	6	2	28	0	0
Senior Investigators, non-U.S.	34	0	0	28	0	6
Postdocs, U.S.	8	1	1	8	0	0
Postdocs, non-U.S.	9	0	0	8	0	1
Students, U.S.	17	3	2	17	0	0
Students, non-U.S.	5	0	0	2	0	3
Technician, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**101**	**10**	**5**	**91**	**0**	**10**

1 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
2 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
3 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
4 The total of university, industry, and national lab users will equal the total number of users.

TABLE 3

EMR Facility: Users by Discipline

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	28	7	9	1	0	11
Senior Investigators, non-U.S.	34	9	17	2	0	6
Postdocs, U.S.	8	1	3	1	0	3
Postdocs, non-U.S.	9	5	3	0	0	1
Students, U.S.	17	2	14	0	0	1
Students, non-U.S.	5	2	2	0	0	1
Technician, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**101**	**26**	**48**	**4**	**0**	**23**

TABLE 4

EMR Facility: Experimental Requests[1] for Magnet Time

Experiment Requests	Experiment Requests Granted	Experiment Requests Declined
53	42 (79.25%)	11 (20.75%)

1. Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

EMR Facility: Research Proposals[1] Profile with Magnet Time

	Number of Proposals
Condensed Matter Physics	8
Chemistry, Geochemistry	21
Engineering	0
Magnets, Materials, Testing, Instruments	1
Biology, Biochemistry, Biophysics	4
TOTAL	**34**

	Number of Proposals
Minority[2]	1
Female[3]	4

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

TABLE 6

EMR Facility: Operations Statistics Number of Magnet Days[1]

	17 T	12 T	Mossbauer	Total Days Allocated /User Affiliated	Percentage Allocated /User Affiliated
NHMFL-Affiliated[2]	7	0	0	7	1.28%
Local[2]	16	36	21	73	13.35%
U.S. University	74	35	0	109	19.93%
U.S. Govt. Lab.	0	0	0	0	0.00%
U.S. Industry	0	0	0	0	0.00%
Non-U.S.	178	65	115	358	65.45%
Test, Calibration, Set-up, Maintenance	0	0	0	0	0.00%
Idle	0	0	0	0	0.00%
TOTAL	**275**	**136**	**136**	**547**	**100.00%**

1 User Units are defined as magnet days. For the EMR Facility, one magnet day is defined as 24 hours in superconducting magnets.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

TABLE 7

EMR Facility: Operations by Discipline Number of Magnet Days[1]

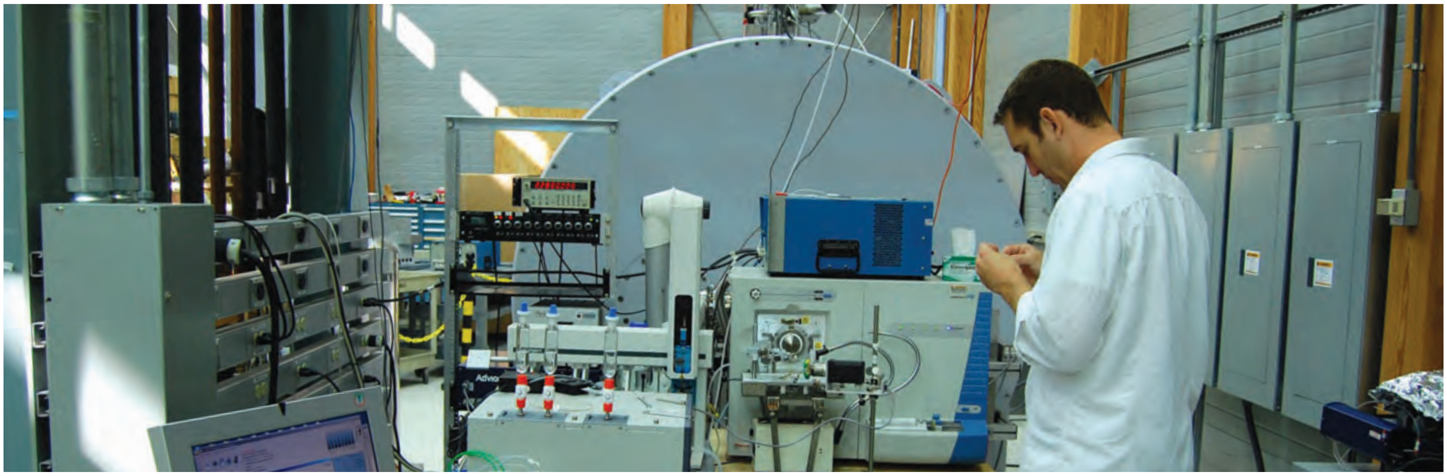
	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL[2]	7	0	7	0	0	0
Local[2]	73	0	71	0	2	0
U.S. University	109	39	45	0	0	25
U.S. Govt. Lab.	0	0	0	0	0	0
U.S. Industry	0	0	0	0	0	0
Non-U.S.	358	105	248	0	0	5
Test, Calibration, Set-up, Maintenance	0	0	0	0	0	0
Idle	0	n/a	n/a	n/a	n/a	n/a
TOTAL	**547**	**144**	**371**	**0**	**2**	**30**

1 User Units are defined as magnet days. For the EMR Facility, one magnet day is defined as 24 hours in superconducting magnets.

2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

2010 USER FACILITY STATISTICS

ICR Facility



Users, Requests & Operations

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users. All user numbers reflect distinct individuals, i.e. if a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once.

TABLE 1

ICR Facility: User Demographics

	Users	Female	Minority[1]	On-Site[2] Users[6]	Remote Users [3,6]	Users Sending Sample [4,6]
Senior Investigators, U.S.	37	6	0	34	0	3
Senior Investigators, non-U.S.	7	0	1	6	1	0
Postdocs, U.S.	10	2	1	10	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students[5], U.S.	20	10	1	20	0	0
Students[5], non-U.S.	0	0	0	0	0	0
Technician, U.S.	6	1	0	5	0	1
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**80**	**19**	**3**	**75**	**1**	**4**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 Users at the Magnet Lab facility operating the magnet. Not all users on the proposal must physically come to the lab; if one or more come, then all members of the group are counted in this category.
3 Users conducting the experiment remotely.
4 Experiments in which the sample was sent by an external PI and the experiment was conducted by in-house user support personnel in service mode. No member of the group comes to the lab, and all are counted in this category.
5 "Students" generally refers to graduate students, but may include a few undergraduate students.
6 The total of on-site users, remote users, and users sending samples will equal the total number of users.

TABLE 2

ICR Facility: User Affiliations

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Investigators, U.S.	37	6	8	23	10	4
Senior Investigators, non-U.S.	7	0	0	5	1	1
Postdocs, U.S.	10	8	2	10	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	20	6	8	20	0	0
Students, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	6	2	1	5	1	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**80**	**22**	**19**	**63**	**12**	**5**

1 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
2 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
3 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
4 The total of university, industry, and national lab users will equal the total number of users.

TABLE 3

ICR Facility: Users by Discipline

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	37	0	20	1	0	16
Senior Investigators, non-U.S.	7	0	5	0	0	2
Postdocs, U.S.	10	0	4	0	1	5
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	20	0	14	1	1	4
Students, non-U.S.	0	0	0	0	0	0
Technician, non-U.S.	6	0	3	0	0	3
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**80**	**0**	**46**	**2**	**2**	**30**

TABLE 4

ICR Facility: Experimental Requests[1] for Magnet Time

Experiment Requests	Experiment Requests Granted	Experiment Requests Declined
85	74 (74.75%)	25 (25.25%)

1. Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

ICR Facility: Research Proposals[1] Profile with Magnet Time

	Number of Proposals
Condensed Matter Physics	0
Chemistry, Geochemistry	29
Engineering	0
Magnets, Materials, Testing, Instruments	8
Biology, Biochemistry, Biophysics	23
TOTAL	**60**
	Number of Proposals
Minority[2]	1
Female[3]	5

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

TABLE 6

ICR Facility: Operations Statistics Number of Magnet Days[1]

	14.5 T Hybrid	9.4 T Passive	9.4 T Active	Total Days Allocated /User Affiliated	Percentage Allocated /User Affiliated
NHMFL-Affiliated[2]	229	135	13	377	54.64%
Local[2]	57	38	0	95	13.77%
U.S. University	72	34	0	106	15.36%
U.S. Govt. Lab.	2	40	0	42	6.09%
U.S. Industry	0	31	0	31	4.49%
Non-U.S.	1	14	0	15	2.17%
Test, Calibration, Set-up, Maintenance	0	24	0	24	3.48%
Idle	0	0	0	0	0.00%
TOTAL	**361**	**316**	**13**	**690**	**100.00%**

1 For the ICR Facility, one magnet day is defined as 24 hours of use.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

TABLE 7

ICR Facility: Operations by Discipline Number of Magnet Days[1]

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL[2]	377	0	82	0	119	176
Local[2]	95	0	52	0	0	43
U.S. University	106	0	55	0	0	51
U.S. Govt. Lab.	42	0	42	0	0	0
U.S. Industry	31	0	31	0	0	0
Non-U.S.	15	0	4	0	0	11
Test, Calibration, Set-up, Maintenance	24	0	0	0	24	0
Idle	0	n/a	n/a	n/a	n/a	n/a
TOTAL	**690**	**0**	**266**	**0**	**143**	**281**

1 User Units are defined as magnet days. For the ICR Facility, one magnet day is defined as 24 hours of use.

2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

2010 USER FACILITY STATISTICS

Geochemistry Facility

Users, Requests & Operations

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the Magnet Lab, are all considered users. All user numbers reflect distinct individuals, i.e. if a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once.

TABLE 1

Geochemistry Facility: User Demographics

	Users	Female	Minority[1]	On-Site[2] Users[6]	Remote Users [3,6]	Users Sending Sample [4,6]
Senior Investigators, U.S.	18	4	1	17	0	1
Senior Investigators, non-U.S.	2	2	0	2	0	0
Postdocs, U.S.	7	3	0	7	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students[5], U.S.	30	20	2	30	0	0
Students[5], non-U.S.	0	0	0	0	0	0
TOTAL	**57**	**29**	**3**	**56**	**0**	**1**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 Users at the Magnet Lab facility operating the magnet. Not all users on the proposal must physically come to the lab; if one or more come, then all members of the group are counted in this category.
3 Users conducting the experiment remotely.
4 Experiments in which the sample was sent by an external PI and the experiment was conducted by in-house user support personnel in service mode. No member of the group comes to the lab, and all are counted in this category.
5 "Students" generally refers to graduate students, but may include a few undergraduate students.
6 The total of on-site users, remote users, and users sending samples will equal the total number of users.

TABLE 2

Geochemistry Facility: User Affiliations

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	18	8	5	16	0	2
Senior Investigators, non-U.S.	2	0	0	1	0	1
Postdocs, U.S.	7	6	1	7	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	30	20	5	30	0	0
Students, non-U.S.	0	0	0	0	0	0
TOTAL	**57**	**34**	**11**	**54**	**0**	**3**

1 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators."
2 In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
3 In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
4 The total of university, industry, and national lab users will equal the total number of users.

TABLE 3

Geochemistry Facility: Users by Discipline

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	18	0	14	0	0	4
Senior Investigators, non-U.S.	2	0	2	0	0	0
Postdocs, U.S.	7	0	7	0	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	30	0	26	0	0	4
Students, non-U.S.	0	0	0	0	0	0
TOTAL	**57**	**0**	**49**	**0**	**0**	**8**

TABLE 4

Geochemistry Facility: Experimental Requests[1] for Magnet Time

Experiment Requests	Experiment Requests Granted	Experiment Requests Declined
23	23	0

1. Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

Geochemistry Facility: Research Proposals[1] Profile with Magnet Time

	Number of Proposals
Condensed Matter Physics	0
Chemistry, Geochemistry	19
Engineering	0
Magnets, Materials, Testing, Instruments	0
Biology, Biochemistry, Biophysics	4
TOTAL	**23**

	Number of Proposals
Minority[2]	1
Female[3]	8

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

TABLE 6

Geochemistry Facility: Operations Statistics Number of Magnet Days[1]

	262/RPQ[3]	MC-ICP-MS Neptune	ELEMENT	Delta XP	Total Days Allocated /User Affiliated	Percentage Allocated /User Affiliated
NHMFL-Affiliated[2]	20	180	110	180	490	50.60%
Local[2]	0	0	50	20	70	7.20%
U.S. University	10	5	0	0	15	1.60%
U.S. Govt. Lab.	15	0	0	10	25	3.60%
U.S. Industry	0	0	0	0	0	0.00%
Non-U.S.	0	0	20	0	20	0.00%
Test, Calibration, Set-up, Maintenance	10	30	30	20	90	10.30%
Idle	187	27	32	12	258	26.60%
TOTAL	**242**	**242**	**242**	**242**	**968**	**100.00%**

1 User Units are defined as magnet days. For the Geochemistry Facility, one magnet day is defined as 12 hours on the instrument.
2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."
3 This instrument is being phased out and is being replaced by the Neptune. We will not report on this instrument in the upcoming years.

TABLE 7

Geochemistry Facility: Operations by Discipline Number of Magnet Days[1]

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL[2]	490	0	470	0	0	20
Local[2]	70	0	30	0	0	40
U.S. University	15	0	15	0	0	0
U.S. Govt. Lab.	25	0	25	0	0	0
U.S. Industry	0	0	0	0	0	0
Non-U.S.	20	0	20	0	0	0
Test, Calibration, Set-up, Maintenance	90	0	90	0	0	0
Idle	258	n/a	n/a	n/a	n/a	n/a
TOTAL	**968**	**0**	**650**	**0**	**0**	**60**

1 User Units are defined as magnet days. For the Geochemistry Facility, one magnet day is defined as 12 hours on the instrument.

2 NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users ar defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local usage equals what was formerly referred to as usage by "Internal Investigators."

APPENDIX B

Research Reports by Category

At the end of each year, Magnet Lab users and faculty at FSU, UF, and LANL submit brief abstracts of their experiments, research, and scholarly endeavors. In 2010, 417 research reports were reviewed and approved by facility or department directors, and all are published online: **http://www.magnet.fsu.edu/usershub/publications/researchreportsonline.aspx**.
The reports are searchable by facility, category, first author, PI, keywords, or general search.

Biochemistry – 44 Reports

Facility	PI	Title
DC Field	Stoll, S., U. California, Davis, Chemistry	The Magnetic Structure of Tryptophan Radicals in Proteins
EMR	Fanucci, G.E., UF, Chemistry	SDSL EPR of the Intrinsically Disordered Protein IA3: A Comparison of X-band and W-band Spectra
EMR	Liu, A., Georgia State U., Chemistry	Spectroscopic Characterization of the Role of Calcium in Diheme Enzyme MauG
ICR	Cooper, H.J., U. Birmingham, UK, Biochemistry	Electron Capture Dissociation Mass Spectrometry of Metallo-Supramolecular Complexes
ICR	Greig, M.J., Pfizer, Biochemistry	Drug Binding and Resistance Mechanism of KIT Tyrosine Kinase Revealed by Hydrogen/Deuterium Exchange FT-ICR Mass Spectrometry
ICR	Kroes, R.A., Northwestern U., Biomedical Engineering, Biology	Polar Lipid Remodeling and Increased Sulfatide Expression are Associated with the Glioma Therapeutic Candidates, Wild Type p53 Elevation and the Topoisomerase-1 Inhibitor, Irinotecan
ICR	Marshall, A.G., FSU, NHMFL, Chemistry	Advantages of Isotopic Depletion of Proteins for H/D Exchange Experiments Monitored by Mass Spectrometry
ICR	Marshall, A.G., FSU, NHMFL, Chemistry	Liquid Chromatography Electrospray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometric Characterization of N-linked Glycans and Glycopeptides
ICR	Marshall, A.G., FSU,NHMFL, Chemistry	Simultaneous Reduction and Digestion of Proteins with Disulfide Bonds for Hydrogen/Deuterium Exchange Monitored by Mass Spectrometry
ICR	Moskal, J.R., Northwestern U., Biochemistry	Glycomic and Transcriptomic Response of GSC11 Glioblastoma Stem Cells to STAT3 Phosphorylation Inhibition and Serum-induced Differentiation
ICR	Moskal, J.R., Northwestern U., Molecular Therapeutics	Overexpression of ST6GalNAcV, a Ganglioside-Specific α2,6 Sialyltransferase, Inhibits Glioma Growth *in vivo*
ICR	Schramm, V.L., Albert Einstein College of Medicine, Biochemistry	Conformational States of Human Purine Nucleoside Phosphorylase at Rest, at Work and with Transition State Analogues
AMRIS	Dossey, A.T., USDA	Continued Discovery of Defensive Chemistry in Walkingstick Insects (Order Phasmatodea)
AMRIS	Edison, A. S., UF, Biochemistry & Molecular Biology	Use of Neuroimaging in Regenerative Medicine
AMRIS	Edison, A.S., UF, Biochemistry & Molecular Biology	Alignment and Statistical Analysis of 2D NMR Spectra of Mixtures
AMRIS	Fanucci, G.E., UF, Chemistry	^{1}H-^{15}N HSQC Spectral Analysis of HIV-1 Protease with Primary and Secondary Mutations
AMRIS	Fanucci, G.E., UF, Chemistry Department	^{1}H, ^{15}N and ^{13}C NMR Backbone Assignment of HIV-1 Protease
AMRIS	Fanucci, G.E., UF, Chemistry	^{2}H-NMR Characterization of Model BMP/POPC/CHOL Membranes
AMRIS	Frost, S.C., UF, Biochemistry & Molecular Biology	Metabolic Reorganization in Breast Cancer Epithelial Cells: Role of the Pentose Phosphate Shunt
AMRIS	Long, J.R., UF, Biochemistry & Molecular Biology	Partitioning, Dynamics, and Orientation of Lung Surfactant Peptide KL4 in Phospholipid Bilayers

Facility	PI	Title
AMRIS	Long, J.R., UF, Biochemistry & Molecular Biology	Solid State ^2H and ^{31}P NMR Characterization of Lung Surfactant Preparations
AMRIS	Long, J.R., UF, Biochemistry & Molecular Biology	Structural Analysis of the C-Terminus of Lung Surfactant Protein B (SP-B)
AMRIS	Long, J.R., UF, Biochemistry & Molecular Biology	Characterization of Hydrogen Bonding in Amphiphilic Peptide Helices via REDOR
AMRIS	Long, J.R., UF, Biochemistry & Molecular Biology	Structural Studies of Adhesin Protein P1
NMR	Akey, C.W., Boston U. Medical School, Physiology & Biophysics	Structural Characterization of the DNA-binding Domain of the Xenopus NO38 Chaperone Complexed with its Duplex DNA Target
NMR	Bruschweiler, R., FSU, Chemistry and Biochem-istry	Arginine Kinase: Joint Crystallographic and NMR RDC Analyses Link Substrate-Associated Motions to Intrinsic Flexibility
NMR	Bruschweiler, R., FSU, Chemistry and Biochem-istry	Characterization of the Structural Dynamics of Human MDM2 Interaction with p53 by Multi-dimensional NMR Spectroscopy
NMR	Bruschweiler, R., FSU, NHMFL and Chemistry and Biochemistry	NMR-Based Protein Force Field
NMR	Brüschweiler, R., FSU/NHMFL, Chemistry and Biochemistry	Direct Evidence for Conformational Heterogeneity in Human Pancreatic Glucokinase from High Resolution NMR
NMR	Cotten, M., Hamilton College, Chemistry	Dynamic Studies of Antimicrobial Piscidin in Aligned Lipid Bilayers with Negative Curvature
NMR	Cotten, M., Hamilton College, Chemistry	Atomic-Resolution Structural Studies of Antimicrobial Piscidin in Aligned Lipid Bilayers with Negative Curvature
NMR	Cross, T.A., FSU, Chemistry and Biochemistry	Structural Studies of Mycobacterium tuberculosis Integral Membrane Protein Rv1861
NMR	Cross, T.A., NHMFL, Biochemistry	Is MgtC, a Potential Drug Target in M. tuberculosis, Inhibited by MgtR?
NMR	Cross, T.A., NHMFL	Drug Sensitivity, Drug-Resistant Mutations, and Structures of Three Conductance Domains of Viral Porins
NMR	Cross, T.A., NHMFL	Insight Into the Mechanism of the Influenza A Proton Channel from a Structure in a Lipid Bilayer
NMR	Cross, T.A., NHMFL	Influence of Solubilizing Environments on Membrane Protein Structures
NMR	Cross, T.A., NHMFL	Magic Angle Spinning Solid State NMR Studies of M2 Proton Channel
NMR	Cross, T.A., NHMFL, FSU, Chemistry and Biochemistry, IMB	Rv0011c a Mtb Membrane Protein Structure Determination by NMR Spectroscopy
NMR	Eisenmesser, E.Z., UCD, Biochem. & Mol. Gen.	Multiple Conformational Exchange Events Underlie cyclophilin-A Catalysis
NMR	Harris, T.K., U. Miami Miller School of Medicine, Biochemistry and Molecular Biology	Backbone Chemical Shift Assignments of the Pleckstrin Homology (PH) Domain of Phosphoinositide-Dependent Protein Kinase-1 (PDK1)
NMR	Long, J.R., UF, Biochemistry & Molecular Biology	Characterization of the Orientation of Pulmonary Surfactant Peptide KL4 in Lipid Bilayers of Varying Composition
NMR	Smirnov, S.L., Western Washington U., Chemistry	Structural Characterization of D6-HP, a Villin Fragment Capable of Bundling of F-actin
NMR	Stemmler, T.L., Wayne State U., Biochemistry	Resonance Assignments and Secondary Structure Prediction of the As(III) Metallochaperone ArsD in Solution
NMR	Tian, F., Penn State College of Medicine, Biochemistry and Molecular Biology	"*In situ*" Detection of the Transmembrane Domain of the APP Binding Protein LR11 in Native E. coli Membrane Using Solid State MAS NMR

Biology – 34 Reports

Facility	PI	Title
EMR	Collier, R. John, Harvard Medical School	Probing Interactions Within Anthrax Toxin by Electron
ICR	Marto, J.A., Harvard Medical School, Cancer Biology	Robust Error Model for iTRAQ Quantification Reveals Divergent Signaling Between Oncogenic FLT3 Mutants in Acute Myeloid Leukemia
AMRIS	Blackband, S.J., UF, Neuroscience	MR Microscopy and Tractography in Human Spinal Cord Tissue at the Cellular Level
AMRIS	Blackband, S.J., UF, Neuroscience	MR Microscopy of Fixed *Aplysia californica* Neurons Using Microsurface Coils
AMRIS	Blackband, S.J., UF, Neuroscience	MR Microscopy of Human and Porcine Neurons with Cellular Processes
AMRIS	Carlier, P. AIM-CEA, NMR Laboratory, Paris, France	Quantitative Measurement of Skeletal Muscle Perfusion Using Arterial Spin Labeling NMR Imaging at High (4.7T) and Ultra-high Field (11.T/17.6T): A Comparative Study
AMRIS	Edison, A.S., UF, Biochemistry & Molecular Biology	Identification of Quorum Sensing Inhibitor Compound(s) from *Caenorhabditis elegans*
AMRIS	Edison, A.S., UF, Biochemistry & Molecular Biology	Identification of Mating Pheromones in *Panagrellus redivivus*
AMRIS	Forder, J.R., UF, Radiology	MR Microscopy of the Complete Purkinje Fiber Conduction System in the Isolated Heart
AMRIS	Gamcsik, M.P., UNC, Biomedical Engineering	Non-invasive Monitoring of OTZ Metabolism in the Rat Brain by *In vivo* ^{13}C MRS
AMRIS	Magin, R.L., U. Illinois at Chicago, Bioengineering	Evidence of Changes in Gray/White Matter in Epileptic Rat Brain Using Fractional Order Diffusion Tensor Imaging (fDTI) at 17.6 T
AMRIS	Mareci, T.H., UF, Biochemistry and Molecular Biology	Digitally Controlled u-Chip Capacitor Array for an Implantable Multiple Frequency Coil
AMRIS	Miller, J.L., UF, Pediatrics	Neuroanatomic Studies in Prader-Willi Syndrome and Early-onset Obesity
AMRIS	Naylor, G., FSU, Scientific Computing	Shark Virtual Comparative Anatomy Using MRI
AMRIS	Simpson, N.E., UF, Medicine	NMR Monitoring a Bioartificial Organ with Implantable Inductively-Coupled Coils
AMRIS	Su, L.-M., UF, Urology	Fiber Tract Mapping in the Isolated Human Prostate
AMRIS	Turner, B.L., Smithsonian Tropical Research Institute	Characterization of Carbon in Water Extracts of Leaf Litter in a Lowland Tropical Forest Using ^{13}C and ^{1}H NMR Spectroscopy
AMRIS	Turner, B.L., Smithsonian Tropical Research Institute	Sources and Stability of Biogenic Phosphorus in Palustrine Wetland Systems
AMRIS	Walter, G.A., UF, Physiology	Changes In Muscle T2 and Tissue Damage Following Downhill Running in mdx Mice
AMRIS	Walter, G.A., UF, Physiology	Noninvasive Monitoring of Arginine Kinase Gene Transfer to Skeletal Muscle
AMRIS	Walter, G.A., UF, Physiology	Morphological and Metabolic Characterization of a New Model of Spinal Cord Injury Without Reloading Using 1H MRI and 31P NMR Spectroscopy
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Tracking of Neuroprogenitor Cells in Association with Traumatic Brain Injury
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Differentiation of Progressive Supranuclear Palsy and Healthy Human Brain Tissue Utilizing High Resolution MR Microscopy at 21.1 T
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	High Field MR Microscopy of Progressive Supranuclear Palsy in the Human Globus Pallidus
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Bimodal Nanoparticles Based on Quantum Dots for High Field MRI at 21.1 T: An Initial *in vivo* Evaluation
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	High Field ^{23}Na Magnetic Resonance Microscopy of Neural Ganglia Under Osmotic Perturbation
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Diffusion Tensor Imaging to Track Changes in Skeletal Muscle Architecture of Sarcopenic Rats
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	In Vivo Tracking of Arterially Injected, Pre-labeled hMSCs with Iron Oxide Nanoparticles in Association with Traumatic Brain Injury
NMR	Harrington, M.G., Huntington Medical Research Institutes, Molecular Neurology	In vivo Sodium MRI in a Rat Model of Migraine

Facility	PI	Title
NMR	Kim, J.S., FSU, Nutrition, Food and Exercise Science	Effects of Resistance Training and HMB on Muscle Fiber CSA and Body Mass in Aged Rats: A DTI and DEXA Study
NMR	Levenson, C.W., FSU, College of Medicine	Traumatic Brain Injury in Rodent Model and Diffusion MRI at 21.1 T
NMR	Schepkin, V.D., NHMFL, CIMAR	The First Chlorine MR Imaging at 21.1 T
NMR	Schepkin, V.D., NHMFL, CIMAR	Rodent Glioma Therapy, *in vivo* Sodium and Diffusion MR Imaging at 21.1 T
NMR	Schepkin, V.D., NHMFL, CIMAR	Non-treated Rodent Glioma, *in vivo* Sodium and Diffusion MR Imaging at 21.1 T

Chemistry – 58 Reports

Facility	PI	Title
DC Field	Dalal, N., FSU, Chemistry and Biochemistry; NHMFL	An Investigation of Quantum Critical Phenomenon of S=1/2 Alkali Metal Peroxychromates (M_2NaCrO_8)
DC Field	Long, J.R., UC Berkeley, Berkeley	High-Field EPR Study of a [ReCl4CN)2]2- Magnetic Molecular Building Block
DC Field	Telser, J., Roosevelt U., Biological, Chemical and Physical Sciences	HFEPR Studies of a Series of Five-Coordinate Catalytically Active Nickel(II) Complexes
EMR	Bronisz, R., U. Wroclaw, Faculty of Chemistry	Mössbauer and Magnetic Studies on a Coordination Polymer $\{[Fe(CH_3CN)_4(pyrazine)](ClO_4)_2\}_\infty$ Exhibiting HS↔LS Spin-Crossover Transition
EMR	Dalal, N.S., FSU	High Field EPR Study of Phase Transition in Ammonium Peroxychromate $(NH_4)_3CrO_8$
EMR	Dalal, N.S., FSU, Chemistry	High-Field Electron Paramagnetic Resonance Studies on Mn_7, a Manganese Cluster with S = 29/2
EMR	Erdem, E., U. Freiburg	Investigation of Defect Centers in ZnO Nanomaterials by High-field EPR Spectroscopy
EMR	Hendrickson, D.N., U. California San Diego	A Mn_4 Dicubane SMM Exhibiting Novel Quantum Properties and Sharp HFEPR Transitions
EMR	Jezierska, J., Wroclaw U. (Poland), Chemistry	High-Spin States in Binuclear Oxygen-Bridged Iron(III) Complexes
EMR	Kokozay, VN, Taras Shevchenko U., Kiev, Ukraine, Chemistry	High-Field EPR and Magnetic Studies on Cr-Cr Interactions in New Heterometallic Tetra-nuclear Complexes
EMR	Kortz, U., Jacobs U., Germany, School of Engi-neering and Science	*Magnetic Studies on a* $\{Mn_{19}Si_6W_{60}\}$ *Polyoxometalate*
EMR	Kumbhar, A.S., U. Pune, Chemistry	HFEPR of Mixed Ligand Vanadium(III) Polypyridyl Complexes with Potential DNA Cleavage and Insulin Mimetic Activity
EMR	Kyritsis, P., U. Athens, Chemistry	Electronic Properties of Octahedral Trans-$[Ni\{(OPPh_2)(EPPh_2)N\}_2(sol)_2]$ Complexes, E = S, Se; sol = dmf, thf, Investigated by HFEPR, Magnetization and Theoretical Studies
EMR	Merritt, M.E., U. Texas Southwestern Medical Center, Advanced Imaging Research Center	Electronic Relaxation of DNP Radicals at High Magnetic Fields
EMR	Mindiola, D.J., Indiana U., Bloomington, Chem-istry	HFEPR Studies of a Three-Coordinate Organometallic Vanadium(II) Complex
EMR	Raptis, R.G., U. Puerto Rico, Chemistry	Mapping of Spin States in Mixed-Valent Octanuclear Iron-Oxo-Pyrazolato Clusters
EMR	Reger, D.L., U. South Carolina (Columbia), Chemistry	High-Frequency EPR Studies on Dimeric Carboxylato-Bridged Copper(II) Complexes
EMR	Strouse, G., FSU, Chemistry	High-Field Electron Paramagnetic Resonance as a New Technique to Measure Strain in II-IV Semiconductor Nanoparticles
EMR	Sunatsuki, Y., Okayama U., Graduate School of Natural Science and Technology	HFEPR on Manganese(III) and (IV) Complexes with a Tripodal Ligand

Facility	PI	Title
EMR	Wojciechowska, A. PhD, Wroclaw U. Technology, Chemistry	HF-EPR Studies on a Nickel(II) Complex with L-Tyrosine and Imidazole, $[Ni(im_2 (L\text{-}tyr)_2]\bullet 4H_2O$
EMR	Wojciechowski, K., Warsaw U. of Technology, Faculty of Chemistry	High-Frequency EPR and Magnetic Studies on an Alternating Monomer- Dimer Chain Complex $[Cu(C_5H_{11}CoO_2]_2[Cu(C_{12}H_{26}N_2O_4)(C_5H_{11}CoO)_2]$
EMR	Yang, E.-C., Fu Jen Catholic U., Chemistry	Mn_8 Single-Molecule Magnets: Beyond the Giant Spin Model Proved by HFEPR
Geochem-istry	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Measurements of Intracellular Iron Oxide with Inductively Coupled Plasma Mass Spectros-copy for MRI-based Cell Tracking
EMR	Burlingame, A.L., U. California - San Francisco, Pharmaceutical Chemistry	High Mass Selectivity for Top-Down Proteomics by Application of SWIFT Technology
ICR	Cooper, W.T., FSU, Chemistry	Comprehensive Characterization of Marine Dissolved Organic Matter by FT-ICR Mass Spec-trometry with Electrospray and Atmospheric Pressure Photoionization
ICR	Cooper, W.T., FSU, Chemistry	Characterization of Dissolved Organic Matter in Northern Peatland Soil Porewaters by Ultrahigh-Resolution Mass Spectrometry
ICR	Headley, J.V., Environment Canada, Saskatoon, Chemistry	Characterization of Oil Sands Naphthenic Acids Treated with UV and Microwave Radiation by Negative Ion Electrospray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
ICR	Headley, J.V., Environment Canada, Saskatoon, Chemistry	Ultrahigh Resolution Mass Spectrometry of Simulated Run-Off from Treated Oil Sands Mature Fine Tailings
ICR	Hsu, C.S., NHMFL, Chemistry	Definition of Hydrogen Deficiency for Hydrocarbons with Functional Groups
ICR	Kazazic, S., Institute Rudjer Bošković, Croatia, Chemistry	Automated Data Reduction for Hydrogen/Deuterium Exchange Experiments, Enabled by High-Resolution Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
ICR	Marshall, A.G., FSU, NHMFL, Chemistry	Sites and Extent of Selenomethionine Incorporation into Recombinant Cas6 Protein by Top-Down and Bottom-Up Proteomics with 14.5 T FT-ICR Mass Spectrometry
ICR	Marshall, A.G., FSU, NHMFL, Chemistry	Heavy Petroleum Composition 1. Exhaustive Compositional Analysis of Athabasca Bitumen HVGO Distillates by Fourier Transform Ion Cyclotron Resonance Mass Spectrometry: A Defini-tive Test of the Boduszynski Model
ICR	Marshall, A.G., FSU, NHMFL, Chemistry	Heavy Petroleum Composition 2. Progression of the Boduszynski Model to the Limit of Distil-lation by Ultrahigh Resolution FT-ICR Mass Spectrometry
ICR	Marshall, A.G., FSU, NHMFL, Chemistry	Petroleomics: A Test Bed for Ultrahigh-Resolution Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
ICR	Marshall, A.G., FSU, NHMFL, Chemistry	Automated Broadband Phase Correction of Fourier Transform Ion Cyclotron Resonance Mass Spectra
ICR	Marshall, A.G., FSU, NHMFL, Chemistry	New Reagents for Enhanced Liquid Chromatographic Separation and Charging of Intact Protein Ions for Electrospray Ionization Mass Spectrometry
ICR	Mazzoleni, L.R., Michigan Technological U., Chemistry	Water-Soluble Atmospheric Organic Matter in Fog: Exact Masses and Chemical Formula Identification by Ultrahigh-Resolution Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
ICR	McNeill, K., U. Minnesota, Chemistry	Singlet Oxygen in the Coupled Photochemical and Biochemical Oxidation of Dissolved Organic Matter
ICR	Merdrignac, I., IFP, Lyon, France, Chemistry	Stepwise Structural Characterization of Asphaltenes During Deep Hydroconversion Processes Determined by Atmospheric Pressure Photoionization (APPI) Fourier Transform Ion Cyclotron Resonance (FT-ICR) Mass Spectrometry
ICR	Mullins, O.C., Schlumberger, Chemistry	Combining Biomarker and Bulk Compositional Gradient Analysis to Assess Reservoir Connectivity
ICR	Powell, D.H., UF, Chemistry	The Coupling of Direct Analysis in Real Time Ionization to Fourier Transform Ion Cyclotron Resonance Mass Spectrometry for Ultra-High Resolution Mass Analysis
ICR	Stenson, A.C., U. South Alabama, Chemistry	Chromatographic Reduction of Isobaric and Isomeric Complexity of Fulvic Acids To Enable Multistage Tandem Mass Spectral Characterization
AMRIS	Castro-Gamboa, I., Universidade Estadual Paulista, Chemistry	Dereplication of Brazilian Plants from Cerrado and Atlantic Forest Using Hyphenated Techniques and NMR

Facility	PI	Title
AMRIS	Gower, L.B., UF, Materials Science & Engineering	NMR Investigation of the Mechanisms Underlying Biomineralization
AMRIS	Hamilton, T. D., Barry U., Physical Sciences	NMR Characterization of Porphyrins and Analogues Synthesized Without Solvent
AMRIS	Luesch, H., UF, Medicinal Chemistry	Grassypeptolides A-C, Cytotoxic Bis-thiazoline Containing Cyclodepsipeptides from Marine Cyanobacteria
AMRIS	Luesch, H., UF, Medicinal Chemistry	New Cytotoxic Macrolides and Modified Peptides from Marine Cyanobacteria
AMRIS	Martin, G.D.A., U. Tampa, Chemistry	Bioconversion of Curcumin and Its Analogs by Beauveria bassiana and *Aspergillus niger*
NMR	Brüschweiler, R., FSU, NHMFL, Chemistry & Biochemistry	Higher-Rank Correlation NMR Spectra with Spectral Moment Filtering
NMR	Brüschweiler, R., FSU, NHMFL, Chemistry	Simultaneous de Novo Identification of Molecules in Chemical Mixtures by Doubly Indirect Covariance NMR Spectroscopy
NMR	Dalal, N., FSU, NHMFL, Chemistry	Ferroelectric Transition in Hydrogen Bonded Compounds Like RDP Observed by NMR
NMR	Dalal, N., FSU, NHMFL, Chemistry	Detection of Ethyl Group Orientation in Petroporphyrins by Solid State NMR
NMR	Grey, C.P., SUNY Stony Brook/Cambridge U.	^{45}Sc Solid State NMR of $BaSn_{1-x}Sc_xO_{3-\delta}$, a Potential Protonic Conductor for Solid Oxide Fuel Cells
NMR	Hernandez-Maldonado, A.J., U. Puerto Rico - Mayaguez, Chemical Engineering	MAS NMR Characterization of the Flexible Porous Coordination Polymer CPL-2
NMR	Hernandez-Maldonado, A.J., U. Puerto Rico - Mayaguez, Chemical Engineering	MAS NMR Characterization of the Nanoporous Flexible Titanosilicate Sr-UPRM-5
NMR	Jones, C., Hamilton College	^{19}F-NMR Studies of Water Clathrate Compounds
NMR	Peng, L., Nanjing U., China, Chemistry	^{17}O MAS NMR Studies of Ceria Nanoparticles
UF Physics	Bowers, C.R., UF, Chemistry	Hyperpolarized NMR in Single-File Nanotubes

Condensed Matter Technique Development – 4 Reports

Facility	PI	Title
DC Field	Boebinger, G.S., FSU, NHMFL	Specific Heat Instrumentation and Measurements on the Cuprate Superconductor LSCO
DC Field	Hannahs, S., FSU, NHMFL	Improvement of the Rotating Probes at the NHMFL DC Field
DC Field	Suslov, A., FSU, NHMFL	Vibrations of Si/SiGe – $LiNbO_3$ Sandwich Under Quantum Hall Effect Conditions
Pulsed Field	Zapf, V., NHMFL-PFF	ESR Measurements of $CoCl_2$-$2SC(NH_2)_2$

Engineering Materials – 14 Reports

Facility	PI	Title
DC Field	Cooley, J.C., LANL, MST-6	Solidification in Magnetic Fields
DC Field	Ludtka, G.M., Oak Ridge National Laboratory	First Principles Modeling, Fabrication, and Characterization of the Next Generation of Advanced Magnetocaloric Materials for Energy Efficiency Applications
DC Field	Molodov, D.A., RWTH Aachen U., Institute of Physical Metallurgy and Metal Physics	*In-situ* Measurements of Magnetically Driven Motion of Specific Individual Grain Boundaries in Zn with a High Field Magnet Microscopy Probe
AMRIS	Eic, M., U. of New Brunswick, Chemical Engineering	Combined Application of Pulsed Field Gradient (PFG) NMR and Tracer Zero Length Column (TZLC) Technique for Studies of Diffusion of Small Sorbate Molecules in Mesoporous Silica SBA-15
AMRIS	Santra, S., U. Central Florida, Chemistry	"Targeted Cellular-Shuttle" – an Activatable Multimodal/Multifunctional Nanoprobe for Direct Imaging of Intracellular Drug Delivery
AMRIS	Santra, S., U. Central Florida, Chemistry	Fluorescent and Paramagnetic Chitosan Nanoparticles that Exhibit High MR Relaxivity: Synthesis, Characterization and *in vitro* Studies
AMRIS	Talham, D.R., UF, Chemistry	DNA Surface Modified Gadolinium Phosphate Nanoparticles as MRI Contrast Agents
AMRIS	Vasenkov, S., UF, Chemical Engineering	Pulsed Field Gradient NMR Investigation of Sorbate Transport in Zeolites
AMRIS	Vasenkov, S., UF, Chemical Engineering	Diffusion in Room Temperature Ionic Liquids With and Without Water by Pulsed Field Gradient (PFG) NMR
AMRIS	Walter, GA, UF, Physiology	Gd Doped Multimodal Silica Nanoparticles Encapsulating Indocyanine Green
MS & T	Han, K., NHMFL	A Study of Submicron Grain Boundary Precipitates in Ultralow Carbon 316LN Steels
MS & T	Markiewicz, W.D., NHMFL, MS&T	77 K Electro-Mechanical Characterization of YBCO Coated Conductors
MS & T	Walsh, R.P., NHMFL, FSU	Fatigue Properties of Modified 316LN Stainless Steel at 4 K for High Field Cable-In-Conduit Applications
Pulsed Field	Fanelli, V.R., NHMFL, LANL	Elastic Moduli Measurement of a Pure Aluminum Single Crystal Specimen as a Function of Temperature

Geochemistry – 20 Reports

Facility	PI	Title
Geochemistry	Chanton, J.P., FSU, EOAS	Flux by Fin: Fish Mediated Carbon and Nutrient Flux in the N.E. Gulf of Mexico
Geochemistry	Froelich, P. N., NHMFL, Geochemistry	Chemostratigraphic Evidence of Deccan Volcanism from the Seawater Lithium Isotope Record
Geochemistry	Froelich, P.N., FSU, Earth, Ocean, and Atmospheric Science	Modern Calibration of $\delta^{18}O$ and $\delta^{13}C$ Paleoclimate Proxies in a Natural Cave System
Geochemistry	Froelich, P.N., NHMFL, Geochemistry	Lithium Isotope Evolution of Cenozoic Seawater – A New Proxy for Silicate Weathering
Geochemistry	Humayun, M., FSU, Earth, Ocean & Atmospheric Science	The Eagle Station Meteorite: A Clue to Ancient Planetary Magnetic Fields
Geochemistry	Humayun, M., FSU, Earth, Ocean, & Atmospheric Science	Magnesium Isotopic Composition of the Solar Wind
Geochemistry	Humayun, M., FSU, Earth, Ocean, & Atmospheric Science	Chemical Abundances Within the Matrix of a Unique CM Chondrite
Geochemistry	Landing , W.M., FSU	Isotopic Composition of Hg in Rain and Aerosols Collected Near a Coal Fired Power Plant Determined by Cold-vapor Multi-collector Inductively Coupled Plasma Mass Spectrometry (CV-MC-ICPMS)
Geochemistry	Landing, W.M., FSU, EOAS	Determination of Arsenic and Selenium in Chloro-matrix Rainwater Collected Near a CFPP by Quadrupole-ICP-MS with an Octopole Reaction System
Geochemistry	Odom, A.L., NHMFL, Earth Ocean and Atmospheric Sciences	Isotopic Composition of Flue Gas Hg from a Coal Fired Power Plant

Facility	PI	Title
Geochemistry	Odom, A.L., NHMFL, FSU Earth Ocean and Atmospheric Science	On the Isotopic Composition of Mercury in Some C3 and C4 Plants
Geochemistry	Salters, V.J.M., EOAS, EOAS	Geochemical Variability along the East Pacific Rise; Ridge Segmentation and Source Composition
Geochemistry	Salters, V.J.M., NHMFL/FSU, EOAS	The Oxygen Fugacity of the Sub-Oceanic Lithosphere and Upper Mantle as Recorded by Spinel Peridotite and Garnet Clinopyroxenite Xenoliths from O'ahu, Hawai'i
Geochemistry	Salters, V.J.M., NHMFL/FSU, EOAS	Domains of Ultra Depleted Mantle; New Evidence from Hafnium and Neodymium Isotopes
Geochemistry	Salters, V.J.M., NHMFL/FSU, EOAS	Plume Asthenosphere Interaction; New Evidence from Hafnium and Neodymium Isotopes
Geochemistry	Salters, V.J.M., NHMFL/FSU, EOAS	Trace Element Partitioning in Natural Samples
Geochemistry	Salters, V.J.M., NHMFL/FSU, EOAS	Magma Transport at the Siqueiros Transform Fault
Geochemistry	Wang, Y., Geochemistry Program, NHMFL, EOAS	Strengthening of the East Asian Summer Monsoon Revealed by a Shift in Seasonal Patterns in Diet and Climate after 2-3 Ma in Northwest China
Geochemistry	Wang, Y., Geochemistry Program, NHMFL, EOAS	Paleoecologies and Paleoclimates of Cenozoic Mammals from Southwest China: Evidence from Stable Carbon and Oxygen Isotopes
Geochemistry	Findlay, R.H., U. Alabama, Biology	Influence of Bedrock Geology on Dissolved Organic Matter Quality in Stream Water

Graphene – 12 Reports

Facility	PI	Title
CMT/E	Vafek, O.V., NHMFL/FSU	Interacting Fermions on the Honeycomb Bilayer: From Weak to Strong Coupling
DC Field	Engel, L.W., NHMFL FSU	Microwave Measurements of Graphene Conductance
DC Field	Jiang, Z., Georgia Institute of Technology, Physics	Infrared Magneto-spectroscopy Study of Graphite
DC Field	Kim, P., Columbia U.	Spin Character of Degeneracy-broken Graphene Landau Levels
DC Field	Kono, J., Rice U., Electrical & Computer Engineering, Physics & Astronomy	Magneto-Raman Spectroscopy of Graphite
DC Field	Lau, C.N., U. California, Riverside	Evidence for Fractional Quantum Hall States in Suspended Bilayer and Trilayer Graphene
DC Field	Lau, C.N., U. California, Riverside, Physics	Magnetotransport of High Mobility Double-Gated Graphene Devices
DC Field	Newell, D.B., NIST	Graphene Quantum Hall for Quantum Resistance Standard
DC Field	Shepard, K.L., Columbia U., Electrical Engineering	Fractional Quantum Hall Effect in Graphene on Boron Nitride
DC Field	Tutuc, E., The U. Texas at Austin, Electrical and Computer Engineering	Coulomb Drag and Quantum Hall Effect in Independently Contacted Graphene Bilayers
DC Field	Valla, T., Brookhaven National Laboratory, CMP&MS	Metal to Insulator Transition on the N=0 Landau Level in Graphene
DC Field	Ye, P.D., Purdue U., Electrical and Computer Engineering	Snake Orbits in Graphene Underneath an Array of $Ni_{0.80}$ $Fe_{0.20}$ Nano-dots

Kondo/Heavy Fermion Systems – 11 Reports

Facility	PI	Title
DC Field	Brooks, J.S., NHMFL, Physics	Superconducting Phase in UFeGe
DC Field	Harrison, N., LANL	Magnetic Quantum Oscillations Within the Hidden Order Phases of URu2Si_2
DC Field	Sakai, H., Japan Atomic Energy Agency	^{29}Si-NMR Study of URu_2Si_2 Under High Field: Investigation of the 22 T Anomaly Found Within the Hidden Order Phase and Its Critical Behavior Around 35 T
DC Field	Schmiedeshoff, G.M., Occidental College, Physics	Phase Diagram and Quantum Criticality of YbAgGe
DC Field	Ho, P.-C., California State U., Fresno, Physics	Shubnikov-de Haas Effect Measurements on $NdOs_4Sb_{12}$ for Fields along [001] and [011]
DC Field	Ho, P.-C., California State U., Fresno, Physics	Shubnikov-de Haas Effect Measurements on $CeOs_4Sb_{12}$ for Fields along [001]
DC Field	Lawrence, J.M., U. California Irvine, Physics and Astronomy	Magnetization of Ce_3In Under Magnetic Field up to 14 T
DC Field	Lawrence, J.M., U. California Irvine, Physics and Astronomy	Magnetization of Ce_3Sn Under Magnetic Field Up to 14 T
DC Field	Nakotte, H., New Mexico State U., Physics	Specific Heat and Magnetization Measurement on $UCu_{4+x}Al_{8-x}$
DC Field	Ronning, F., LANL	The Fermi Surface of $CePt_2In_7$
DC Field	Weickert, F., MPI for Chemical Physics of Solids	Probing the Anisotropy of the Kondo Gap in $CeRu_4Sn_6$ by Magnetoresistance Measurements

Magnet Technology – 11 Reports

Facility	PI	Title
DC Field	Bai, H., NHMFL	Nb_3Sn-NbTi CICC Joint Design and Test for the Series-Connected Hybrid
DC Field	Markiewicz, W.D., NHMFL	Lap Joint Resistance of YBCO Coated Conductors
DC Field	Markiewicz, W.D., NHMFL	YBCO Pancake Wound Test Coil for 32 T Magnet Development
DC Field	Trociewitz, U.P., NHMFL, ASC	$Bi_2Sr_2CaCu_2O_{8+x}$ (Bi2212) Round Wire Conductor R&D for High Field Magnets
DC Field	Weijers, H.W., NHMFL, MS&T	HTS Current Lead Development
MS & T	Bird, M.D., NHMFL, MS&T	Characterization of Nb_3Sn RRP Superconductor for the Series-Connected Hybrid Magnets
MS & T	Goddard, R.E., NHMFL, MS&T	Microscopic Grain Definition of Heat Affected Zone in Stainless Steel Conduit Weld
MS & T	Markiewicz, W.D., NHMFL, MS&T	Computer Analysis of the Performance of Quench Protection Heaters for YBCO Coils of the 32T All-Superconducting Magnet System
MS & T	Markiewicz, WD, NHMFL	Insulation of YBCO Coated Conductor Tapes
MS & T	Powell, J.A., NHMFL, MS&T, DC Instrumentation	Improvement of the Design of a Passive Filter for a Resistive Magnet Power Supply
NMR	Brey, W.W., NHMFL, NMR	Noise Measurements in the Keck Magnet

Magnetic Resonance Technique Development – 24 Reports

Facility	PI	Title
EMR	Stoll, S., U. California, Davis, Chemistry	Atomic Hydrogen as High-precision Field Standard for High-field EPR
AMRIS	Blackband, S.J., UF, Neuroscience	A Novel Interlaced/BCC Multi-shell Sampling Scheme for Improved Fiber Tract Mapping
AMRIS	Edison, A.S., UF, Biochemistry & Molecular Biology	1.5-mm HTS Probe Design for 600 MHz NMR
AMRIS	Mareci, T.H., UF, Biochemistry and Molecular Biology	Measures of Brain Fibrous Connectivity from Diffusion Weighted MR Images
AMRIS	Montie, E.W., U. South Carolina Beaufort, Biology	Determining the Effects of Thyroid Hormone Disruption on Brain Development in Rats Using Magnetic Resonance Imaging In Vivo at 11.1 T and in Excised Brains at 17.6 T
AMRIS	Walter, G.A., UF, Physiology and Functional Genomics	Development and Characterization of Proton Imaging Coils for AMRIS Horizontal Bore Magnet Systems
NMR	Brey, W.W., NHMFL	Simulations of the Electric and Magnetic Fields in the NMR Low-E Resonator Coils
NMR	Brey, W.W., NHMFL-FSU	Efficient Triple-resonant $^{1}H/X/Y$ Low-E MAS Probe for Biological Applications
NMR	Fu, R., NHMFL	Spin Dynamics of Cross-Polarization Mediated ^{15}N Spin Diffusion in NMR of Aligned Samples
NMR	Gan, Z., NHMFL	Infinite Magic-Angle Spinning ^{7}Li NMR Spectra of Paramagnetic Battery Materials
NMR	Gan, Z., NHMFL	A Magic-angle Turning NMR Experiment for Separating Spinning Sidebands of Half-integer Quadrupolar Nuclei
NMR	Gan, Z., NHMFL	A TIMES Homonuclear Decoupling Sequence for High-resolution Proton NMR of Solids
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Quadrature Surface Coils for in vivo Imaging in 900-MHz Vertical Bore Spectrometer
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Contrast Enhancement in Preserved Tissue Utilizing Low Temperatures at High Magnetic Field
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	MR Microimaging with a Cylindrical Ceramic Dielectric Resonator at 21.1 T
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Quadrature RF Coil and Phased Array Operation at 21.1 T
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Intracellular SPIO Labeling of Microglia: High Field Considerations and Limitations for MR Microscopy
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Switchable Surface Coil for High Field ^{31}P & ^{1}H MR Evaluations of the Living Mouse Leg
NMR	Grant, S.C., NHMFL-FSU, Chemical & Biomedical Engineering	Magnetic Resonance Electrical Impedance Tomography at Ultra High Magnetic Fields
NMR	Jakobsen, H.J., Aarhus U., Chemistry	High-Field Variable-Temperature ^{17}O MAS NMR of Cs_2WO_4
NMR	Kiruluta, A., Harvard U., Physics	High Field MR Imaging in the Far Field: Holographic Interferometry & Spatial Encoding
NMR	Long, J.R., UF, Biochemistry & Molecular Biology	Measurement of Weak Dipolar Couplings Via $^{13}C\{^{15}N\}$REDOR Using a Low-E Probe
NMR	Sadleir, R.J., UF, Biomedical Engineering	An Active Membrane Bidomain Model for Planning MREIT Studies of Neural Tissue
NMR	Van Sciver, S.W., NHMFL, FSU Mechanical Engineering	MRI of Adsorbed Water in Solid Foams at 21.1 T

Magnetism & Magnetic Materials – 64 Reports

Facility	PI	Title
CMT/E	Chiorescu, I., NHMFL and FSU Physics	On-Chip SQUID Measurements in the Presence of High Magnetic Fields
DC Field	Choi, E.S., NHMFL/FSU	Magnetoelectric Effect of Antiferromagnet $MnTiO_3$
DC Field	del Barco, E., U. Central Florida, Physics	High-Field Torque Measurement of an Antiferromagnetically Coupled $[Mn^{III}]_3$ Triangle
DC Field	del Barco, E., U. Central Florida, Physics	High-Field Magnetic Torque Studies of Single Molecule Magnets
DC Field	Dickerson, J.H., Vanderbilt U., Physics and Astronomy	Optical and Magneto-Optical Characteristics of Europium Chalcogenide Nanocrystals
DC Field	Hong, T., Oak Ridge National Laboratory	Field-Induced Tomonaga-Luttinger Liquid Phase of a Two-Leg Spin-1/2 Ladder with Strong Leg Interactions
DC Field	Hosokoshi, Y., Osaka Prefecture U., Physical Science	Calorimetric Study of an Organic Triangular Antiferromagnet TNN in Magnetic Fields
DC Field	Kim, K.H., Seoul National U., Physics and Astronomy	Investigation of a Quantum Critical Point in Multiferroic $Ba_2CoGe_2O_7$
DC Field	Kimura, T., Osaka U., Graduate School of Engineering Science	Investigation of Magnetodielectric Effect of $SmMnO_3$ in High Fields
DC Field	Kismarahardja, A.W, Condensed Matter Science, Physics	The Electrical Properties of Single Crystal CoV_2O_4 in High Magnetic Field
DC Field	McGill, S.A., NHMFL	Raman Spectroscopy of Low Dimensional Spin Systems: $SrCu_2(BO_3)_2$
DC Field	McGill, S.A., NHMFL	Optical Study on Structural Phase Transition of $BaCuSi_2O_6$
DC Field	Musfeldt, J.L., U. Tennessee, Chemistry	Magneto-elastic Coupling in Magnetically Frustrated $Co_3V_2O_8$
DC Field	Musfeldt, J.L., U. Tennessee, Chemistry	Magnetoelastic Coupling in a Low-dimensional Quantum Heisenberg Antiferromagnet
DC Field	Popovic, D., FSU, NHMFL	Evidence for Quantum Skyrmions in a Doped Antiferromagnet
DC Field	Takano, Y., UF, Physics	Angle-Dependent Phase Diagram of a Spin-1/2 Triangular-Lattice Antiferromagnet
DC Field	Tsujii, H., Kanazawa U., Physics, Faculty of Education	Magnetic Phase Diagram of the Quasi-One Dimensional Antiferromagnet $BaCo_2V_2O_8$
DC Field	Vaknin, D., Ames Lab and Iowa State U.	Level Crossings and Zero-field Splitting in the {Cr8}-cubane Spin Cluster Studied Using Inelastic Neutron Scattering and Magnetization
DC Field	Wiebe, C.W., Chemistry, U. Winnipeg	Field-induced XY-AFM in Low Dimensional Molecular Magnet $Pb_2V_3O_9$
DC Field	Wolf, S., U. Virginia, Materials Science and Engineering	High H Field Magneto-Transport of Diluted Magnetic Mn_xGe_{1-x}
DC Field	Zhou, H.D., NHMFL-FSU	Spin Liquid State in the S = 1/2 Triangular Lattice $Ba_3CuSb_2O_9$
DC Field	Zhou, H.D., NHMFL-FSU	Low Temperature AC Susceptibility of $Dy_2Ti_2O_7$
EMR	Aromi, G., Universitat de Barcelona, Chemistry	Magnetic and HFEPR Studies of a Weakly-coupled Manganese(III) Dimer
EMR	Bonanni, A., Johannes-Kepler U., Physics	Magnetic Resonances of Mn^{3+} in (Ga,Mn)N
EMR	Choi, K.-Y., Chung-Ang U.	Inhomogeneous Magnetic Cluster States in $Lu_2V_2O_7$ Revealed by High-Frequency ESR
EMR	Coronado, E., U. Valencia	Coherent Manipulation of Mononuclear Lanthanide-Based Single-Molecule Magnets

Facility	PI	Title
EMR	Hill, S., FSU, Physics and NHMFL	Spin Decoherence in an Iron-Based Magnetic Cluster
EMR	Hill, S., FSU, Physics and NHMFL	EPR Studies of Magnetostructural Correlations Under High Pressures
EMR	Hill, S., FSU, Physics and NHMFL	High-Frequency EPR Studies of Dicubane Mn4 Single-Molecule Magnets
EMR	Kortz, U., Jacobs U., Bremen, Germany, School of Engineering and Science	EPR Study on a Di-Copper(II) Containing 22-Palladate(II), $[Cu_2Pd_{22}P_{12}O_{60}(OH)_8]^{20-}$
EMR	Meisel, M.W., UF, Physics	Magnetic Anisotropy in Thin Films of Prussian Blue Analogues
EMR	Oakley, S.M., U. Waterloo, Chemistry	HFESR Probing of Anisotropic Interactions in an Isostructural Radical Family
EMR	Shatruk, M., FSU, Chemistry and Biochemistry	Study of Magnetic Ordering in Layered Pnictides and Chalcogenides by Mössbauer Spectroscopy
EMR	Zorko, A., Jožef Stafan Institute, Ljubljana Slovenia	High-field Electron Spin Resonance of the Kagome Compound Kapellasite
High B/T at UF	Meisel, M.W., UF, Physics and NHMFL	Metal Monophosphonates $M\{(2\text{-}C_5H_4NO)CH_2PO_3\}(H_2O)_2$ (M = Co, Ni, Mn, Cd): Synthesis, Structure, and Magnetism
High B/T at UF	Zapf, V., NHMFL-PFF	Investigation of the Magnetic Susceptibility of the Disordered BEC System $NiCl_{0.85}Br_{0.15}$–$4SC(NH_2)_2$ at Ultra-low Temperatures
Pulsed Field	Balicas, L., NHMFL	Magnetization Measurements in $Pb_2V_3O_9$ Single Crystals Under Pulsed Magnetic Fields
Pulsed Field	Cichorek, T., Institute of Low Temperatures and Structure Research, Polish Academy of Sciences, Wroclaw, Poland	Anisotropy of Magnetic-field-induced Insulator-metal Transition in $CeOs_4As_{12}$
Pulsed Field	Daou, R., Max-Plank Institute, Dresden, Germany	Study of Spin-Lattice Coupling in $SrCu_2(BO_3)_2$ with Magnetostriction to 65 T
Pulsed Field	Franco Jr., A., Instituto de Física, Universidade Federal de Goias	Magnetic Properties of ZnO:Ce Nanoparticles
Pulsed Field	Franco Jr., A., Instituto de Física, Universidade Federal de Goias	Study the Magnetic Properties of Nanoparticles of $(Co\text{-}Zn)Fe_2O_4$ Ferrites
Pulsed Field	Goddard, P.A., U. Oxford, Physics	Determining the Exchange Parameters of Spin-1 Metal-organic Molecular Magnets in Pulsed Magnetic Fields
Pulsed Field	Hoch, M.J.R., NHMFL / FSU	Triplet-singlet Gap Closing in $LaCoO_3$: A New Antiferromagnetic Phase
Pulsed Field	Karaman, I., Texas A&M U., Mechanical Engineering	Magnetic Field-Induced Shape Change in Sub-Micron Scale Magnetic Shape Memory Alloys
Pulsed Field	Kono, J., Rice U., Electrical and Computer Engineering and Physics and Astronomy	Magnetic Brightening of Dark Excitons in Carbon Nanotubes at Ultralow Temperatures: Role of Nonthermal Distribution
Pulsed Field	Manson, J.L, Chemistry and Biochemistry, Eastern Washington U.	Observation of Field-induced BKT Transition in 2D S=1/2 $[Cu(pyz)_2(pyO)_2](PF_6)_2$
Pulsed Field	Manson, J.L., EWU, Chemistry	Magnetization Studies of Ni(II)-based Polymeric Magnets $[Ni(HF_2)(pyrazine)_2]X$ (X = PF_{6-}, SbF_{6-})
Pulsed Field	Manson, J.L., EWU, Chemistry	Pulsed-field Magnetization of Novel Spin-1 Quantum Magnets $[Ni(HF_2)(pyrazine)_2]X$
Pulsed Field	Manson, J.L., EWU, Chemistry	EPR Study of the Onset of Long-range Order in the 2D Organo-metalic Magnet $Cu(pyz)_2(pyo)_2(PF_6)_2$
Pulsed Field	Manson, J.L., EWU	Temperature-dependent Magnetization of the Spin-1/2 Square Lattice Antiferromagnet $Ag(nic)_2$
Pulsed Field	Martin, I., LANL, T4	Hall Effect and Magnetization of UCu_5 in Pulsed Magnetic Fields

Facility	PI	Title
Pulsed Field	Mielke, C.H., NHMFL-LANL	Implementation of Cyclotron Resonance Measurements at Ultrahigh Magnetic Fields
Pulsed Field	Nakotte, H. New Mexico State U.	rf Skin-depth Measurement of UIrGe in High Magnetic Field
Pulsed Field	Nocera, D.G., MIT, Chemistry	Potential Observation of Plateau at 1/3 Magnetic Saturation in the Candidate Spin Liquid Herbertsmithite, $ZnCu_3(OH)_6Cl_2$
Pulsed Field	Raptis, R.G., U. Puerto Rico, Chemistry	Mapping the Energy Spectrum of the Spin States of Mixed-Valent [Fe8]n– via Pulsed Field Magnetization
Pulsed Field	Sutherland, M., Cambridge	Detailed Quantum Oscillation Study of $SrFe_2As_2$
Pulsed Field	Yuan, H., Physics, Zhejiang U.	High-field Specific Heat Measurements for $CeRhIn_5$
Pulsed Field	Zapf, V., NHMFL-LANL	Thin Film and Grain-aligned Samples of Lu_2MnCoO_6
Pulsed Field	Zapf, V., NHMFL-LANL	Electrical Polarization Measurements of $CoCl_2$-2thiourea Single Crystals
Pulsed Field	Zapf, V., NHMFL-LANL	Magnetization of $CoCl_2$-2thiourea
Pulsed Field	Zapf, V., NHMFL-LANL	Magnetic Properties of $CoBr_2$-2thiourea
Pulsed Field	Zapf, V., NHMFL-LANL	Magneto-electric Behavior in $MnBr_2$-2thiourea
Pulsed Field	Zapf, V., NHMFL-LANL	Multiferroic Behavior in Polycrystalline Lu_2MnCoO_6
Pulsed Field	Zapf, V., NHMFL-LANL	Understanding and Controlling Complex States Emerging from Frustration

Molecular Conductors – 4 Reports

Facility	PI	Title
DC Field	Brooks, J.S., NHMFL / FSU, Physics	NMR Studies of the Quasi-One Dimensional Organic Conductor $Per_2[Pt(mnt)_2]$
DC Field	Kang, W., Ewha Womans U.	Precise Determination of the Hall Resistance in the N=0 Quantum Hall State of Bechgaard Salts
DC Field	Tozer, S.W., NHMFL	Fermiology Study of a Dual-Layered Molecular Superconductor
DC Field	Tozer, S.W., NHMFL	Quantum Oscillations in $EtMe_3P[Pd(dmit)_2]_2$ Under Pressure

Other Condensed Matter – 19 Reports

Facility	PI	Title
CMT/E	Brooks, J.S., FSU / NHMFL, Physics	Physical Characterization of Spider Silk for Electronic and Sensing Applications
CMT/E	Brooks, J.S., FSU / NHMFL, Physics	Thermal Characterization and Carbonization of Spider Silk
CMT/E	Cao, J., FSU, Physics	Real Time Probing of Ultrafast Residual Charge Dynamics
CMT/E	Cao, J., FSU, Physics	Real-time Probing the Photo-induced Structure Phase Transition
CMT/E	Dobrosavljevic, V., NHMFL FSU, Physics	Nearly Frozen Coulomb Liquids
CMT/E	Terletska, H., FSU/NHMFL, Physics	Quantum Critical Transport Near Interaction-Driven Metal-Insulator Transition
CMT/E	Winter, L.E., FSU/NHMFL, Physics	Studies on Kukulcaina Hibernalis Spider Silk: Stress-Strain Measurement and AFM
CMT/E	Yang, K., NHMFL	Theoretical Studies of Strong Correlation Physics in Cold Atoms
DC Field	Chen, Y.P., Purdue, Physics, ECE	Magneto-transport in Bi_2Se_3: Shubnikov–de Haas Oscillation and Quantum Hall Effect
DC Field	Conradi, M.S., Washington U. in St. Louis, Physics	Field Dependence of Phonon-Driven, Nuclear Spin-Lattice Relaxation
DC Field	Dordevic, S.V., The U. Akron, Physics	Magneto-optical Study of Topological Insulators Bi_2Se_3, Bi_2Te_3 and Sb_2Te_3
DC Field	Gleeson, J.T., Kent State U., Physics	High Field Magneto-Optical Studies of Liquid Crystals and Complex Fluids
DC Field	Jiang, Z., Georgia Institute of Technology, Physics	Infrared Magneto-spectroscopy Study of Topological Insulators
DC Field	McDonald, R.D., LANL, NHMFL	The Surface-state of the Topological Insulator Bi_2Se_3 Revealed by Cyclotron Resonance Using DC Field Facilities at NHMFL-Tallahassee
DC Field	Ong, N.P., Princeton U., Physics	High-field Transport Experiments on the Topological Insulator Bi_2Te_3
DC Field	Schnyders, H.S., Grand Valley State U. , Physics	Magnetoresistance Measurement in a Quantifiable N-Type/P-Type Composite
Pulsed Field	Hellman, F., U. California - Berkeley, Physics	Direct Measurement of Electric Capacitance of Relaxor Ferroelectrics
Pulsed Field	Keppens, V., The U. Tennessee, Materials Science and Engineering	Resonant Ultrasound Spectroscopy Measurements of Tb2Ti2O7 at Low Temperatures and in High Magnetic Fields
Pulsed Field	McDonald, R.D., NHMFL-PFF	The Surface-state of the Topological Insulator Bi_2Se_3 Revealed by Cyclotron Resonance Using Pulsed Field Facilities at NHMFL-LANL

Quantum Fluids & Solids – 7 Reports

Facility	PI	Title
CMT/E	Yang, K., NHMFL	Theoretical Studies of Non-Abelian Fractional Quantum Hall Liquids
High B/T at UF	Chan, M.H.W., Penn State U.	Measurement of the Dielectric Constant of Solid ^{4}He in the Region of the Proposed “Supersolid” Phase
High B/T at UF	Lee, Y., UF, Physics	Anisotropic Disorder in Superfluid ^{3}He: Effect of High Porosity Aerogel on Superfluid Phases of ^{3}He
High B/T at UF	Pan, W., Sandia National Lab.	Impact of Disorder on the 5/2 Fractional Quantum Hall State
High B/T at UF	Sullivan, N. S., UF, Physics	Kinetics of ^{3}He Droplet Formation in Dilute Solutions of ^{3}He in Solid ^{4}He
High B/T at UF	Sullivan, N. S., UF, Physics	Molecular Kinetics of HD in Zeolite
High B/T at UF	Sullivan, N. S., UF, Physics	NMR Studies of the Microscopic Dynamics of the Proposed “Supersolid” Phase of Solid ^{4}He

Qubits & Quantum Entanglement – 4 Reports

Facility	PI	Title
CMT/E	Bonesteel, N.E., FSU, Physics	New Pulse Sequences for Exchange Based Quantum Computation
CMT/E	Chiorescu, I., NHMFL and FSU Physics	Magnetic Strong Coupling in a Spin-Photon System and Transition to Classical Regime
EMR	Boehme, C., U. Utah, Physics and Astronomy	An Electrically Accessible Nuclear Spin Memory Using Phosphorus Donors in Silicon
EMR	Morley, G.W., UCL, London Centre for Nanotechnology and Physics and Astronomy	The Initialization and Manipulation of Quantum Information Stored in Silicon by Bismuth Dopants

Semiconductors – 27 Reports

Facility	PI	Title
DC Field	Ashoori, R., Massachusetts Institute of Technology, Physics	Magnetization of the Oxide Interface $LaAlO_3/SrTiO_3$
DC Field	Dagan, Y., Tel Aviv U., Physics	Magneto-transport Properties of $SrTiO_3$\$LaAlO_3$ Interfaces
DC Field	Drichko, I.L., A.F. Ioffe Physicotechnical Institute	Magnetoresistance in Dilute p-Si/SiGe with Anisotropic g-factor in Tilted Magnetic Fields
DC Field	Gervais, G., McGill, Physics	Parallel-field Induced Resistivity Saturation in a 2D Semiconductor System
DC Field	Khodaparast, G.K., Virginia Tech	Time Resolved Spectroscopy of Narrow Gap Ferromagnetic Films in the Presence of High-magnetic Fields
DC Field	Knappenberger, K.L., FSU, Chemistry and Biochemistry	Magneto-optical Photoluminescence Studies of Semiconductor Quantum Dots at 4.5 K
DC Field	Kono, J., Rice U.	Time-Resolved Evidence for Superfluorescent Radiation from Quantum Wells in Strong Magnetic Fields
DC Field	Levy, J.L., U. Pittsburgh, Physics and Astronomy	Quantum Transport in Nanostructures at the Interface of $LaAlO_3/SrTiO_3$
DC Field	Mascarenhas, A., National Renewable Energy Lab	Diamagnetic Photoluminscence Shift in $GaAs_{1-x}Bi_x$ Alloys
DC Field	Santos, M.B., U. Oklahoma, Physics & Astronomy	Cyclotron Resonance in P-doped InSb Quantum Wells
DC Field	Shayegan, M., Princeton U., Electrical Engineering	Composite Fermion Valley Polarization Energies: Evidence for Particle-hole Asymmetry
DC Field	Smirnov, D., NHMFL	Magnetic Field Assisted Emission from THz Quantum Cascade Lasers
DC Field	Stemmer, S., UCSB, Materials	Shubnikov de Haas Effect in La Doped $SrTiO_3$: n - Doped 2-D and High Mobility 3-D Electron Gases
DC Field	Suchalkin, S., SUNY at Stony Brook	Cyclotron Resonance in InAs/GaSb Type II Superlattices for Mid-IR Photodetectors
DC Field	Tsui, D.C., Princeton U., Electrical Engineering	In-Plane Magnetoresistivity of High-Mobility Dilute Two-Dimensional Electrons in Undoped Si/SiGe Heterostructures
DC Field	Yakunin, M.V., Institute of Metal Physics, Ekaterinburg, Russia, Russian Academy of Sciences, Ural Division	Level Anticrossings in the Coincidence Effect in a HgTe Quantum Well Under Quantum Hall Regime
DC Field	Zudov, M.A., U. Minnesota, School of Physics & Astronomy	Hall Field-induced Resistance Oscillations in Tilted Magnetic Fields
EMR	Das, D., Consortium for Scientific Research, Kolkata Centre, India, UGC-DAE	Tailoring the Magnetic Characteristics of Nanocrystalline $BiFeO_3$ by Ce Doping
Pulsed Field	Crooker, S.A., NHMFL-LANL	Spin Noise of Electrons in Bulk n:GaAs in Longitudinal Magnetic Fields
Pulsed Field	Crooker, S.A., NHMFL-LANL	Circularly-polarized Photoluminescence from Platinum Porphyrins in Organic Hosts: Magnetic-field and Temperature Dependence
Pulsed Field	Fisher, I.R., Stanford Applied Physics	High Magnetic Field Studies of Topological Insulators

Facility	PI	Title
Pulsed Field	Klimov, V.I., LANL, Chemistry Division	Breakdown of Volume Scaling in Auger Recombination in CdSe/CdS Hetero-nanocrystals: The Role of the Core-Shell Interface
Pulsed Field	Klimov, V.I., LANL, Chemistry Division	New Paradigm for Controlling Exciton Dynamics Via Engineered Electron-Hole Exchange Interaction
Pulsed Field	Paglione, J.P., U. Maryland, Center for Nanophysics and Advanced Materials	Topological Insulator Quantum Oscillations
Pulsed Field	Schaller, R.D., LANL, Chemistry Division	Magneto-optical Properties of PbSe Colloidal Nanocrystal Quantum Dots
Pulsed Field	Schaller, R.D., LANL, Chemistry Division	Revealing the Fine Structure of Excitons in PbSe Nanocrystals with Time-resolved Magneto-optics
Pulsed Field	Schuller, I., UC San Diego, Physics	Magnetic Circular Dichroism of Iron-phthalocyanine Films

Superconductivity Applied – 21 Reports

Facility	PI	Title
ASC	Hellstrom, E., NHMFL-ASC, Mechanical Engineering	Understanding Why T max Affects J_c in Bi-2212 Round Wire
ASC	Larbalestier, D., NHMFL-ASC	Sub-Angstrom Scanning Transmission Electron Microscope at NHMFL-FSU
ASC	Larbalestier, D.C., NHMFL-ASC	Study of Electromagnetic Granularity, Grain Conductivity and Pinning in New Fe-based Superconductor Forms: Polycrystalline and Single Crystal Thin Films
ASC	Larbalestier, D.C., ASC-NHMFL	Evidence for Long Range Movement of Bi-2212 Within the Filament Bundle of Multifilament Bi-2212 Round Wire on Melting and Its Significant Effect on J_C
ASC	Larbalestier, D.C., NHMFL-ASC	Quench Initiation in YBCO Layer-Wound Coils Using AC Current or AC Magnetic Field
ASC	Larbalestier, D.C., NHMFL-ASC	The Effect of Strain on Grains and Grain Boundaries in $YBa_2Cu_3O_{7-d}$ Coated Conductors
ASC	Larbalestier, D.C., NHMFL-FSU, ASC	Strong Vortex Pinning in Co-doped $BaFe_2As_2$ Single Crystal Thin Films
ASC	Larbalestier, D.C., NHMFL-FSU, ASC	Comparative Studies of New Bi-2212 Round Wires
ASC	Lee, P.J., NHMFL-ASC	Extended Fatigue Testing of Nb_3Sn Composite Strand for ITER Conductor Use
ASC	Lee, P.J., NHMFL-ASC	Suppressed Superconductivity on the Surface of Superconducting RF Quality Niobium for Particle Accelerating Cavities
ASC	Lee, P.J., NHMFL-ASC	Metallographic Analysis for Production Nb_3Sn Superconducting Strand for ITER
DC Field	Chiesa, L., Tufts U., Mechanical Engineering	Characterization of Superconducting Wires Under Pure Bending Load
DC Field	Jaroszynski, J., NHMFL	Properties of Recent IBAD-MOCVD Coated Conductors Relevant to Their High Field, Low Temperature Magnet Use
DC Field	Larbalestier, D.C., NHMFL-ASC	Isotropic Pinning at 4 K and Magnetic Fields Up to 31 T Induced by $BaZrO_3$ Nanorods in $YBa_2Cu_3O_{7-d}$ Coated Conductors
DC Field	Larbalestier, D.C., NHMFL-ASC	High Field Magnet R&D with ReBCO Coated Conductor
DC Field	Lee, P.J., NHMFL-ASC	The Effects of Variable Sn Content on the Properties of A15 Superconducting Nb_3Sn
DC Field	Zuev, Y.L., Oak Ridge National Laboratory	Angular Dependence of the Irreversibility Field in Doped REBCO with BZO Nanocolumns
Pulsed Field	Eom, C.B., U. Wisconsin	Performance of Co-doped $BaFe_2As_2$ Thin Films in High Field
Pulsed Field	Maiorov, B., MPA-STC, LANL	Effects of $BaZrO_3$ Inclusion on the Upper Critical Field and Irreversibility Line of Coated Conductors
Pulsed Field	Rabin, M. W., LANL, ISR	Characterization of NbN Films for Superconducting Nanowire Single Photon Detectors
UF Physics	Hirschfeld, P.J., U. Florida, Physics	Modeling High-Temperature Superconductor Grain Boundaries

Superconductivity – Basic – 39 Reports

Facility	PI	Title
ASC	Hellstrom, E.E., NHMFL-ASC	Synthesis of Phase Pure Ferro-Pnictide Superconductors
CMT/E	Gor'kov, L.P., FSU, NHMFL, CMS	Inherent Inhomogeneity of the Superconducting Iron Pnictides
DC Field	Balicas, L., NHMFL	Comparing the High Field Phase-diagram of Fe-pnictide and Fe-chalcogenide Superconductors
DC Field	Balicas, L., NHMFL	Evidence for Intrinsic Pinning and Kinked Vortex Structures in $LaFeAsO_{0.9}F_{0.1}$
DC Field	Balicas, L., NHMFL	Rearrangement of the Antiferromagnetic Ordering at High Magnetic Fields in SmFeAsO and $SmFeAsO_{0.9}F_{0.1}$ Single Crystals
DC Field	Brown, S.E., UCLA, Physics and Astronomyu	High-field Superconductivity in κ-$(BEDT\text{-}TTF)_2Cu(NCS)_2$
DC Field	Ferdeghini, C., CNR-SPIN, Genova-Italy	High Upper Critical Field in the $FeSe_{0.5}Te_{0.5}$ Thin Films with Enhanced Properties
DC Field	Fisher, I.R., Stanford U. Applied Physics	High Magnetic Field Studies of Pnictide Superconductors
DC Field	Fisher, I.R., Stanford U., Applied Physics	Linear Magnetoresistance and Nematic Electrons in Underdoped Iron Pnictides
DC Field	Goddard, P.A., U. Oxford, Physics	Chasing Angle-dependent Magnetoresistance Oscillations in Cuprate Superconductors
DC Field	Halperin, W.P., Northwestern U., Physics	High Field NMR Studies of $Ba(Fe_{0.93}Co_{0.07})_2As_2$
DC Field	Halperin, W.P., Northwestern U., Physics	Charged Vortices and Vortex Structure Instability in $Bi_2Sr_2CaCu_2O_{8+\delta}$
DC Field	Hussey, N.E., U. Bristol, H. H. Wills Physics Laboratory	Angle-dependent Quantum Oscillation Studies of Overdoped $Tl_2Ba_2CuO_{6+d}$
DC Field	Hussey, N.E., U. Bristol, H. H. Wills Physics Laboratory	Anomalous Superconductivity in Quasi-one-dimensional $Li_{0.9}Mo_6O_{17}$
DC Field	Jo, Y.J., Ewha U., Physics	Resolve the Upper Critical Field of Binary Nb_3Sn for the Sn Rich Compositions
DC Field	Kapitulnik, A., Stanford U., Physics and Applied Physics	Hall Effect Across the Superconductor-Insulator Transition in Indium Oxide Films
DC Field	Kim, K.H., Seoul National U.	Upper Critical Field Measurements of Isovalent-doped $BaFe_2As_2$ Single Crystals
DC Field	Lonzarich, G.G., U. Cambridge, Physics	Angular Dependence of Quantum Oscillations Measured Using Magnetic Torque in Under-doped YBCO
DC Field	Stewart, G.R., UF, Physics	Low Temperature Specific Heat vs. Field of Fe Pnictide Superconductors - Investigation of Nodal Structure
DC Field	Terashima, T., NIMS, Japan	Determination of the Upper Critical Field of a Single Crystal LiFeAs: The Magnetic Torque Study up to 35 Tesla
DC Field	Tozer, S.W., NHMFL	Fermi Surface Study of $BaFe_2As_2$ Under Pressure
DC Field	Urbano, R.R., NHMFL	High Field Dependence and Ordered Moment Anisotropy in Underdoped $Ba_{1-x}KxFe_2As_2$
DC Field	Warusawithana, M.P., FSU, Physics	Correlated Electron Properties at Complex Oxide Interfaces
Pulsed Field	Batlogg, B., ETH Zurich, Switzerland, Solid State Physics	Fermi Surface Study of the Pnictide Superconductor $LaRu_2P_2$: Superconductivity in a Weakly Correlated System
Pulsed Field	Boebinger, G.S., FSU, NHMFL	Resonant Ultrasound Spectroscopy Study of Detwinned Single Crystal YBCO(6.56). Definitive Evidence for Thermodynamic Phase Boundary at the Pseudogap Temperature in Underdoped Cuprates
Pulsed Field	Bozovic, I., Brookhaven National Laboratory	Magnetoresistance of Optimally Doped $La_{2-x}Sr_xCuO_4$ in Fields Up to 85 T
Pulsed Field	Fanelli, V.R., NHMFL LANL	Resonant Ultrasound on Optimally Doped LSCO from 300 K to 4 K
Pulsed Field	Haugan, T.J., The Air Force Research Laboratory, AFRL/RZPG	Ultrafast Quenching of Y-Ba-Cu-O Cuprate Superconductor with a Pulsed Magnetic Field for Varying Subcritical Currents
Pulsed Field	Larbalestier, D.C., NHMFL-FSU, ASC	Upper Critical Field in Fe-based Superconductors Measured Up to 85T
Pulsed Field	Lonzarich, G.G., U. Cambridge, Physics	Angular Dependence of Quantum Oscillations in Underdoped YBCO up to 85 T
Pulsed Field	Luke, G.M., McMaster U.	Weakly Anisotropic Upper Critical Fields in New 111 and 122 FeAs Superconductors

Facility	PI	Title
Pulsed Field	Maiorov, B., MPA-STC, LANL	Inversion of the Apparent Anisotropy of the Upper Critical Field in FeTeSe Films
Pulsed Field	McDonald, R.D., NHMFL, NHMFL	Technique Development for Upper Critical Field Studies of SmFeAs(O,F) in the 300 T Single Turn System
Pulsed Field	Moll, P.J.W., ETH Zurich, Switzerland, Solid State Physics	Development of Pulsed Critical Current Measurements in Pulsed Fields for FIB-carved SmFeAs(O,F) Single Crystal Nanostructures
Pulsed Field	Naren, H.R., Tata Institute of Fundamental Research	Study of Quantum Oscillations in $Rh_{17}S_{15}$
Pulsed Field	Yu, W., Renmin U., China	Seebeck Effect in $Ca_{0.25}Na_{0.75}Fe_2As_2$ and $NaFe_{0.95}Co_{0.05}As$ Single Crystals
Pulsed Field	Yuan, H. Q., Zhejiang U., China, Physics	Upper Critical Field Anisotropy in LiFeAs
Pulsed Field	Yuan, H., Zhejiang U., Physics	Weak Anisotropy of the Superconducting Upper Critical Field in $Fe_{1.11}Te_{0.6}Se_{0.4}$ Single Crystals
UF Physics	Hirschfeld, P.J., U. Florida, Physics	Freezing of Spin Fluctuations by Disorder in Cuprate Superconductors

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1800 E. Paul Dirac Drive
Tallahassee, FL 32301-8350

www.magnet.fsu.edu

The Magnet Lab is supported by the State of Florida
and the National Science Foundation.