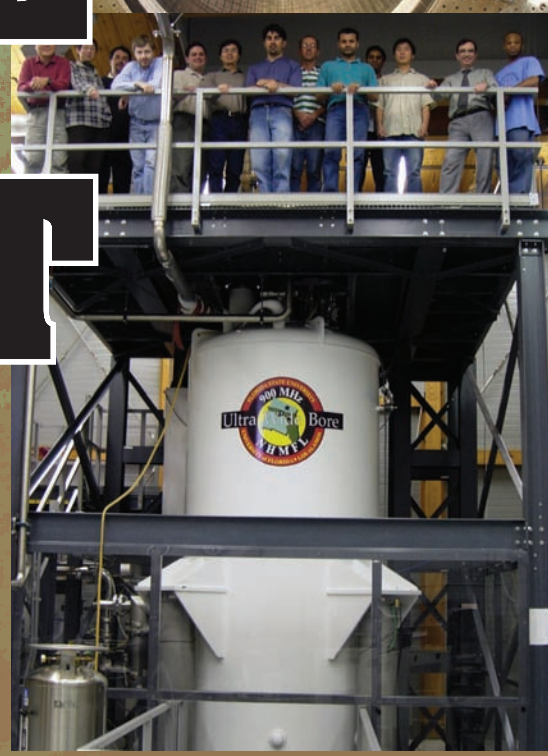
NATIONAL HIGH MAGNETIC FIELD LABORATORY

2005 ANNUAL REPORT



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NATIONAL HIGH MAGNETIC FIELD LABORATORY

2005 NHMFL ANNUAL REPORT

CONTENTS

1	Year in Review	1
2	Research Highlights	5
	Life Sciences	7
	Chemistry	11
	Magnet Science & Technology	18
	Condensed Matter Physics	22
3	Users Programs	37
4	Magnet Science & Technology	61
5	In-House Research Program	71
6	Education	75
7	Collaborations	79
8	Conferences & Workshops	87
9	Management & Administration	91
10	Science & Research Productivity	103
Appendices		
	A--Research Reports by Category	137
	B--Publications Index by Authors	153

PUBLISHED BY:
NATIONAL HIGH MAGNETIC FIELD LABORATORY
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CHAPTER 1
2005 YEAR IN REVIEW

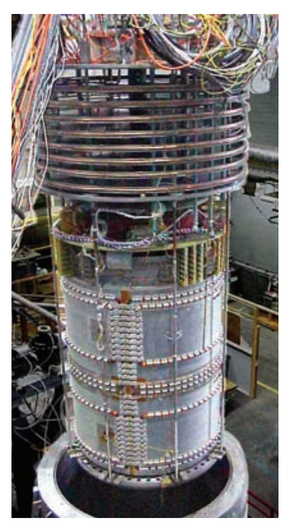
At one time or another—and several times simultaneously—science, magnets, education, public outreach, and institutional partnerships each took center stage in 2005. The dedication, energy, and teamwork of the lab's faculty and staff at Florida State University, the University of Florida, and Los Alamos National Laboratory resulted in world-record magnets for users, new collaborations, a host of scientific conferences, and a seemingly endless stream of students, teachers, and visitors attracted to the laboratory by unique learning experiences.

There were two milestone scientific reports in 2005 of great importance to the National High Magnetic Field Laboratory. The National Research Council's Committee on Research Opportunities in High Magnetic Fields released their report in mid-2005. The COHMAG report documents the broad scientific merit and excitement of research in high magnetic fields, and also affirms the past contributions and future promise of the NHMFL's role in high magnetic field research. Shortly thereafter, an NSF Blue Ribbon Panel was convened to formally review the NHMFL in the context of the COHMAG report. The Blue Ribbon Panel made a strong recommendation with which the National Science Board agreed: to renew, rather than compete, the core NSF grant that funds the National High Magnetic Field Laboratory.

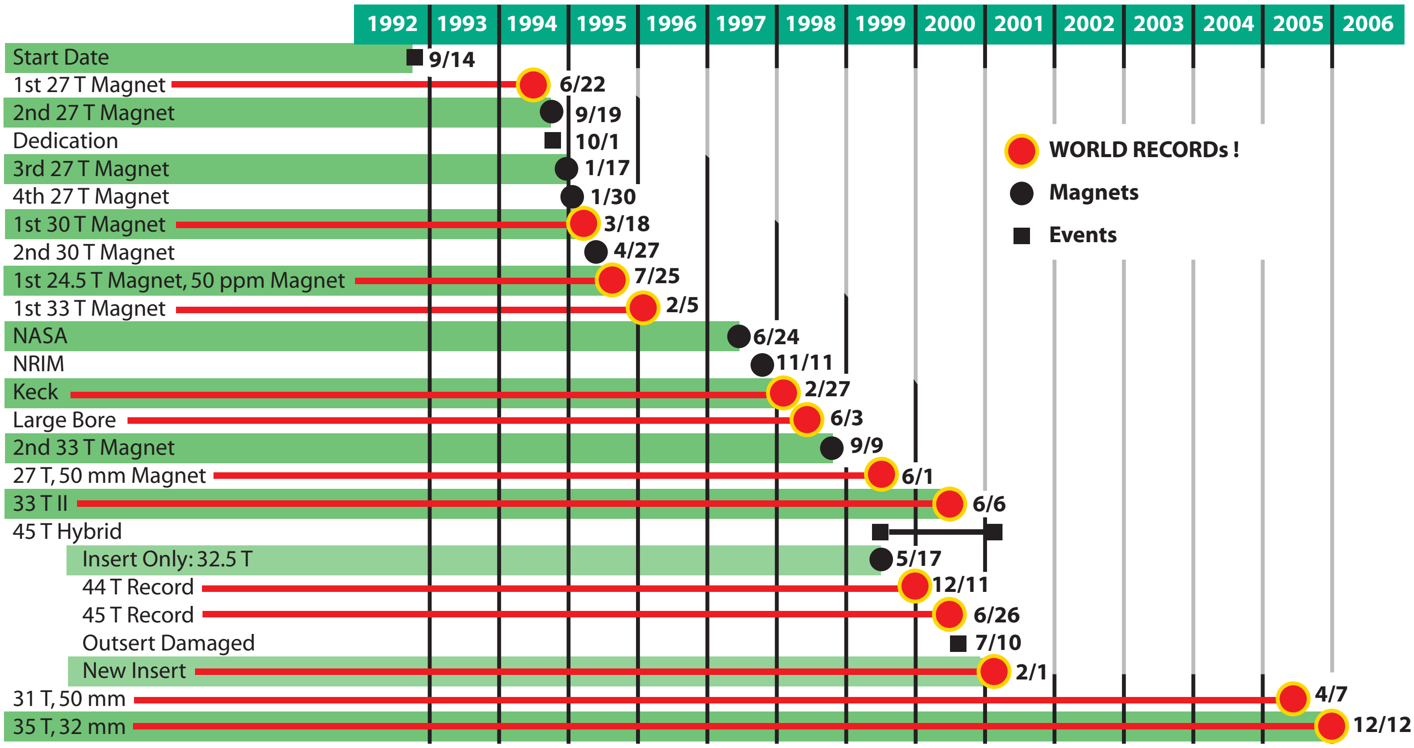
A major scientific partnership was announced in August 2005 that will come to full fruition in mid-2006: The Applied Superconductivity Center, now located at the University of Wisconsin, will be moving to Florida State University to join the Magnet Lab. Many of you already know of the ASC's strong record of research accomplishment and close collaboration with the private sector. The ASC will keep its independent identity, yet join the Magnet Lab as a materials research group led by National Academy of Engineering member David C. Larbalestier.

Two new world-record powered magnets were turned over to the DC Magnet user program in 2005. In April, a new 50 mm bore, Florida-Bitter magnet reached 31 T – a 6 T upgrade and a world-record for 50 mm bore DC magnets. In December, the Magnet Science and Technology Division delivered a 32 mm bore, 35 T magnet that upgraded an existing 30 T magnet and surpassed the previous record of 33 T, also held by the laboratory.

At the other end of the NHMFL-FSU building, July 28 commissioning ceremonies officially delivered the world-record 900 MHz, 105 mm warm bore NMR magnet to our chemistry and biological research user programs. This was the culmination of a year of tests during which probes were tuned and the capabilities of the instrument were demonstrated for high resolution (1 ppb) solution NMR, solid state NMR, and magnetic resonance imaging. Over 150 people attended the special ceremony that featured real-time imaging of a mouse brain and remarks by FSU President



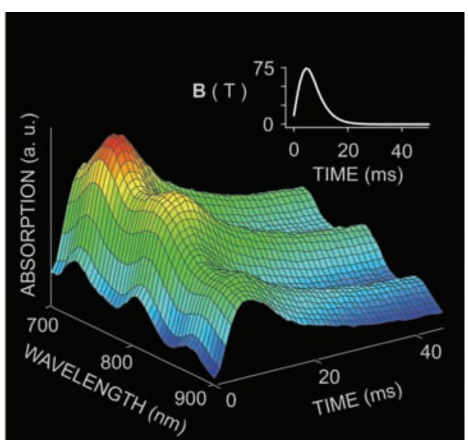
POWERED MAGNET HISTORY @ NHMFL



T.K. Wetherell; University of Florida Dean of Arts and Sciences and Magnet Lab co-PI Neil Sullivan; and NSF Program Director for National Facilities Guebre X. Tessema. News coverage of the magnet was unprecedented, making headlines across the nation and around the world. Over 100 media outlets carried the story: leading newspapers included *USA Today,* the *Washington Post*, the *Miami Herald,* the *San Francisco Chronicle*, and the *LA Times*; as well as *National Public Radio*, and *Late Night with David Letterman.*

At the NHMFL/LANL, construction continued steadily on the NSF-DOE funded 100 T Multi-Shot Magnet. A prototype insert magnet for this system reached a cumulative total of 100 pulses at 70 T on May 23, 2005. Its operational evaluation included 14 shots at 75 T without failure, during which a visiting user collaboration measured the polarization-dependent optical absorption in single-walled carbon nanotubes. This work continues studies of carbon nanotube absorption and emission that were published in *Science* in 2004 and used the 45 T Hybrid magnet at the NHMFL/FSU.

For details and progress reports on these and other magnet R&D projects, see Chapter 4.

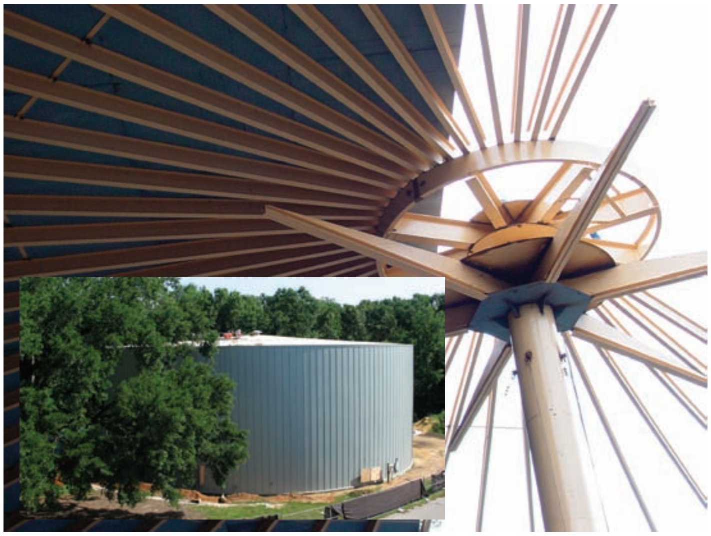


Optical absorption of magnetically-aligned carbon nanotubes to 75 T. Peaks in the spectra correspond to specific helicities of nanotubes.

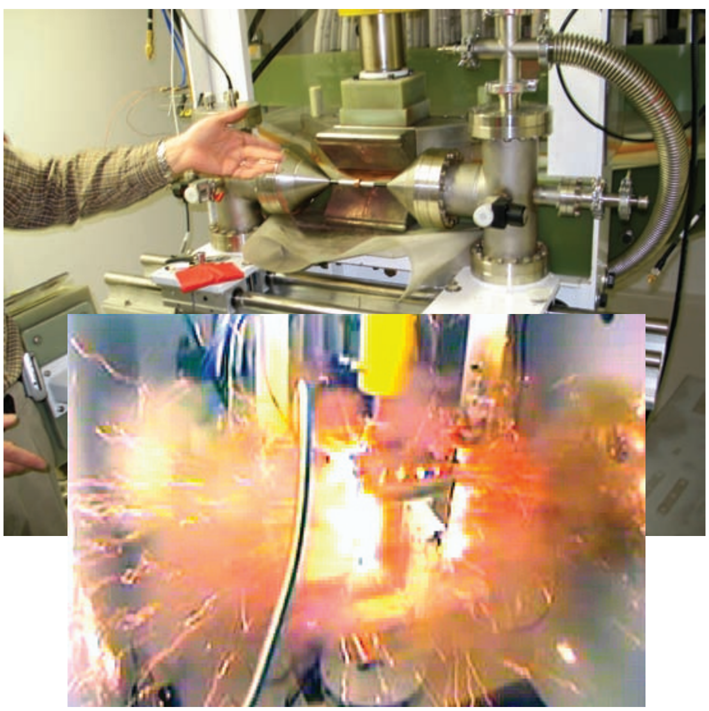
Researchers continue to flock to all of the Magnet Lab's user programs, resulting in a record number of 416 research reports received from external users and lab faculty. All of these reports may be viewed online at http://www.magnet.fsu.edu/publications/2005annualreport/. *Chapter 2* of this annual report features 30 selected highlights that represent the strength, breadth, and interdisciplinary nature of science being conducted using Magnet Lab facilities at UF, LANL, and FSU. *Chapter 10* details the publications and presentations of NHMFL users and affiliated faculty. We are particularly pleased that the research productivity of our user programs, evidenced in part by the number of publications in the world's most prominent physics, chemistry, biology, and engineering journals, continues to compare favorably with all other user programs in the United States.

Research productivity relies critically on real synergy of the highest-field magnets, user-friendly facilities, unique instrumentation, and strong support services of Magnet Lab faculty and staff. *Chapter 3* details Magnet Lab user assets and operations of the various facilities. For example:

- New magnets, upgrades, and user-driven instrumentation in the **DC Field Facility**, including an update on $7.5 million power and cooling upgrades funded by the State of Florida



- New techniques and a single-turn magnet system at the **Pulsed Field Facility** at Los Alamos purchased with DOE funds through LANL's internal Laboratory Directed Research and Development program.



- Multi-million dollar instrumentation enhancements, including update on the acquisition of a new 20 T superconducting magnet for the **High B/T Facility** at the University of Florida, all purchased with funding from the State of Florida
- Faculty recruitments and probe development in the **NMR** Program and the scientific case for the NHMFL's first Series Connected Hybrid magnet, a revolutionary magnet design that we hope to feature in a future suite of more flexible and efficient magnets for our DC user program.
- Faculty recruitments and new instrumentation were also important events at the MagLab's **Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS)** facility in Gainesville. AMRIS is purchasing a second new 600 MHz and cryogenic probes, with State of Florida funding.
- Improvements to **Electron Magnetic Resonance** instrumentation in 2005 extended the available frequency range for experiments and allow sample rotation of single crystals.
- The 14.5 T, 104 mm bore **Ion Cyclotron Resonance** system (installed in 2004) retains its status as the highest field superconducting ICR magnet in the world. An additional pumping stage for ultrahigh resolution of small molecules and other enhancements are under development.
- A quadrupole inductively coupled plasma mass spectrometer was added to the arsenal of analytical tools used for geochemical and environmental research. This new spectrometer and the MagLab's **Geochemistry Program** are funded by nine external research grants.

Interwoven with the MagLab's user operations and scientific productivity are our sponsored conferences, education programs, and community outreach. The 11th Annual Open House—celebrating the 2005 World Year of Physics—attracted a record number of 4,200 guests. Visitors viewed a new introductory video, learned about the 45 T Hybrid and the new 900 MHz superconducting magnets, and engaged with dozens of scientists and staff about complex science and engineering concepts…made "layperson-friendly" by demonstrations and hands-on activities.

The laboratory also hosted Ira Flatow (picture in center, right picture), host of *NPR Science Friday*; as well as 20 summer interns in the Research Experiences for Undergraduates program; 11 teachers in the Research Experiences for Teachers program; and the State of Florida Disability Mentoring Day. The laboratory entered four teams in FSU's Relay for Life campaign and contributed over $15,000 to cancer research. The teams were aptly named "Crow's Feet #1, 2, 3, 4," in honor of the laboratory's founding director Jack E. Crow.

The exceptional programs, initiatives, and accomplishments of the education group—with its strong emphasis on K12 students and teachers and underrepresented undergraduates—are reported in *Chapter 6*. Summaries of the laboratory's 2005 scientific conferences and workshops are presented in *Chapter 8*.

The Magnet Lab continues to build inter-institutional collaborations when motivated by a strong scientific case. Early in the year, the laboratory and the Korea Basic Science Institute forged a long-term partnership that focuses initially on the co-development of a 21 T, 110 mm bore ICR superconducting magnet system that is modeled after our 900 MHz, 105 mm bore NMR magnet and will provide a 45 percent increase in magnetic field over the current world-record 14.5 T Fourier transform ICR instrument at the NHMFL. The KBSI-NHMFL Research Collaboration has completed a conceptual design for the magnet, with support from the KBSI, the NSF, and the DOE's Battelle Pacific Northwest National Laboratory.

Major Workshops & Conferences in 2005
National High Magnetic Field Laboratory

5th North American FT-ICR Mass Spectrometry Conference
Key West, Florida, April 17-20

Workshop on a 30 T High Resolution Magnet for NMR Spectroscopy and Imaging
Tallahassee, Florida, July 28

Workshop on Probing Matter at High Magnetic Fields with X-Rays and Neutrons
Tallahassee, Florida, May 10-12

5th International Conference on Physical Phenomena at High Magnetic Fields (PPHMF-V)
Tallahassee, Florida, August 5-9

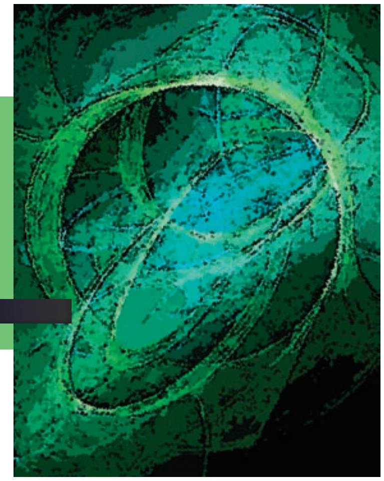
24th International Conference on Low Temperature Physics (LT24)
Orlando, Florida, August 10-17
Principal host: University of Florida, Department of Physics

International Conference on Ultra-Low Temperature Physics (ULT 2005)
Gainesville, Florida, August 18-20
Principal host: University of Florida, Department of Physics

6th International Symposium on Crystalline Organic Metals, Superconductors, and Ferromagnets (ISCOM 2005)
Key West, Florida, September 11-16

The laboratory's consistent record of advancing science, pioneering magnet technology, and developing model educational programs has provided us with a strong record of achievement in support of the best high magnetic field research in the world. The National Science Board recognized these past achievements and the continued promises of high magnetic field research in physics, materials science, chemistry and biology. The decision to renew our core NSF funding frees us to compete *and* collaborate: compete against our own record of success, and collaborate with our users and world-class laboratories alike…when, where, and how ever the frontiers of science call for high magnetic field research.

CHAPTER 2
RESEARCH HIGHLIGHTS



In November and December of each year, NHMFL users and affiliated faculty submit brief abstracts that describe their scientific and R&D activities for the year. For 2005, we received a record number of research reports, and all of them were reviewed by Magnet Lab facility or department directors. Ultimately, 416 reports in 18 categories were approved and are available on the Web at ***http://www.magnet.fsu.edu/publications/2005annualreport/.***

In January, the **Magnet Lab Science Council**, comprising **Lev Gor'kov (chair), James Brooks, Rafael Bruschweiler, David Larbalestier, Albert Migliori, Carol Nilsson, and Glenn Walter,** conducted a second review to identify research activities that were particularly noteworthy and representative of the strength, breadth, and interdisciplinary nature of all of the reports. The Council's recommendations were reviewed by NHMFL Director Gregory Boebinger, and 30 reports were selected and are published here as representative of the outstanding science being conducted by Magnet Lab users and staff across all three campuses of the laboratory.

	Reports Received	Highlights Selected
Life Sciences *including Biochemistry and Biology*	81	4
Chemistry *including Chemistry, Magnetic Resonance Techniques, Geochemistry*	99	6
Magnet Science & Technology *including Cryogenics, Engineering Materials, Instrumentation, Magnet Technology*	28	4
Condensed Matter *including Kondo/Heavy Fermion Systems; Magnetism and Magnetic Materials; Metal-Insulator Transitions; Molecular Conductors; Other Condensed Matter; Quantum Fluids and Solids; Semiconductors; Superconductivity—Applied and Basic*	208	16
Total	**416**	**30**

Funding for research at the laboratory spans an impressive array of public and private organizations, and includes both national and international agencies and institutions. See the table on the next page for details. **While the National Science Foundation** (including the Divisions of Materials Research, Chemistry, Earth Sciences, Ocean Sciences, the Directorate for Biological Sciences, and the Office of International Science and Engineering, and others) and the **U.S. Department of Energy** (including Basic Energy Sciences, Energy Biosciences, Energy Efficiency & Renewable Energy, High Energy Physics, and others), and the **National Institutes of Health** (the National Center for Research Resources, National Institute for Biomedical Imaging and Bioengineering, National Institute of General Medical Sciences, and others) **fund more than half of the research at the laboratory, other cutting-edge research is being supported by organizations such as Children's Miracle Network, the Juvenile Diabetes Research Foundation, NASA, and universities around the world.**

Funding Source

Funding Source	Number of Reports
American Heart Association	3
Argonne National Laboratory	1
Australian Research Council	1
Bioheart, Inc. (Sunrise, FL)	1
Brown University Solomon Research Fund	1
Children's Miracle Network	1
Clark University	1
Colby College Natural Science Division Grant	1
Darmstadt Technical University	1
DARPA	3
Department of Energy	55
Deutsche Forschungsgemeinschaft	2
East Carolina University	1
EPSRC (UK)	7
Estonian Science Foundation	4
European Community	1
FOM	2
FSU Research Foundation	1
German Research Society	1
IBM, Grant-in-Aid for Scientific Research from MEXT	1
Industrially funded R&D	1
INTAS, Ukraine project 03-51-4532	2
JSPS	1
Juvenile Diabetes Research Foundation	2
Korea Research Foundation	3
Korea Science and Engineering Foundation	1
Louisiana Board of Regents	1
MEXT Japan	1

Funding Source	Number of Reports
Ministry of Education, Science, Sports and Culture of Japan	2
NASA	7
National Institutes of Health	53
National Science Foundation	137
NHMFL	54
NHMFL In-House Research Program	29
NSERC of Canada	1
Queens College of CUNY	1
Research Corporation and the Dreyfus Foundation	1
Roosevelt University	3
Russian Foundation for Basic Research	2
Seoul National University	1
SLO-USA bilateral project	1
Slovenian Ministry of Science and Higher Education	1
State of Pennsylvania	1
Swiss National Science Foundation	1
U.S. Air Force Office of Scientific Research	3
U.S. Army	1
U.S. Environmental Protection Agency	1
U.S. Navy	3
University of Akron	1
University of California at Davis	1
University of Florida	3
University of Florida McKnight Brain Institute	6
Washington University	1
TOTAL	**416**

LIFE SCIENCES

Including: BIOCHEMISTRY & BIOLOGY

Most biological macromolecules function when small molecules known as substrates diffuse into the vicinity of a macromolecule that "recognizes" the substrate. The macromolecule attracts the substrate to an "active site" on its surface where some biological function is carried out and the "substrate" is converted to a "product" before being released. Nuclear magnetic resonance or NMR spectroscopy is a powerful technique for studying molecular structure and molecular motions, but functional processes are not often studied in a direct fashion because we rarely have the opportunity to flow substrates through our small NMR samples. **Prof. Alex Smirnov at North Carolina State University** has worked with the NHMFL (E.Y. Chekmenev *et al.*) to develop a way to solve this challenge. By using thin wafers formed by an array of nanotubes (anodic aluminum oxide) that trap the biological macromolecules, it is possible to change the solvent conditions without reforming the NMR sample. Here ions have been added to the sample, NMR signals are seen to be shifted and when the ions are removed by using a molecular sponge, the signal returns to its original frequency with little loss of intensity. This demonstration will be followed by the straight-forward development of a flow probe such that the sample does not need to taken out of the NMR magnet. It can be expected that the function of a great many biological systems could be studies by this elegant application of a nano-material to facilitate biological studies.

*This research was supported by the **NHMFL Visiting Scientist Program**, which provides financial assistance for new users and early career researchers. VSP pays special attention to increasing the diversity of the MagLab user program.*

FLOW-THROUGH NANOTUBE ARRAYS FOR STRUCTURE-FUNCTION STUDIES OF MEMBRANE PROTEINS BY SOLID-STATE NMR SPECTROSCOPY

E.Y. Chekmenev (NHMFL); A.M. Alaouie (NCSU, Chemistry); P.L. Gor'kov (NHMFL); A.I. Smirnov (NCSU, Chemistry); T.A. Cross (NHMFL/FSU, Chemistry and Biochemistry)

Introduction

Structure determination of membrane proteins remains one of the most difficult problems of structural biology and biochemistry today. One of the principal advantages of NMR spectroscopy over other methods is its ability to study proteins embedded in phospholipid bilayers—a natural environment for membrane proteins. Nanopore-confined phospholipid bilayers introduced recently provide an attractive alternative way for aligning membrane protein samples for solid-state NMR experiments. We studied, for example, the utility of such experiments of an ultra-high magnetic field (19.6 T) NMR ^{17}O anisotropic chemical shift study of ion binding to the gramicidin A (gA) ion channel.

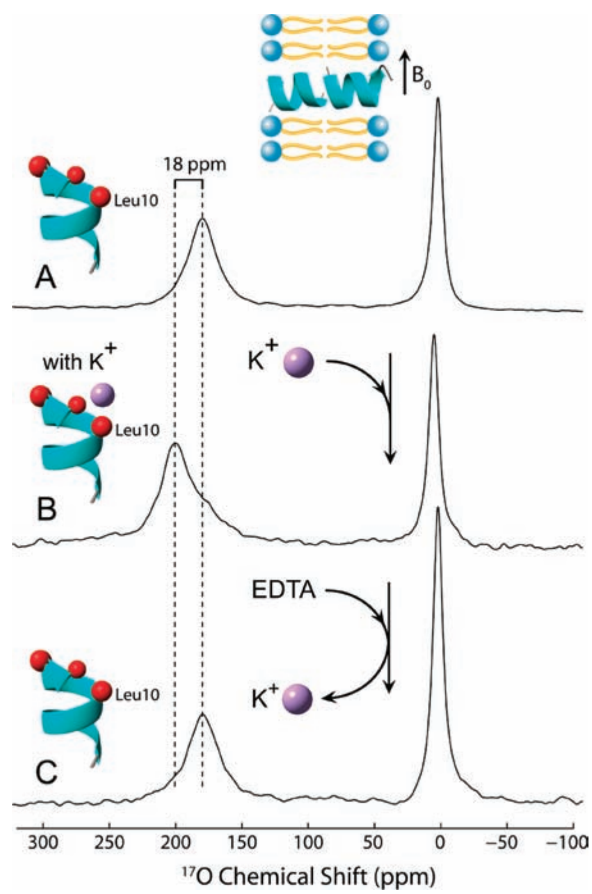


Figure 1. ^{17}O NMR spectra of ^{17}O-[D-Leu10]-gA uniformly aligned in DMPC bilayers in the absence and the presence of KCl (2.4 M) acquired at 40 ºC with at 19.6 T.

Results and Discussion

The Leu10 carbonyl in the gramicidin A pore is one out of three carbonyl sites involved in K^+ binding. We have monitored K^+ binding from the ^{17}O resonance of selectively labeled Leu10 carbonyl when gramicidin A dimers were incorporated into DMPC bilayers and aligned by our Anodic Aluminum Oxide (AAO) method. AAO substrates were positioned with the nanopores aligned along B_0 so the gramicidin A pores would be approximately perpendicular to B_0 (Figure 1, cartoon on top). When DMPC bilayer is in a fluid bilayer phase (i.e., T>24 °C), the tumbling of gA around the pore axis is fast and therefore its NMR spectrum is largely dictated by the average of the two components of the chemical shift tensor, δ_{22} and δ_{33} and the resonance appears at about $\delta=(\delta_{22}+\delta_{33})/2\approx 180$ ppm. Quadrupole relaxation largely determines the width of the ^{17}O resonance that is 15-25 ppm at 19.6 T. Since the surfaces of nanotubular bilayers are fully accessible to water soluble molecules, we are able to study reversible effects of K^+ binding to the gramicidin A channel from ^{17}O chemical shift using the same sample without losing its macroscopic alignment. When the sample was exposed to 2.4 M KCl to yield the double occupancy of K^+ in the dimeric channel, or one ion per monomer, a downfield shift of $\Delta\delta\approx 18$ ppm was observed (Figure 1B). When K^+ was removed by EDTA wash, the resonance returned to its original position (Figure 1C). Note, that 0 ppm peak is due to natural abundance ^{17}O water signal. We believe that a large number of solid-state NMR-based studies would benefit significantly from the method we described here. Specifically, for the first time solid-state NMR could be used to monitor structural changes in membrane proteins in pH and other titration experiments.

Conclusions

The aligned nanoporous network of AAO substrate provides the advantages of fast accessibility by solute molecules, reversible ion exchange, and titration experiments with physically the same sample of membrane proteins. Thus, one achieves better control of the bilayers by exposing the lipid nanotubes to various solutions and fine-tuning the bilayer properties.

Much of the chemistry conducted by biological macromolecules is initiated at oxygen atoms in these structures and yet one of the most powerful tools available in science has not been able to directly observe these oxygen sites. This tool, known as nuclear magnetic resonance or NMR spectroscopy, is closely related to magnetic resonance imaging (MRI) used commonly in the medical profession. The most common isotope (or variety) of oxygen that is observable by NMR is ^{17}O and spectra of this isotope are very complex. For years NMR spectroscopists have been recording spectra of carbon, hydrogen and nitrogen—the other common atoms in biological systems—in an effort to understand the chemistry occurring at the oxygen sites. Part of this complexity is dependent on the strength of the magnetic field used: the higher the field, the less complex the spectra. The NHMFL's ultrawide bore 21.1 tesla NMR magnet is being used to develop ^{17}O spectroscopy in collaboration with **Prof. Richard Wittebort at the University of Louisville**. Here ^{17}O spectra of small molecules and biological macromolecules are shown. In particular, a molecule that conducts ions across cell membranes (gramicidin A) is being studied to understand how this molecule facilitates this activity. In E.Y. Chekmenev *et al.*, the authors show that the carbonyl oxygens that line the pore of this ion channel interact strongly with ions as they are attracted to the channel and passed from one side of the membrane to the other. The details of *how* the ionic charge is absorbed by the carbonyls are being investigated with this unique tool.

This research was published in J. Am. Chem. Soc., **127**, 11922-11923 (2005).

TOWARDS ^{17}O SOLID-STATE NMR SPECTROSCOPY OF ION-SELECTIVE CHANNELS AT ULTRA-HIGH MAGNETIC FIELDS

E.Y. Chekmenev (NHMFL); L.N. Miller, Y. Mo (FSU, Chemistry and Biochemistry); P.L. Gor'kov (NHMFL); R.J. Wittebort (Univ. of Louisville, Chemistry); K.W. Waddell, (Vanderbilt University, Institute of Imaging Science); T.A. Cross (NHMFL/ FSU, Chemistry and Biochemistry)

Introduction

^{17}O, spin 5/2 quadrupole nucleus, has recently been extensively employed to study ion-binding in proteins due to high sensitivity through its quadrupolar coupling (QC) and chemical shift (CS) to the intermolecular interactions. While ^{17}O spectroscopy is considered difficult, advent of high magnetic fields potentially allows functional studies in large ion channels, the Holy Grail for many biochemists today. Here, we provide the progress report on ^{17}O work conducted at the NHMFL when the 21.2 T NMR spectrometer became available.

Results and Discussion

Ultra-high magnetic fields became available recently, and as a result much of the ^{17}O results to date are largely obtained from relatively small molecules such as individual amino acids. Recently we were able to demonstrate that ion binding significantly affects both CS and QC of carbonyl oxygen in polycrystalline peptides (Figure 1-top spectra). Moreover, it was found that ^{17}O is a significantly more sensitive probe for ion binding than the widely used ^{15}N nuclei of the peptide backbone. We also studied ion binding by ^{17}O anisotropic CS in the cation conductive pore of gramicidin A, the binding site

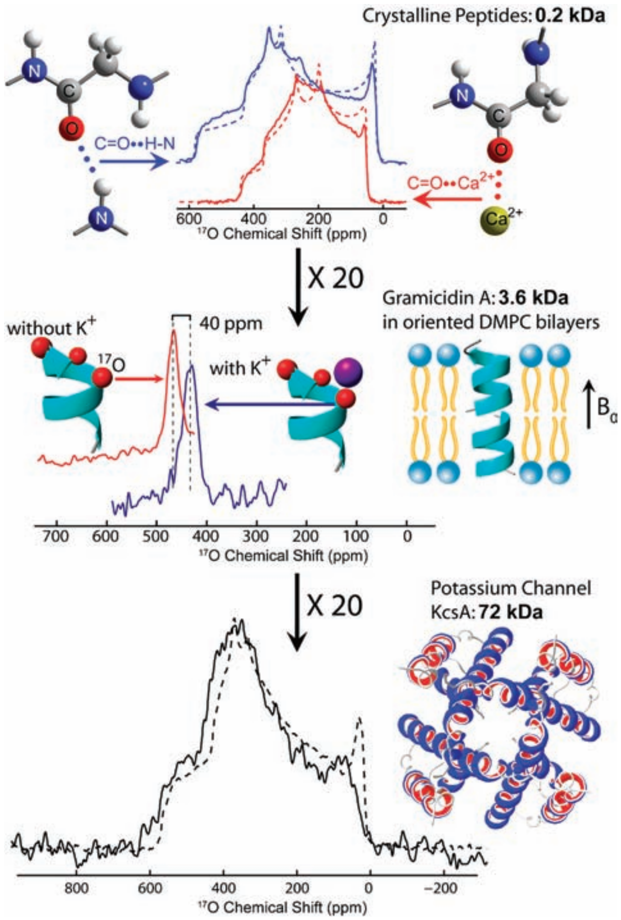


Figure 1. Progress in solid-state ^{17}O NMR spectroscopic studies of ion channels at high field. The top spectrum is acquired at 19.6 T, while the others were obtained from the ultra-wide bore 21.2 T spectrometer.

of which has similar intermolecular interactions that contribute to the biologically important function of highly selectivity and high conductance rates in ion channels. While the sensitivity is always a challenge for NMR spectroscopy, we take advantage of high fields to aid the sensitivity in addition to high ^{17}O isotopic enrichment (~60%), favorable relaxation and orienting the channels, which resulted in reducing the line width from >500 ppm to ~25 ppm, a 20 fold reduction. The insights gained from ion binding effects on CS in the relatively small gramicidin A pore (Figure 1-middle) helps potentially to approach the KcsA potassium channel. The preliminary results (Figure 1-bottom, solid line) suggest librational motions have negligible effects. CS tensor span and CS distribution is similar to those observed in crystalline solids (Figure 1-bottom, dashed line, polycrystalline Gly-Gly-Gly).

Conclusions

Solid-state ^{17}O NMR spectroscopy is a sensitive and accurate probe for ion binding to proteins. Our preliminary results obtained in a full length 72 kDa bundle of KcsA suggest that ^{17}O can be successfully applied to study the mechanism of ion solvation in ion-selective channels, including KcsA, in the native membrane environment.

While biologists have paid a great deal of attention to how biological macromolecules are structured, their attention is now turning to the motions that these molecules undergo in their native environment. Indeed, the motions are critical for achieving the biological function of these molecules. **Professor Dorothee Kern at Brandeis University** has been correlating molecular motions of biological catalysts with their biological function. By studying the motion for the enzyme with and without its substrate bound, the authors (W. Labeikovsky *et al.*) have demonstrated that the molecular motions necessary for the functional activity are present in the catalyst even without the substrate being present. This suggests that the protein is designed not only for its structure, but also for its molecular motions. How proteins are designed for specific motions is not known, but as a result of Dr. Kern's research it is a question that the protein community is beginning to think about.

This research by Dr. Kern continues her investigations reported in last year's annual report and recently published in Nature, **483**, 117-121 (2005).

STRUCTURAL REARRANGEMENTS OF THE PIN1 PROLYL ISOMERASE DURING CATALYSIS

W. Labeikovsky, E.Z. Eisenmesser (Brandeis, Biochemistry); D. Kern (Brandeis/HHMI, Biochemistry)

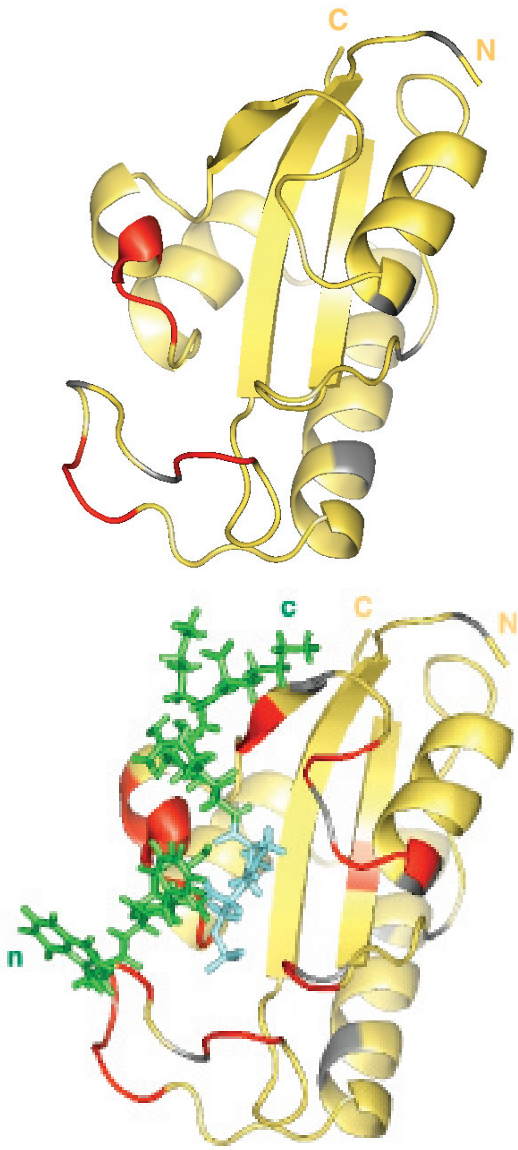
Introduction

Prolyl isomerases (PPIases) catalyze the cis-trans isomerization about the prolyl peptide bonds. Pin1 is unique among prolyl isomerases in that it specifically isomerizes phosphorylated Ser/Thr-Pro (pSer/pThr-Pro) bonds. The acceleration of this isomerization may serve as a second regulatory mechanism in addition to phosphorylation in the form of a kinetic control. Known substrates of Pin1 include a subset of cell cycle proteins (e.g. NIMA, Cdc25, Cyclin D) as well as the Alzheimer protein Tau and the transcriptional activator p53; however, the role of a conformational switch and the mechanism of its regulation by Pin1 is not understood. Here we perform structural and dynamic NMR experiments on Pin1cat during catalysis of a true substrate. Intermolecular NOE data collected during turnover of the peptide substrate together with backbone dynamics measured during catalysis reveals insight into the reaction trajectory. Conformational exchange in the free enzyme similar to the one observed during turnover suggests the pre-existence of dynamics.

Experimental

NHMFL Varian 720 and 600 solution magnets were used in this study.

Results and Discussion



Backbone ^{15}N probes exhibiting conformational exchange in the free enzyme (top) and in the saturated, turning-over complex (bottom) are highlighted in red. Similar conformational exchange suggests preexisting functional protein motions in the free enzyme.

Acknowledgements

We thank Jack Skalicky and Ashley Blue at NHMFL for magnet time. We would also like to thank Lewis Kay, Erik Zuiderweg, and Robert Konrat for pulse sequences and Dmitry Korzhnev for global-fitting code as well as Ming Lei for computational structure modeling tips.

The dynamics of molecular motors can be studied by labeling with heavy hydrogen atoms and high resolution mass spectrometry. The technique provides detailed structural snapshots of the protein complex, which complement the static structures obtained by X-ray crystallography. In the work of **Prof. R. Tuma of the University of Helsinki** (J. Lisal *et al.*), the technique was applied to a viral motor that is activated by transport of genetic material through its outer shell. Knowledge of the functional mechanisms of viral proteins can define structural targets for intelligent drug design.

This research was published in Nature Structural & Molecular Biology, **12**, 460-466 (2005).

FUNCTIONAL VISUALIZATION OF A VIRAL MOLECULAR MOTOR BY HYDROGEN-DEUTERIUM EXCHANGE REVEALS TRANSIENT STATES DURING RNA PACKAGING

J. Lisal (U. Helsinki, Biology); T.T. Lam (NHMFL); D.E. Kainov (U. Helsinki, Biology); M.R. Emmett (NHMFL/FSU, Chemistry and Biochemistry); A.G. Marshall (NHMFL/FSU, Chemistry and Biochemistry); R. Tuma (U. Helsinki, Biology)

Results and Discussion

Molecular motors undergo cyclical conformational changes and convert chemical energy into mechanical work. The conformational dynamics of a viral packaging motor, the hexameric helicase P4 of dsRNA bacteriophage ϕ8, may be visualized by hydrogen-deuterium exchange and high-resolution mass spectrometry (with NHMFL's homebuilt 9.4 T electrospray ionization FT-ICR mass spectrometer). Concerted changes of exchange kinetics revealed a cooperative unit that dynamically links ATP binding sites and the central RNA binding channel. The cooperative unit is compatible with structure-based model in which translocation is affected by a swiveling helix. Deuterium labeling also revealed the transition state associated with RNA loading that proceeds via opening of the hexameric ring. The loading mechanism is similar to that of other hexameric helicases. Hydrogen-deuterium exchange provides an important link between time-resolved spectroscopic observations and high resolution structural snapshots of molecular machines.

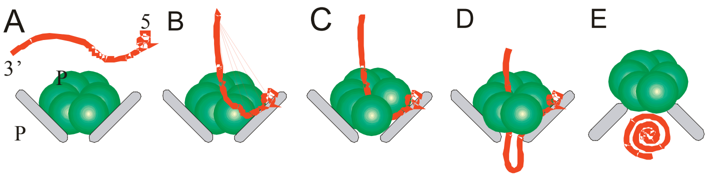


Figure 1. Schematic representation of the progression of single-stranded RNA as it passes through the hexameric pore helicase (204 kDa). H/D exchange reveals that the RNA squeezes through a cleft between adjacent monomers of the hexamer.

Acknowledgements

We thank Ayman Abu Ramadan for the software development. J.L. is supported by Viikki Graduate School in Biosciences, D.E.K is supported by the National Graduate School in Informational and Structural Biology. This work was supported by Academy of Finland grant 206926 (RT), the Finnish Centre of Excellence Program 2000-2005, the NSF National High Field FT-ICR Mass Spectrometry Facility (DMR-00-84173), Florida State University, and the National High Magnetic Field Laboratory in Tallahassee, FL.

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2005 RESEARCH HIGHLIGHTS

CHEMISTRY

Including: CHEMISTRY, MAGNETIC RESONANCE TECHNIQUES & GEOCHEMISTRY

Hawaii is the largest volcanic structure on Earth and its height above the seafloor is larger then the height of Mt. Everest. Last year, this group of researchers led by V. Salters of the NHMFL reported on the discovery of depleted material (depleted in elements that prefer a melt) of cumulate rocks that were carried by the basalts to the surface. Their studies this year (M. Bizimis *et al.*) have shown how extensive the occurrence of this component is. The report presented here discusses the identification of long term (in excess of one billion years) depleted mantle material in the Hawaiian peridotites (solid material).

Readers may also be interested in the complimentary research of **J. Blichert-Toft of Ecole Ecole normale superieure de Lyon** and V. Salters, which is available online at *http://www.magnet.fsu.edu/publications/2005annualreport/*.This study shows convincing evidence for the presence of a depleted component in the source of basalts (melts) from the Koolau volcano on Hawaii, although the Koolau basalts are the most enriched on Hawaii. The evidence for this depleted material lies in the radiogenic isotope systems that record the long term history of the magma sources. The identification of the depleted material is difficult, as by its nature the depletion is not easily recognized in melts. Implications of this finding are that the heterogeneities, observed in basalts, represent only a fraction of the heterogeneity present in the source of the basalts. Additionally, these findings show that mantle material can undergo several episodes of melting without refertilization between melting episodes.

THE HAWAIIAN PLUME IS REPLACING THE PACIFIC LITHOSPHERE: EVIDENCE FROM PERIDOTITE XENOLITHS FROM OAHU AND KAUAI

M. Bizimis, V.J.M. Salters (NHMFL, Geochemistry); G. Sen (FIU, Earth Sciences); J.C. Lassiter (UT Austin, Geological Sciences)

Introduction

Subduction of basaltic oceanic crust is a key mechanism for introducing chemical heterogeneities into the Earth's mantle. Together with the crust, however, the associated depleted lithosphere is also subducted. In the mantle, basaltic crust has a lower solidus while the depleted lithosphere has a higher solidus temperature than the ambient mantle. Thus, if a recycled depleted lithosphere is part of an upwelling plume, it could survive melting and be more easily recognized in mantle xenoliths associated with plume volcanism, than its basaltic counterpart. Here, we report on new isotope data from peridotite xenoliths from Oahu and Kauai, and we show that plume material of recycled origin is recognized in these peridotites.

Results and Discussion

Isotope and trace element analyses were performed at the Geochemistry Division, NHMFL, using a Finnigan MAT-262 TIMS, the ISOLAB (a modified VG 54 MS with Hot-SIMS) and a Finnigan ELEMENT ICP-MS. Two Kauai peridotites overlap the post erosional Kauai lava compositions in Sr-Nd isotope space. A third Kauai peridotite has higher $^{87}Sr/^{86}Sr$ (0.70422) and lower $^{143}Nd/^{144}Nd$ (0.51291) than any published Kauai lava and extends towards more radiogenic Sr (for a given Nd) than the Hawaiian lavas in general (Figure 1). This sample has depleted characteristics with high Mg# (0.925) and Cr# (0.31), and low HREE in cpx. It also has the highest La/Yb ratio and largest Ti depletions yet determined in Hawaiian peridotites. In contrast, three peridotites from SLC have less radiogenic $^{87}Sr/^{86}Sr$ for a given $^{143}Nd/^{144}Nd$ than all other analyzed Hawaiian peridotites and lavas (Figure 1). One peridotite straddles the so-called *LoNd* array, thought to represent mixing between HIMU and EM-I mantle components. In Hf-Nd space, this peridotite falls below the Hawaiian lava array having lower $^{176}Hf/^{177}Hf$ (0.28287) than the most isotopically enriched Koolau lavas suggesting that both depleted and enriched compositions are present in mantle peridotites, perhaps alleviating the need for an enriched pyroxenitic lithology in the Hawaiian plume. The new peridotite data shows greater Sr and Nd isotope variation in the Hawaiian peridotites than previously thought, and supports our conclusions from the Hf-Os systematics for a highly heterogeneous lithosphere. The total Sr-Nd-Hf isotope variability in the Oahu and Kauai peridotites cannot be explained by metasomatism of the Pacific lithosphere with erupted Hawaiian - type melts.

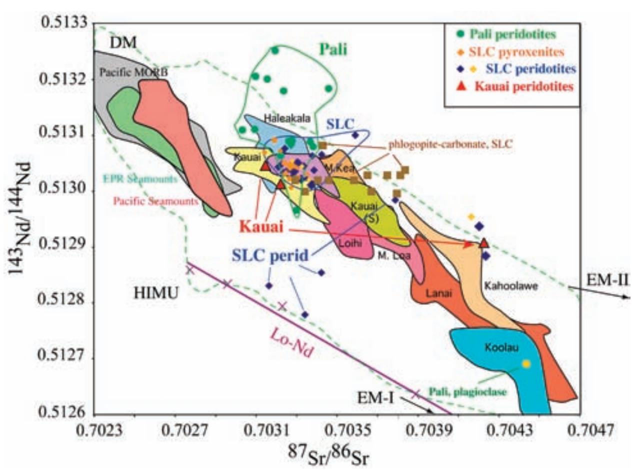


Figure 1. Sr-Nd isotope compositions of Oahu and Kauai peridotites compared with data from the Hawaiian lavas and Pacific MORB and seamounts.

Conclusions

We propose that the observed isotope heterogeneity in the Oahu and Kauai peridotites reflects the presence of plume-derived peridotites within the Pacific lithosphere. The Pali peridotites have compositions compatible with the 90 million year old Pacific lithosphere beneath Oahu. The SLC are best explained as fragments of an ancient (>1 billion year old) recycled mantle lithosphere that is brought to the surface by the Hawaiian plume. The similar temperatures of last equilibration of both the SLC and Pali peridotites (800-1000°C) suggests that plume and Pacific mantle peridotites are juxtaposed beneath Oahu at depths as shallow as 60 km. This provides independent evidence for thinning of the 90-100 km thick Pacific lithosphere by the Hawaiian plume, downstream from the present day plume center under the Big Island. The preliminary Kauai data suggests that such heterogeneity could be observed in the Kauai lithosphere. Additional analyses on Kauai peridotites will test the lateral extent of replacement of the lithosphere by plume-derived material.

Heterogeneous catalysts composed of metal ions supported on an oxide substrate represent an important class of industrial catalysts. Notwithstanding their industrial utility, the active sites that gives rise to the catalytic activity in many of these materials is poorly understood due to their low concentration on the surface. It has long been suggested, however, that they are metal-ligand multiple bonded species such as imido, M=NR, or akylidene, M=CR2, groups that form on the surface. In this study, C. Brown *et al.* supported vanadium oxide on silica is reacted with aniline to produce a catalytic site. The surface species was unambiguously characterized as a phenylimido species, V=NPh, through the use of $^{51}V/^{15}N$ rotational echo double resonance (REDOR) NMR spectroscopy. This technique allowed the identification of V-N bond formation even at low concentrations. When used in conjunction with proton dephasing studies and vibrational spectroscopy, the formation of a vanadium imido group on the surface could be unambiguously established.

This research was published in the Journal of the American Chemical Society, **127**, (33),11590-11591 (2005).

CHARACTERIZATION OF REACTIVE SITES IN SUPPORTED CATALYSTS BY $^{51}V/^{15}N$ ROTATIONAL ECHO DOUBLE RESONANCE NMR SPECTROSCOPY: FORMATION OF PHENYLIMIDO GROUPS AT SURFACE-BOUND OXOVANADIUM SITES

C. Brown, R. Achey (FSU, Chemistry and Biochemistry); R. Fu (NHMFL); T. Gedris (FSU, Chemistry and Biochemistry); A.E. Stiegman (FSU, Chemistry and Biochemistry)

Introduction

Surface-supported transition metals containing multiply bonded ligand systems such as akylidene and imido groups have long been proposed as key intermediates in heterogeneous catalytic reactions such as olefin metathesis, polymerization, and ammoxidation. In spite of the importance of these proposed species, their positive characterization on catalyst surfaces has been difficult due to their low concentration and transient nature. We report here the generation of metal-imido functional groups at discrete silica-supported vanadium-oxo sites under catalytic conditions. Specifically, vanadium-oxo groups in a silica xerogel matrix react cleanly and quantitatively with aniline in a gas-solid reaction to generate a phenylimido group at the vanadium center with concomitant elimination of water.

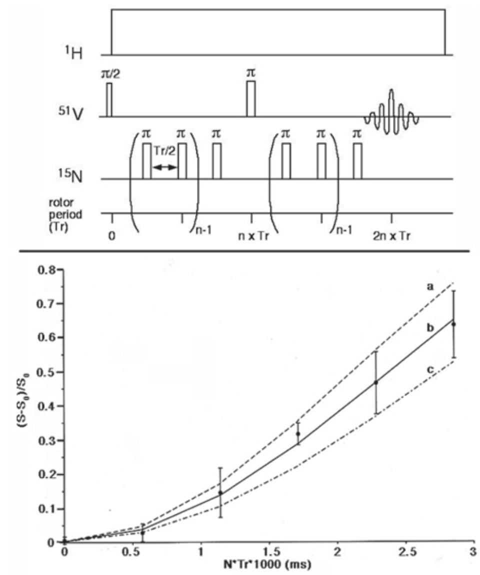
Experimental

Characterization of metal-imido bond formation was carried out using $^{51}V/^{15}N$ rotational echo double resonance (REDOR) NMR spectroscopy where the more sensitive quadrupolar ^{51}V nucleus was monitored while the ^{15}N nucleus was pulsed. While REDOR has been used to characterize a number of dense and porous inorganic solids and both one- and two-dimensional solid-state NMR has been used to characterize surface-grafted organometallic species, we believe this is the first use of REDOR to elucidate such sites.

Results and Discussion

Vanadium oxide supported on silica was fabricated using an established sol-gel derived procedure. Exposure of a monolithic 0.25 mol % V-silica xerogel to vapor phase aniline in a dry nitrogen flow showed systematic changes in the UV-Vis spectrum begin to occur between 120-175 °C with clean conversion to a distinct product observed.

Rotational echo double resonance spectroscopy (REDOR) was used to establish the presence of direct covalent bonding between the V and the N. Because of the low concentration of sites present on the surface, the REDOR fraction was measured by monitoring the more intense ^{51}V NMR signal, while applying two π pulses per rotor period to ^{15}N using the pulse sequence shown in Figure 3a. The ^{51}V echo was measured with and without the ^{15}N pulses and the REDOR fraction, $\Delta S/S_0$, plotted as a function of rotor evolution. Consistent with a short covalent bond length, after 3 msec of dephasing 60 % of the signal is lost. The best fit of the data was with a dipolar coupling constant of 419 Hz. In small molecule analogs, vanadium(V)-nitrogen covalent lengths typically range from around 1.60-1.70 Å for arylimido groups and 1.9-2.0 Å for amido groups. Consistent with these covalent lengths the V-N bond length obtained from the fit was 1.96 (±0.09) Å. While this is longer than expected for an imide, it has been established that bond length estimates determined from fits to the REDOR experiment tend to be longer than the experimental distances found through x-ray crystallography. This has been attributed to molecular motion and thermal dynamics that may partially average the dipolar couplings between two spins.



Conclusions

Discrete catalytic sites containing metal-ligand multiple bonds have been generated on a silica surface. Specifically, vanadium-imido functional groups were generated by a gas-solid reaction.

Acknowledgements

Funding was provided by the Air Force Office of Scientific Research through MURI 1606U8.

Structure, dynamics, diffusion: There is no limit to the questions that you can ask about a sample material with nuclear magnetic resonance spectroscopy (NMR). Unfortunately, NMR is much less sensitive than other spectroscopies, so you won't obtain a good answer unless you have a lot of sample. The sensitive RF sample probe developed by a collaboration of **Bruker Biospin, Inc**., and NHMFL scientists (A.S. Edison *et al*.) is a significant step toward solving the NMR sensitivity problem for biological samples that are available only in small quantities. It combines the sensitivity gains of a small sample coil, the low noise possible at cryogenic temperatures, and the low loss of oxide superconductors to establish a new sensitivity benchmark.

This research was supported by the ***NHMFL In-House Research Program****, which funds approximately six projects per year that meet the criteria of scientific quality on par with other NSF grants and are designed to extend or improve a component of the Magnet Lab user program.*

This research has been accepted for publication by the Journal of Magnetic Resonance.

ULTRA HIGH SENSITIVITY NMR: 1-MM HTS TRIPLE RESONANCE PROBE

A.S. Edison, J.R. Rocca (NHMFL/UF); W.W. Brey, S. Saha (NHMFL/FSU); R.E. Nast, R.S. Withers (Bruker Biospin, Fremont, CA)

We report a 600-MHz 1-mm triple-resonance high-temperature-superconducting (HTS) probe for NMR spectroscopy. The probe has a real sample volume of about 7.5 µl, an active volume of 6.3 µl, and appears to have the highest mass sensitivity at any field strength. The probe is constructed with 4 sets of HTS coils that are tuned to ^{1}H, ^{2}H, ^{13}C, and ^{15}N, and there is a z-axis gradient. The ^{1}H coil pair has two features that allow it to be placed very close to the sample: First, the resonators, based on two distributed interdigital capacitors, with a spatial periodicity of only 0.125 mm, place a very low fringing electric field on the sample. Second, the current-carrying fingers are extensively slit to reduce shielding currents that would reduce B_0 homogeneity. The ^{1}H coil pair also has a large height-to-width ratio to produce a homogeneous RF field. The ^{2}H and ^{13}C coils are spiral resonators. Lock sensitivity with such a small sample volume was given higher priority than carbon observe sensitivity, and for this reason the ^{2}H coils are in the second position from the inside, and the ^{13}C coils are in the third position. On the outside are the ^{15}N coils, also spiral resonators to achieve a resonance frequency of 60 MHz. Because the ^{15}N coils are far from the sample, their rather large electric field is acceptable. The simple spiral design, however, supports additional modes at approximate multiples of 60 MHz. Final frequency-trimming relied upon extensive simulations to prevent these modes from interfering with the other coils. The coils are cooled with a commercial Bruker CryoPlatform to about 20 Kelvin, and the sample chamber can be regulated above or below room temperature over a moderate range using a Bruker variable temperature unit. The S/N value of 292±28 for 0.1% ethylbenzene is approximately 3.5-fold less than a standard 600 MHz 5-mm triple-resonance probe (S/N ~1000) with about 70-fold less sample. Thus, the mass sensitivity of the 1-mm HTS probe is about 20 times greater than a conventional 5-mm probe. Commercial 5-mm Bruker 600 and 800 MHz cryoprobes have S/N values approximately 4,000 and 8,000, respectively. The 1-mm HTS probe has a mass sensitivity that is over 4 times that of a 5-mm cryogenic probe at the same field strength and over 2 times that of state-of-the-art 5-mm technology at 800 MHz.

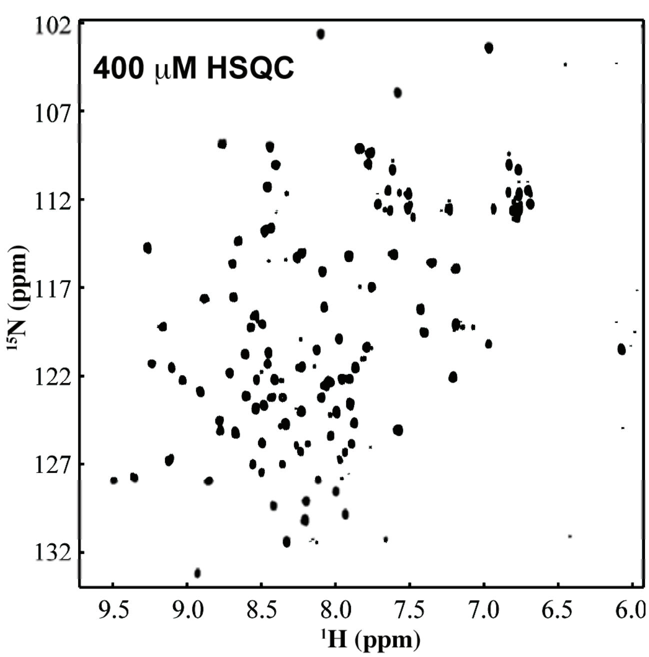


Figure 1. Experimental data from the 1-mm HTS triple-resonance probe. Data were collected using 400 µM ubiquitin using gradient 15N-HSQC and were recorded in 41 m using 16 scans and 128 t_1 increments. High quality data on 8 µL 1 mM samples can be obtained in about 10 min (not shown).

The extremely high mass sensitivity of this probe suggests that it may be useful for metabolomics, natural products, and protein screening applications. Figure 1 demonstrates the utility of this probe for small molecules and proteins with a 2D spectrum of 400 µM ^{15}N-labeled ubiquitin in 8 µl phosphate buffer (pH 5.5) with 10% D_2O for lock.

Acknowledgements

The author would like to acknowledge the support of Dr. Werner Mass and Bruker Biospin, Inc.

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1 Brey, *et al.*, *J. of Magn. Reson.*, **179**, (2006), in press.

As the global supply of "light sweet" crude oil is depleted by expanding energy needs, petroleum reserves must evolve toward heavier crude oils that are more difficult to process. Heavy petroleum is comparatively rich in polyaromatic hydrocarbons (PAHs), some of which contain heteroatoms such as nitrogen, sulfur, and oxygen. Variations in petroleum molecular composition directly impact the cost and efficacy of all refinery processes, and efficient removal of heteroatoms is required to minimize environmental impact. The first step toward efficient processing is a fundamental understanding of the types of molecules present in each oil. In this work (S. Kim *et al.*), NHMFL scientists team with **ExxonMobil** to characterize six similar oils that had undergone varying degrees of microbial degradation due to deposition at different depths below the Earth's surface. Changes in oil composition reveal new chemicals created by biodegradation and the preferred microbial food sources.

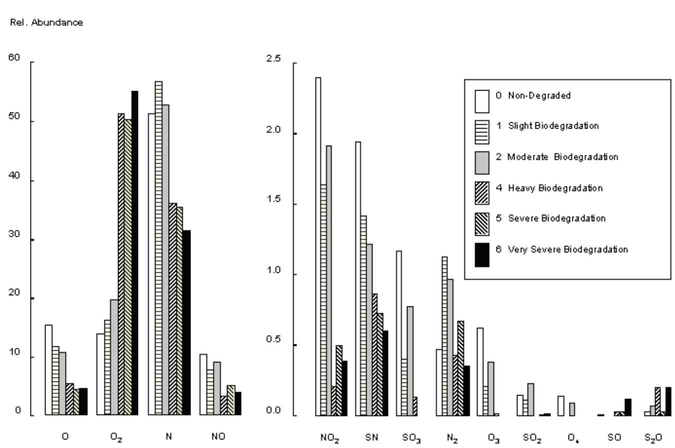
This research was published in Organic Geochemistry, **36**, 1117-1134 (2005).

COMPOSITIONAL CHARACTERIZATION OF THE MICROBIAL DEGRADATION OF PETROLEUM BY ELECTROSPRAY IONIZATION FT-ICR MASS SPECTROMETRY

S. Kim (NHMFL); L. Stanford (NHMFL/FSU, Chemistry and Biochemistry); R.P. Rodgers (NHMFL/FSU, Chemistry and Biochemistry); A.G. Marshall (NHMFL/FSU, Chemistry and Biochemistry); C.C. Walters, K.Qian, L.M. Wenger, P. Mankiewicz (ExxonMobil, Petroleum)

Results and Discussion

A suite of six genetically related oils that had experienced varying degrees of subsurface, anaerobic biodegradation are analyzed by ultrahigh-resolution 9.4 T Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS). Electrospray ionization of whole oil samples selectively characterizes all neutral nitrogen compounds and acid NSO compounds, from ~300 to 900 Da, with unambiguous assignment of molecular formulae. Evidence for selective biodegradation is observed in all compound classes. NSO compounds associated with long alkyl side chains are removed, regardless of the NSO core, under conditions associated with moderate (saturated biomarkers unaffected) to severe biodegradation. Changes in aromaticitiy and alkyl distributions of the O_2 species result from simultaneous microbial degradation and generation. The ratio of acyclic to 2-4 ring cyclic O_2-species provides a new parameter to define the degree of biodegradation.



Acknowledgements

We thank D. McIntosh for machining all of the custom parts required for the 9.4 T instrument construction, M.R. Emmett and J.P. Quinn for design and construction of the microelectrospray source, and C.L. Hendrickson for help in optimizing instrument operating parameters. We also thank John Okafor, Phuc Nguyen, and Frank Chen of ExxonMobil Upstream Research Company for conducting the supporting geochemical analysis. Work supported by NSF (DMR-00-84173), Florida State U., and NHMFL. We thank Barry Bennett and a reviewer for their careful proofing and helpful suggestions.

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When exactly does something deviate from the norm? The laboratory mouse is the mammal of choice for exploring genetic variation and for modeling human biology. But to take advantage of the information emerging from mouse genome sequencing efforts, it has become necessary to systematically collect phenotypic information to establish a baseline of normal variability. As part of a worldwide effort, **H. Benveniste of Brookhaven National Laboratory** and colleagues (Y. Ma *et al.*) have constructed a three-dimensional (3D) probabilistic mouse brain atlas database derived directly from Magnetic Resonance Microscopy (MRM) images acquired at the AMRIS facility at the University of Florida. Using 10 excised adult brains of the laboratory mouse strain C57BL/6J, these researchers utilized a 17.6 T widebore magnet and homebuilt MRI coils to generate 3D gradient-echo datasets at an isotropic resolution of 47 μm. These datasets were co-registered, segmented into 20 distinct anatomical structures, and incorporated into three different atlas types: 10 single-specimen brain atlases, a minimum deformation atlas, and a probabilistic atlas. With these resources, genomics researchers can visualize the shapes and volumes of brain structures directly while registering their own data to the 3D space defined by the atlases. Furthermore, this atlas database readily provides quantitative structural information, such as a structure volume, surface area, and local geometric variations, which can be integrated into finer anatomical phenotyping efforts. And because of the inherent digital and 3D nature of the MRM-based atlases, this important resource can be made available on the Internet for widespread use by the scientific community: (*www.bnl.gov/CTN/mouse*).

This research was published in Neuroscience, **135**, 1203-1215 (2005).

A 3D DIGITAL ATLAS DATABASE OF THE C57BL/6J BRAIN BY MR MICROSCOPY

Y. Ma (BNL, Medical); P.R. Hof (Mount Sinai, Neuroscience); S.C. Grant, S. J. Blackband (UF, Neuroscience); R. Bennett, L. Slatest, M.D. McGuigan (BNL, Computer Science); H. Benveniste (BNL, Neuroscience)

Introduction

A comprehensive 3D digital atlas database of the C57BL/6J mouse brain was developed based on MR microscopy images acquired on a 17.6-T superconducting magnet. By using both manual tracing and an atlas-based semi-automatic segmentation approach, T2*-weighted magnetic resonance microscopy images of 10 adult male formalin-fixed, excised C57BL/6J mouse brains were segmented into 20 anatomical structures. The segmentation data were formatted and stored into a database containing three different atlas types: 10 single-specimen brain atlases, an average brain atlas, and a probabilistic atlas. Additionally, quantitative group information, such as variations in structural volume, surface area, MR microscopy image intensity and local geometry, were computed and stored as an integral part of the database.

Experimental

Intact, fixed adult C57BL/6J mouse brains were imaged at 17.6 T with a 3D gradient-echo sequence at an isotropic 47 µm isotropic resolution in 5.5 hrs. One of the brain datasets was chosen as a "representative brain," which was segmented manually into 20 neuroanotmical structures. Subsequent brains were co-registered to this brain and its structures through linear and elastic transformations by means of a guided semi-automatic process (see (1) for complete details). This process generated not only the 10 individual mouse brain atlases but also a minimum deformation atlas based on the minimum spatial transformation required to nonlinearly normalize all brains to the geometric center of the entire population. Further, the 10 brains were used to generate a 3D probabilistic atlas that represents the anatomical variability in the segmented structures.

Figure 1. Segmented MRI of mouse brain.

Results and Discussion

Figure 1 presents a single brain MRI segmented into the 20 neuroanatomical structures. Figures 2A and B display the 3D average local deformation map with the intensity of color representing the average distance transformed when the target brains were registered. Figure 2C displays the 3D probabilistic atlas with the color intensity showing the probability of a structure occupying the corresponding location within a segmented region. Areas on the exterior of the brain (cerebellum, stem, olfactory) undergo the greatest deformation and show the biggest statistical variation.

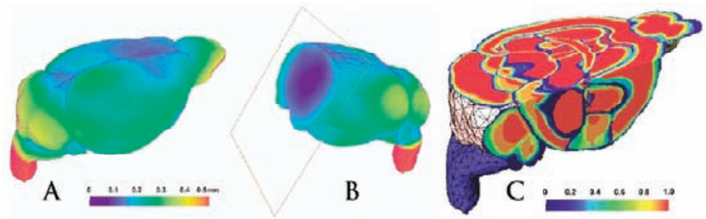

Figure 2. A&B: 3D average local deformation map C: 3D probabilistic atlas.

Conclusions

The database augments ongoing efforts with other high priority strains as defined by the Mouse Phenome Database focused on providing a framework for accurate mapping of functional, genetic and protein expression patterns. The database can be browsed and visualized online at site (www.bnl.gov/CTN/mouse).

Acknowledgements

Support provided by the NIH (R01 EB 00233–04; P41 RR16105) and the National High Magnetic Field Laboratory. MRI data were obtained at the AMRIS facility of the McKnight Brain Institute of the University of Florida.

References

1 Ma, Y., *et al.*, *Neuroscience*, **135**, 1203–15 (2005).

Over the recent past, site-directed spin-labeling EMR has emerged as a powerful and versatile biophysical method to study structure-function relationships in proteins and protein-membrane systems. Advances in high field (HF) EMR methodology extend its applicability even further to address important questions of membrane proteins such as the roles of hydrogen bonding and electrostatics for membrane protein structure and dynamics. Unfortunately, membrane protein samples are quite difficult to handle in HF EMR experiments because of high dielectric losses associated with liquid water.

This report (A.I. Smirnov *et al.*) combines advances in hybrid nanomaterials introduced at **North Carolina State University** with HF EMR instrumentation developed at the NHMFL to construct a nanoporous sample cell to study membrane proteins in the native lipid bilayer environment. Lipid bilayers are self-assembled into nanotubular macroscopically aligned structures inside nanoporous channels of anodic aluminum oxide that is fabricated as a 60 micron-thick disk. Such lipid structures retain many properties of unsupported bilayers and can accommodate membrane proteins with their native membrane conformations.

*This research was supported by the **NHMFL Visiting Scientist Program**, which provides financial assistance for new users and early career researchers. VSP pays special attention to increasing the diversity of the MagLab user program.*

NANOPOROUS SAMPLE HOLDERS FOR MULTIFREQUENCY/HIGH-FREQUENCY EPR OF FULLY HYDRATED MACROSCOPICALLY ALIGNED SPIN-LABELED MEMBRANE PROTEINS

A.I. Smirnov, A.M. Alaouie, M.A. Voinov (NCSU, Chemistry); J. van Tol, L.-C. Brunel (NHMFL, EMR)

Introduction

Studies of liquid aqueous samples with EPR encounter a problem of high dielectric losses occurring in water at microwave frequencies 2-3 GHz and above. The losses result in non-resonant (magnetic field independent) energy absorption and a rather short penetration depth of electromagnetic field into an aqueous sample. This dictates special arrangements for aqueous samples and specialized sample holders constructed in a way to minimize the Eddy currents through the sample. The latter could be achieved by positioning an aqueous sample within a plane of the magnetic field component of the mm-wave field (*i.e.*, at the electrical field node). In high field/high frequency EPR spectrometers that employ Fabri-Perot resonators this is accomplished by sandwiching an aqueous sample between thin quartz or mylar discs. For example, for water at 20 ^{o}C and 250 GHz the sample thickness should be about 18 µm. Such a sample could be configured by putting together two thin quartz discs with one of the disc having a groove etched in. It might, however, be difficult to maintain the 18 µm thickness uniformly throughout the sample. Additional problems arise when macroscopically aligned membrane protein samples are studied with HF EPR. For example, positioning of planar bilayers with director vector perpendicular to magnetic field require a different resonator design. None of the designs described so far allow for convenient examination of physically the same macroscopically aligned membrane protein sample with, for example, at 240 and 9 GHz EPR.

Experimental

Lipid bilayer were prepared from DMPC (1,2-dimyristoyl-*sn*-glycero-3-phosphocholine), doped with 1 mol% of spin-labeled phospholipid 5PC (1-palmitoyl-2-stearoyl-(5-doxyl)-sn-glycero-3 phosphocholine) or spin-labeled ion channel gramicidin A. Hydrated lipid samples were deposited onto 60 µm-thick nanoporous anodic aluminum oxide discs (Whatman, Ltd) to form a macroscopically aligned lipid nanotubular structure. The samples were sealed with a polyvinylidene chloride film with a thickness of 25 µm. 240 GHz EPR spectra were recorded with multi-purpose transient EMR spectrometer equipped with a Fabri-Perot resonatore (NHMFL). Consequently, the same samples were examined with a conventional Varian 9 GHz EPR spectrometer (NCSU).

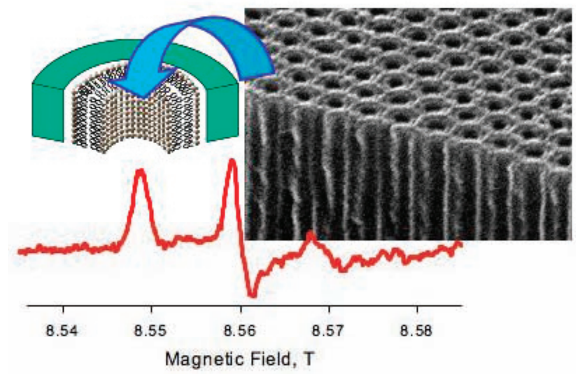

Figure 1. A representative 240 GHz EPR spectrum from DMPC/gramicidin A.

Results and Discussion

Figure 1 shows a representative room temperature 240 GHz EPR spectrum from fully hydrated DMPC/spin-labeled gramicidin A (100:1) aligned by nanoporous AAO. Similar well-aligned spectra were observed from DMPC doped with 1mol% of 5PC. Physically the same AAO discs were used for consequent examination with conventional X-band EPR (not shown). It was determined that polyvinylidene chloride film provides an exceptional moisture seal allowing for several hours of experimentation. We also found that these samples remained to be macroscopically aligned for a period of more than 1 month when stored in a refrigerator at 100 % humidity.

Conclusions

The new technology we describe here allows one to study hydrated and macroscopically aligned membrane proteins with both high frequency/high field and conventional EPR for the first time. Sample handling is also significantly simplified.

Acknowledgements

Support of NHMFL Visiting Scientist Program as well as NIH 1R01GM072897 and DOE contract DE-FG02-02ER15354 (to A.I.S) are gratefully acknowledged.

MAGNET SCIENCE & TECHNOLOGY

Including: CRYOGENICS, ENGINEERING MATERIALS, INSTRUMENTATION & MAGNET TECHNOLOGY

This cryogenics research of S. Fuzier *et al.*,— done in collaboration with **GE Global Research Center**— is noteworthy because a better understanding of the properties of liquid helium could lead to development of a medium in which to classify and potentially separate micron and sub-micron particles by size, density and defect. Unlocking the mystery of how to separate very tiny particles has tremendous applications for the pharmaceutical industry and could change how some medications are delivered and how effective they are.

This research was published in Nature Physics, **1**, 36-38 (2005).

PIV MEASUREMENTS OF HE II COUNTERFLOW AROUND A CYLINDER

S. Fuzier, S.W. Van Sciver (FSU, NHMFL & Mechanical Engineering); T. Zhang (GE Global Research Center)

Introduction

The two-fluid model describes He II as if it consists of two interpenetrating fluid components, the viscous normal fluid and the inviscid superfluid. The normal fluid component contains the thermal excitations while the superfluid component carries no entropy. A heat current in He II is carried by the entropy containing normal fluid, which flows at a velocity given by the relation, $v_n = q/\rho sT$, with q being the applied heat flux, ρ being the total fluid density and s the specific entropy. A special case is that of the bulk fluid at rest with the normal fluid flow balanced with flow of the superfluid component such that the superfluid velocity v_s is counterflowing to the normal fluid. Here we report the first Particle Image Velocimetry (PIV) experiments that visualize thermal counterflow around a cylinder immersed in He II.

Experimental

In the PIV technique, one seeds the He II with micron sized particles and tracks their motion to obtain a full field map of the flow. In thermal counterflow, we have previously shown that the particle mainly tracks the normal fluid flow, but may also be affected by the turbulent superfluid component.[1] In our recent study,[2] we placed a 6.35 mm OD transparent circular cylinder in a one dimensional rectangular channel, which is 200 mm long and 38.9×19.5 mm^2 in cross section. The channel is immersed in a constant temperature He II bath with the top end open to the bath while the lower end is closed by a thin film heater. The front wall has a 45×20 mm^2 optical window for imaging the particles with a CCD camera. The cylinder is located inside the channel spanning the full width and orthogonal to the flow.

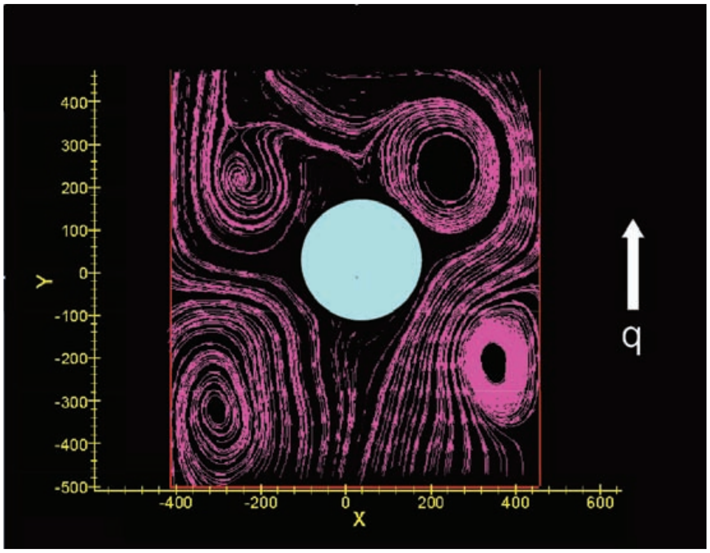

Figure 1. Turbulent structures generated by thermal counterflow around a 6.35 mm OD cylinder. T = 2.03 K and q = 7.2 kW/m^2 of channel cross section, which corresponds to normal fluid velocity of v_n = 23 mm/s.

Results and Discussion

Figure 1 contains an example of the observed counterflow field around the cylinder. These are representative data that actually fluctuate in time and are therefore only typical. They were acquired at 2.03 K and for a heat flux of 7.2 kW/m^2 directed upward, which corresponds to ν_n = 23 mm/s. Clearly seen are turbulent structures both below and above the cylinder. However, a more subtle effect is the tendency for the large vortices below the cylinders to cling more closely to the channel walls than do those above the cylinder. Although we have no theoretical explanation for these structures, it is speculated that the large vortices below the cylinder are the result of some form of flow separation occurring in the turbulent superfluid component. Since the normal fluid component interacts more strongly with the suspended particles,[2] however, it is possible that the transverse velocity component of ν_n as it flows around the cylinder could push these vortices toward the channel walls. Further work is required to confirm this suggestion.

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In the report by G.M. Ludtka *et al*. high magnetic fields are used to influence the structure and property of steel. In general, the strength of a steel depends both on its chemistry (the combination of atoms included) and the structure of the steel (the way those atoms are grouped together to form "phases"). Thus, two steels of identical chemistry can have very different properties depending on what phases are present. In this **international collaboration of Oak Ridge National Laboratory, Nanyang Technological University, and the University of Cambridge**, it is shown that processing this particular high strength steel can improve the steel's properties by influencing the growth of the desired phase.

This research was published in Scripta Materialia, **52** (6), 461-466 (2005).

EFFECT OF 30 T MAGNETIC FIELD ON PHASE TRANSFORMATIONS IN A BAINITIC HIGH STRENGTH STEEL

G.M. Ludtka, R.A. Jaramillo, S.S. Babu, R.A. Kisner, J.B. Wilgen, G. Mackiewicz-Ludtka, D.M. Nicholson, S.M. Kelly (Oak Ridge National Laboratory); M. Murugananth (Nanyang Technological University); H.K.D.H. Bhadeshia (University of Cambridge)

Introduction

Recently, the effect of a 30 T magnetic field on phase transformations in a high-carbon bainitic alloy was evaluated[1] while continuously cooled at a rate of 1 °C/s. In this work, additional research has been performed to understand the alloying element partitioning characteristics during the pearlite formation. Moreover, the tendency for the pearlite formation under isothermal conditions with and without magnetic field was evaluated.

Experimental

In this study, two steels (see Table 1) were used. The steel identified as "SK" exhibits very sluggish transformation kinetics. In contrast, the steel identified as "FK" is alloyed with Co and Al to enhance the transformation kinetics.

Table 1. Compositions of steel used in the current investigation in at.%

Alloy	C	Si	Mn	Mo	Cr
SK	3.34	3.10	1.89	0.16	1.52
FK	3.43	3.01	1.94	0.13	1.03
Alloy	**Co**	**Al**	**V**	**Fe**	
SK	-	0.02	0.10	Balance	
FK	3.47	2.68	-	Balance	

A 32 mm diameter bore resistive magnet with maximum field strength of 33 teslas at the NHMFL was used.

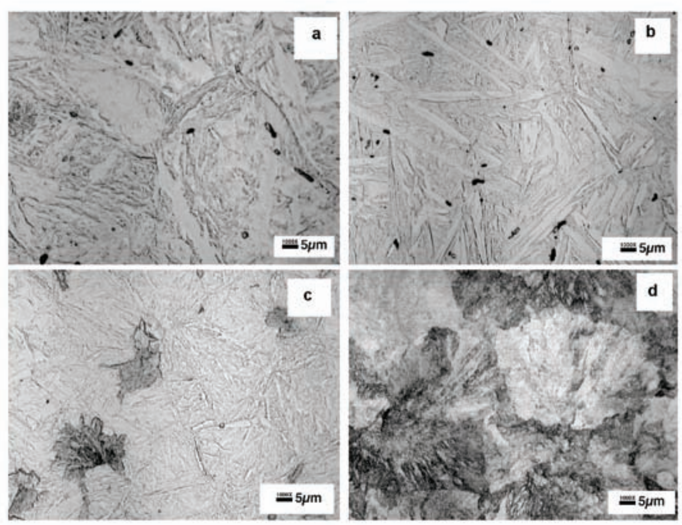


Figure 1. Summary of microstructures attained by continuous cooling from austenitizing temperature with and without magnetic field: (*a*) SK steel – no field; (*b*) FK steel – no field; (*c*) SK steel – 30 T; and (*d*) FK steel – 30 T.

Results and Discussion

The SK and FK steels subjected to continuous cooling from austenitizing temperature without magnetic field did not show any major differences in the microstructure [Figures 1*a* and 1*b*]. On application of a 30-tesla magnetic field, the SK steel showed some localized regions of softer microstructure [Figure 1*c*]. In contrast, the FK steel with an applied magnetic field led to a uniform soft microstructure [see Figure 1*d*].

Conclusions

Although all of the results of this study are not presented here, this research investigated the effects of 30 T magnetic field on the austenite decomposition in two high-carbon steels with different austenite decomposition kinetics. In the steel alloyed with Al and Co, the decomposition of austenite to fine pearlite occurred while continuously cooling from austenite phase field. The pearlite microstructure exhibited a lamellar spacing of less than 50 nm. Atom probe analysis of this pearlite showed enrichment of Cr, Mn, and C and depletion of Si, Al, and Co in the cementite phase. The decomposition of austenite was not extensive during continuous cooling in the alloy without Al and Co due to the sluggish kinetics.

References

[1] Jaramillo, R.A., *et al*., *Scripta Materialia*, **52**, 461-466 (2004).

This work by C. Pantea *et al*. significantly enhances the state of the art in ultrasound measurements that are used to determine the velocity of sound in a material. These enhancements simultaneously simplify the instrumentation and improve the precision of the measurement.

This research was published in Review of Scientific Instruments, **76**, 114902 (2005).

DIGITAL ULTRASONIC PULSE-ECHO OVERLAP SYSTEM AND ALGORITHM FOR UNAMBIGUOUS DETERMINATION OF PULSE TRANSIT TIME

C. Pantea, D.G. Rickel, A. Migliori (MST-NHMFL, LANL); R.G. Leisure (Colorado State University, Physics); J. Zhang, Y. Zhao (LANSCE-12, LANL); S. El-Khatib (New Mexico State University, Physics); B. Li (State University of New York at Stony Brook, MPI)

The widely applied ultrasonic pulse-echo method uses a short pulse of ultrasound generated by a transducer, often in direct contact with the specimen. The pulse propagates through the material of interest, reflects from the opposite end, and returns to generate a signal in the same transducer: the echo. A measurement of the round-trip travel time and travel distance yields the sound speed from which an elastic constant is determined.

We report an evolution of an all-digital ultrasonic pulse technique for measurements of elastic constants of solids. We use an unambiguous analytical procedure for determining the correct time delay of echoes without any need for actual echo overlap, using a cross-correlation procedure between the buffer rod (BR) and sample (S) signal. We also provide a simple procedure for making corrections for transducer-bond-induced phase shifts.[1] The precision of a measurement made with this system at ambient temperature exceeds one part in 10^7 without the use of mixers, gates, time delays, and other complications normally associated with such measurements.

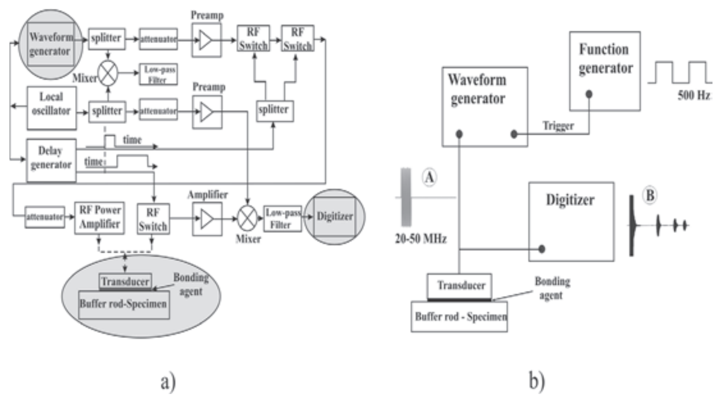


Figure 1. (a) Block diagram of a typical ultrasonic interferometry setup. The blocks marked in gray are the ones we are keeping in the present measurement setup. (b) Block diagram of the present experimental setup.

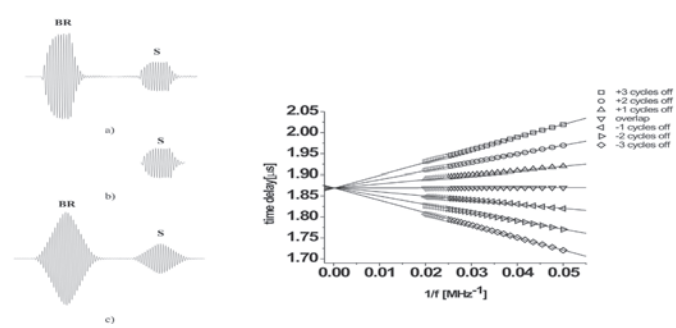


Figure 2. Illustration of the cross-correlation process. (a) BR (buffer rod) and *S* (specimen) signals as collected on the digitizer, (b) the *S* echo signal, and (c) result of cross-correlation procedure. Right side: Measured time delay between the BR and *S* signals vs. the inverse of frequency of the excitation signal.

The present approach has the advantage that it eliminates the need for complicated electronics (see Figure 1) used in ultrasonic interferometry, where two gated sinusoidal pulses need to be generated, spaced in time at different values as a function of the specimen size. The need for only one excitation pulse is a great advantage and can be obtained with a single gating procedure.

Also, we demonstrate that substantial oversampling of the measured signal is not necessary if individual cycles in the BR and *S* signals are fitted to a polynomial function. The use of cross correlation and different overlap peaks determines the correct overlap condition unambiguously. We also show that excitation frequencies higher than the natural transducer resonance should not be used because of additional errors introduced by the presence of an additional frequency component at the natural transducer resonance.

Acknowledgements

This work was performed under the auspices of the National Science Foundation, the State of Florida, and the U.S. Department of Energy.

References

[1] Pantea, C., *et al*., *Rev. Sci. Instrum.*, **76**, 114902 (2005).

T.M. Schaub *et al.* of the NHMFL and Florida State University report an exciting development that opens the powerful technique of Ion Cyclotron Resonance Spectroscopy up to a new class of materials. This technique can accurately determine the chemical basis of a large number of industrially important materials (including but not limited to crude oil). The information derived from these measurements holds the possibility of drastically improving many industrial processes with positive economic—as well as environmental—consequences.

This research was published in Analytical Chemistry, **77**, 1217-1324 (2005).

INSTRUMENTATION AND METHOD FOR ULTRAHIGH RESOLUTION FIELD DESORPTION IONIZATION FOURIER TRANSFORM ION CYCLOTRON RESONANCE MASS SPECTROMETRY OF NON-POLAR SPECIES

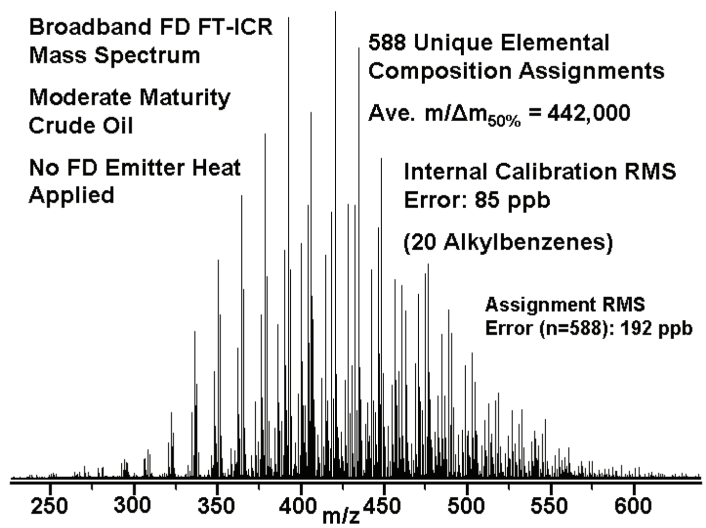
T.M. Schaub (NHMFL Tallahassee); C.L. Hendrickson (NHMFL Tallahassee and FSU, Chemistry & Biochemistry); J.P. Quinn (NHMFL Tallahassee); R.P. Rodgers, A.G. Marshall (NHMFL Tallahassee and FSU, Chemistry & Biochemistry)

Experimental

We have interfaced a commercial field desorption ion source to our 9.4 T FT-ICR mass spectrometer for high resolution, high mass accuracy measurements of non-polar species. The FT-ICR MS instrument includes a liquid injection field desorption ionization source, octopole ion guides, external octopole ion trap capable of an axial potential gradient for ion ejection, capacitively-coupled open cylindrical ion trap, and pulsed gas valve for ion cooling. Model compound responses with regard to various source and instrument conditions provide a basis for interpretation of broadband mass spectra of complex mixtures.

Results and Discussion

As an example, we demonstrate broadband speciation of a Gulf Coast crude oil (see Figure), with respect to numerous heteroatomic classes, compound types (rings plus double bonds), and carbon number distributions.



Acknowledgements

The authors thank Daniel McIntosh for the manufacture of all custom system components, Bernhard Linden for technical assistance with the FD source, Steven Beu for the SIMION modeling, and Kuangnan Qian for helpful discussions regarding petroleum mass spectrometry. This work was supported by ExxonMobil Research and Engineering, NJ, NSF (DMR-00-84173), Florida State University, and the National High Magnetic Field Laboratory in Tallahassee, FL.

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CONDENSED MATTER

Including: KONDO/HEAVY FERMION SYSTEMS, MAGNETISM & MAGNETIC MATERIALS, METAL-INSULATOR TRANSITIONS, MOLECULAR CONDUCTORS, OTHER CONDENSED MATTER, QUANTUM FLUIDS AND SOLIDS, SEMICONDUCTORS & BASIC AND APPLIED SUPERCONDUCTIVITY

KONDO/HEAVY FERMION SYSTEMS

Essential efforts were concentrated on studying magnetic quantum critical points (mQCP) in a few Kondo/Heavy Fermion systems in attempts to establish degree of universality of the phenomenon. Generally, QCP marks a change in the ground state (T=0) driven by an external parameter, such as pressure, alloying, etc. In particular, such change in the ground state at zero temperature is often driven by strong enough magnetic field, e.g., metamagnetic (MM) transitions or suppression the antiferromagnetic (AFM) state by field in the rare- earth (RE) and actinides intermetallics. The basic challenge is whether the 4f- or 5f- electrons on the high field side of a QCP become fully or partially localized.

In the report by C. Capan *et al*., a MM QCP at 28 T in $CeIrIn_5$ shows an upturn in resistivity and non-Fermi liquid behavior; however, the de Haas-van Alphen experiments do not show many changes in the Fermi surfaces' sizes.

For the Kondo material $CeIn_3$, the research of A.V. Silhanek *et al*. indicates against universality of behavior near mQCP.

METAMAGNETISM AND NON-FERMI LIQUID BEHAVIOR IN $CeIrIn_5$

C. Capan, R. Goodrich, J.F. DiTusa (Louisiana State University, Physics); L. Balicas, T. Murphy, E. Palm (NHMFL); R. Movshovich, E.D. Bauer, M.F. Hundley, J.D. Thompson, J.L. Sarrao (LANL)

Introduction

Quantum phase transitions correspond to a continuous ground state transformation at T=0 driven by quantum fluctuations. One of the intensively investigated issues is the possibility of a Fermi Surface volume change at a quantum critical point. In this context, the metamagnetic transition, corresponding to a non-linear increase in magnetization of a paramagnet, have been focus of attention since it might involve such a change, even tough its microscopic mechanism is not fully established. Moreover, strong deviations from Fermi Liquid theory reported in $Sr_3Ru_2O_7$ have raised the possibility of a metamagnetic quantum critical end-point.[1] $CeIrIn_5$, a heavy fermion compound with a recently discovered metamagnetic transition at high fields,[2] offers yet another playground for such investigations. In a preliminary study, we observed a field induced non-Fermi Liquid behavior in both resistivity and specific heat up to 17 T.[3] Here, we report a low temperature study of transverse magnetoresistance and quantum (dHvA) oscillations of cantilever magnetization in a $CeIrIn_5$ single crystal, using the 33 T magnet with the portable dilution refrigerator at NHMFL in Tallahassee.

Results and Discussion

The temperature dependence of the resistivity, shown in Figure 1, is obtained from field sweeps between 20 T-32.75 T. For fields below metamagnetic transition (28 T), resistivity has an upturn for temperatures below 0.3 K. The upturn becomes more pronounced near the transition. The power law fit with an exponent 1.5 (solid

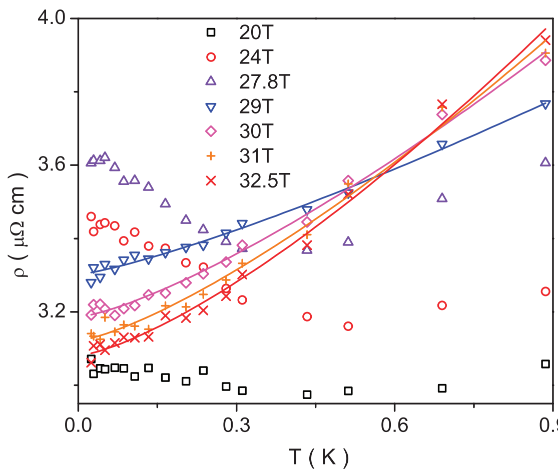

Figure 1. Resistivity vs. temperature in $CeIrIn_5$ for H||[001].

lines in Figure 1) above the transition is indicative of non-Fermi Liquid behavior. Figure 2 shows the FFT spectrum of the dHvA oscillations resolved in cantilever magnetization at 51 mK in the same field range. The frequencies correspond to the quasi-2D "α" and "β" sheets of the Fermi Surface, in good agreement with a previous report.[4] A more detailed analysis revealed that the frequency of the orbits increase slightly across the transition, pointing to a Fermi Surface topology change, not accompanied by an effective mass enhancement.

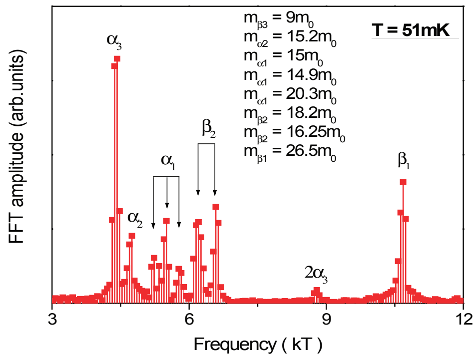

Figure 2. FFT spectrum of the magnetization oscillations.

Taken together with our earlier report of non-Fermi Liquid behavior in the low field phase up to 17 T, this is evidence for a metamagnetic quantum critical point in $CeIrIn_5$. The unusual upturn of resistivity close to the metamagnetic field indicates that disorder effects might be important near this quantum critical point.

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NON-LOCAL QUANTUM CRITICALITY IN HIGH-SYMMETRY SYSTEMS $CeIn_{3-x}Sn_x$

A.V. Silhanek (MST-NHMFL, LANL); T. Ebihara (Shizuoka University, Japan); N. Harrison, M. Jaime (MST-NHMFL, LANL); K. Tezuka (Shizuoka University, Japan); V. Fanelli (MST-NHMFL, LANL); C.D. Batista (T-11, LANL)

When the Neel temperature T_N of an antiferromagnet is tuned to absolute zero at a quantum critical point (QCP), the uncertainty principle leads to a divergence in the characteristic lengthscale of the fluctuations of the staggered-moment order parameter.[1] In itinerant electron antiferromagnets, strong on-site correlations often cause the renormalized Fermi bandwidth T* to become comparable to T_N. A potential locally critical scenario arises in which the extent to which the d- or f-electrons locally contribute charge degrees of freedom to the Fermi liquid becomes subject to fluctuations at the QCP[2,3] and their effective localization is conditional upon the inequality T_N>T* being satisfied necessitating T*→0 at the QCP as depicted in Figure 1(a). Several f-electron antiferromagnets, including $CeCu_{6-x}Au_x$, $YbRh_2Si_{2-x}Ge_x$, and $CeRhIn_5$, appear to provide examples of such behavior as function of pressure p, magnetic field H, or chemical substitution x. No experiment, however, has yet been able to gauge the extent to which local criticality requires the spin fluctuations to be two-dimensional (2D). Were this an absolute requirement, the unambiguously three-dimensional (3D) spin fluctuation spectrum of cubic $CeIn_3$ should then provide the essential f-electron counterexample to local criticality. In such a case, one might expect a quantum critical spin-density wave (SDW) scenario[4] in which T* remains finite at the QCP (see Figure 1(b)).

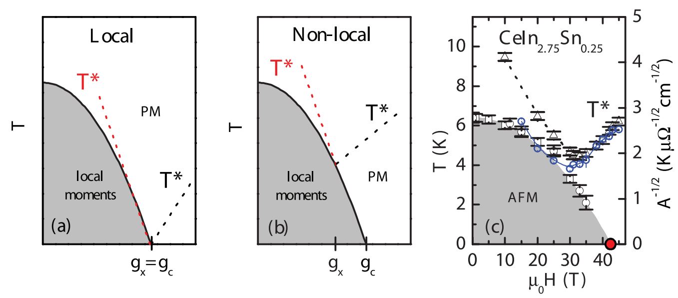

Figure 1. Schematic of antiferromagnetic quantum criticality tuned at g = g_c according to (a) the locally critical scenario and (b) the SDW scenario, where T* represents the Fermi temperature. The parameter g can correspond to p, H or x, depending on the system. (c) T,H phase diagram of $CeIn_{2.75}Sn_{0.25}$ extracted from Cp(T) (○ symbols) and ρ(T) data (□ symbols), with the grey region represents the antiferromagnetic (AFM) phase under the fitted $T_N = T_{N,0}(1 - (H/H_c)^2)$ curve. Δ symbols delineate maxima in ∂ρ/∂T that are approximately representative of the Fermi bandwidth T* in the paramagnetic (PM) region. Blue circles represent $A^{-1/2}$ in the low temperature limit T << T*.

In the present work we utilize the fact that Sn-substitution of only 8 % of the In sites in $CeIn_3$ (yielding $CeIn_{2.75}Sn_{0.25}$) reduces T_N to ~6.4 K so as to enable quantum criticality of the same type II antiferromagnetic phase as in pure $CeIn_3$ to be tuned by a static magnetic field $\mu_0 H_c = 42 \pm 2$ T (see Figure 1(c)). Electrical transport and thermodynamic measurements reveal that m* does not diverge, suggesting that cubic $CeIn_3$ is representative of a critical spin-density wave (SDW) scenario. The existence of a maximum in m* at a lower field $\mu_0 H_x = 30 \pm 1$ T may be interpreted as a field-induced crossover from local moment to SDW behavior as the magnitude of the antiferromagnetic order parameter falls below the Fermi bandwidth.

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MAGNETISM & MAGNETIC MATERIALS

In the report by L. Balicas *et al*. important information is found concerning the nature of the metamagnetic transition in $Sr_4Ru_3O_{10}$. The latter material is a typical ferromagnet when field is applied along the c-axis. For the in-plane field around 30 T a metamagnetic transition takes place with the strong change in magnetization. Study of the Shubnikov de Haas oscillations in the in-plane resistivity (at slightly inclined fields) reveals the appearance of the new frequencies above the transition, meaning considerable changes in the structure of the (almost cylindrical) Fermi surfaces spectrum.

*This research was supported by the **NHMFL In-House Research Program**, which funds approximately six projects per year that meet the criteria of scientific quality on par with other NSF grants and are designed to extend or improve a component of the Magnet Lab user program. It was also supported by the **Visiting Scientist Program**, which provides financial assistance for new users and early career researchers. VSP pays special attention to increasing the diversity of the MagLab user program.*

SHUBNIKOV DE HAAS EFFECT IN HIGH QUALITY SINGLE CRYSTALS OF $SR_4RU_3O_{10}$

L. Balicas, Y.J. Jo (NHMFL); N. Kikugawa (U. St. Andrews, Physics); K. Storr (Prairie View A&M U., Physics); Z.Q. Mao (Tulane U., Physics)

Introduction

$Sr_4Ru_3O_{10}$ is the triple-layered member of the Rudlesden-Poper series with $n = 3$. Although this material has not been as widely studied as the other ruthenates in the series, earlier work by Cao *et al.*[1] revealed that its ground state has intriguing characteristics. When the field is applied along the *c*-axis typical ferromagnetic behavior occurs, while for field applied along the in-plane direction a first-order metamagnetic transition accompanied by critical fluctuations is observed. One possible way to understand its metamagnetic behavior within a mean-field theory is by considering the eventual proximity of its Fermi level to a van Hove singularity.

Experimental

We performed a detailed electrical transport study at low temperatures using the hybrid magnet in high quality single crystals of the tri-layered ferromagnetic metal $Sr_4Ru_3O_{10}$. We observed Shubnikov de Haas oscillations for several frequencies.

Results and Discussion

The most prominent orbits have two-dimensional character and display frequencies $F_\alpha = 9959$ T, $F_\beta = 3949$ T, $F_\gamma = 1877$ T corresponding respectively to 73.5, 29.2 and 13.9% of the area of the orthorhombic first Brillouin zone (FBZ). Several additional orbits, mostly with frequencies below 2 kT have also been identified, whose spectral weight and frequencies are shifted by a metamagnetic transition induced by an in-plane field component.

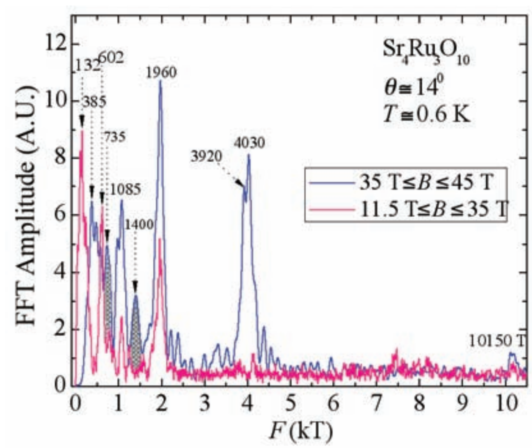

Figure 1. The FFT spectrum of the Shubnikov de Haas signal of a $Sr_4Ru_3O_{10}$ single crystal for two ranges of magnetic field, i.e., above and below a metamagnetic transition. Shaded areas indicate the existence of peaks in the FFT spectrum that are not seen at lower fields.

Conclusions

Our results indicate the reconstruction of the Fermi surface at the metamagnetic transition. The mechanism remains to be determined.

Acknowledgements

LB acknowledges support from the NHMFL In-House Research Program.

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Low temperature ^{133}Cs NMR data are presented by V.F. Mitrovic *et al*. for the Cs_2CuCl_4 single crystal. Cs_2CuCl_4 is a S=1/2 2D frustrated antiferromagnet compound that reveals exotic phases in the presence of magnetic fields. The reported NMR data provide clear evidences for a contra-intuitive behavior with the increase of the applied longitudinal field: namely, it leads to the increased complexity of the local spin textures. That fact demonstrates the important effect of the quantum fluctuations in this spin liquid system.

This research was supported by the ***NHMFL Visiting Scientist Program****, which provides financial assistance for new users and early career researchers. VSP pays special attention to increasing the diversity of the MagLab user program.*

MAGNETIC INDUCED PHASES IN THE FRUSTRATED QUANTUM AF Cs_2CuCl_4

V.F. Mitrovic, M.-A. Vachon (Brown University); R. Coldea (Oxford University); A.P. Reyes, P. Kuhns, T. Murphy, E. Palm (NHMFL)

We report ^{133}Cs NMR data on Cs_2CuCl_4 single crystals. This compound is a 2D S=1/2 frustrated Heisenberg antiferromagnet (AF) on an anisotropic triangular lattice. It is one of only two candidate materials to show strong evidence for 2D spin liquid behavior. Furthermore, a magnetic field stabilizes exotic phases, as shown by neutron measurements.[1] Our NMR measurements at the 60 mK reveal multiple field-induced phase transitions in a magnetic field applied parallel to the Cu chains, *b*-axis. The phases are distinct by their local spin structure. Contrary to common belief, the complexity of the local spin structure increases with applied longitudinal field. Our measurements were performed at the millikelvin facility on the 18 T magnet and with the top-loading $^3He/^4He$ dilution refrigerator.

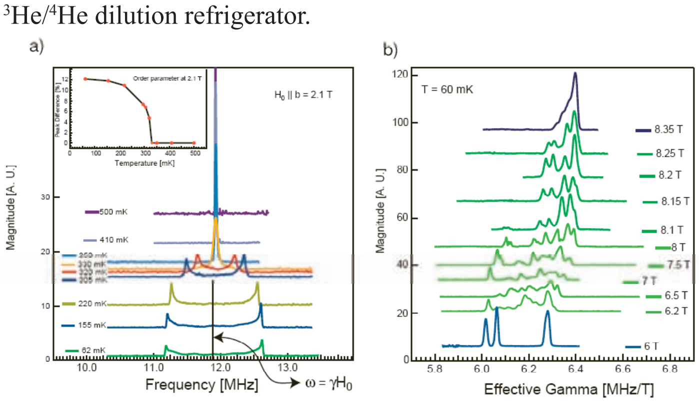

Figure 1. (a) Temperature dependence of $^{133}Cs(B)$ Spectra at H = 2.1 T. Solid line denotes zero shift position. Inset: Temperature dependence of the order parameter, defined as the difference between extrema peaks. (b) Section of the field dependence of the spectra at T = 60 mK showing a field induced phase transition around H = 6.2 T.

Results

In Figure 1(a) we show a temperature dependence of the $^{133}Cs(B)$ NMR spectra at H = 2.1 T. A double peak structure centered on the Larmor frequency is observed below T = 330 mK. This represents the local spin density probability distribution of an incommensurate phase. The order parameter in this state is defined as the difference between two peaks and its temperature dependence is shown. This difference, related to a sub-lattice magnetization M_s, obeys the power law $[(T_N-T)/T_N]^\beta$ with $\beta \approx 0.34$. This value is in agreement with the theoretical value for a 3D XY spin model. In Figure 1(b), we present a section of the spectra between 6 T and 8.35 T at T = 60 mK. The abrupt change around 6.2 T is associated with a field induced quantum phase transition. The spectra converge into one single peak (not shown) above the saturation field. We find that the complexity of the local spin texture increases with applied longitudinal fields, signaling that the quantum fluctuations effect are important in the intermediate field regime.

Acknowledgements

Work is supported in part by the Brown University Solomon Research fund. Work at NHMFL is supported by the NHMFL Visiting Scientist Program through the NSF and the state of Florida.

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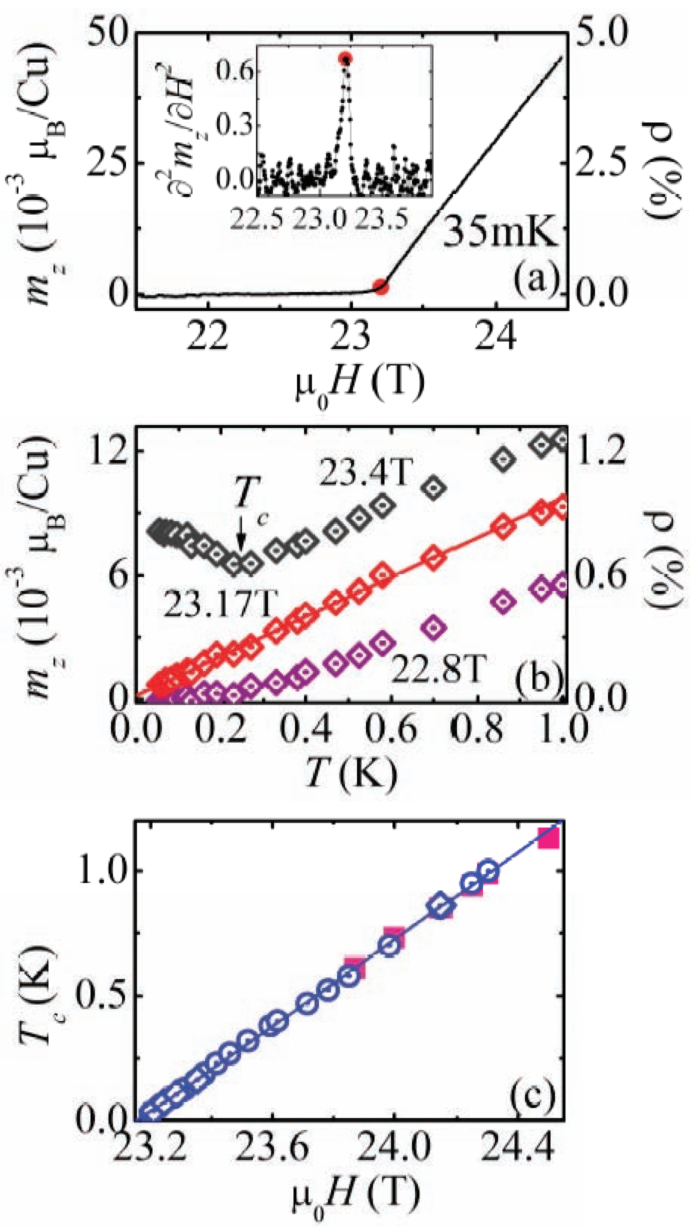
The idea in the report by S.E. Sebastian *et al*. is that by going down to the lowest temperatures possible in the strong enough magnetic field one can realize in Han Purple pigment, $BaCuSi_2O_6$, the crossover from 3D to 2D regime of the enhanced quantum fluctuation near the BEC quantum critical point (QCP).The experimentally found scaling behavior near the QCP agrees with the theoretical predictions for the 2D criticality.

This research has been accepted for publication in Nature.

DIMENSIONAL REDUCTION AT A QUANTUM CRITICAL POINT

S.E. Sebastian (Stanford, Physics); N. Harrison (LANL, NHMFL); C.D. Batista (LANL); L. Balicas (NHMFL, FSU); M. Jaime (LANL, NHMFL); P.A. Sharma (LANL, NHMFL); N. Kawashima (U. Tokyo, Physics), I.R. Fisher (Stanford, Physics)

Low dimensional systems exhibit enhanced quantum fluctuations, and hence offer a rich opportunity to study novel states near a quantum critical point (QCP). The possibility of realizing two-dimensional (2d) quantum criticality embedded within a three-dimensional (3d) manifold has been extensively theoretically explored in the context of systems such as frustrated magnets, layered superconductors, free-standing liquid crystal films, sliding Luttinger liquids, and lipid bi-layers. However, there has as yet not been an experimental realization of 2d quantum criticality in any bulk 3d system. Measurements in the 33 T magnet with dilution fridge temperatures have enabled for the first time, an experimental realization of dimensional reduction in a 3d lattice of s = ½ spins, in which geometrical frustration reduces system dimensionality, resulting in a 2d-QCP. In this sense, the very notion of dimensionality can be said to acquire an "emergent" nature: although the individual particles move on a 3d-lattice, their collective behavior occurs in lower-dimensional space. The system we study is the Mott insulator $BaCuSi_2O_6$, which comprises coupled layers of Cu^{2+} s = ½ pairs (spin dimers).[1] As verified by experimental power scaling measurements, the high-field magnetically ordered state can be interpreted as a Bose-Einstein condensate (BEC) of triplets. We report the experimental observation of a continuous crossover in critical scaling behavior near the QCP from 3d to 2d BEC universality. This provides experimental evidence for inter-layer decoupling at the QCP, leading to purely 2d-quantum fluctuations of the BEC order parameter.



The figure shows the magnetization m_z as a function of field H, the magnetization as a function of temperature T and the phase boundary T_c as a function of H, all determined using magnetic torque. The linear behaviors in all these quantities are the direct consequence of a 2d QCP.

Acknowledgements

This work is supported by the NSF and DOE. We would like to thank Eric Palm and Tim Murphy for high quality user support.

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There is a block of interesting reports [V.S. Zapf *et al*., Magnetostriction in the BEC Compound $NiCl_2$-4SC$(NH_2)_2$; D. Zocco *et al*., Thermodynamic Measurements of $Ni(Cl_{1-x}Br_x)_2$-4SC$(NH_2)_2$'; V.S. Zapf *et al*., Angle-dependent Properties of $NiCl_2$-4SC$(NH_2)_2$; and the representative report presented here] ,where, by making use of different experimental tools, it was shown that Ni S=1 spin degrees of freedom in the organic quantum magnet $NiCl_2$-4SC$(NH_2)_2$ may also exhibit BEC in a range of low temperatures and fields. The BEC QCP was assigned at H_{c1} in the (T,H)-plane for the measured XY antiferromagnetic phase diagram.

BOSE-EINSTEIN CONDENSATION OF MAGNONS IN $NiCl_2$-4SC$(NH_2)_2$

V.S. Zapf, D. Zocco (NHMFL, LANL); C.D. Batista (LANL); M. Jaime, N. Harrison, A. Lacerda (NHMFL, LANL); A. Paduan-Filho (Instituto de Física, Universidade de Sao Paulo, Brazil)

Introduction

We have investigated Bose-Einstein Condensation (BEC) of the Ni spin degrees of freedom in the organic quantum magnet $NiCl_2$-4SC$(NH_2)_2$ (DTN) using thermodynamic measurements to dilution refrigerator temperatures at the NHMFL at Los Alamos. This is one of the first quantum magnets to exhibit BEC, and the first one based on Nickel. XY antiferromagnetic (AFM) order occurs for fields between H_{c1} = 2.1 T and H_{c2} = 12.6 T and below T = 1.2 K. We show that the quantum phase transitions (QPT) into the ordered state at H_{c1} can be understood in terms of Bose-Einstein condensation. For a BEC, critical field-temperature phase diagram is expected to follow a power-law temperature-dependence $H_c - H_{c1} \sim T^{3/2}$.[1] We mapped the phase diagram of this compound and searched for this power-law behavior using specific heat and magnetocaloric effect measurements.

Experimental

The calorimeter consists of a sapphire plate suspected from thin strings, on which the sample, a ruthenium oxide thermometer, and a solid state heater are mounted. The measurements are conducted in a dilution refrigerator in the 20 T magnet at the NHMFL in Los Alamos. Specific heat is measured by a semi-adiabatic heat pulse technique, and the magnetocaloric effect is measured by sweeping the magnetic field up and down while monitoring the temperature. The ruthenium oxide thermometers were calibrated in fields using the compensated region of the 20 T magnet at NHMFL at Los Alamos.

Results and Discussion

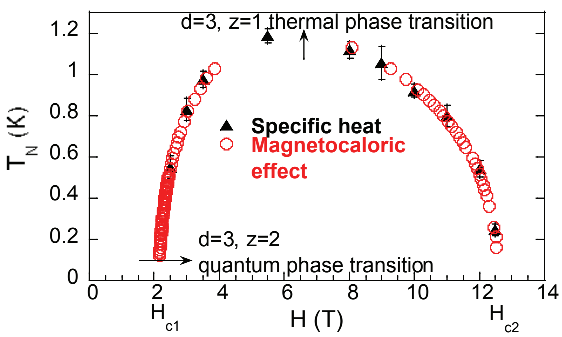

Figure 1. Temperature-field phase diagram of $NiCl_2$-$4SC(NH_2)_2$ for magnetic fields along the c-axis.

The phase diagram determined from specific heat and magnetocaloric effect measurements is shown in Figure 1. More details can be found in Ref. 2. The power-law exponent α where H_c-$H_{c1} \sim T^{\alpha}$ is difficult to extract since it is only valid as $T \mapsto 0$, so any fits over a finite temperature range will distort the behavior. The exponent α was thus determined by fitting the low-temperature data points in Figure 1 between base temperature and various maximum temperatures T_{max}, and extrapolating to $T_{max} = 0$. Our results are consistent with the BEC prediction of $\alpha = 1.5$.

Acknowledgements

This work was supported by the DOE and the NSF through the National High Magnetic Field Laboratory. A.P.F. acknowledges support from CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil).

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QUANTUM FLUIDS & SOLIDS

A remarkable recent development in the theory of quantum computation has been the realization that exotic states of matter, so-called topologically ordered states, which include certain fractional quantum Hall states, may provide a natural medium for storing and manipulating quantum information. In these states, quantum information is stored globally, throughout the entire system, and so is intrinsically protected against decoherence. Quantum computation is then carried out by moving quasiparticle excitations around one another in 2 dimensions, forming “braids” in 3 (=2+1) dimensional space-time. Because these braids are topologically robust (i.e., they cannot be unbraided without cutting one of the strands), the resulting computation is insensitive to error. In this work by L. Hormozi and others at FSU and **Lucent Technologies**, it was shown, *for the first time*, how to compute braids for carrying out quantum computation using quasiparticles conjectured to exist in the recently observed ν=12/5 fractional quantum Hall state.

This research was published in Physical Review Letters, **93**, 140503-1 – 140503-4 (2005).

QUANTUM COMPUTING WITH NONABELIAN QUANTUM HALL STATES

L. Hormozi, G. Zikos, N.E. Bonesteel (FSU, Physics); S.H. Simon (Lucent Technologies)

Introduction

A quantum computer must be capable of manipulating quantum information while simultaneously protecting it from error and loss of quantum coherence due to coupling to the environment. Topological quantum computation (TQC)[1] offers a particularly elegant way to achieve this using quasiparticles that obey nonabelian statistics. Such quasiparticles, which are expected to arise in a variety of two-dimensional quantum many-body systems, have the property that the usual phase factors of +/-1 associated with the exchange of identical bosons or fermions are replaced by noncommuting (nonabelian) matrices that depend only on the topology of the paths (braids) used to effect the exchange. The matrices act on a degenerate Hilbert space whose dimensionality is exponentially large in the number of quasiparticles and whose states have an intrinsic immunity to decoherence because they cannot be distinguished by local measurements, provided the quasiparticles are kept sufficiently far apart.

In TQC this protected Hilbert space is used to store quantum information, and quantum gates are carried out by adiabatically braiding quasiparticles around each other. Because the resulting quantum gates depend purely on the topology of the braids, errors only occur when quasiparticles form "unintentional" braids. This built in protection from error and decoherence is an appealing feature of TQC that may compensate for the extreme technical challenges that will have to be overcome to realize it.

Results and Discussion

Previous work on TQC has taken the form of mathematical "existence proofs" that braiding patterns can, in principle, be found. We have shown[2] for the first time how such braiding patterns can be efficiently found for the case of so-called Fibonacci anyons—a particular kind of nonabelian quasiparticle that is thought to exist in the recently observed $\nu = 12/5$ fractional quantum Hall state.[3] Our controlled-NOT gate is shown in Figure 1.

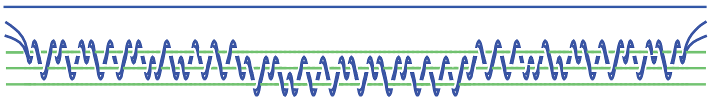

Figure 1. A braid that carries out a controlled-NOT gate between two qubits encoded using triplets of quasiparticles. A NOT operation is performed on the target (green) qubit if, and only if, the control (blue) qubit is in the state |1>.

Conclusions

We have compiled explicit braids for carrying out TQC using a kind of nonabelian quasiparticle that is thought to exist in an experimentally observed fractional quantum Hall state. Our results are the first to give a clear picture of the resources that will be required to carry out this exotic form of quantum computation.

Acknowledgements

This research is supported by U.S. DOE Grant # DE-FG02-97ER45639.

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SEMICONDUCTORS

The three reports published here represent a very substantial group of research activities in the Semiconductor category.

The report by S. Crooker *et al.*, shows spectacular imaging of non-equilibrium electron spin polarization and illustrates spin transport, decay, and polarization by reflection in GaAs.

This research was published in Science, **309**, 2191 (2005).

The next report by Y.D. Jho *et al*. is the first observation of superfluorescence from a semiconductor—a spectacular signature of macroscopic coherence that evolves spontaneously in a population of electron hole pairs in a quantum well in high magnetic field.

This research was supported by the ***NHMFL In-House Research Program****, which funds approximately six projects per year that meet the criteria of scientific quality on par with other NSF grants and are designed to extend or improve a component of the Magnet Lab user program.*

The report by Y. Zhang *et al*. describes transport measurements on a new exciting system, showing spin and valley degeneracies breaking in strong magnetic field.

This research has been accepted for publication by Physical Review of Letters.

IMAGING SPIN TRANSPORT IN LATERAL Fe/GaAs STRUCTURES

S. Crooker, M. Furis (NHMFL-LANL); D. Smith (LANL, Theoretical Division); X. Lou, C. Adelmann, C. Palmstrøm, P. Crowell (University of Minnesota)

Introduction

The ability to control and measure the spin of an electron in semiconductors has recently been proposed as the operating principle for a new generation of spin-electronic, or "spintronic" devices. By taking advantage of the electron's spin degree of freedom, today's charged-based microelectronics may realize significant improvements in operating speed and power consumption. Many designs for functional spintronic devices have been recently proposed; for example, the "spin transistor"—a device whose "on" and "off" states depend on whether the current-carrying electrons are polarized spin-up or spin-down. Proposed schemes for spintronic devices generally require three essential elements: (i) a mechanism for *electrically injecting* spin-polarized electrons into semiconductors, (ii) a practical means for *spin manipulation* and transport, and (iii) an electronic scheme for *detecting* the resulting spin polarization.

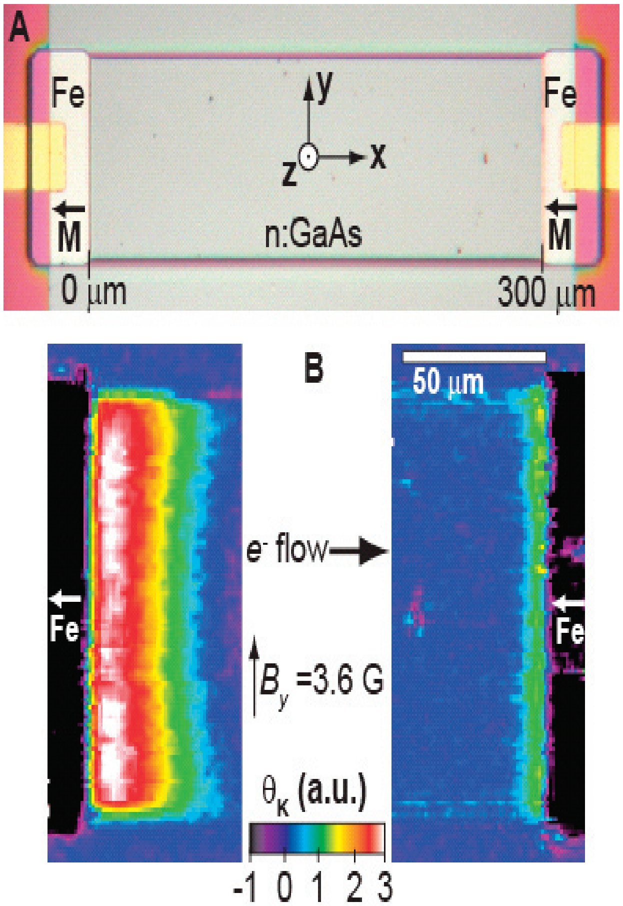

Figure 1. (a) Photograph of a lateral ferromagnet/ semiconductor spin transport device. The Fe/GaAs tunnel-barrier source and drain contacts are magnetized along **–x** as shown. The GaAs channel is 300 µm long. (b) 2-D images of electron spin polarization near the source and drain contacts. Efficient electrical spin injection from the source contact is clearly observed. The spin polarized electrons that accumulate near the drain contact are flowing "upstream" (against the net electron current).

Experimental

We have applied scanning Kerr microscopy to the study of lateral ferromagnet/semiconductor devices that provide an all-electrical means for injection of spin-polarized electrons into semiconductors.[1] These devices, grown and fabricated in the research groups of Profs. Chris Palmstrøm and Paul Crowell at the University of Minnesota, have ferromagnetic iron (Fe) source and drain contacts at opposite ends of a 300 µm long channel of lightly-doped n-type GaAs (see Figure 1a). Each contact is a Schottky tunnel barrier formed by an epitaxial Fe film grown on a thin layer of highly-doped n+:GaAs. This design permits electrons to tunnel directly from the spin-polarized Fermi surface of iron into the n:GaAs channel.

With a small (0.4 V) voltage across the device, Figure 1b shows 2D images of the steady-state electron spin polarization in the GaAs channel. Electrical spin injection from the source (left) contact, and subsequent lateral spin flow in the channel, is clearly observable. The decay length of the injected spin polarization (~50 µm) is much less than the 300 µm channel. Therefore, in this device, injected spins lose their polarization long before they arrive at the drain (right) contact. However, the right-hand side of Figure 2b reveals an appreciable spin polarization in the channel within ~10 µm of the drain. It is possible to demonstrate, through the use of applied stress to the sample substrate, that these "accumulated" electron spins become polarized by *reflection* from the ferromagnetic drain contact, and that they are actually flowing upstream, against the net electron current.[1]

Moreover, these Fe/GaAs tunnel barrier contacts also function as electrical spin detectors (in addition to their role as spin injectors). In this experiment, optically-injected spin polarized electrons are caused to flow through the drain contact, and an in-plane magnetic field (B_y) forces precession of these spins parallel or antiparallel to the magnetization **M** of the drain. The conductance of the device is larger (smaller) when the spin current at the drain is polarized parallel (antiparallel) to **M**, thereby confirming that the electrical conductance is spin-sensitive. All the essential elements of a spin transport device (electrical spin injection, manipulation, and detection) are therefore demonstrated in these structures, an important step towards all-electrical functional spin transport devices.

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ULTRAFAST OPTICS IN HIGH MAGNETIC FIELDS: COOPERATIVE RECOMBINATION OF A QUANTIZED, DENSE ELECTRON-HOLE PLASMA

Y.D. Jho (NHMFL/UF, Physics); X. Wang, D.H. Reitze (UF, Physics); J. Kono (Rice, ECE); C.J. Stanton (UF, Physics); A.A. Belyanin (Texas A&M, Physics); X. Wei (NHMFL)

Introduction

The ultrafast optics facility in Tallahassee uses high magnetic fields and intense ultrashort (<150 fs) laser pulses in combination to investigate electronic excitations in semiconducting quantum-confined systems, with an emphasis on creating and probing quantum coherence in these systems. We have investigated light emission in an $In_{0.2}Ga_{0.8}As/GaAs$ quantum well system in a strong perpendicular magnetic field and observed for the first time the emission of superfluorescence (SF) from a semiconductor. The magnetic field fully quantizes the QW system into an atomic-like system with a series of Landau levels (LLs) and thus strongly increases the density of states (DOS) to accommodate a high-density e-h plasma.[1] The resulting density and energy confinement is sufficient to generate a spontaneous macroscopic polarization that decays through the emission of picosecond superfluorescent pulses.[2]

Experimental

We used a 150 fs, 775 nm, Ti:Sapphire laser system to measure the photoluminescence from the center and edges of the sample as a function of laser fluence F_{laser}, magnetic field B, and excitation spot size and geometry. The 31 T magnet was used in these studies. Emission was collected using optical fibers from the opposite face and cleaved edges of the sample and analyzed with a grating spectrometer equipped with a charge-coupled device detector.

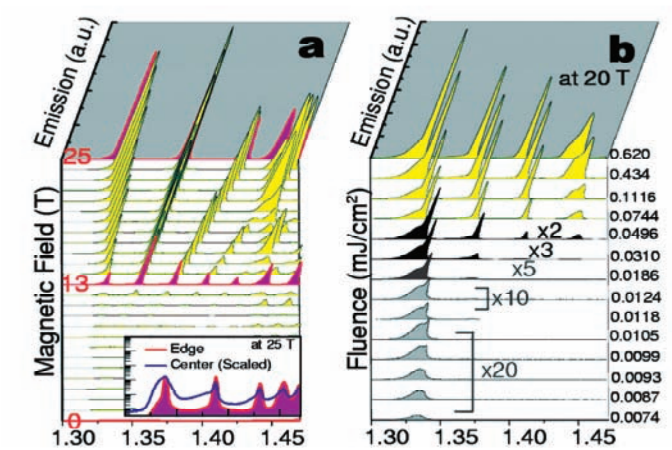

Figure 1. Emission spectra as a function of (a) magnetic field for fixed F_{laser} = 0.62 mJ/cm^2, and (b) F_{laser} for a fixed 20 T field. To compare the edge (red line) to center (blue line) collection in the inset of Fig. 1(a), the center collection data is multiplied by 5000. The threshold field B_{th} for 0-0 LL in the inset of Fig. 1 (b) increases from 12 to 30 T as the temperature rises from 10 K to 110 K.

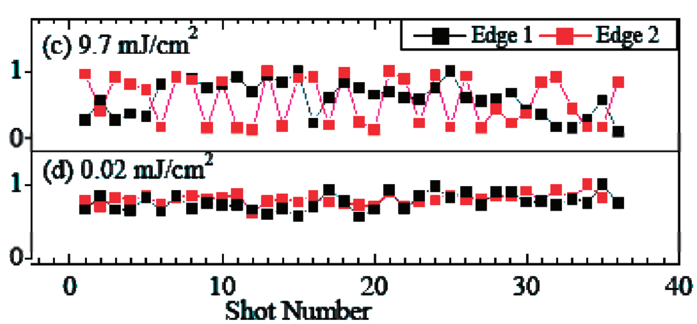

Figure 2. (a) Normalized emission strength for different edges from the 0th LL versus shot number in the SF regime. (b) Normalized emission strength in the ASE regime.

Results and Discussion

Figure 1 displays the spectra collected at the sample edge perpendicular to the excitation direction (a) versus B at a fixed F_{laser}, and (b) versus F_{laser}, at a fixed B (20 T) for a temperature of 10 K. A threshold is observed in both cases; inhomogeneously broadened PL peaks (~9 meV) are seen at each interband Landau level transition until F_{laser} and B exceed a threshold value, whereupon a narrow peak (~ 2 meV) emerges from the high-energy side of the broad feature and dominates at high F_{laser}. This transition, along with the associated increase in linewidth at higher B and F_{laser}, is an indicator of SF emission. Figure 2 displays the directionality of the emission for single pulse excitation, obtained by collection from orthogonal sides of the sample. In the SF regime (upper panel), the maximum observed emission strength fluctuates as much as eight times the minimum value, *far greater* than the pump pulse fluctuation. This strong anticorrelation between signals received by different edges indicates randomly changing emission direction on each shot. This is a hallmark of SF: polarization fluctuations grow from initially incoherent quantum noise in the electronic system and reach a macroscopic level, leading to randomly oriented dipole and subsequently random bursts.

Acknowledgements

This research was sponsored by the NHMFL IHRP and NSF (DMR0325499).

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SPIN AND VALLEY SPLITTING OF TWO-DIMENSIONAL ELECTRONS IN GRAPHENE IN THE HIGH MAGNETIC FIELD LIMIT

Y. Zhang, Z. Jiang, J.P. Small, M.S. Purewal, Y.-W. Tan, M. Fazlollahi, J.D. Chudow (Columbia University); J.A. Jaszczak (MTU); H.L. Stormer, P. Kim (Columbia University)

Introduction

Graphene, a single atomic layer of graphite, is a monolayer of carbon atoms arranged in a hexagonal lattice. Such a two-dimensional (2D) system is drastically different from the well-studied conventional 2D systems in that the conduction and the valence band in graphene touch at two inequivalent points (K and K') at the corners of the Brillouin zone, where the Fermi level resides. Around those two points (termed “Dirac points”), the 2D energy dispersion relation is linear and the electron dynamics is thus “relativistic”, and described by a 2+1-dimensional quantum electrodynamics.[1,2] Such a unique band structure has profound implications for the quantum transport in graphene. Indeed, it was recently discovered that graphene exhibits remarkable phenomena, such as an unusual half-integer quantum Hall effect (QHE) as a consequence of the exceptional topology of its band structure.[3,4] In particular, the half-integer QHE observed in high mobility graphene reveals that there is one Landau level situating exactly at the Dirac point, and all the Landau levels have degeneracy of 4, accounting for spin 1/2 degeneracy and the double valley degeneracy. Further investigations of the QHE states near the Dirac point will significantly advance our knowledge of the dynamics of the Dirac Fermions in graphene.

Experimental

We performed magnetotransport measurements in graphene samples in very strong magnetic field, in 33 T and 45 T (hybrid) systems with the ^{3}He cryogenic setup.

Results and Discussion

The splitting of Landau levels n = 0 and ±1, caused by the lifting of spin and valley degeneracies in strong magnetic fields, is observed at T<5 K. In particular, the quantum Hall states $\nu = \pm 4$ are found to arise from the spin splitting of Landau level n = ±1. The effective Lande g-factor measured at this state is close to 2. The spin origin of $\nu = \pm 4$ is further confirmed in magnetotransport experiments performed in a tilted magnetic field. The correction to the measured g-factor due to Landau level broadening is also observed.

Conclusions

Both spin and valley degeneracies are all lifted in strong magnetic fields. While the spin lifting is understood, the valley degeneracy lifting poses intriguing theoretical questions.

Acknowledgements

This work is supported primarily by the Nanoscale Science and Engineering Initiative of the National Science Foundation under NSF Grant No. CHE-0117752, and by the New York State Office of Science, Technology, and Academic Research (NYSTAR).

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SUPERCONDUCTIVITY - *Applied*

The ITER fusion reactor is now a formal international project. More than 500 tons of Nb_3Sn conductor will be used in the toroidal and central solenoid. Enormous stresses mean that tests of the strain performance of the very high current cables are essential. In the present tests reported by J.V. Minervini *et al*. of MIT, a 36-strand 14,000 amp cable test facility has been built to fit into the 20 T Bitter magnet that will help validate the conductor design for this important magnet system.

CHARACTERIZATION OF Nb_3Sn SUPERCONDUCTING WIRES UNDER STRAIN

J.V. Minervini, M. Takayasu, D. Harris, L. Chiesa
(Massachusetts Institute of Technology, Plasma Science and Fusion Center)

A series of tests of the ITER CS model coils confirmed that design and fabrication methods for a large scale niobium-tin cable-in-conduit conductors (CICC) magnet had been well developed for 13 T field operation with a 40 kA pulsed-current of 1.2 T/s. These tests, however, also indicate the importance of further understanding the strain effects of Nb_3Sn conductor cables, including longitudinal load strain and transverse bending effects on individual strands in the large conductor. Degradations due to transverse strain and bending effects on large Nb_3Sn superconducting cables like ITER conductors have been investigated in various ways; bending tests of strands and external transverse load tests of a sub-sized cable using the 20 T, 195 mm bore high-field large-bore DC magnet. This work will contribute to understanding strand and cable degradation effects that need to be included in design criteria and magnet performance analysis.

Fixed Strain Bending Test: Strand bending critical current tests of Nb_3Sn internal tin and bronze processed wires have been continued using two types of Nb_3Sn wire developed by a previous experimental method. The investigation has been expanded over a wide bending range up to 1.4 %. Nb_3Sn wires were heat-treated in straight form, and then mounted in a groove on a Ti-6Al-4V clamping-fixture at room temperature in order to bend the wire to a predetermined radius. The preliminary results of the critical current vs. bending show noticeable difference between the two wires. In the low bending range up to 0.4% the critical currents of IGC internal tin wire decrease, while those of Furukawa bronze wire increase. Microstructure cracking investigation of these bending strand samples have be carried out at the University of Wisconsin, Applied Superconductivity Center after the critical current test, in order to correlate the critical current results with filament breakage.

Single Strand Variable Bending Test: A variable bending device has been designed and constructed for characterizing the critical currents of Nb_3Sn superconducting strand under pure bending. This device allows applying strand bending during a test operation in liquid helium. The strand is placed on a support beam plate that is bent through an evolution of pure bending states. This device is capable to apply a large range of bending strain up to 0.7%. The principal mechanism is similar to the previous work of Goldacker, *et al.* with high temperature superconductor. The challenge to our device development was to establish a given uniform bending to a strand over a large range of applied strain under an electromagnetic force that was generated by the background field and the transport current of the test sample. Verification tests have been performed in the magnetic field of 12 T at 4.2 K. The measured bending distribution along the loaded beam over the sample of about 100 mm length remained within 20% of the intended bending strain. This work will be continued to characterize new ITER wires presently under development.

Effect of transverse stress on the critical current of a 36-strand Nb_3Sn cable: In this experiment, the transverse pressure is applied mechanically. The goal of the experiment is to investigate a critical current degradation of CICC Nb_3Sn cables due to a transverse load. The test cable is composed of 36 (3x3x4) strands resembling the sub-cable pattern 3x3x4x4x6 of an ITER CS cable. To measure the transverse load applied on the cable in the 10-20 MPa range, a strain gauge array is mounted along the outer surface of a sample holder ring while the cable is placed in a groove on the inner surface. The strain gauges measure the surface expansion strains due to the applied transverse load as well as the hoop force due to the electromagnetic Lorentz force of the cable itself. The transverse load is applied to the cable using a conical wedge that transfers a vertical force to a radial, horizontal force. The conical wedge pushes against the sample holder ring while the conical wedge is sliding vertically, so that the cable is squeezed between the ring and the conical wedge. The vertical force is provided with a linear actuator mounted on the top dewar cover flange. The critical current is measured as a function of magnetic fields between 14 T and 10 T at a fixed transverse load. The load is increased in steps. Preliminary tests have been performed and confirmed the probe functionality. A sub-cable of ITER CS model coil wire will be tested early next year.

Acknowledgements

This work was supported by the U.S. Department of Energy, Office of Fusion Energy Science under Grant Number: DE-FC02-93ER54186.

The great hope for cheap conductors of the high temperature superconductors are the coated conductors made from YBCO deposited with excellent biaxial texture on strong Ni alloy substrates. In this work by C.L.H. Thieme *et al*. of **American Superconductor Corp.**, small coils have allowed critical currents of over 300 A in fields up to 19 teslas, validating the capability of this new conductor type to operate in the very high field regime.

SMALL DOUBLE PANCAKE COILS MADE WITH SECOND GENERATION HTS WIRE TESTED IN HIGH MAGNETIC FIELDS

C.L.H. Thieme, D. Aized, D.T. Verebelyi, J. Voccio (American Superconductor Corp.)

Introduction

For the production of Second Generation (2G) HTS, based on a Coated Conductor approach, American Superconductor (AMSC) uses a low cost combination of deformation-textured NiW substrates (RABiTS™) with an epitaxial oxide buffer layer and a solution-based YBCO layer.[1-3] The high field properties at 4.2 K make the 2G conductor interesting for high field NMR, and for this reason small coils are tested on a regular basis at 4.2 K and fields between 10 T and 25 T.

Experimental

In the past year the processing width of the 2G HTS conductor was extended to 40 mm, an important step in the scaling of its manufacture. At the end of all deposition steps the 40 mm wide foil was slit into multiple 4 mm wide insert conductors that were subsequently laminated to copper 155 on both sides for mechanical and electrical stabilization. A second step was the modification of the YBCO chemistry to reduce the difference of the critical current in perpendicular and parallel magnetic fields with regard to conductor plane. This field dependence of the doped YBCO was explored at 20-25 T using a modified ITER barrel that could accommodate tape-like conductors. Second, coil manufacture was developed for the 4.4 mm wide conductor that included improved insulation and epoxy impregnation methods. Several double pancake configurations were tested that used 10 m long conductor pieces per pancake.

Results and Discussion

The doped YBCO conductor was tested in a parallel field orientation. The performance was virtually unchanged compared with the undoped conductor (450 A/cm-width at 25 T). As the parallel field performance can decrease with an increase in the perpendicular field performance, this was an important confirmation of the high field, 4.2 K performance, and of the capability of the slitting and lamination steps at the end of the 2G HTS manufacture. The ITER barrel configuration was very useful even at these high fields, and with a tape-like geometry.

The double pancakes were tested at fields of 0-19 T, the first time this configuration was explored at 4 K and high fields. The assembly stably carried 300 A in fields of up to 19 T. The assembly quenched at 340 A, independent of field, likely caused by the inner joint where current transfers from one coil to the other. Repeated quenching did not damage the coils. Coils were measured again in zero field at 77 K, and the self field performance was exactly the same as before the 4 K measurements.

Conclusions

Second Generation HTS conductors are made using an important scaling step, processing at a 40 mm width and slitting to final conductor with at the very end. The stabilization, applied through a lamination process, has been very effective for 4.2 K, high B performance. The conductor geometry is sturdy enough to allow coil construction suitable for use at fields up to 19 T, without any further reinforcement. The double pancake coils could be safely quenched without sustaining damage. Dopants used to increase the field performance in the c-axis direction could be included without seriously affecting the parallel performance, as was demonstrated at fields between 20 T and 25 T.

Acknowledgements

The authors wish to acknowledge the financial support from NIBIB, NIH, and from the U.S. Department of Energy.

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Measurements by U.P. Trociewitz *et al.* in the 45 T Hybrid magnet show that Bi-2212 conductors made at **Oxford Superconducting Technology Inc.** show a maximum in the pinning force at 4.2 K only at the maximum DC field of about 45 T. An irreversibility field of about 100 T is inferred from this data. The results of this Magnet Lab-corporate collaboration are excellent news for the technology of magnets beyond Nb because these conductors also have critical current density, suggesting a useful superconducting performance well above 30 T—the next big mark for high field superconducting magnets.

Bi2212 SUPERCONDUCTORS IN HIGH FIELD APPLICATIONS

U.P. Trociewitz (NHMFL); J. Schwartz (NHMFL/FAMU-FSU College of Engineering); K. Marken, H. Miao, M. Meinesz, B. Czabaj (Oxford Superconducting Technology Inc., NJ)

Ag-clad Bi2212 superconductor is a potential candidate for the innermost sections of high-field magnets like the proposed 1.3 GHz (30 T) NMR magnet.[1,2] At 30 T, 4.2 K Bi2212 has very high J_c, which makes it not only the conductor of choice but also the only available conductor for this type of application. In a collaborative effort with Oxford Superconducting Technology (OST), the most recent generation of multifilament round wires is currently being studied in a variety of aspects in an effort to creating a data base to allow for reliable parameterization of new magnet designs. Round wire is isotropic and is not sensitive toward a specific field orientation. It can be manufactured in a variety of diameters, it can be aspected if necessary (with anisotropy) and above all has the obvious advantage being more easily implemented in a standard layer-wound approach.

A series of transport characterizations on short round and aspected samples has been completed providing an overview of $I_c(B)$ properties of Bi2212 round wires up to 45 T, as presented in Figure 1. Several aspects become readily clear from the graphs: Bi2212 round wire offers excellent transport properties over a wide range of applied magnetic fields. At an aspect ratio of 1.5:1, Bi2212 wires show only small anisotropy when rotated in field, particularly in the high-field range, offering improved packing density in a winding pack at small trade-off in transport property. Though there is considerable scatter in I_c in the low field range, $I_c(B)$ curves of samples with various geometries and slight variations in composition as well as heat treatment parameters appear to converge at around 10 T where strongly linked current paths take over, which may alleviate some of the restrictions in processing control. At 25 T J_e of Bi2212 wire at 4.2 K is higher than 350 A/mm^2, which is more than double the J_e reported for the best Nb_3Sn wire in the same field range at 1.8 K (150 A/mm^2, 23.5 T).[3] At 31 T the samples retained *n*-values between 14 and 21. Pinning force maximum is just being reached at about 45 T and a fit through the available data applying the Fietz-Webb law,[4] and acknowledging the uncertainty due to extrapolation in the field range above 45 T, the upper critical field is in the range of around 100 T, as shown in Figure 2.

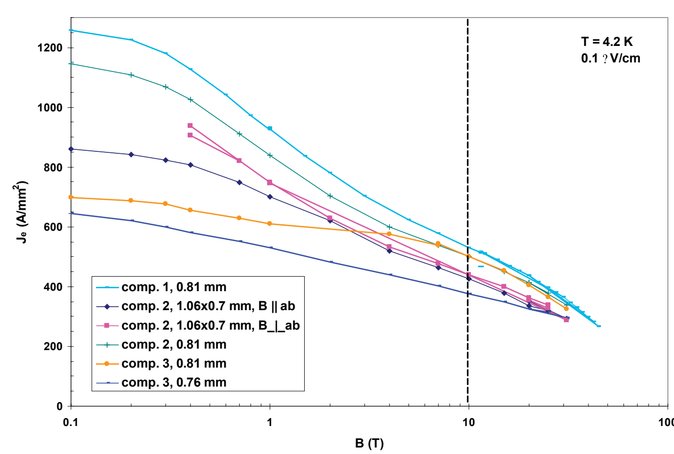

Figure 1. $J_e(B)$ curves for Bi2212 wires.

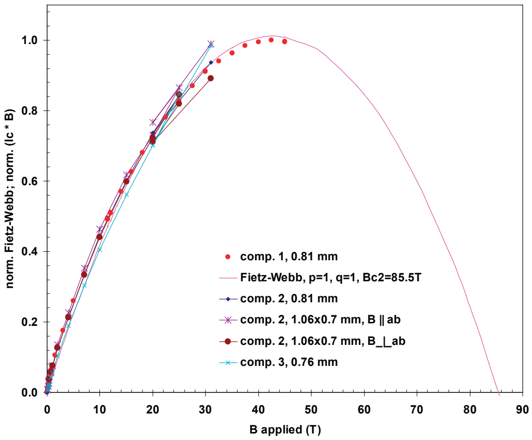

Figure 2. Pinning forces and B_{c2} extrapolation for Bi2212 wires.

A set of test coils with various numbers of turns have been wound to address a variety of processing issues with Bi2212 round wire, like heat-treatment procedures, coil winding approaches, insulation, and conductor homogeneity over longer lengths. Core leakage, which can occur during Bi2212 conductor heat-treatment, is also present in heat-treated Bi2212 wire to some degree. It, however, did appear to neither significantly degrade coil performance nor cause turn-to-turn shorts in coils that were manufactured with glass-fiber sleeve insulated wire. The coils have been successfully tested in a background field of 19 T. To address quench protection requirements of Bi2212 solenoids as part of a high-field magnet system, their quench behavior needs to be studied in detail. Quench experiments on short, 25 cm long, wire samples are currently being carried out in self-field. Quench experiments will be extended on small test-coils soon to study quench behavior of Bi2212 solenoids in a more realistic high field environment.

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SUPERCONDUCTIVITY - *Basic*

In the research of F.F. Balakirev *et al.*, a discontinuity in the doping dependence of the Hall coefficient for $La_{1-x}Sr_xCuO_4$ has been found near the optimal doping (x=.16). Just above approximately the same concentration the temperature dependence of R_H persists down to the lowest temperatures. That contrasts to its saturation for samples with smaller x. The authors consider the two features as a signature of a phase transition near optimal doping.

NORMAL-STATE HALL EFFECT IN HIGH-T_c $La_{2-x}Sr_xCuO_4$ AT LOW TEMPERATURES

F. Balakirev, J.B. Betts, A. Migliori (NHMFL, LANL), G.S. Boebinger (NHMFL/FSU, Physics), I. Tsukada, Y. Ando (CRIEPI, Tokyo, Japan)

We report Hall effect measurements in the normal state of the high-T_c superconductor $La_{2-x}Sr_xCuO_4$ (LSCO). The Hall resistivity was measured by suppressing superconductivity in 65 T magnetic field, thus revealing the normal-state behavior in the low temperature limit down to 0.5 K. The Sr doping x is varied from underdoped (x= 0.08) to overdoped (x=0.22) regimes in a set of 9 thin film samples that were prepared by Pulsed Laser Deposition. The resistivity and Hall voltage were measured simultaneously using digital lockin technique developed at NHMFL.

We find a that R_H (T) saturates in samples with $x \leq 0.16$ in the low temperature limit while in samples with $x \geq 0.17$ the R_H (T) remains temperature dependent down to the lowest temperature measured. Temperature and doping dependence of the Hall number, $1/R_H$, normalized per Cu at high magnetic field in LSCO thin film samples with different levels of Sr doping are plotted on Figure 1a.We find a discontinuity in the doping dependence of the Hall number at around optimal doping level. A similar behavior

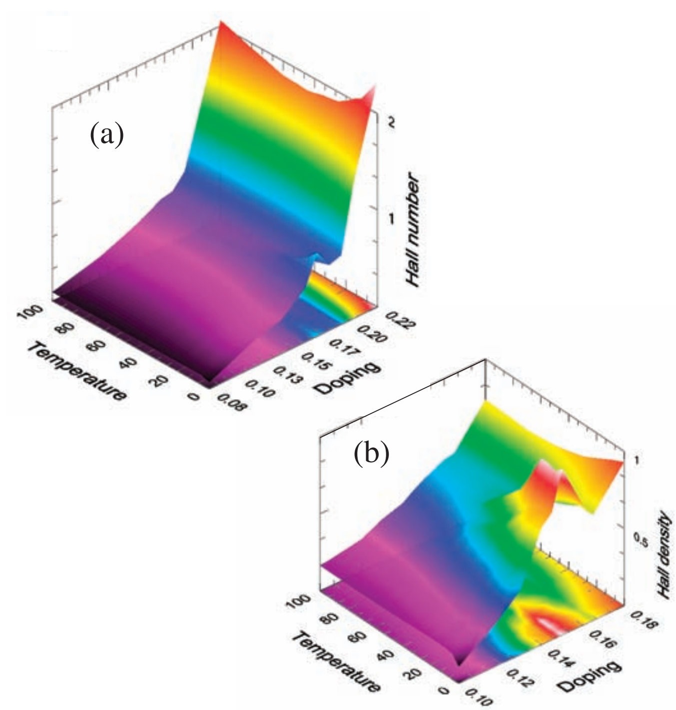

Figure 1. Peaks in the Hall number for two High-Tc compounds **(a)** Temperature and doping dependence of the Hall number at 65 T in $La_{2-x}Sr_xCuO_4$ thin film samples with different levels of Sr doping x. **(b)** Previously published results [1] on the temperature and doping dependence of the Hall number at 65 T in $BiSr_{2-x}La_xCuO_6$ as a function of p, the effective doping.

was observed in another high-T_c compound, $BiSr_{2-x}La_xCuO_6$ [1] (Figure 1b), suggesting a common phenomenon that is generic for high temperature superconductors. This Hall effect anomaly is most commonly associated with a phase transition in the normal state near "optimal doping", the same doping level where superconductivity is most robust.

Acknowledgements

The work at the National High Magnetic Field Laboratory was supported by the National Science Foundation, DOE Office of Science, and the State of Florida.

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In the report by P. Li *et al*., high field measurements of the magnetoresistance, of the critical field, H_{c2}, and of the Hall coefficient in the normal state of the electronically doped $Pr_{2-x}Ce_xCuO_4$ have shown somewhat unusual dependences on the strength of the external field. Although not much information can be extracted directly from the report itself due to its brevity, it is worth emphasizing the importance of obtaining such information for the electronically doped materials to compare with properties of hole-doped cuprates.

RESISTIVITY AND HALL EFFECT MEASUREMENTS IN $Pr_{2-x}Ce_xCuO_{4-y}$ UP TO 60 T

P. Li, R.L. Greene (University of Maryland-College Park, Center for Superconductivity Research and Department of Physics); F. Balakirev (NHMFL-LANL)

We report resistivity and Hall effect measurements in the electron-doped cuprate system $Pr_{2-x}Ce_xCuO_{4-y}$ in pulsed magnetic field up to 60 T. The resistivity and Hall voltage were measured simultaneously using a digital lockin technique developed at the NHMFL. We find negative magnetoresistance (MR) in the underdoped region for all magnetic field values, similar to low field data reported previously.[1] The MR becomes positive at high field in the optimal doped (x=0.15) sample at low temperature. Most surprisingly, we observed a substantial magnetic field dependence of the Hall coefficient at high field (above ~40 T) in optimally doped and overdoped samples (from x=0.15 to 0.19) (Figure 1). A spin density wave induced Fermi surface reconstruction model can be used to explain this phenomenon. We also report for the first time the parallel upper critical field (H//ab plane) for $Pr_{2-x}Ce_xCuO_{4-y}$.

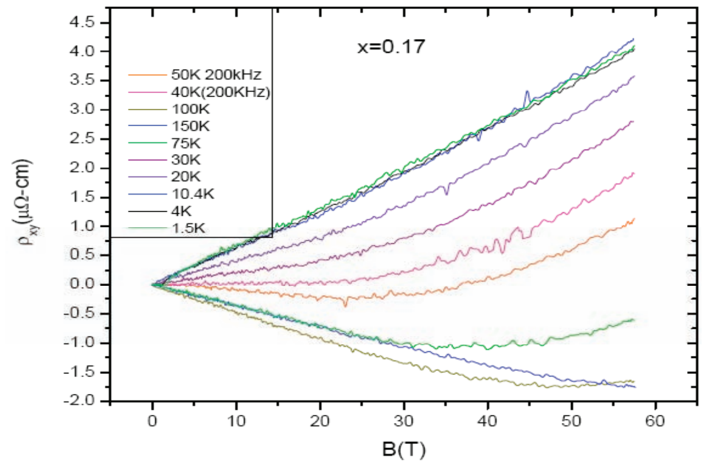

Figure 1. Magnetic field dependence of Hall resistivity in a $Pr_{1.83}Ce_{0.17}CuO_{4-y}$ thin film sample.

Acknowledgements

This work is supported by NSF Grant DMR-0352735. The work at the NHMFL was supported by the National Science Foundation, DOE Office of Science, and the State of Florida.

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IIn the report by J. Singleton *et al*., attenuation of the angle-dependent magnetoresistence oscillations (AMRO) with temperature in quasi-2D organic superconductor *k*-(BEDT-TTT)$_2$Cu(NCS)$_2$ behaves as T^{-5} (i.e., in a phonon like manner), which is in the remarkable contrast with the T- dependence, T^2, for the in-plane resistivity. This seems to indicate breaking of the transverse inter-plane coherence in the material at finite temperatures.

This research was supported by the ***NHMFL Visiting Scientist Program****, which provides financial assistance for new users and early career researchers. VSP pays special attention to increasing the diversity of the MagLab user program.*

THE COHERENCE CONUNDRUM IN BEDT-TTF SUPERCONDUCTORS; THE PROLONGED DEATH OF INTERLAYER TRANSPORT AS TEMPERATURE RISES

J. Singleton (NHMFL-LANL); P.A. Goddard, A. Ardavan (University of Oxford); R.D. McDonald (NHMFL-LANL); S. Tozer (NHMFL-FSU); J. Schlueter (Argonne National Laboratory)

Introduction

Much recent attention has focused on so-called “bad metals”, systems that appear to be Fermi liquids at low temperatures, but whose conductivity falls below the minimum metallic limit as the temperature rises.[1] Examples of this behavior may be found among the cuprates, the ruthenates and organic superconductors.[1,2] A key question in such systems concerns the coherence of the electron orbitals, and whether, as suggested by Anderson and others, it is destroyed by thermal fluctuations as the temperature T rises.[2] Upon such suggestions has a wealth of theoretical supposition been based.

Experimental details and results

To address this question, we have studied magnetic-field-orientation-dependent transport in the crystalline organic superconductor κ-(BEDT-TTF)$_2$Cu(NCS)$_2$ at Ts of up to 45 K.[3] This material was chosen because it possesses a simple low-temperature Fermi surface that has been very well characterized by experiment.[2] Experiments were carried out using two-axis rotator probes from Oxford and LANL in the 33 T Bitter and 45 T hybrid magnets at Tallahassee. We find that the angle-dependent magnetoresistance oscillations (AMROs) (Figure 1) due to orbits on the quasi-one-dimensional and quasi-two-dimensional Fermi-surface sections are suppressed by rising T with a power-law dependence suggestive of phonon scattering (Figure 1). This result is an interesting contrast with the zero-field resistivity, which follows a T^2 dependence that has been attributed to electron-electron scattering. The coherence peak in the resistivity seen in exactly in-plane fields, and other signatures of a three-dimensional Fermi surface, remain to values of T that exceed the proposed Anderson criterion for incoherent interlayer transport by a factor of order 80. This result suggests that some of the work using the Anderson criterion as an underlying justification may be at best questionable. Theoretical studies of this question are in progress.

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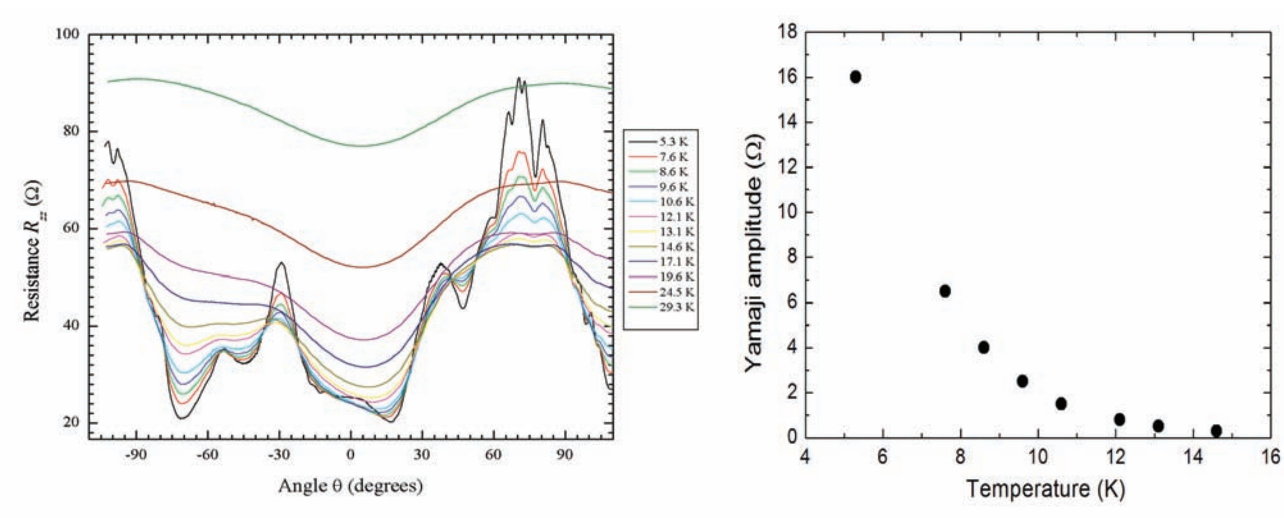
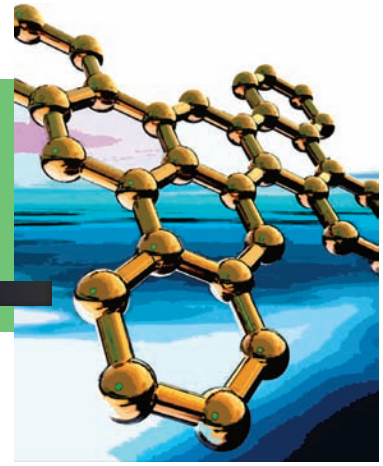


Figure 1. Left; typical AMRO data for a range of temperatures (see inset key); θ is the angle between the field and the normal to the sample quasi-two-dimensional layers. Right: amplitude of a typical AMRO feature (Yamaji oscillation) vs. temperature, showing a T^{-5} dependence suggestive of phonon scattering.

CHAPTER 3
USERS PROGRAMS



The strength and success of NHMFL users programs and facilities are carefully built around the synergies of the highest field magnets, unique instrumentation, and strong supportive services of faculty and staff. The narratives in this chapter describe the measurement capabilities of each facility with special emphasis on magnet systems, instruments, and techniques that were new in 2005. Important developments are illustrated with examples of the science that they made possible. The tables list magnet systems and show the distribution and amounts of user activity. The breadth of research activity by users of the NHMFL can be seen in the tables listing users and projects and in the individual research reports that are available at *http://www.magnet.fsu.edu/publications/2005annualreport/.*

General Purpose DC Field Facilities–Tallahassee

The DC magnetic field facility at the NHMFL's headquarters in Tallahassee provides the user community with the strongest and quietest DC and slowly varying magnetic fields in the world. The magnet systems are coupled with state-of-the-art instrumentation. Expert experimental staff members provide scientific and technical support to researchers using the DC facilities.

The research in the DC general-purpose facility is supported by eight magnet plant and cryogenic system operators. Mechanical and electronic engineers and technicians design, build, and repair instruments for user research, as well as the research of the rest of the NHMFL in Tallahassee. Three technicians and thirteen scientists, whose specialties cover the kinds of measurements needed for most of the science done at the NHMFL, work directly with users. Other members of the laboratory's scientific staff and faculty also support the user program by developing instrumentation and collaborating with visitors.

Further information on the facilities and services available to users of the continuous field, general purpose magnets can be obtained by contacting Bruce Brandt at 850-644-4068 or *brandt@magnet.fsu.edu* or by viewing *http://www.magnet.fsu.edu/users/facilities/dcfield/*.

New Magnets and Upgrades

- Two significantly upgraded magnets were brought on line in 2005. The 50 mm bore magnet in Cell 5 was upgraded to 31 T April 25th, and a 35 T, 32 mm bore magnet was made available to users December 12th. At least one of the two existing 33 T magnets will be replaced with 35 T coils when it wears out. The other will be replaced with either a 35 T magnet or a 31 T, 50 mm bore magnet; the choice will depend on user needs.
- Modulation of the background field for Fermi surface studies has been advanced by the development of a 32 mm bore, water-cooled insert for the 31 T, 50 mm bore magnet. The maximum modulation field is 0.1 T now, but can be increased in the future.
- A magnetic field gradient can be superimposed on the 31 T background field by another 32 mm bore insert. It will be very useful for AC and DC magnetic force and torque measurements. The maximum gradient is now 4.7 T/m, but can be increased in the future.
- A new 17.5 T, 34 mm bore, sweepable, superconducting magnet has been purchased for NMR studies of condensed matter systems. It will be mated with a new Janis Research sorption-pumped ^{3}He refrigerator capable of 24-hour experiments at 350 mK. Probes for this cryostat can be top-loaded. Other cryostats will also be available. New software will allow 24/7 operation of this system starting in the third quarter of 2006.

User-Driven Instrumentation Developments

- **Vesna Mitrovic** and her Magnet Lab collaborators used a standard probe specially modified for high frequencies for ^{133}Cs NMR measurements at dilution refrigerator temperatures in the 18/20 T superconducting magnet. They showed that a magnetic field applied parallel to the copper chains of Cs_2CuCl_4 single crystals induces multiple phase transitions. (See the research highlights in Chapter 2).
- **G. Schmiedeshoff's** design for a dilatometer has been copied in both copper and titanium for use in high magnetic fields (Figure 1). The resolution is 20 pm in zero field and 200 pm at 45 T (due to vibration).

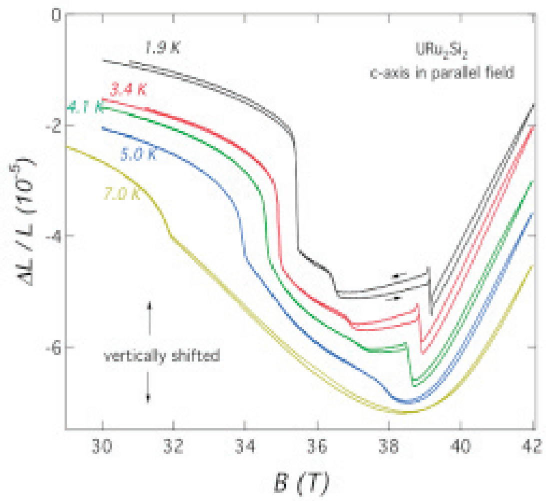


Figure 1. Volume changes in URu_2Si_2 as a function of magnetic field at several temperatures. Dilatometers of copper or titanium are available for measurements at temperatures down to 40 mK and fields up to 45 T. The data show that the volume change associated with the transition to the "hidden" order phase becomes increasingly discontinuous as the magnetic field is raised above 30 T. This confirms recent thermal conductivity and specific heat experiments indicating a strong coupling between the "hidden" order parameter and the lattice. (V.F. Correa, T.P. Murphy, P. Sharma, E.C. Palm, G. Schmiedeshoff, N. Harrison, M. Jaime, J. A. Mydosh, S.W. Tozer)

- **Jurek Krzystek** and colleagues developed a novel method for tunable-frequency high-field (HF) electron spin resonance (ESR). The new method has distinct advantages in investigating high-spin (S ≥ 1) paramagnetic systems, such as transition metal ion complexes and their clusters. This methodology uses backward wave oscillators, which are voltage-controlled, tunable sources that operate in the sub-THz frequency range (150-700 GHz) in conjunction with the 25 T "Keck" magnet. Tunable-frequency HFESR enables one to identify particular transitions in the spectra and derive very accurate spin Hamiltonian parameters from the frequency dependencies of these transitions. The same methodology also works exceedingly well with correlated systems such as ferro- or antiferromagnetically ordered solids. See Figure 2.

- A "noise crash cart" has been equipped and can be deployed with an expert to run it and analyze the noise in a user's measurements.

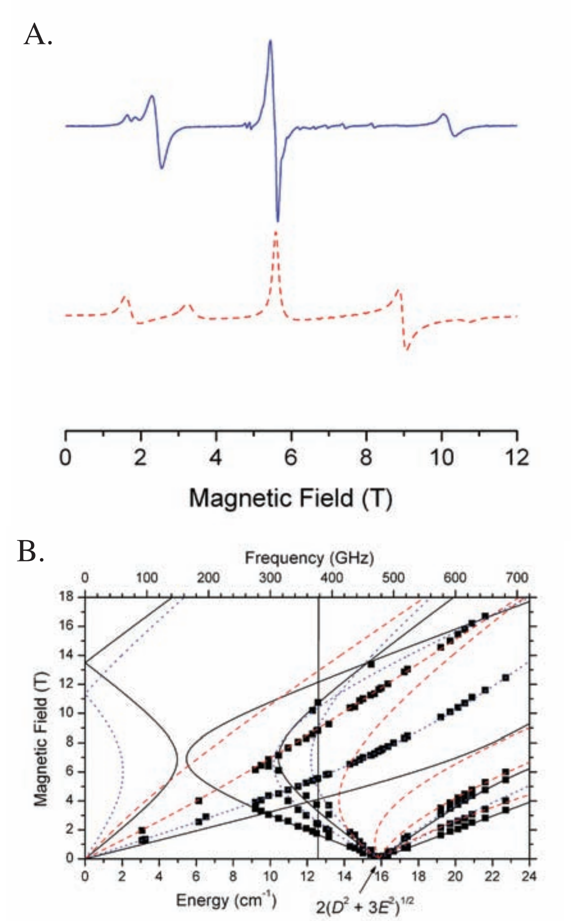


Figure 2. The typical single-frequency (377 GHz) spectrum of the high-spin complex $Tp^{tBu}CoN_3$ (A, top) cannot be adequately interpreted nor simulated (A, bottom). The use of tunable-frequency ESR (B) allows one to identify and simulate all transitions in the experimental spectra, and obtain spin Hamiltonian parameters for this S = 3/2 state: D = +7.457(2), E = +1.575(3) cm^{-1}; g_x = 2.48(2), g_y = 2.02(1), g_z = 2.31(2) [J. Krzystek, *et al.*, *J. Magn. Reson.*, **178**, 174-183 (2006)].

Improvements Scheduled for 2006

DC Magnet Power and Cooling Upgrades

The State of Florida appropriated $10 million for improvements to the Magnet Lab's facilities in Tallahassee and Gainesville. The Tallahassee share, $7.5 million, is being used to renew and upgrade the resistive magnet power supplies and cooling water systems. The improvements are crucial for experiments requiring long times at high field and allow future magnet development.

NHMFL staff members have been working with consultants to plan the upgrades based on experience with the existing equipment and input from users of the DC High Field Facility.

Table 1. Magnet Systems & Techniques for Users of the Continuous Field Facility, Tallahassee, as of January, 2006

FLORIDA-BITTER and HYBRID MAGNETS		
Field (T), Bore (mm)	**Power (MW)**	**Supported Research**
45, 32, 25 ppm/mm homogeneity 33, 32 35, 32 31, 32 to 50[1] 20, 195	29.3 17.2 19.2 18.4 18.8	Magneto-optics – ultra-violet through far infrared, Magnetization, Specific heat, Transport – DC to microwaves, High Pressure, Temperatures from 40 mK to 1500 K, Dependence of optical and transport properties on field, orientation, etc.
25, 52, 1 ppm/mm homogeneity[2]	19	Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.
SUPERCONDUCTING MAGNETS		
Field (T), Bore (mm)	**Temperature**	**Supported Research**
18/20, 52 18/20, 52 17.5, 47[3] 17.5, 34, 50 ppm homogeneity[2,4]	20 mK - 2 K 0.3 K - 300 K 4 K - 300 K 0.3 K - 300 K	Magneto-optics – ultra-violet through far infrared, Magnetization, Specific heat, Transport – DC to microwaves, High pressure, Temperatures from 20 mK to 300 K, Low to medium resolution NMR, Dependence of optical and transport properties on field, orientation, etc.

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 Special system for optical measurements will be available in May, 2006.

4 Available to users 3rd quarter of 2006.

- **Schedule**
  Scope Development: Complete
  Detailed Design / Engineering: Complete
  Purchasing / Construction: March 1, 2005 to April 15, 2006
  Installation: First through third quarters, 2006

Details of the planned improvements are as follows:

- **Power Supply Upgrade**
  - The goal of the funded expansion is 56 MW total or 14 MW per power supply.
  - The first upgrade step, to 48 MW, will be completed by the fall of 2006. Each 12 MW supply will deliver 600 V and 20,000 A to the magnets.

The main components of the upgrade and the performance improvements they will make possible are as follows:

- The City of Tallahassee Electric Department is replacing the existing 13.4 kV feeder cables connecting the substation to the Magnet Lab with a new feeder that will be able to carry the full Magnet Lab load.
- New transformers rated at 16 MW each will replace the existing 8.5 MW transformers.
- New power supply controllers will replace the existing, obsolete controllers.

- **Cooling Capacity Upgrade**
  A 35 m diameter cooling water tank, larger heat exchangers, and additional pumps have been purchased to support 56 MW, 14 hour/day operation of the water-cooled magnets.

New User Cryostats and Probes for Resistive Magnet Users
New cryostats modeled on the very successful new ^{3}He refrigerator and variable temperature inserts purchased from Janis Research for the 18/20 T general purpose superconducting magnet will be mounted on two of the resistive magnets.

Table 2. DC Facility User Statistics for 2005 (1/1/05 – 12/31/05)

User and Project Data	Total	Minority	Female
Number of Research Projects	172	3	8
Number of Senior Investigators, U.S.	170	2	10
Number of Senior Investigators, non-U.S.	80	NA	3
Number of Students, U.S.	82	2	5
Number of Students, non-U.S.	10	NA	1
Number of Postdocs, U.S.	39	0	3
Number of Postdocs, non-U.S.	15	NA	1

Table 3. DC Facility Operations Statistics for 2005 (1/3/05 – 1/2/06)

User Affiliation	Florida-Bitter & Hybrid Number of Magnet Days	Superconducting Number of Magnet Days
NHMFL, UF, FSU, FAMU, LANL	309	324
U.S. University	219	232
U.S. Govt. Lab.	12	25
U.S. Industry	26	0
Non-U.S.	158	89
Test, Calibration, Maintenance	13	43
Idle	28	14
Total	**765**	**727**

The Pulsed Field Facility at Los Alamos National Laboratory

The Pulsed Field Facility (PFF) and the Los Alamos branch of the NHMFL are located in Northern New Mexico at the Los Alamos National Laboratory (LANL). The pulsed field users program is designed to provide researchers with a balance of the highest research magnetic fields and robust scientific diagnostics. The connection with the DC Field Facility is strong and complementary in expertise. Achieving the highest magnetic fields possible is not what the PFF is focused on. Instead, we strive to create the very best research environment possible and to provide users with assistance 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, 1.6 mega-joule capacitor bank system is at the heart of the pulsed field activities at the NHMFL-PFF. Some 4000 shots per year are fired for the users program, which accommodates approximately 120 user groups.

This past year marks an incredible journey for the NHML-PFF as two of our large magnet systems are being completed and prepared to deliver research pulsed magnetic fields to users in 2006. The 60 T Controlled Waveform magnet (60TCW) is now completed and final installation has begun (see Figure 3). This magnet system allows for a customized magnetic field waveform that can be designed to suite the experiment, for example a step-like waveform allows for multiple heat capacity measurements to be performed in a single field pulse.

Concurrent with the rebuild project of the 60TCW, the long awaited 100 T Multi-Shot (100TMS) is being assembled and readied for installation in early spring 2006 (Figure 4). The 100TMS will for the first time ever give users the ability to measure sample to magnetic fields of 100 T with a millisecond duration. The magnet is physically larger than the 60TCW and is designed on a hybrid technology that uses an "outsert" magnet system powered by the 1.4 GW generator system for a relatively long (seconds in duration) 46 T background field and a capacitor driven "insert" magnet delivers a 54 T millisecond duration field pulse. The two fields add and result in a final peak field intensity of 100 T.

Other system advances in 2005 included the Single Turn system; now fully operational. This system provides NHMFL users with an ultra-high field capability, extending to 300 T. The system uses a "fast" capacitor bank that is capable of producing a 4 MA current pulse into a low inductance (7 nH) load. The result is a microsecond duration (actually 6 μsec) magnetic field pulse. The forces are so far beyond the material strengths that the simplistic coil is destroyed with each pulse, however the system has been carefully designed to cause no damage to the sample and the cryostat, allowing for a comprehensive study of the sample. The base temperature of the liquid helium flow cryostat is ~2.3 K, with a sample diameter of ~5.4 mm.

Figure 3. The completed 60TCW being installed in the liquid nitrogen dewar.

Research and Development Highlights for 2005

- **Fermi surface evolution through a martensite transition.** A well established technique at the NHMFL-PFF was recently used to investigate a shape memory alloy AuZn [P.A. Goddard, *et al*., *Phys*. *Rev. Lett*., **94**, 116401 (2005)] to study the electronic structure changes as the material undergoes a martensitic transition at low temperatures (T_m *~65 K*). (See Figure 5.) The deHaas-van Alphen (dHvA) effect was used to measure the changes in the electronic structure as the temperature was adjusted through T_m. This is a unique situation as the dHvA effect is a bulk measurement of the change in magnetic susceptibility whereas typically martensite

Table 4. Magnet Systems & Techniques for Users of the Pulsed Field Laboratory at Los Alamos, as of January, 2006

Capacitor-Bank-Driven Magnets	
Field (T), Duration, Bore (MM)	**Supported Research**
50 T Short Pulse, 25 msec, 24 mm 50 T Mid-Pulse, 400 msec, 15 mm 40 T Mid-Pulse, 400 msec, 24 mm 65 T Short Pulse, 25 msec, 15 mm 60 T Short Pulse, 40 msec, 9.8 mm 300 T Single Turn, 6 µsec, 10 mm	Magneto-optics (IR through UV), magnetization and magneto-transport from 350 mK to 300K. Pressure from 10 kbar typical up to 100 kbar. GHz conductivity, MHz conductivity, Pulse echo ultra-sound spectroscopy. 60 T controlled wave form magnet to return to service the summer of 2006.
Superconducting Magnets	
Field (T), Bore (MM)	**Supported Research**
20 T magnet, 52 mm 17 T magnet, 35 mm 15 T magnet, 52 mm 14 T – PPMS magnet	Same as pulsed fields, plus thermal-expansion, specific heat and 20 mK to 600 K temperatures. Heat capacity, THz resistivity, magnetometry, electron para-magnetic resonance (EPR).

Figure 4. Coil number 7 being installed on the 100 T MS magnet.

transitions are characterized by microstructure (i.e. optical micrographs). The advantage is that the percentage of martensite can be characterized throughout the bulk in contrast to the surface.

- **Linear magnetoresistance in $Ag_{2+\delta}Se$.** The silver chalcogenide $Ag_{2+\delta}Se$ has the rather interesting liner magnetoresistance effect that makes it a potential field sensor for device applications. The theoretical understanding of the linear magnetoresistance has recently been revisited and is applied to measurements in a *Physical Review Letter* by users, **Hu, Rosenbaum, and Betts [J. Hu**, *et al*., *Phys*. *Rev. Lett*., **95**, 186603 (2005)]. Figure 6 shows the magnetoresistance to fields extending to 60 T at various temperatures.

- **Carbon nanotubes in high magnetic field**. Carbon nanotubes (CNTs) are potentially the perfect one dimensional conductors: their magnetic field properties are intriguing and provide a useful physical insight into systems with restricted dimensionality. Despite the intrigue, it is difficult to handle CNTs the way that ordinary condensed matter samples are handled due to their nano-scopic dimensions. **Users from Rice University in the research group of Jun Kono** and extensive collaborators from around the globe used magneto-absorption spectroscopy in the highest millisecond duration pulsed magnetic fields (to 75 T) to study the diamagnetic alignment and chirality dependent photo-absorption of aqueous suspended CNTs [S. Zaric, *et al*., *Phys*. *Rev*. *Lett*., **96**, 016406 (2006)] (See Figure 7.).

- **Quantum Criticality of 5*f* electrons**. NHMFL-PFF postdoc **Silhanek** and co-authors revisit quantum criticality (QC) in $URu_{1.92}Rh_{0.82}Si_2$ and $CeRu_2Si_2$ [A.V. Silhanek, *et al*., *Phys*. *Rev*. *Lett*., **95**, 026403 (2005)]. Using specific heat measurements taken at the NHMFL-TLH and resistivity data from the PFF a common model which involves a strongly renormalized hybridized-band model uniformly applies to these QC compounds. Figure 8 shows data from the compounds plotted on a common phase plot.

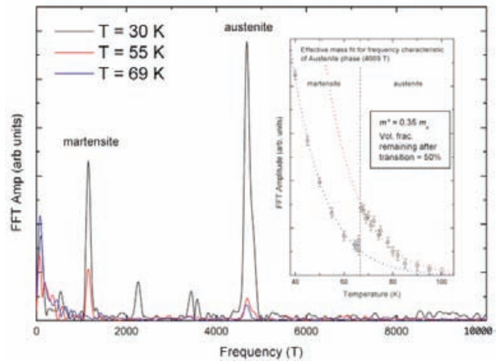


Figure 5. The deHaas-van Alphen effect in AuZn at various temperatures. The evolution of the electronic structure can be measured through the martensite transition.

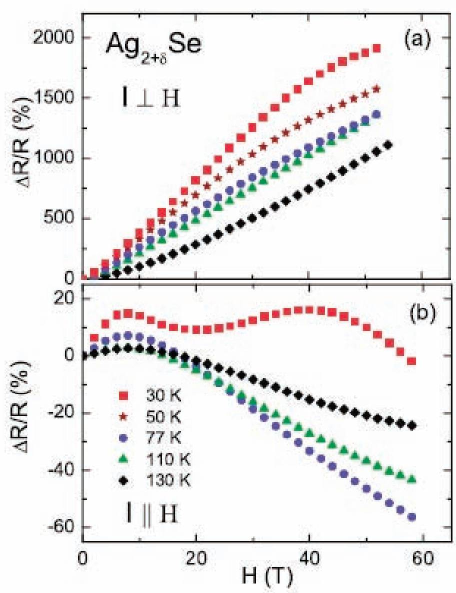


Figure 6. The magnetoresistance in $Ag_{2+\delta}Se$ is linear to magnetic fields extending to 60 T with the current perpendicular to the applied field.

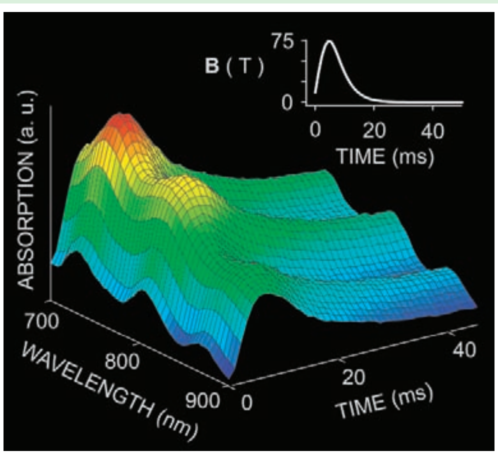


Figure 7. Magneto-absorption spectroscopy of carbon nanotubes in an aqueous solution. Data were taken up to 75 T at the NHMFL-PFF.

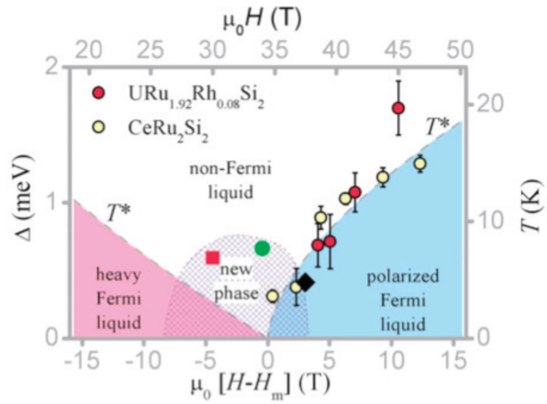


Figure 8. Fitted values of the hybridized bandwidth for both $URu_{1.92}$ $Rh_{0.82}$ Si_2 and $CeRu_2Si_2$, plotted vs. H-H_m (and also H in the former case). The dashed gray lines denote the regions of Fermi liquid and non-Fermi liquid recently identified from a crossover T^* in the electrical resistivity. The vertical axes Δ and T are scaled only by the Boltzmann constant k_B, revealing that $k_BT \sim \Delta$.

User Statistics for 2005

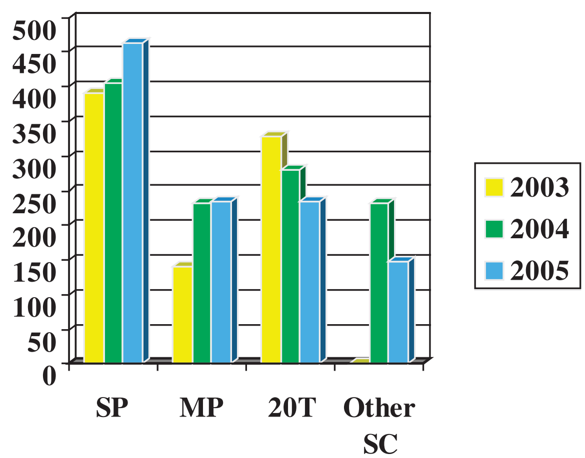


Figure 9. The number magnet days for Short Pulse (SP), Mid Pulse (MP), 20 T superconducting (20T) and other superconducting magnet systems at the NHMFL-PFF.

The statistics in Tables 5 and 6 show a steady rise in pulsed field users while the superconducting magnet use at the PFF has had a slight downturn. The total number of "Magnet Days" for 2005 is 1080, which is similar to the total for 2004.

Table 5. Pulsed Field Facility User Statistics for 2005 (1/1/05 – 12/31/2005)

User and Project Data	Total	Minority	Women
Number of Projects	113		
Number of Research Groups	55		
Number of Users	116	8	24
Number of Senior Investigators, U.S.	39	0	4
Number of Senior Investigators, non-U.S.	15	2	4
Number of Postdocs, U.S.	33	2	6
Number of Postdocs, non-U.S.	6	0	4
Number of Students, U.S.	14	2	4
Number of Students, non-U.S.	1	0	0

Table 6. Pulsed Field Facility Operations Statistics for 2005 (1/1/05 – 12/31/2005)

User Affiliation	Short Pulse Number of Magnet Days	Mid-Pulse	Superconducting
NHMFL	225	125	140
U.S. Universities	165	65	153
U.S. Government Labs	18	10	55
Industry	10	0	0
Non-U.S.	57	22	35
Total	**475**	**222**	**383**

High B/T Facility—Gainesville

The NHMFL High B/T Facility in Gainesville is operated as part of the Microkelvin Laboratory, which is located in the Physics Department at the University of Florida. The facility is designed to meet the needs of NHMFL users who wish to conduct experiments in high magnetic fields (up to 15 T) and at very low temperatures (down to 0.4 mK) simultaneously. Faculty members in the facility work with users in the design of experiments where needed. Instrumentation is available for studies of magnetization, thermodynamic quantities, transport properties, magnetic resonance, viscosity, diffusion, ultrasound propagation, superfluid density, capacitance, and pressure. The facility is housed in an ultra-quiet environment with electromagnetic shielding and vibration isolation of the experimental station to permit high sensitivity measurements.

Access to the facility is through submission of a proposal, which is evaluated by the High B/T Facility staff. The use of the High B/T Facility is restricted to experiments that need the special low temperature and high field configurations. Many of the experiments require special assemblies and direct interaction with personnel on site, as well as having need for long running times. Prospective users should contact the facility manager and resident research scientist, Dr. J.S. Xia (352-392-8871, *jsxia@phys.ufl.edu*) and Prof. Yasu Takano (*takano@phys.ufl.edu*) or Prof. Neil S. Sullivan (*sullivan@phys.ufl.edu*) in advance.

Status of the Magnet Upgrade

With funding from the State of Florida, a new superconducting magnet system is being purchased to bring the maximum field from the present 15.2 T to at least 20 T. The system (see Figure 10) will comprise a 20+ T high field magnet for a sample, as well as an 8 T demagnetization magnet for the nuclear-magnetic cooling stage and a 5 T active-shielded, moderate-field magnet. The new magnet system is expected to be delivered by early 2007. Our long term goal is to achieve a 25 T capability that will include a 20+ T conventional superconducting magnet with a 25 mm ID experimental volume, and a high-Tc insert capable of bringing the full field above 25 T with a 12.5 mm experimental access.

Instrumentation Updates

- Because of their weak coupling to the lattice, two-dimensional electrons embedded in a semiconductor heterostructure are notoriously difficult to cool to millikelvin temperatures. A recent experiment by **Daniel Tsui's group from Princeton** (Figure 11), in collaboration with the scientists at the High B/T Facility, demonstrates that they can now be cooled to a temperature of at least 13 mK. In this experiment, the slope of the Hall resistance R_{xy} was measured in the transition region between two adjacent plateaus of inter quantum Hall effect in $Al_xGa_{1-x}As$-$Al_{0.33}Ga_{0.67}As$ heterostructures of various aluminum concentration x. Each sample exhibited a power-law dependence on temperature, indicative of a quantum critical point of the metal-insulator transition, until the sharpness dR_{xy}/dB was limited by the sample inhomogeneity. In the high- mobility x=0.85% sample ($\mu = 3.7\times10^6$ cm^2/Vs), the power-law behavior persisted down to 13 mK, indicating that the two-dimensional electrons have cooled at least to this temperature—a very conservative estimate.

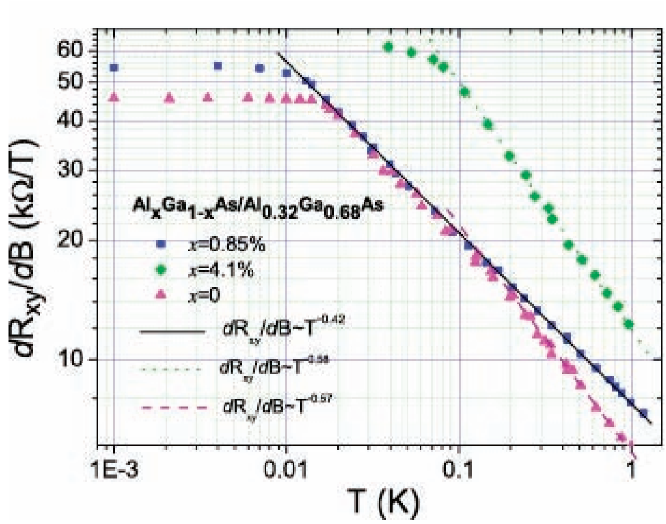


Figure 11. Sharpness of the transition between the ν = 3 and ν = 4 integer plateaus of the quantum Hall resistance of $Al_xGa_{1-x}As$-$Al_{0.33}Ga_{0.67}As$ heterostructures. Note the persistence of a quantum-critical behavior to 13 mK in the x = 0.85% sample. Inhomogeneities limiting the transition's sharpness are responsible for the deviation from the power-law dependence on temperature with a critical exponent of -0.42.

- Ultra-low temperature sample holder for difficult-to-cool samples (Figure 12). Each electrical lead for transport measurements is individually cooled through a sintered-silver heat exchanger. The entire assembly, including the sample and heat exchangers, is immersed in liquid ^{3}He, which is cooled by the copper nuclear-demagnetization stage via a separate sintered-silver heat exchanger (not shown). The built-in sample rotator, actuated by a "hydraulic" system employing liquid ^{3}He, can orient the sample by an angle up to 90° relative to the magnetic field.

- In addition, two new measurement capabilities were added this year, in collaboration with two groups of users: **Moses Chan's group from Penn State and Steve Julien's group from Toronto.** These are a high-precision torsion-pendulum technique and an ac magnetic susceptometer. Employing a beryllium-copper torsion rod to provide a mechanical Q value of 2 million, the pendulum has a state-of-the-art sensitivity of 1 part per 10^{11} to detect the superfluid component of a superfluid or a supersolid. The susceptometer uses a low-temperature transformer to achieve impedance matching to enhance the signal-to-noise ratio.

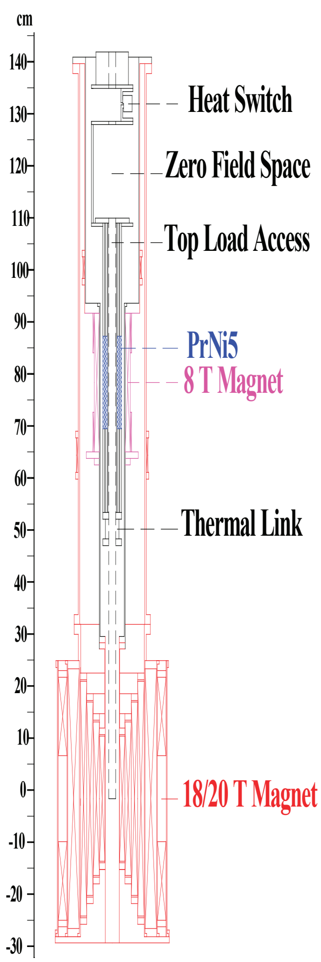


Figure 10. New superconducting magnet system for the High-B/T Facility, expected to be installed in 2007. The active-shielded 5 T magnet (not shown) will be located in the zero field space.

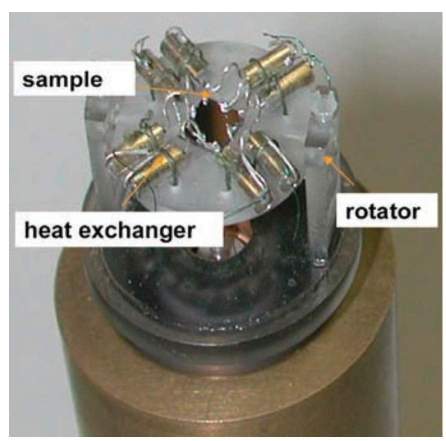


Figure 12.

Table 7. Magnet Systems & Instrumentation for Users of the High B/T Facility at UF, as of January, 2006

Equipment	Features	Supported Research
15.2 T SC magnet, 25 mm diameter experimental volume	Temperatures down to 0.4 mK	Instrumentation available for diameter experimental volume studies of magnetization, thermodynamic quantities, transport measurements, NMR, viscosity, diffusion, ultrasound, torsion pendulum measurements, capacitance and pressure
20+ T SC magnet, 25 mm diameter experimential volume	Additional high Tc insert capable of bringing full field above 25 T with a 12.5 mm diameter experimental space	*Under development*
Miniature sample rotator in liquid ^{3}He	Below 5.0 mK, 1-100 degrees	QHE, FQHE, and metal-insulator transition
Sub-femto ampere current source	Ultra high accuracy, low noise	High resistance, low density samples
AC magnetic susceptometer	Below 1.0 mK	Magnetic materials and superconductors

Table 8. High B/T Facility User Statistics for 2005 (1/1/05 – 12/31/05)

	Total	Minority	Female
Number of Research Projects	2		
Number of Senior Investigators, U.S.	8		
Number of Senior Investigators, non-U.S.			
Number of Students, U.S.	4		
Number of Students, non-U.S.			
Number of Post docs, U.S.	2	1	
Number of Post docs, non-U.S.			

Table 9. High B/T Facility Operations Statistics for 2005 (1/1/05 – 12/31/05)

User Affiliations	Number of Magnet Days	Percent of total
NHMFL, UF, FSU, FAMU, LANL	161	44%
U.S. University	171	47%
U.S. Govt. Lab.		
Industry		
Overseas		
Experiment setup, Maintenance	33	9%
Idle		
Total	**365**	**100%**

Center for Interdisciplinary Magnetic Resonance (CIMAR)

The NHMFL's Center for Interdisciplinary Magnetic Resonance supports a broad range of research in the biological, chemical, and physical sciences, as well as cross-disciplinary programs in areas like environmental science. The techniques available to users include nuclear magnetic resonance (NMR), magnetic resonance imaging and spectroscopy (MRI/S), electron magnetic resonance (EMR), and Fourier transform ion cyclotron resonance mass spectrometry (ICR). Cross-fertilization among the four fields is a unique feature of the Center that is facilitated by broadly based external and internal users programs.

Table 10. CIMAR Facilities in Tallahassee, as of January, 2006

MAGNETIC RESONANCE SYSTEMS in Tallahassee

NMR Frequency	Field (T), Bore (mm)	Homogeneity	Measurements
1.7 GHz	40, 32	10 ppm	Solid state NMR
1.5 GHz+	36, 40	0.1 ppm	Solid state/solution NMR
1066 MHz	25, 52	1 ppm	Solid state/solution NMR
900 MHz	21.1, 105	1 ppb	Solid state/solution 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 state NMR
500 MHz	11.75, 52	1 ppb	Solution state NMR
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
EMR Frequency	**Field (T), Bore (mm)**	**Homogeneity**	**Measurements**
Up to 7 THz	30, 32	100 ppm	ECR*
700 GHz	25, 52	10 ppm	Multi-frequency EMR
470 GHz	17, 61	3 ppm	Multi-frequency EMR
336 GHz	12.5, 88	3 ppm	Transient EMR
95 GHz	≤6 T	1 ppm	W-band Pulsed EPR
9 GHz		1 ppm	X-Band EPR
ICR	**Field (T), Bore (mm)**	**Homogeneity**	**Measurements**
	14.5, 103+	1 ppm	ESI FT-ICR
	9.4, 220	1 ppm	ESI FT-ICR
	9.4, 155+	1 ppm	FD, APPI, FT-ICR
	7, 155+	1 ppm	EI, CI, FT-ICR
	7, 150	1 ppm	ESI FT-ICR

+ Under development * ECR: Electron Cyclotron Resonance

Table 11. CIMAR Facilities at the University of Florida, as of January, 2006

MAGNETIC RESONANCE SYSTEMS in Gainesville

Frequency	Field (T), Bore (mm)	Homogeneity	Measurements
750 MHz	17.6, 89	1 ppb	Solution/solid state NMR and MRI
600 MHz	14, 52	1 ppb	Solution state NMR and MRI
500 MHz	11.7, 52	1 ppb	Solution/solid state NMR
470 MHz	11.1, 400	0.1 ppm	MRI and NMR of animals
200 MHz	4.7, 330	0.1 ppm	MRI and NMR of animals
130 MHz	3, 600	0.1 ppm	MRI of human heads and large animals

NMR Spectroscopy and Imaging Program

This program is a joint effort between the NHMFL in Tallahassee and Gainesville through collaboration with the Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) program in the McKnight Brain Institute at the University of Florida. The NHMFL NMR program has a mission to develop technology, methodology, and applications at the highest magnetic fields through both in-house and external user activities. This is a very broad mission in solution and solid-state NMR spectroscopy as well as imaging and diffusion measurements. Both locations have experienced research faculty, engineers, and technicians spanning these disciplines who are available to facilitate user activities on a wide range of unique instrumentation and to develop novel experiments and new instrumentation.

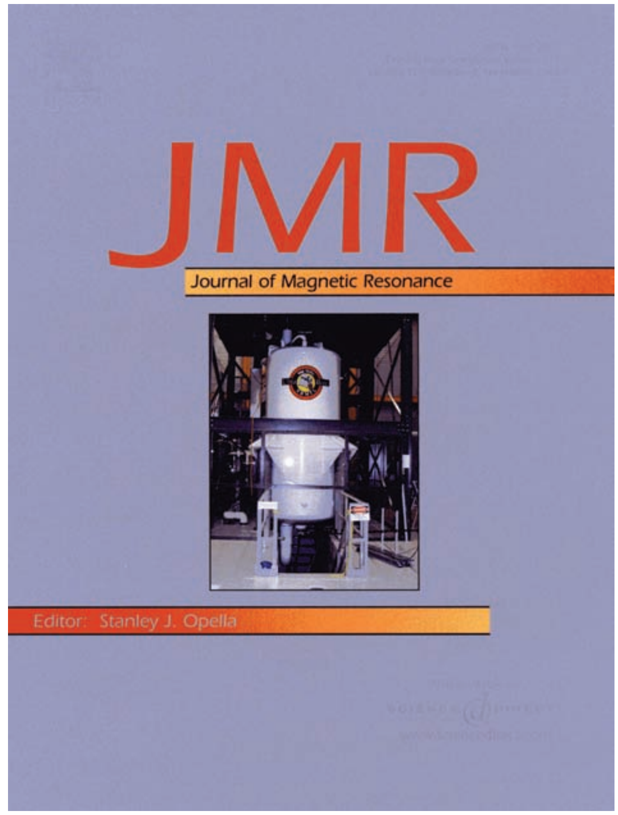


Figure 13. Cover of the October 2005 issue of the *Journal of Magnetic Resonance* featuring the NHMFL's ultra-wide bore 900 MHz system for imaging and spectroscopy.

Tallahassee Update

- **Faculty Recruitment.** We are pleased to announce that Prof. **Samuel Grant has agreed to join the FSU-FAMU College of Engineering** as an NHMFL affiliated faculty member in chemical and biomedical engineering as of January 1, 2006. Dr. Grant, who was a postdoctoral associate with Stephen Blackband at the University of Florida, is an expert in magnetic resonance (MR) microscopy. His Ph.D. thesis work with Richard Magin involved applying microcoil solenoids to the MR microscopy of single cells. His research interests have grown to include the effects of diffusion and compartmentalization in neuronal tissue, and MR contrast mechanisms at high field. At UF, Dr. Grant made extensive use of the 750 MHz widebore NMR system. At the College of Engineering, his research will involve animal and tissue studies on the NHMFL's new 900 MHz Ultra-Wide Bore NMR User Facility. His initial studies on rodent brain tissue have already indicated that there is excellent and interesting susceptibility contrast in gradient echo images at 21.1 T.

- **NMR Spectroscopy and Imaging Program Spectrometer Systems in Tallahassee.** On July 28, 2005, the NHMFL celebrated the completion of the 900 MHz Ultra-Wide Bore NMR Spectrometer Commissioning Phase. High resolution solution, magic angle spinning, and aligned sample NMR have all been demonstrated in addition to magnetic resonance imaging. The capabilities were described in a cover story in the *Journal of Magnetic Resonance*. While the activities of this unique magnet are focused on wide bore spectroscopy and imaging research considerable high resolution NMR spectroscopy has also been performed.

- To help keep the most appropriate spectroscopy on the 900 MHz instrument, the NHMFL has two wide bore 600 MHz spectrometers and a narrow bore 830 MHz instrument that provide a broad range of solid state NMR and imaging capabilities. For solution NMR, a small fraction of the new Bruker 800 MHz system with a cryoprobe purchased for Prof. Rafael Bruschweiler is available to the user community as well as 720, 600, and 500 MHz instruments. The latter also has a Cryoprobe. It is the highest priority of the NMR spectroscopy and imaging program in Tallahassee to gain an appropriate maintenance budget to keep our instrumentation at state of the art and to enhance our solution NMR capabilities as we prepare for the next generation of NMR instruments at the NHMFL.

- The NMR Program has spear-headed the science justification for the NHMFL's first Series Connected Hybrid magnet with enhanced temporal stability and spatial homogeneity while achieving a field strength of 36 T. The magnet is envisioned to be largely used for solid-state NMR and EMR spectroscopy. In addition, the NMR program is now leading the proposal effort to gain funding for the development of a 30 T high resolution magnet that will utilize both low and high temperature superconductors. This magnet will be primarily dedicated to high resolution solution NMR spectroscopy.

NMR Science Highlights for 2005

- While biologists have paid much attention to how biological macromolecules are structured, their attention is now turning to the motions that these molecules undergo in their native environment. Indeed, the motions are critical for achieving the biological function of these molecules. **Prof. Dorothee Kern at Brandeis University** has been correlating molecular motions of biological catalysts with their biological function [*Nature*, **438**, 117 (2005)]. By studying the motion for the enzyme with and without its substrate bound the authors have demonstrated that the molecular motions necessary for the functional activity are present in the catalyst even without the substrate being present (Figure 14). This suggests that the protein is designed not only for its structure, but also for its molecular motions. How proteins are designed for specific motions is not known, but as a result of Dr. Kern's research it is a question that the protein community is beginning to think about.

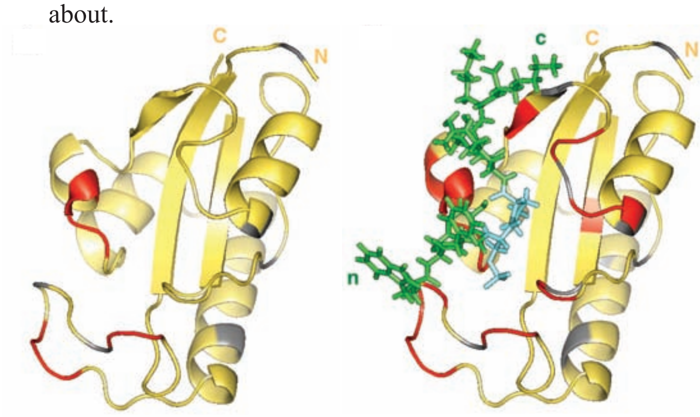


Figure 14. Backbone ^{15}N probes exhibiting conformational exchange in the free enzyme (left) and in the saturated, turning-over complex (right) are highlighted in red. Similar conformational exchange suggests pre-existing functional motions in the free enzyme.

- Many biological macromolecules function when small molecules known as substrates diffuse into the vicinity of a macromolecule that "recognizes" the substrate. The macromolecule attracts the substrate to an "active site" on its surface where some biological function is carried out and the "substrate" is converted to a "product" before being released. While NMR spectroscopy is a powerful technique for studying molecular structure and dynamics, functional processes are not often studied in a direct fashion because we rarely have the opportunity to flow substrates through the NMR samples. **Prof. Alex Smirnov at North Carolina State University** has worked with the NHMFL to develop a way to solve this challenge. By using thin wafers formed by an array of nanotubes (anodic aluminum oxide) that trap the biological macromolecules, it is possible to change the solvent conditions without making a new NMR sample. For Figure 15 ions have been added to the sample, ^{17}O NMR signals are seen to be shifted [*J. Am. Chem. Soc.*, **127**, 11922 (2005)] and when the ions are removed by using a molecular sponge, the signal returns to its original frequency with little loss of intensity. This demonstration will be followed by the development of a flow probe such that the sample does not need to be taken out of the NMR magnet. It can be expected that the function of a great many biological systems could be studied by this elegant application of a nano-material to facilitate biological studies.

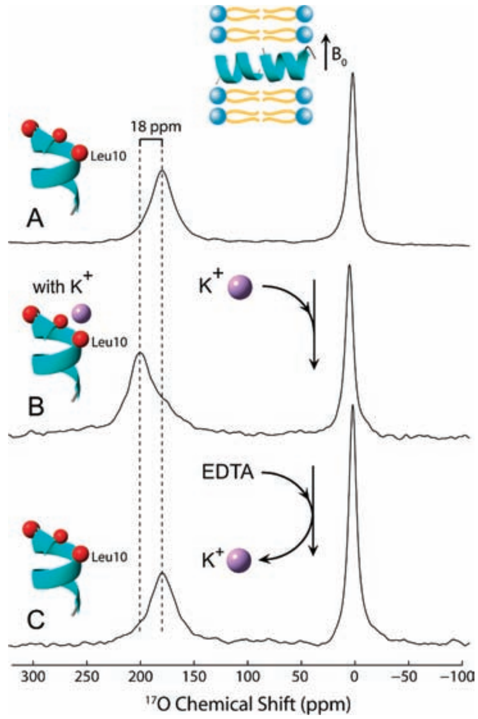


Figure 15. ^{17}O NMR spectra of ~2 μmol ^{17}O-[D-Leu10]-gA with and without KCl (2.4 M) in uniformly AAO-aligned nanotubular bilayers with the magnetic field perpendicular to the bilayer normal. Spectra were acquired for ~4 hours at 40 ºC with an NHMFL static probe at 19.6 T. The 0 ppm peak is due to natural abundance ^{17}O water signal.

- Biological solid state NMR spectroscopy can take great advantage of high fields—for example, a factor of two improvement in resolution in each dimension represents a factor of four in two dimensional spectra and a factor of 8 in 3D spectra in terms of the number of resonances that can be spectrally resolved. In Figure 16 (*J. Am. Chem. Soc.*, 2006, in press) such a factor of 2 is illustrated by **Prof. Myriam Cotten at Pacific Lutheran University**, in PISEMA spectra of a bacterial toxin. By increasing the field strength from 600 to 900 MHz this resolution enhancement represents an improvement in spectral resolving power of B_o^4. However, the observation of this dramatic field dependence would not have been possible without enhanced probe technology that greatly diminishes sample heating from the radio frequency irradiation. The RF program at the NHMFL has developed a novel coil technology that reduces the heating of hydrated biological samples by an order of magnitude (Figure 17).

- Surface-supported transition metals containing multiply bonded ligand systems such as the akylidene and imido groups have long been proposed as key intermediates in heterogeneous catalytic reactions such as olefin metathesis, polymerization, and ammoxidation. In spite of the importance of these proposed species, their positive characterization on catalyst surfaces has been difficult due to their low concentration and transient nature. **Prof. Albert Stiegman**

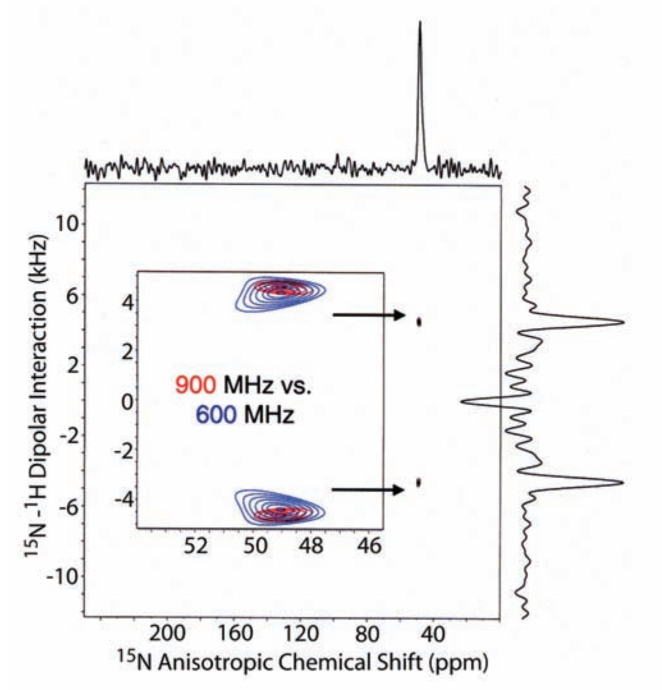


Figure 16. ^{1}H-^{15}N PISEMA spectrum of ^{15}N Leu_{20} amidated piscidin 3 in hydrated lipid bilayers at pH 6 and 40 °C.

Figure 17. The 900 MHz low electric field probe that minimizes the electric field in the sample volume thereby minimizing the sample heating.

in collaborating with the NHMFL reported this year in the *Journal of the American Chemical Society* [**127**, 11590 (2005)] the generation of metal-imido functional groups at discrete silica-supported vanadium-oxo sites under catalytic conditions using $^{51}V/^{15}N$ rotational echo double resonance (REDOR) NMR spectroscopy where the more sensitive quadrupolar ^{51}V nucleus was monitored while the ^{15}N nucleus was pulsed. Specifically, vanadium-oxo groups in a silica xerogel matrix react cleanly and quantitatively with aniline in a gas-solid reaction to generate a phenylimido group at the vanadium center with concomitant elimination of water.

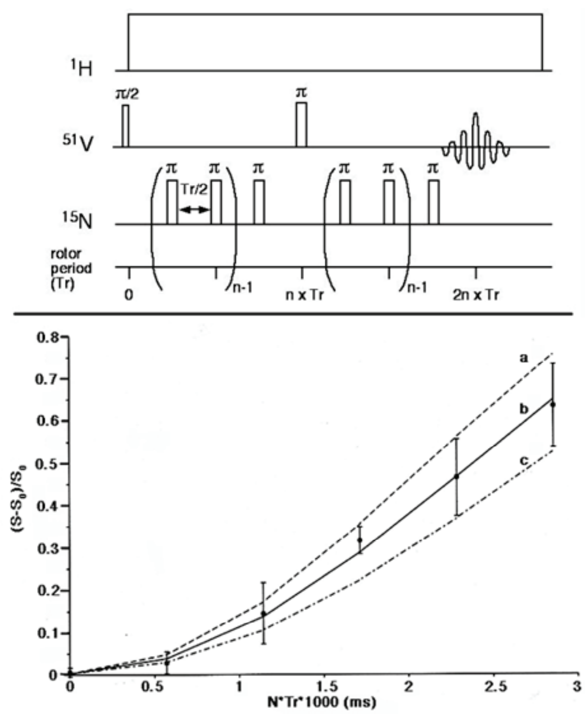


Figure 18. $^{51}V/^{15}N$ REDOR data of vanadium oxide exposed to analine at elevated temperatures. This spectral accomplishment at 600 MHz represented both a significant scientific and technological advance.

Table 12. NMR Spectroscopy and Imaging Facility User Statistics for 2005 (1/1/2005 – 12/31/2005)

	Total	Minority	Women
Number of Projects	75		
Number of Research Groups	38		
Number of Users	139	19	46
Number of Senior Investigators, U.S.	58	0	6
Number of Senior Investigators, non-U.S.	2	0	0
Number of Postdocs, U.S.	14	2	2
Number of Postdocs, non-U.S.	2	0	1
Number of Students, U.S.	61	1	18
Number of Students, non-U.S.	2	0	0

Table 13. NMR Spectroscopy and Imaging Facility Operations Statistics for 2005 (1/1/2005 – 12/31/2005)

User Affiliation	900**	833 NB	720	600	600WB	600WB2*
	Number of Magnet Days					
NHMFL	76	175	237	238	133	59
U.S. Universities	217	101	122	127	200	0
U.S. Government Labs	0	0	0	0	0	0
Industry	0	0	0	0	0	0
Non-U.S.	9	70	0	0	19	54
Development, Maintenance	63	10	6	0	13	7
Idle	0	9	0	0	0	0
Total	**365**	**365**	**365**	**365**	**365**	**120**

Note 1 In addition, 210 days of spectrometer time have been used by external users and collaborators on Tallahassee low field instruments.

** January 1-July 31, 2005 was commissioning phase; August 1-December 31, 2005 was normal user operations.

* New system operating 120 days in 2005.

Gainesville Update-AMRIS

- **Faculty Recruitment.** Two new biological magnetic resonance faculty members have been hired at UF during the past year. **Dr. Aneta Petkova** is an assistant professor in physics. Dr. Petkova is an expert in biological solid state NMR and is studying the structures of polymorphic proteins associated with disease such as amyloid fibers. She received her Ph.D. at Brandeis University in 2000 and did postdoctoral studies in solid state NMR at the NIH with Dr. Robert Tycko. **Dr. Sergey Vasenkov** is an assistant professor in chemical engineering. Dr. Vasenkov uses pulsed field gradient NMR and other biophysical methods to study molecular diffusion of ions across membranes and other molecular transport phenomena. He obtained a Ph.D. in physics and mathematics from the Institute of Chemical Kinetics and Combustion at Novosibirsk University in 1994. He did postdoctoral studies at the Lawrence Berkeley Laboratory, UC-Berkeley from 1995-1998, and taught and conducted research at Leipzig University in the Department of Physics and Earth Sciences from 1998-2005.

Figure 19. Cover photo of the April, 2006, *Journal of Magnetic Resonance* with the initial report of the 1-mm HTS probe.

- **Instrumentation Highlights.** 2005 was the busiest ever on AMRIS instrumentation. The vertical magnets have been essentially fully booked, and the horizontal animal magnets were heavily used during prime time hours. The result of this activity has been a strong year of publications, highlights of which are summarized below, under AMRIS Science Highlights. One of the major highlights in AMRIS this year has been a novel NMR 1-mm high temperature superconducting (HTS) probe, a collaborative project between the NHMFL, Bruker NMR, and the University of Florida's NIH Resource Grant, High Field Magnetic Resonance Research & Technology (HiFiMR).

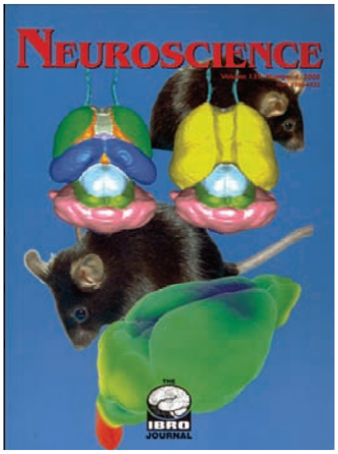
  The 600 MHz 1-mm HTS probe is triple resonance (^{1}H, ^{13}C, ^{15}N, and ^{2}H lock) and has a z-axis gradient. It uses a capillary sample tube with volume of about 8 µL. The planar HTS coils were designed by **Dr. William Brey and his group at the NHMFL**. They worked closely with Dr. Rich Withers and his group Bruker NMR to construct the probe using a Bruker CryoProbe body and CryoPlatform. The probe has been installed and tested by **Dr. A. Edison and his group in AMRIS**. The HTS probe has a volume that is about 1/70 and an absolute sensitivity that is about 1/3 of a conventional 5-mm probe. We believe that the HTS probe has the highest mass sensitivity of any probe at any field strength in the world, and there are now numerous studies that have started on small molecule natural products, metabolic studies, and protein screening. The importance of this development was recognized by a cover article in the April, 2006 *Journal of Magnetic Resonance*.

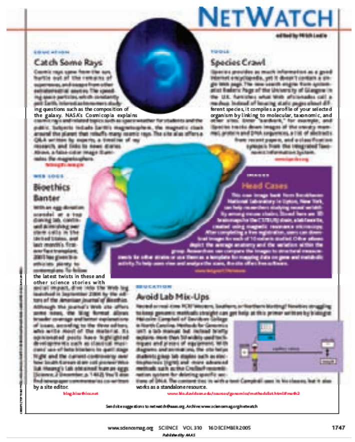
- AMRIS received $1.3 million for infrastructure development as part of the state of Florida $10 million enhancement to the NHMFL in 2004. In anticipation of the 1-mm HTS probe, AMRIS has used some of these funds to purchase a second 600 MHz system that will be devoted to the 1-mm HTS and 5-mm commercial cryogenic probes. This will allow us to substantially increase user access to the unique probe. The new 600 MHz has been delivered and will be installed in the spring of 2006 in the same room as the existing 600 MHz system. With the state funds, we also have purchased a new console for the 750 MHz/89 mm system, which also received a new magnet last year. The 11.1 T/40 cm magnet will also get a new small gradient set for optimized rodent imaging with the same funds.

AMRIS Science Highlights for 2005

AMRIS investigators published more than 30 peer reviewed papers in 2005, including 2 additional cover articles and a feature in *Science*. The use of transgenic mice has revolutionized biomedical research and genetics, and numerous genetic diseases can be studied and better understood with a "mouse model" of the disease. Before the effects of the mutations can be fully understood, however, a bench-mark study of a normal mouse is needed. **Drs. Blackband and Grant at UF** and **Dr. Benveniste at Brookhaven National Laboratory** have used microimaging at 750 MHz in AMRIS to make a comprehensive 3D digital mouse brain atlas of the standard lab mouse, C57BL/6J [Ma, *et al*., *Neuroscience*, **135**, 1203-15 (2005)]. This work has been recognized by a cover story in *Neuroscience* as well as a "NetWatch" highlight in *Science*. The work utilizes high-resolution images from 10 adult male mice to make 10 individual atlases, an average atlas, and a probabilistic atlas. This work is on the web and allows investigators to compare experimental animals with this "gold standard" mouse brain atlas. Blackband and Grant and collaborators have now applied the same approach to the study to disease models, including a mouse model of ALS (Lou Gehrig's disease) [Wilson, *et al*., *Neuroimage*, 336-43 (2004)].

Dr. Mareci's laboratory at UF has used very high-resolution imaging of spinal cord injury and compared *in vitro* MRI, *in vivo* MRI, and standard histology. The motivation of this work was to investigate whether MRI is capable of identifying the temporal profile of pathologic changes following spinal cord injury. The authors used the AMRIS 4.7 T/33 cm and 600 MHz systems to collect a variety of datasets 17-24 days following injury. Bleeding, neuronal loss, cavities, and expansion of the central canal were seen with T2-weighted *in vivo* images. The important conclusion of the work is that high-resolution *in vivo* MRI can be used to monitor the progression and therapeutic intervention in spinal cord injury [Berens, *et al., Am. J. Neuroradiol*. 1612-22 (2005)]. This work was also recognized by a cover article in the prestigious *American Journal of Neuroradiology*.





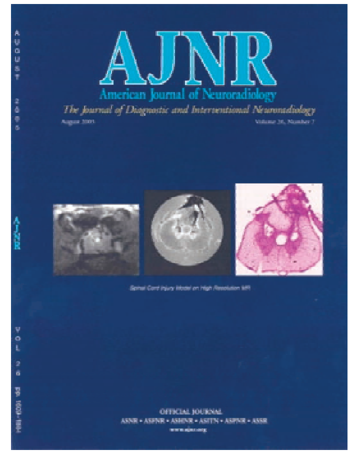


Figure 20. Digital Mouse Brain Atlas cover article of *Neuroscience.*

Figure 21. The Digital Mouse Brain Atlas featured in *Science*.

Figure 22. Cover article for MRI study of spinal cord injury, *American Journal of Neuroradiology*.

Table 14. AMRIS User Statistics for 2005 (1/1/2005 – 12/31/2005)

	Total	Minority	Women
Number of Projects	49		
Number of Research Groups	71		
Number of Users	132		
Number of Senior Investigators, U.S.	45		23
Number of Senior Investigators, non-U.S.	26		5
Number of Postdocs, U.S.	23		6
Number of Postdocs, non-U.S.	8		
Number of Students, U.S.	21	1	2
Number of Students, non-U.S.	3	1	

Table 15. AMRIS Operations Statistics for 2005 (1/1/2005 – 12/31/2005)

User Affiliation	500 MHz	600 MHz	750 MHz	4.7 T	11 T	3 T
	Number of Magnet Days*					
NHMFL	26	104	97	32	66	14
U.S. Universities	285	180	224	192	167	61
U.S. Government Labs						
Industry						
Non-U.S.						
Development, Maintenance	50	61**	36	20	20	15
Idle	4	20	8	16	7	170
Total	**365**	**365**	**365**	**260**	**260**	**260**

* 500, 600, and 750 MHz days are 24 hours. 4.7 T, 11 T, 3 T days are 8 hours because of animal care.

** This includes 5-mm cryoprobe maintenance, installation and testing of new 1-mm HTS probe, switching time from spectroscopy to imaging, implementation of new pulse sequences, and maint/repair.

Electron Magnetic Resonance Program

The Electron Magnetic Resonance (EMR) facilities at the NHMFL provide users with several home built high field and high frequency (23-700 GHz) instruments and a commercial 9/95 GHz (X-/W-band) spectrometer. The specifications of these instruments are given in the Table 16, for more details see *2004 NHMFL Annual Report*.

Table 16. Specifications of EMR Instruments

Spectrometer	Freq. GHz	CW-EPR	Pulse EPR	TR-EPR	ENDOR	Abs. sens.[1] Spins/G	Conc. Sens. Spins/G·cm³	Aqueous Conc. Sens. nM/G	Max Sample Size μl
Broad Band Transmission	23-550[2]	■				10^{12}	5×10^{12}		200
Homodyne QO	190-475	■			■	2×10^{10}	2×10^{12}		10
Heterodyne QO	120, 240, 336	■		■	■	10^{8} (cavity) 2×10^{10} (no cavity)	10^{12} 2×10^{11}	6	0.1 100
Keck Spectrometer	150-700	■				10^{12}	5×10^{12}		200
Bruker Elexsys X-band	9.7	■	■		■	10^{10}	10^{11}	2	70
Bruker Elexsys W-band	94.5	■	■		■	5×10^7	10^{11}	4	0.4

1 Absolute sensitivity is the minimum number of detectable spins per Gauss linewidth and a 1 Hz bandwidth at room temperature.

2 In combination with the Far-Infrared laser, selected frequencies up to 2500 GHz are available.

Instrumentation Update

In the past year the following improvements to existing instrumentation were accomplished:

- A solid state multi-frequency source (26, 52, 104, 208, and 312 GHz) was added to the homodyne instrument. The new source increased power output and extended the available frequency range.
- A high power IMPATT amplifier for pulsed EPR ($\pi/2$ pulse ~ 32 ns) was purchased for the W-band spectrometer.
- The frequency range of the heterodyne spectrometer was extended to cover 120, 240, and 336 GHz. A goniometer was installed on this instrument to allow rotation of single crystals.

A quasioptical transient electron spin resonance spectrometer operating at 120 and 240 GHz. This paper [J. van Tol, *et al.*, *Rev. Sci. Instrum.*, **76** (2005)] describes six different sample configurations: (a) Fabry-Perot resonator; (b) 5 mm o.d. quartz tube with optical excitation for transient EPR. Light is delivered via a quartz optical fiber coupled to a right-angle prism; (c) holder for solid or powdered samples for cw EPR; (d) single crystal holder with single axis rotation; (e) thin-film holder, with perpendicular *B* field and optical excitation; (f) thin-film holder with parallel *B field*. The sample positions in Figure 23 are labeled "S", the curved (a) or flat [(b)-(f)] mirrors are "M", modulation coils are in "X" areas.

Featured Results of the 2005 EMR Program

- **Tunable-frequency high-field EPR**. This work using the Keck magnet is described in the DC Field section of this Annual Report. [J. Krzystek, *et al., J. Magn. Reson.*, **178**, 174-183 (2006)].

- **Hyperfine Structure of Sc@C82 from ESR and DFT.** The electron spin *g*- and hyperfine tensors of the endohedral metalofullerene Sc@C_{82} are anisotropic. (Figure 24) Tensor values were determined by EPR, and density functional theory (DFT) was used to relate them to the molecular structure: (a) optimized geometry of Sc@C_{82} from DFT simulations. The red ball is the Sc atom, the dotted lines indicate the mirror

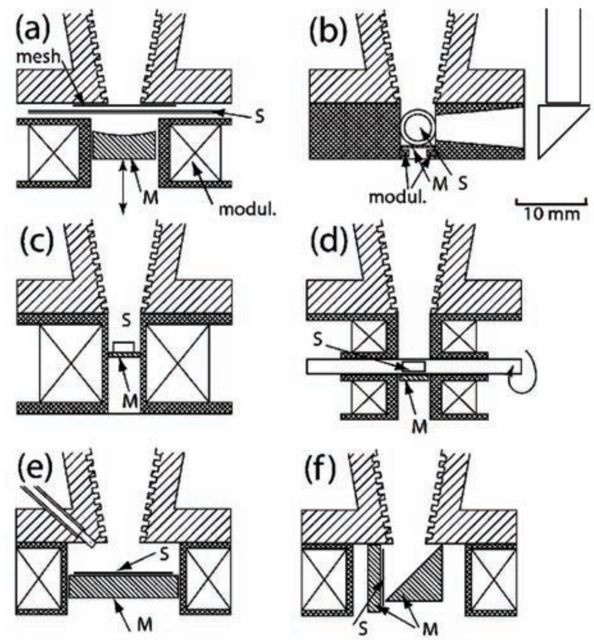


Figure 23

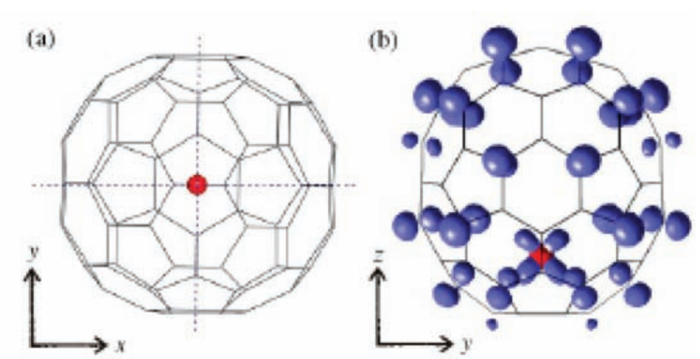


Figure 24

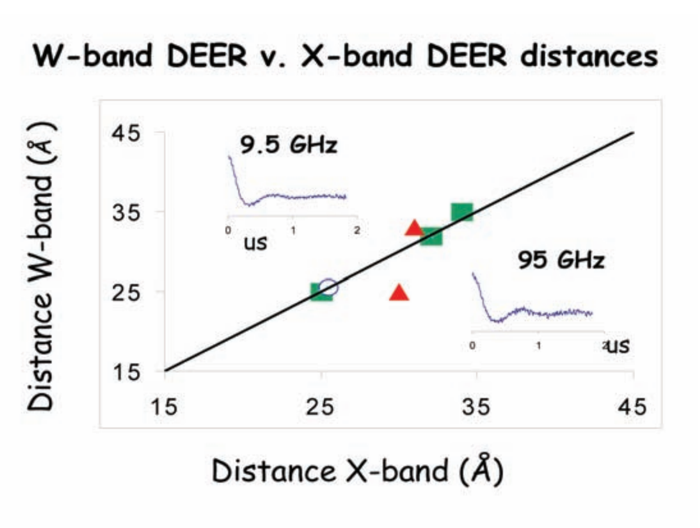


Figure 25

planes of the C_{2v} symmetry. (b) Computed spin density with isovalue: 0.10 μ_BÅ^{-3}. [G.W. Morley, *et al., Nanotechnology,* **16**, 2469-2473 (2005)]

- **DEER at 95 and 9 GHz.** High field DEER at 95 GHz offers an additional Larmor frequency to sample dipolar interactions between coupled spins. As shown in Figure 25, DEER at 9.5 GHz and at 95 GHz (*inset*) was compared for 6 double mutants on three different proteins, troponinC, Band3, and T4 lysozyme. Good, 1:1 correlation was observed between the distances obtained from the two frequencies. Thus one can combine the experiments at X- and W-band to analyze the distance distribution in a "global" analysis manner. (L. Song, M. Bonora, E. Hustedt, A. Beth and P. Fajer)

- **Molecular Ruler – Double Electron Electron Resonance.** A novel computational method (using Monte Carlo/Molecular Dynamics) was developed to account for spin label length and conformation. The uncertainty in the label position confounds the interpretation of the spin-spin distances in molecular terms. Figure 26 shows one of the pulsed EPR methods, DEER, that allows for measurement of weak dipolar couplings. 4-pulse DEER sequence is shown in the *upper-left*: the coupling of spins B to spins A is observed as the modulation of echo when the pumping pulse is swept through the mixing time between the π pulses. The positions of spins A and B are shown in the *upper-right*. The echo is modulated with a frequency related to the spin-spin distance: low frequency for long distance, higher frequency modulation for shorter distances, *lower-left*. The distance extracted from the DEER, however, is between the spins rather than between the protein backbone. Molecular modeling allows us to account for the spin label as demonstrated in the correlation of the measured distances and known backbone distances for 4 different proteins, *lower-right*. [K. Sale, *et al*., *JACS*, **127**, 9334-5 (2005)]

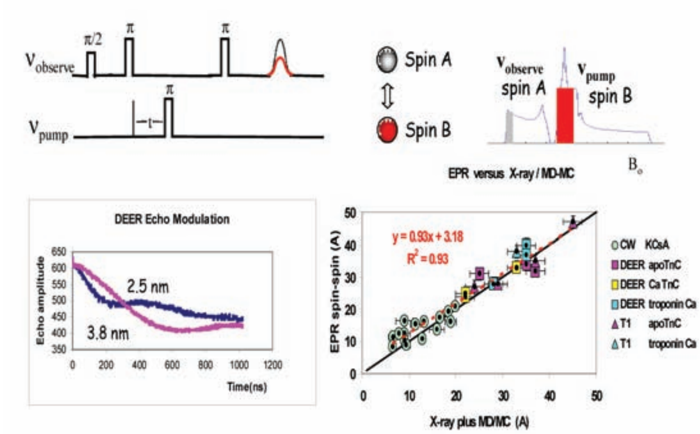


Figure 26

- **EPR Shift in $II_{1-x}Mn_xVI$ Diluted Magnetic Semiconductors in the Presence of Strong Exchange Coupling.** This group observed a significant shift of the Mn^{2+} resonances as a function of ion concentration and temperature (Figure 27). The use of multiple frequencies identified origins of the observed shift as an internal field of the spin sublattice within the $II_{1-x}Mn_xVI$ host. [McCarty, *et al*., *Phys. Rev. Lett*., **95**, 157201 (2005)]

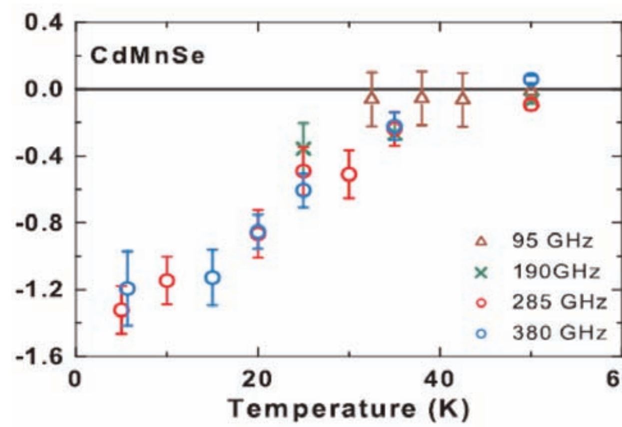


Figure 27

Table 17. EMR Facility User Statistics for 2005 (1/1/2005 – 12/31/2005)

Research Projects/Groups	Total	U.S.	Non-U.S.
Number of Research Projects	56	45	11
Number of Research Groups	56	45	11
Users	**Total**	**Minority**	**Female**
Numbers of Users	104	2	13
Number of Senior Investigators, U.S.	72	2	10
Number of Senior Investigators, non-U.S.	22	0	6
Number of Students & Postdocs, U.S.	6	0	1
Number of Students & Postdocs, non-U.S.	4	0	1

Table 18. EMR Operations Statistics for 2005 (1/1/2005 – 12/31/2005)

User Affiliation	17 T	12.5 T Number of Magnet Days	X & W-band
NHMFL, UF, FSU, FAMU, LANL	68	82	171
U.S. University	36	46	17
U.S. Government Lab	-	-	-
Industry	-	-	-
Non-U.S	89	56	13
Development	11	30	-
Maintenance, Repair	9	14	12
Total	**213**	**228**	**213**

Fourier Transform Ion Cyclotron Resonance Mass Spectrometry

During 2005, the ICR 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 directors for instrumentation, biological applications, environmental applications, and user services, as well as a machinist, technician, and seven rotating postdocs who are available to collaborate and/or assist with projects.

FT-ICR Magnet and Instrumentation Update

- An actively-shielded **14.5 T, 104 mm bore system** (the highest-field superconducting ICR magnet in the world) is available. The spectrometer features an electrospray ion source; 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 makes sub-ppm mass accuracy routine without the need for an internal calibrant. Mass resolving power >200,000 at m/z 400 is achieved at one scan per second, which is ideal for LC-MS. Robotic sample handling allows unattended or remote operation. An additional pumping stage (for ultrahigh resolution of small molecules) and 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. 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 (Infrared Multiphoton Dissociation (IRMPD), and electron-induced (ECD). A robotic sample-handling system allows unattended and geographically remote operation. An atmospheric pressure photoionization (APPI) source can be used for analysis of nonpolar analytes. HPLC and CE interfaces are also available.

- **9.4 and 7 T** actively shielded **FT-ICR instruments** are available for analysis of complex nonpolar mixtures. The 9.4 T magnet is currently used for field desorption [*Anal. Chem.,* **77**, 1317-1324 (2005)] and matrix-assisted laser desorption/ionization (MALDI). The 7 T magnet is optimized for volatile mixture analysis [*Rev. Sci. Instrum.,* **77**, 0000 (2006)]. 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 have been achieved with both systems. Thousands of components in a complex mixture (e.g., petroleum distillates) can thus be resolved and identified.

Table 19. FT-ICR Mass Spectrometry Facility User Statistics for 2005 (1/1/2005 – 12/31/2005)

	Total	Women	Percent Women
Total Number of Projects	78		
Number of Research Groups	71		
Total Number of External Users	121	27	18%
Number of Senior Investigators, U.S.	52	6	10%
Number of Senior Investigators, non-U.S.	19	4	17%
Number of Postdocs, U.S.	12	2	14%
Number of Postdocs, non-U.S.	5	2	29%
Number of Students, U.S.	8	8	50%
Number of Students, non-U.S.	3	1	25%
Number of Collaborators, U.S.	4	1	20%
Number of Collaborators, non-U.S.	4	0	0
Total Number of Visitors to ICR Facility	83	23	22%
Total Number of Users Sending Samples	38	4	10%
Remote Users	3	1	33%

ICR Applications

- **Biomolecular sequence verification** continues to be in high demand. Protein and oligonucleotide masses can be determined with ppm accuracy. Molecules can be fragmented (by collisions, photons, or electron capture by multiply-charged positive ions) to yield sequence-specific products [*Anal. Chem.*, **77**, 7163-7171 (2005)]. Sites and nature of post-translational modification (e.g., glycosylation, phosphorylation, etc.) are readily determined [*Proteomics,* **4**, 970-981 (2004)]. In-house software has been developed for rapid data analysis.

- Tertiary and quaternary structure can also be probed. Automated **hydrogen/deuterium exchange** can be carried out [*Anal. Chem.,* **78**, 1005-1014 (2006)] and monitored with the mass spectrometer. Details of biomolecular conformation and surface contact between molecules in a noncovalent complex can be deduced. For example, we were able to characterize intersubunit interactions underlying assembly and maturation in the HIV-1 RNA virus [*Nat. Struct. Mol. Biol.,* **11**, 676-677 (2004)].

- The 7 and 9.4 T instruments are primed for immediate impact in **environmental, petrochemical, and forensic analysis**, where intractably complex mixtures are common. For example, post-blast soil samples can be extracted and compared with a library of commercial and military explosives to identify the active agent and the source of the product [*Anal. Chem.*, **74**, 1879-1883 (2002)]. Further, fossil fuel samples can be analyzed and components resolved without chromatographic separation. In a recent study more than 10,000 distinct chemical components were resolved and identified (elemental formulas) in a single electrospray FT-ICR mass spectrum of coal [*Energy & Fuels,* **18***,* 1424-1428 (2004)].

Table 20. FT-ICR Mass Spectrometry Operations Statistics for 2005 (1/1/05 – 12/31/05)

User Affiliation	9.4 T 220 mm		9.4 T active shield		14.5 T	
	Number of Magnet Days					
NHMFL, UF, FSU, FAMU, LANL	105	29%	35	10%	38	10%
U.S. Universities	61	17%	2	1%	29	8%
U.S. Government Labs	1	0.3%	0	0	8	2%
Industry	70	19%	0	0	13	4%
International	70	19%	0	0	12	3%
Development, Maintenance	36	10%	73	20%	151	41%
Idle	22	6%	255	69%	114	32%
Total	**365**	**100%**	**365**	**100%**	**365**	**100%**

Geochemistry

In the past year the **Geochemistry Program** has concentrated on using existing instrumentation for geochemical and environmental research. The program had nine active research grants (6 from NSF, one from EPA, two from NASA). The research funded through these programs concerns the study of the chemical evolution of the solid Earth and solar system through trace element and isotope analyses as well as the use of isotopes to study several aspects of environmental geochemistry and global change. This past year a quadrupole inductively coupled plasma mass spectrometer (ICP-MS) was added to our arsenal of analytical tools. This instrument, which was installed in the spring, allows rapid and precise analysis of lithium isotope ratios as well as the elemental concentrations in a large variety of geological materials.

The program was successful in obtaining NSF-MRI and NASA funds to acquire a new generation multi-collector ICP-MS with a laser ablation system. The laser ablation is operational and is used in a number of projects and has attracted some new outside users. With additional investment from FSU and the NHMFL, the group will construct a new plasma analytical facility in 2006.

Table 21. Mass Spectrometers for Geochemical and Environmental Research, as of January, 2006

Name	Type of ionization	Mass analyzer configuration	Detection systems	Measurements	Sample introduction
Isolab	Thermal and Sputtering	E-M-D1-E-D2	D1: 4 faraday cups after M D2: Daly Ion counting and faraday cup	Isotope ratios: Th, Hf and Hg	Solids and chemical separates
262/RPQ	Thermal	M-D1-E-D2	D1: 7 faraday cups, 1 electron multiplier D2: Electron multiplier	Isotope ratios: Pb, Sr, Nd, Os	Chemical separates
ICP-MS ELEMENT	Plasma	M-E-D	D: Electron multiplier	Concentrations and isotope ratios	Solutions/ Solids
ICP-MS	Plasma	E-D	D: Electron multiplier	Concentrations and isotope ratios	Solutions
Delta XP	Thermal	M-D	D: 5 faraday cups	Isotope ratios: H, C, N, O	Gas

E = energy filter
M = magnetic mass filter

Table 22. Geochemistry Facility User Statistics for 2005 (1/1/05 – 12/31/05)

	Total	Minority	Female
Number of Research Projects	29	n/a	n/a
Number of Senior Investigators, U.S.	18	3	5
Number of Senior investigators, non U.S.	1	-	1
Number of Students, U.S.	11	-	8
Number of Students, non-U.S.	-	-	-
Number of Postdocs, U.S.	3	-	1
Number of Postdocs, non-U.S.	-	-	-

Table 23. Geochemistry Operations Statistics for 2005 (1/1/05 – 12/31/2005)

	Isolab	262/RPQ	ICP-MS ELEMENT	DELTA XP	Total
User Affiliation	**Number of Magnet Days**				
NHMFL, UF, FSU, FAMU, LANL	140	140	190	150	620
U.S. University	50	50	30	20	150
U.S. Govt. Lab	-	-	20		20
U.S. Industry	-	-	-		-
International	-	-	-		-
Maintenance	50	20	30	60	160
Total	**240**	**210**	**270**	**230**	**950**

Access to NHMFL Facilities

User access to the NSF-funded NHMFL Continuous (DC) and Pulsed Field Facilities is controlled by a proposal and review process that is administered by the directors of the respective user programs. A brief initial proposal is reviewed by NHMFL staff and approved or denied by the director of the facility in which magnet time was requested. Continuing requests are evaluated based on the published results from the ongoing work. The final decision for use of the DC Field Facility rests with the director of the NHMFL.

Access to the High B/T Facility is through submission of a proposal that is evaluated by the High B/T Facility staff. The use of the High B/T Facility is restricted to experiments that need the special low temperature and high field configurations. Many of the experiments require special assemblies and direct interaction with personnel on site, as well as having need for long running times. Prospective users should contact the facility manager and resident research scientist before requesting magnet time.

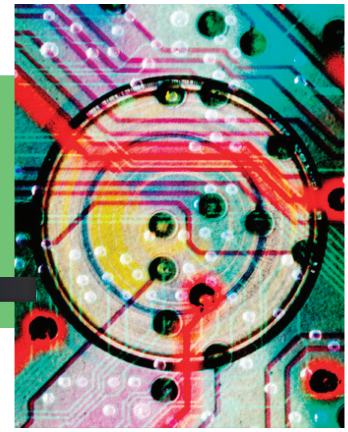
The ICR mass spectrometer facilities, electron magnetic resonance facilities using the superconducting magnets and X-band spectrometer, isotope geochemistry facilities, and many of the magnetic resonance spectroscopy and imaging facilities are supported by grants other than the NHMFL Cooperative Agreement with the NSF. The fraction of time on these systems available to general users equals the fraction of the facility cost paid by the NHMFL. Collaborative access to them is governed by the terms of the grants and the principal investigators.

User access to the NSF-funded NHMFL NMR Spectroscopy and Imaging facilities is controlled by submission of a brief proposal that is reviewed by the program director or assistant program directors. The potential users are notified of the decision and put in contact with the appropriate NHMFL staff to schedule spectrometer time.

Access to the ICR equipment requires a one-page proposal and is at the discretion of the director. Long term use (more than 2-3 days), equipment, or salary support requires a 2-3 page proposal (and budget) that is reviewed by an advisory panel.

The isotope geochemistry facilities are in general open to any user for research projects. Access to the geochemistry facilities is done on an individual basis through contacting Dr. Salters. Although there is a charge for the use of the facilities, pilot projects and development of analytical techniques are regularly accommodated without a charge.

CHAPTER 4
MAGNET SCIENCE & TECHNOLOGY



The Magnet Science and Technology (MS&T) Division has as it primary mission providing state-of-the-art magnet systems for NHMFL users. These magnet systems typically fall into one of the following categories:

- Pulsed magnets (fractions of a second at field), comprising short-pulse capacitively-driven magnets and long-pulse, extended-life magnets powered by the energy stored in the flywheel of a motor/generator
- Powered dc magnets (seconds to hours at field), comprising a variety of resistive and hybrid magnets (combinations of resistive and superconducting technologies)
- Persistent magnets (hours to years at field), characterized by the all-superconducting magnets for research in NMR, EMR, ICR, MRI, etc.

In the latter group, we generally include those systems that share technologies with fully persistent systems (e.g. low-current, high-inductance, impregnated windings), even though the particular system may not be, or need to be, operated in persistent mode.

During the past year, MS&T has made substantial progress in each of these areas. The projects undertaken by MS&T were funded either by the NSF core grant or by a variety of separate grants or contracts. In some cases, the funds were obtained to explore advanced magnet systems expected to significantly impact the service provided to future users of the NHMFL. Design studies of the Series-Connected Hybrid (SCH) system or the 21 T FT-ICR mass-spectrometer system are examples of these. In other cases, for example the design of a horizontal-axis SCH for neutron-scattering experiments at the Hahn-Meitner Institute or the modeling of a high field, short-period, planar undulator for the Advanced Photon Source, funds were obtained from other laboratories with similar missions to ours. In still other cases, MS&T provided service to both privately and publicly funded customers with special magnet-technology needs having synergy to our own near-term needs and our long-term development goals. In all these instances, the activities underscore the recognition of various external reviewers that MS&T should serve as a national and international resource for magnet technology.

Pulsed Magnets

The primary programmatic objectives remain:

- Manufacture pulse coils to sustain aggressive physics research by users of the NHMFL Pulsed Field Facility at Los Alamos
- Upgrade magnet performance in terms of field, reliability and pulse-repetition frequency
- Identify and pursue the needed engineering and materials R&D to continuously advance pulsed-magnet technology.

The user facilities at Los Alamos are equipped with both capacitor-driven (the 65 T short-pulse and the 50 T mid-pulse) and generator-driven (the 60 T long-pulse) magnets. In a program using the combined resources of the U.S. Department of Energy (DOE) and the U.S. National Science Foundation (NSF), a system is being created using a combination of generator and capacitor-driven components with the goal of achieving a large number of pulses at 100 T.

65 T Short-Pulse User Magnets

The second year of user operations with the 65 T gap-cooled design was completed. User activity at the facility was up about 10%. Engineering development for user magnets focused upon production tooling to simplify the manufacturing process for the new magnet systems and to standardize the power-feed structures based upon the new 75 T prototype geometry (Figure 1) developed as part of the DOE/NSF 100 T Multi-Shot Magnet.

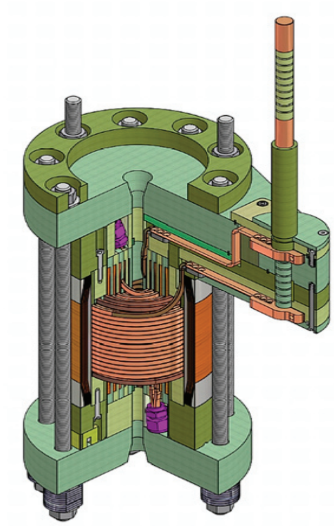


Figure 1. Sectional view of 75 T magnet illustrating winding structure, coaxial power feed, and improved "solid" flange structure. The solid flange structure was adopted in the 65 T production design to enhance the mechanical reliability of the assembly. The solid flange structure ensures the containment of axial loads in both normal operational and fault conditions.

50 T Mid-Pulse User Magnets

Because of other priorities, no new spares for the 50 T mid-pulse facility were fabricated, resulting in reduced availability. Nevertheless, user service was up slightly for the year.

100 T Multi-Shot Development

Objective

The 100 T Multi-Shot Magnet is a highly visible project that demanded high priority during 2005, and will continue to do so in 2006. The objective of MS&T activity in Tallahassee is to design, construct, and test a 15 mm bore, capacitor-powered insert coil for use with an outer, generator-driven, long-pulse coil set whose design and construction is the responsibility of the NHMFL Pulsed Field Science Facility at Los Alamos. The combined systems will ultimately be capable of producing a total field of 100 T. The 100 T program is jointly supported by DOE, which funds the outer coil, and NSF, which funds the insert under the core grant for the NHMFL. In its initial configuration, the combined magnet is specified by DOE to achieve a 90 T pulse.

Status

The Phase I insert-development program will culminate in 2006 with delivery of the first insert prototype during the summer of 2006. The 100 T technology-development program was implemented to gain as much operational experience as possible with relatively low-risk, stand-alone coils operating in the same temperature, stress, and strain ranges as will be encountered in a 100 T insert coil. This firmly grounded, experience-based process was deemed essential to properly evaluate the required materials, engineering, and fabrication techniques. We have followed through with a classical engineering program based upon data gleaned from experimental trials. This incremental development process has mitigated the risks associated with 100 T insert operations, and has also benefited the NSF Pulsed Field Science program through the demonstration of advanced materials and techniques. The small-coil program's structure is outlined in Table I.

Table 1. Outline of technology development program for 100 T insert program

Dev. Seq.	Magnet System	Geometry	Inner Coil	Outer Coil	Benefit [MJ]	Energy Testing	Prototype Status	Status 05/11/04
1	65T Gap Cooled	Nested Two Coil	Insert Structure	Improved Monolith	User & 100 T	1.3	Finished 10/15/03	User Operation
2	75T Insert Development	Nested Two Coil	Improved Insert	Improved Monolith	User & 100 T	1.4	Finished 6/30/05	In Service
3	80T Insert Development	Nested Two Coil	Graded Insert	Improved Monolith	User & 100 T	1.5	Scheduled 4/06	Fab. & Assembly
4	90T Insert (Gen. #1)	Insert Only	Improved Insert	N/A	100 T	1.4-2.0	Scheduled 6/06	Final Design & Fab.

The insert required the full development of a totally new coil construction method to mitigate lead loads in the 100 T. The basic insert design template was developed during the 65 T magnet project. The resulting 65 T structure was a nested two-coil design with the insert coil located inside a conventional outer coil. The insert magnet program required the development of new reinforcement technology. The 65 T magnets validated the effectiveness of the Zylon and MP35N reinforcement for this application. Operation at 100 T requires a high-strength, high-conductivity wire with a large, ~17 mm^2 cross-sectional area. The developed conductor is a copper wire with a distributed Cu-Nb, nano-composite substructure. The 75 T magnet provided a low-risk test bed for the Cu-Nb wire. The 75 T model experiences mechanical stresses and peak temperatures comparable to those in the insert of 100 T Multi-Shot magnet. The "100 T Intensity" phase of the testing protocol for this magnet was completed on November 18, 2004. Magnet training and performance closely followed design predictions. The drive-voltage calculation was within 50 volts of the measured experimental value. Both the 75 T magnet and capacitor bank operated together according to specification. The 75 T testing protocol required 100 pulses at 70 T to validate insert reliability at stress levels comparable to the Multi-Shot Insert at 90 T.

The outer coil of the 75 T experienced electrical fault during operation in 2005. A magnet recovery plan was implemented and the insert magnet returned to service. Magnet operations continued at 70 T. The magnet has accumulated in excess of 120 pulses above 70 T and 14 pulsed above 75 T. The magnet is in service at the NHMFL Pulsed Field Facility where scientific staff have access for 70 T operations.

An 80 T model magnet is designed to further explore the limits of insert magnet operations. Data from this magnet will allow refinement of our reliability and fault-mode predictions as well as provide much needed fabrication experience for techniques needed in the insert magnet program. Delivery of the 80 T magnet will be in April 2006.

The 90 T insert magnet is scheduled for delivery in the summer of 2006. The insert magnet support shell assembly has been released for manufacture. We anticipate completion of both the magnet CAD and tooling packages in March 2006, and delivery of the first prototype in slated for June.

Summary of the 100 T program

Significant technical progress has been achieved. We have now operated magnets at mechanical and thermal conditions comparable to 100 T operations. The 80 T magnet will further explore the limits expected for insert operation. The delivery of the insert magnet system will be completed in the summer of 2006. Funding for maintenance and production of insert spares will be requested after system commissioning to 90 T. The 100 T development projects have substantially benefited the NSF User Program as well as the 100 T Multi-Shot Magnet Program.

Powered Magnets

Maintenance and Upgrades

During 2005, we were very fortunate in that the installed magnet coils demonstrated unusually long lifetimes. We installed 8 new coils to maintain the seven resistive magnets and one hybrid insert in Tallahassee.

We also completed the upgrade of two magnet cells during the past year. Cell 5 (the 50 mm bore magnet) was upgraded from 25 T to 31 T in April 2005. This is now the highest-field 50 mm bore resistive magnet in world. The 50 mm hybrid configuration in Tsukuba, Japan has attained 35.5 T in a 52 mm bore with minor damage to the resistive insert [T. Asano, *et al*., *IEEE Trans. in Appl. Supercond*., June 2006].

Once the new 50 mm bore magnet was operational, it was possible to install modulation and gradient coils inside it for de Haas van Alphen and magnetization experiments, respectively. These new inserts are different from the previous modulation insert in that they fit entirely inside the bore of the magnet, which should reduce the probability of failure of such an insert coil damaging the dc coils. In addition, the new inserts can be installed without opening the magnet housing, which should allow users to more rapidly change from one configuration to another. The modulation coil provides field variations up to 0.2 T peak-to-peak at frequencies up to ~1 kHz. The gradient coil provides up to 4.7 T/m gradients.

In December 2005, we upgraded the 32 mm bore magnet in cell 8 from 30 T to 35 T setting a new world mark for this class of resistive magnets. Of course, our own 45 T hybrid provides higher dc field in this bore and the 32 mm hybrid configuration in Tsukuba has reached 37.9 T with minor damage to the resistive insert [T. Asano, *et al*., *IEEE Trans. in Appl. Supercond*., June 2006.].

Formerly, we had a high-homogeneity resistive magnet in cell 7. Its field uniformity was measured in 3 dimensions via NMR to be about 50 ppm over a 10 mm-diameter spherical volume, which is high homogeneity compared with the 500 to 1000 ppm typical of high field resistive magnets. It provided 23 T for extended periods and 24.5 T for up to one hour (limited by the power supply). The upgraded version should be available in July 2006 and should provide 27 T for extended periods and 29 T for up to one hour initially. In October 2006, the power supply upgrade should be completed, enabling this magnet to operate at 29 T for extended periods. This magnet is not only expected to provide a unique facility world-wide for low-resolution NMR, it will also be the first demonstration of a high-uniformity resistive magnet including coils electrically in parallel. This is seen as an important demonstration of technology suitable for the 36 T Series-Connected Hybrid described later.

As mentioned above, the dc power supplies used to drive the resistive magnets are expected to be upgraded from 10 MW each to 12 MW each in June 2006. This increase in power is to be accomplished by replacing the transformers and other equipment to allow higher operating voltage and provide better cooling. In addition, we expect to be able to increase the voltage yet another 10% within a few years by changing taps on the transformers. This 20% increase in power allows us to upgrade the field from the various magnets by about 10%. Eventually, we expect to upgrade all the magnets. However, the most urgent upgrades at this time (due largely to logistical drivers) appear to be the Keck magnet in cell 6, which might be upgraded from 25 T to 28 T for NMR and EMR use, and the 20 mm bore magnet that might be upgraded from 19.5 T to 23.5 T. This magnet is especially useful for conductor testing and is expected to be key for developing the next generation of HTS wire suitable for use in the 30 T NMR magnet.

Split Magnet

To date, all high field resistive magnets at the NHMFL have been solenoids with cylindrical bores. Historically, high field magnet split magnets at other magnet laboratories have provided field up to 18 T with 4 mm access ports [P. Rub and G. Maret, *IEEE Trans. on Magn*., **30** (4), July 1994] or 17 T with 19 mm ports [R.J. Weggel and M.J. Leupold, *IEEE Trans. on Magn*., **24** (2), March 1988]. Presently, a project at the NHMFL is underway to design and build a split magnet providing field perpendicular to the access tube and using two of the NHMFL's dc power supplies. We anticipate the field at the center of the magnet to be in the range of 25 to 30 T depending upon the final configuration.

Phase I of this project (Conceptual Design) started in October, 2004, and was completed on schedule in June, 2005. During that phase, we decided the magnet would be an all-resistive magnet instead of a resistive-superconducting hybrid. It was also decided that the magnet should support two different types of experiments: scattering and rotation. For the scattering configuration, the bore (and field) will be vertical and the split in the coils will be very small with a conical taper. In the vertical plane, the taper should be +/- 5.7°, which corresponds to *f*5. In the horizontal plane, there will be 4 ports, each of which subtends 45° as shown in Figure 2. In this manner, by rotating the magnet or the source, one can obtain 360° of photon scattering in two experiments. To convert to the rotation configuration, the inner coils would be removed and replaced with another set that has a larger gap (32 mm) and no taper. The entire magnet would then be overturned such that the bore (and field) would be horizontal. At this point, a cryostat could be installed vertically from the top (and perpendicular to the field). The sample could then be rotated about the vertical axis to measure anisotropy of materials properties.

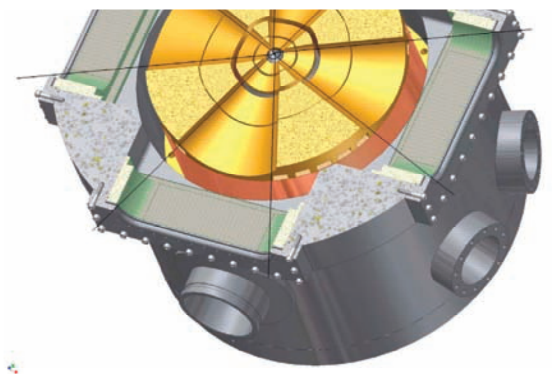


Figure 2. Mid-plane of split magnet showing four scattering ports of 45° each.

To accomplish these goals, a new "Split Florida-Helix" magnet technology has been invented and is being patented and demonstrated, and conceptual designs of these configurations using the split Florida-Helix have been developed.

Phase II of this project (Model Coils) began in July, 2005, and is anticipated to continue through the 1st quarter of 2007. In this phase, we are building model coils that will be operated inside the large-bore, 20 T magnet at high current density, power density, stress, and magnetic field. The layout design of these insert coils is nearing completion, fabrication of a few parts has started, and we expect to have a design review in March, 2006, which would be followed by detailing and large-scale fabrication. It is important to note that this split magnet requires significantly more technology development than previous new resistive magnets have required. In addition, there are intellectual property issues that complicate this process. Consequently, a model-coil phase is required and its scope and duration are difficult to foretell, as the performance of the model coils will have significant impact on the overall project.

Phase III (User Magnet) will include detailed design and fabrication of the user magnet system including housing, coils, platform, optics, rotation equipment, power cables, etc. It will require input from the user community regarding taper angles, bore sizes, etc. Its schedule has not yet been developed but it is expected to start this year.

45 T Hybrid, Coil A Rebuild

The goal of this project is to restore the superconducting outsert magnet to its full design performance, i.e. to 10 kA operating current and 14 T on-axis field contribution. At that level, and with the recently upgraded performance of the resistive insert, it is reasonable to expect the full system to operate in the 47-48 T range. The restoration will involve extracting the existing Coil A from the superconducting outsert and replacing it with a completely remanufactured one. The project scope also includes replacement of the existing cryogenic current leads with HTS leads for a significant reduction in the predominant cryogenic refrigeration load, allowing an overall improvement in system performance and reliability.

Status

As reported last year, work to build the replacement for Coil A, the innermost Nb_3Sn coil of the superconducting outsert, was suspended in November, 2002, and plans made to restart the project in the fall of 2005. Superconductor wire (approximately half a ton of Cu:Nb_3Sn multi-filamentary composite from Oxford Instruments-Superconductor Technologies) was delivered late in 2005, but the project has been further delayed in deference to other core projects. However, fabrication of the new Coil A of the 45 T outsert is viewed as a vital component of preparations for fabricating the outsert for the Series-Connected Hybrid (which we hope will be approved for construction in July, 2006), and as such, new plans have been made to restart this part of the 45 T Hybrid Rebuild in the 2nd quarter of 2006, thereby providing optimum overlap between the two projects. Completion of the full project, including extraction of the existing outsert and replacing the degraded Coil A, must still be worked out in conjunction with other NHMFL priorities, but a possible schedule is presented in Table II along with the rebuild schedule presented previously.

In addition to restarting the Coil-A fabrication, it was decided (with recommendation by the External Oversight Committee for the Series-Connected Hybrid Conceptual and Engineering Design study) to change the conduit alloy that will be used to fabricate the cable-in-conduit conductor for the 45T Hybrid Coil A. The new alloy, a high-strength, high-modulus, low-thermal-expansion super-alloy called Haynes 242, appears to have substantial performance advantages over the modified 316LN previously intended for this application. Preparations for using this alloy in the Coil-A rebuild give an important and unique opportunity for the Series-Connected Hybrid project, i.e. to evaluate a "production" quantity of material with limited risk (since we retain the fall-back option of using the 316LN material already procured for the Coil A rebuild). This action, which potentially raises both the current and stress allowables in the 45 T Hybrid outsert, also provides possible performance advantages for 45 T Hybrid operation that probably could not have been achieved by other means.

Table 2. Projected schedule for rebuilding Coil A of the 45 T Hybrid's superconducting outsert

Milestone	Previous Schedule	Revised Schedule
800 m conductor jacketed	January 2006	July 2006
Coil wound	May 2006	December 2006
Coil heat-treated	July 2006	February 2007
Vacuum-pressure impregnation complete	August 2006	March 2007
Coil form removed, coil finished (Begin Coil-A extraction 6 mo. earlier)	October 2006	May 2007
Reassembly complete	December 2006	July 2007
Outsert reinstalled in cryostat and ready for cooldown	March 2007	October 2007

Development has continued on HTS current leads for the 45 T Hybrid with the intent to replace the existing normal leads in the 45 T Hybrid cryostat at the first reasonable opportunity. The basic requirements for these leads are as follows:

- 10 kA normal operation
- Tolerance of an 11 kA insert trip
- Higher protection reliability than required for the magnet
- Dimensional compatibility with existing lead ports and other components
- Substantially reduced HeI heat load.

Leads have been designed with the following three principal elements:

- An HTS element using Bi-2223 tape conductor with Ag-Au matrix mated to a stainless-steel shunt for protection
- A copper heat-intercept block inserted between the resistive and HTS elements with an integral two-phase LN_2 reservoir
- A resistive element cooled by N_2 vapor.

A sectional view of one such lead is presented in Figure 3, components for the LN_2 reservoir are pictured in Figure 4, and fabrication of the resistive element by "jelly-rolling" pierced-copper sheet is shown in Figure 5. Successful tests of the various key elements have been performed separately and full performance tests of the finished leads are planned for the 2nd quarter of 2006. If these tests are successful, the leads will replace the normal leads presently in the 45 T Hybrid cryostat during the next maintenance shutdown, which is presently planned for the 3rd quarter of 2006. Since the extraction of the existing normal leads is a somewhat involved process, the replacement will not be undertaken unless tests of the HTS leads are completely successful.

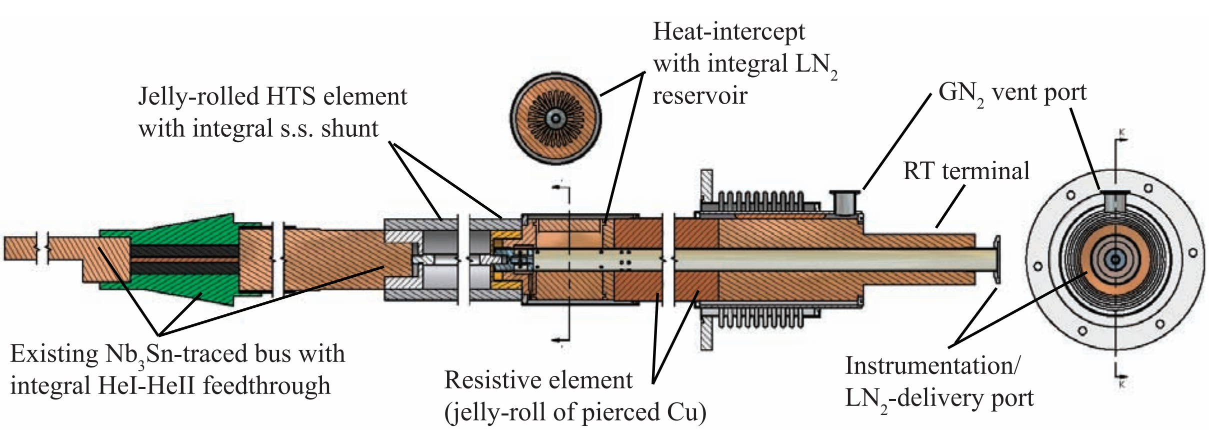


Figure 3. Sectional view of the HTS lead system showing principal components.

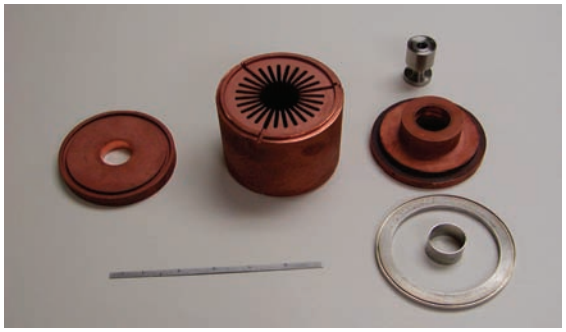


Figure 4. Heat-intercept with integral LN_2 reservoir.

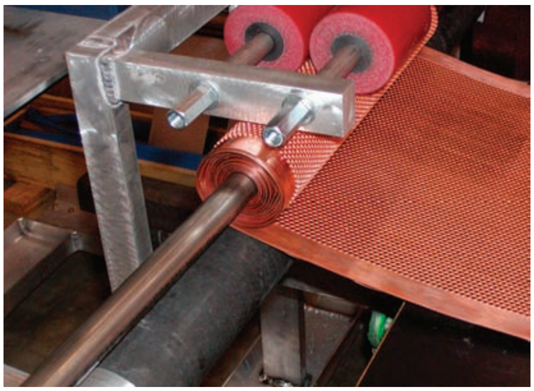


Figure 5. “Jelly rolling” the resistive section.

Series-Connected Hybrid Magnet CED

MS&T proposed, and in July 2004 was funded for, a Conceptual and Engineering Design (CED) study to define a new generation of powered dc magnet that would be targeted initially to operate in a regime of field, field quality, and sample volume not previously attempted. High field resistive magnets approaching 35 T, and the 45 T Hybrid, have uniformities on the order of 1000 ppm over a 10 mm DSV. The Keck magnet, a high-homogeneity resistive magnet, has a uniformity approaching 10 ppm, but provides only 25 T central field. High field persistent magnets like the NHMFL’s ultra-wide-bore, 900 MHz system provide field uniformity and stability in the ppb range but are presently limited to about 21-22 T. With a uniformity goal of 1 ppm and a central field of at least 36 T, the proposed magnet system will substantially expand the frontier for science in this region of parameter space. This comparison of systems is made graphically in Figure 6.

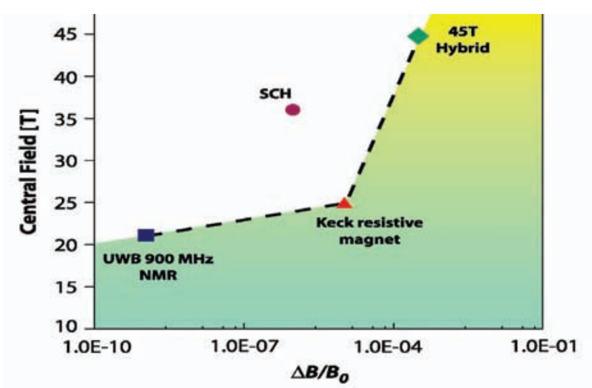


Figure 6. Uniformity and central field of the series-connected hybrid magnet in relation to other state-of-the-art facilities at the NHMFL. The region above the curve represents a regime that is presently unavailable.

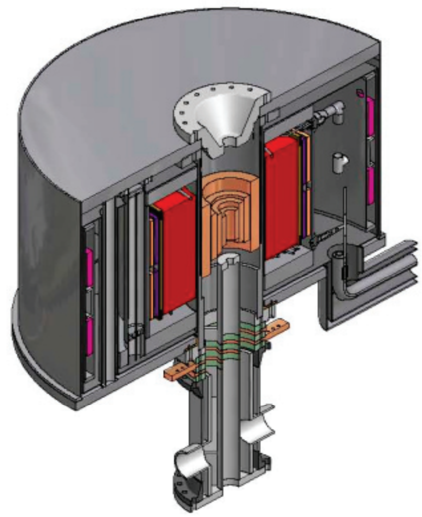


Figure 7. Sectional view of the series-connected hybrid magnet.

Called the series-connected hybrid (SCH), the proposed magnet system is a unique hybrid configuration comprising a large-bore superconducting outsert and a high-homogeneity resistive insert that are connected electrically in series. This configuration is illustrated in Figure 7. The housing for the resistive insert and the cryostat for the superconducting outsert are blended into a single structure for a more compact and cost-effective design. As shown, the system also incorporates a set of superconducting shield coils (also connected electrically in series) that reduce nearby fringe fields to less than the earth’s field within 15 m of the magnet center and a set of superconducting 1st order shim coils (powered separately).

A few important performance parameters of the SCH are listed in Table 3. At 36 T, the design field of the SCH exceeds presently available all-superconducting fields by 62% and fields in existing all-resistive magnets with similar bore and uniformity by 44%. Because of its naturally higher inductance/resistance ratio, substantially greater temporal stability can be achieved than with present all-resistive or traditional hybrid magnets. Importantly, the amplitude of the high-frequency fluctuations will be preferentially suppressed, and new flux-stabilization techniques will further enhance the field stability.

Table 3. General Parameters of the Series-Connected Hybrid Magnet System

Central field	36 T
Warm bore	
(inside resistive shim set)	40 mm
Operating current	20 kA
DC power required	12 MW
Uniformity over 10-mm DSV	1 ppm

Homogeneity in the SCH will be improved by an order of magnitude over the world's highest-homogeneity resistive magnet, the NHMFL's 25 T Keck magnet, through the use of both superconducting and water-cooled resistive shims, allowing scientific exploration into a region of high field and high-homogeneity parameter space unavailable anywhere else in the world. The SCH will consume about one half the power of the existing high-uniformity, 25 T Keck magnet while operating at 11 T higher field. This system will have substantially lower operating costs than any magnet in its class. Some of the science applications envisioned for the SCH are listed below by category:

- Condensed Matter Physics: Electronic, magnetic, optical, and superconducting properties of materials
- Materials Chemistry: Characterization of inorganic metal oxides, catalysts, conductors, semiconductors, and biocompatible surfaces
- Biological Science: Structures of membrane proteins and ion channels, novel contrast in magnetic resonance microscopy.

The primary objectives of the CED study are (1) to provide detailed designs and specifications for the principle subsystems (including the superconducting outsert, the resistive insert, the combined insert housing/outsert cryostat, the refrigeration system, the power/protection system, etc.), (2) to identify and carry out essential development tasks, and (3) to produce reliable cost estimates for magnet-system construction when approved. We are on-target for meeting these objectives by July, 2006.

Technology & Innovations

Resistive Insert. Most of the field generated will come from the resistive insert (23.1 T) that uses Florida-Bitter construction, now a standard and proven technology. However, the insert for the first version will incorporate new techniques for achieving high homogeneity. Future SCHs can have different inserts to accommodate a broad range of field environments and science applications.

Superconducting Outsert. The superconducting outsert comprises a primary Nb_3Sn coil and a NbTi shield coil. This combination contributes 13.5 T to the central field. Both are wound with cable-in-conduit conductors (CICC), which have similarities to conductors used in the 45 T Hybrid. The cabled strands of superconductor wire (up to several hundred) are contained within a high-strength conduit that provides the structural support against the magnetic loads and contains flowing liquid helium in direct contact with the strands. Figure 8 shows the CICC configurations for the primary coil, the shield coil, and the superconducting shim coils. The conduit for the primary coil is a Cr-Ni-Mo superalloy, chosen for its high strength, high toughness, high modulus, and good thermal expansion match to the strain-sensitive Nb_3Sn superconductor in this coil.

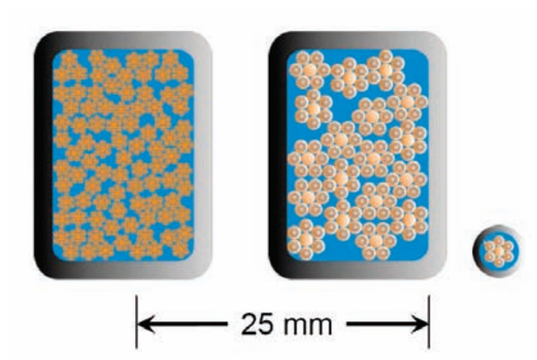


Figure 8. Cross sections of the cable-in-conduit conductors for the primary outsert coil, shield coil, and superconducting shim coils (from left to right).

Shield Coil. With the long-term future prospect of having up to four SCH magnets operating simultaneously, the issue of fringe field becomes important. The SCH includes a shield coil designed to null the magnetic moment of the insert and primary outsert coils. With the magnet shielded, the 10 g line is 4.3 m from the magnet center, otherwise it would be 10.6 m.

Shims. To achieve the 1 ppm uniformity both superconducting and resistive, shims will be utilized. The superconducting shims are designed to adjust the *X, Y,* and *Z* terms of the central field. They are constructed with NbTi CICC with a maximum operational current of 1 kA. The strengths are 40 ppm from the Z shim and 20 ppm for the X and Y shims. The resistive shims complete the eight terms for uniformity. They are contained on the outer diameter of the bore tube where they are cooled by the cooling water of the resistive insert.

HTS Leads. To reduce the consumption of liquid helium, high temperature super-conductor (HTS) will be used extensively in the power leads that drive the superconducting magnet and superconducting shims.

Cryogenically Cooled Support Column. The structural supports for the superconducting magnet vessels are designed with a novel method of intercepting heat. The support columns are configured with a double shell for containment of helium that flows up the column and recycles back to the refrigeration system.

Flux Stabilization. Small fluctuations in magnetic field are present in powered magnets from the ripple in the power supplies and thermal transients in the resistive coils. As part of the Series-Connected Hybrid program, technological developments are being conducted to compensate for the time dependent changes in magnetic field. This flux stabilization is achieved by using a small sensing coil, located in the warm bore, to pickup changes in the magnetic field. This information is then used to drive a compensation coil to negate the changes.

Persistent Magnets

Ultra-Wide Bore 900 MHz NMR Magnet

The Ultra-Wide Bore 900 MHz magnet reached full field on July 21, 2004. At that time a commissioning phase was begun that included characterization of the magnet and the development of probes. It also marked the beginning of a transfer of responsibility for system operations to the NMR Science group. The commissioning phase has now been completed and MS&T has assumed a secondary support role for both maintenance and operations. During recent operations of the UWB 900 MHz system, the most significant achievement was the recharge, which at the present drift rate must be performed every 12 months. The magnet current was successfully increased to raise the frequency from 895 MHz to 900.4 MHz.

30 T, 1.3 GHz NMR Study

The COHMAG report of the National Academy of Sciences provided an assessment of high field magnet science and technology in the United States and identified possible new initiatives for future high field magnets. Regarding NMR, the report identified high-resolution NMR spectrometers in the range of 30 T/1.3 GHz as having great scientific interest. As a result, a scoping study was undertaken to examine issues associated with 30 T superconducting magnets. The enabling technologies are HTS conductors and the associated coil technologies. Significant issues remain for application of HTS conductors to large coils, including quality of conductors in long lengths, heat-treatment processes, anisotropy in the critical current capacity of conductors, and strain dependence. The outer LTS coil sections are necessarily large, with high stress and stored energy. Structural issues in these coils (including high-strength conductor and reinforcement) and quench-protection issues are significant. The status of technology required for a 30 T NMR magnet has been examined, and a preliminary conceptual design has been created in preparation for generating a credible proposal for a design and development program.

21 T FT-ICR Study

The laboratory has identified as one of its next high field, persistent-magnet targets, a 21 T superconducting magnet system for a Fourier Transform Ion Cyclotron Resonance (FT-ICR) mass spectrometer. The fundamental parameters required for this system, 21 T central field and 110 mm warm bore, are similar to those already successfully demonstrated in the NHMFL's UWB 900 MHz NMR magnet system. However, there are several ancillary requirements of the FT-ICR spectrometer demanding special technical attention, including fringe-field restrictions requiring shielding, increased length of the uniformity zone, inhomogeneity restrictions, horizontal orientation of the magnet axis, and limitations on the length of the cryostat. The plan for the project is to use a phased approach, beginning with an initial Conceptual Design and Development Phase, then proceeding to the solicitation of proposals from commercial suppliers for completion of engineering design and construction of one system for the NHMFL and possibly others for the Pacific Northwest National Laboratory and the Korea Basic Science Institute, who are also contributing funds to the project. These proposals from the commercial sector will contribute to the foundation of our own proposal to prospective funding agencies for support of an Engineering-Design and Construction Phase.

External Activities

Short-Period, Wide-Gap Nb_3Sn Undulator Study

Our 2004 scoping study of a short-period, Nb_3Sn-based, superconducting undulator for the Advanced Photon Source (APS) at the Argonne National Laboratory pointed out the feasibility of a 15 mm-period system with 0.8 T on the beam using state-of-the-art Nb_3Sn superconductors. Subsequently, the APS awarded a contract to us to develop a demonstration model for such an undulator. Among other things, this project provided MS&T with an opportunity to gain valuable understanding and experience with recently developed and very high-performance, internal-tin conductors. The fact that both the conductor and the magnet are of interest to the high-energy physics (HEP) community adds to the appeal of this project and to the prospect of developing closer relations with that community.

Conceptually, the magnet windings consist of hundreds of small racetrack-shaped coils on two (mostly) ferromagnetic yokes. The beam tube is thermally insulated from the magnet windings to minimize undesirable magnet/beam interactions that might result, for example, from magnet quenches or beam heating. The NHMFL is developing an undulator demonstration model with a limited number of racetracks to qualify the cryogenic concept, to assess achievable current density (J_c), and to evaluate assembly procedures. Recent progress has centered primarily on the latter two issues.

Regarding current density, it should be noted that the conductor envisioned for this project was developed primarily for high field applications ($B \geq 12$ T). Standard specifications at this time include non-Cu current densities of over 2000 A/mm^2 at 12 T, 4.2 K, with record values approaching 3000 A/mm^2. The maximum field value in the undulator is only about 5 T, and the extrapolated current density at those relatively low field values is more than doubled, contributing to the potential for low-field instabilities or flux jumps that may limit the actual performance below the extrapolation. A candidate internal-tin conductor was heat treated and characterized at 4 K using SQUID and VSM, revealing a field dependence of magnetization J_c that is well described by standard flux-pinning models. ITER-barrel measurements of transport I_c will complete the characterization and indicate whether the observed high RRR values lead to sufficient stability. Adjustment of the heat-treatment schedule to maximize RRR, at the cost of a somewhat reduced J_c, is the available tool to enhance the stability. Alternatively, powder-in-tube conductor can be considered, which has shown sufficient current density (at 12 T), albeit somewhat lower than the best internal-tin conductors, and is generally more stable since the effective diameter of the superconducting elements is typically smaller. It may, therefore, achieve a larger fraction of its extrapolated potential at 5 T.

Possible assembly procedures for the yoke and windings range from fully modular on one hand, using a repetitive structure of many elementary parts with joints between racetracks, to a more traditional single-piece yoke with uninterrupted windings. Both approaches are under development, and the machining of hardware was underway at the end of 2005. A modular-assembly approach allows selective application of iron and non-magnetic materials in the yoke, unlike the single piece yoke approach. A finite-element analysis revealed that there are at least two practical material allocations that are more efficient than a fully iron yoke. Iron plates stacked axially between racetracks combined with stainless-steel cores within a racetrack require 10% less current for the same field on the beam. It is equally efficient when only the part of such plate closest to the beam is of iron, and the design becomes slightly more efficient if holmium is used, but these options are less practical. A consequence of the modular approach is the need to connect the large number of individual racetracks with joints that are better than simple solder joints. However, they do not need to be persistent; a simplified approach derived from NMR-style joint processes should be sufficient.

In conclusion, the development of a short period Nb_3Sn undulator demonstration model is underway, with the focus to date on conductor characterization and development of assembly approaches.

JPL Levitation Magnet Feasibility Study

MS&T carried out a study with the support of the Jet Propulsion Laboratory (JPL) for a levitation magnet. The object of the study was to assess capabilities for achieving a set of JPL requirements using current state-of-the-art in superconducting magnet technology.

A parameter study of a variety of ideal magnet geometries has demonstrated a number of general features for three configurations of coil, including: simple solenoid, solenoid with end bucking coil, and solenoid with end bucking coil plus over-wound end coil. The general results found for these configurations include:

- The force density can be displayed as a function of central field and bore size for a range of magnet parameters.
- The force is found to decrease as the bore is increased, even for a constant central field, and increases directly as the central field for a given size magnet.
- The force zone size is found to be almost insensitive to design details, and dependent primarily on bore size.
- The use of end bucking coils improves the force density noticeably, but the most straightforward improvement in force density is through a high central field.

A detailed study of magnet designs limited to conventional conductors (Nb_3Sn and NbTi) gives two versions of a magnet that produces the required 14 T^2/cm. The designs include end bucking coils to increase the force density for the same value of central field and peak field. The designs included attention to practical values of current density in the windings for conventional conductors. The general three-dimensional aspects of the force-uniformity zone were developed for these designs, showing a zone that is broad across the bore of the magnet.

The achievement of the required force in larger-bore magnets, which would also result in larger uniformity zones, required HTS conductors for which there is potential availability in the relatively near future.

30 T Neutron Scattering System for Hahn-Meitner Institute

A study was undertaken to establish practical design parameters of a horizontal-axis, series-connected hybrid (SCH) magnet system for use with neutron-scattering experiments in the field of structural research at the Berlin Neutron Scattering Center (BENSC) of the Hahn-Meitner Institute (HMI), and the results of that study were presented to HMI in November, 2005. The system defined for HMI includes not only the magnets but all subsystems essential for its operation, i.e.: the combination outsert cryostat/insert housing, the outsert refrigeration system, the auxiliary cryogenic subsystems (subcooler and buffer dewar), the high-power dc system for powering the magnet, the low-conductivity water-cooling system, etc. A layout of the complete system as planned for installation at the HMI-BENSC site is shown in Figure 9.

The superconducting outsert is based on the SCH design to be installed at the NHMFL, but the combined system will be adapted to the special requirements at HMI-BENSC, namely:

- Horizontal field orientation
- Down-the-bore beam
- 50 mm clear bore
- Conical entry and exit
- 30^o total view angle (15^o half angle)
- Greater than 25 T central field
- Spatial uniformity, better than 0.5% over 20 mm DSV
- Temporal stability, better than 0.01% to 0.05%
- Actively shielded (< earth's field at 15 m)
- Capability for varying the magnet axis relative to the beam by $\pm 15^o$.

A cross-sectional view of the magnet in its present conceptual design is shown in Figure 10. The expectation is that MS&T will

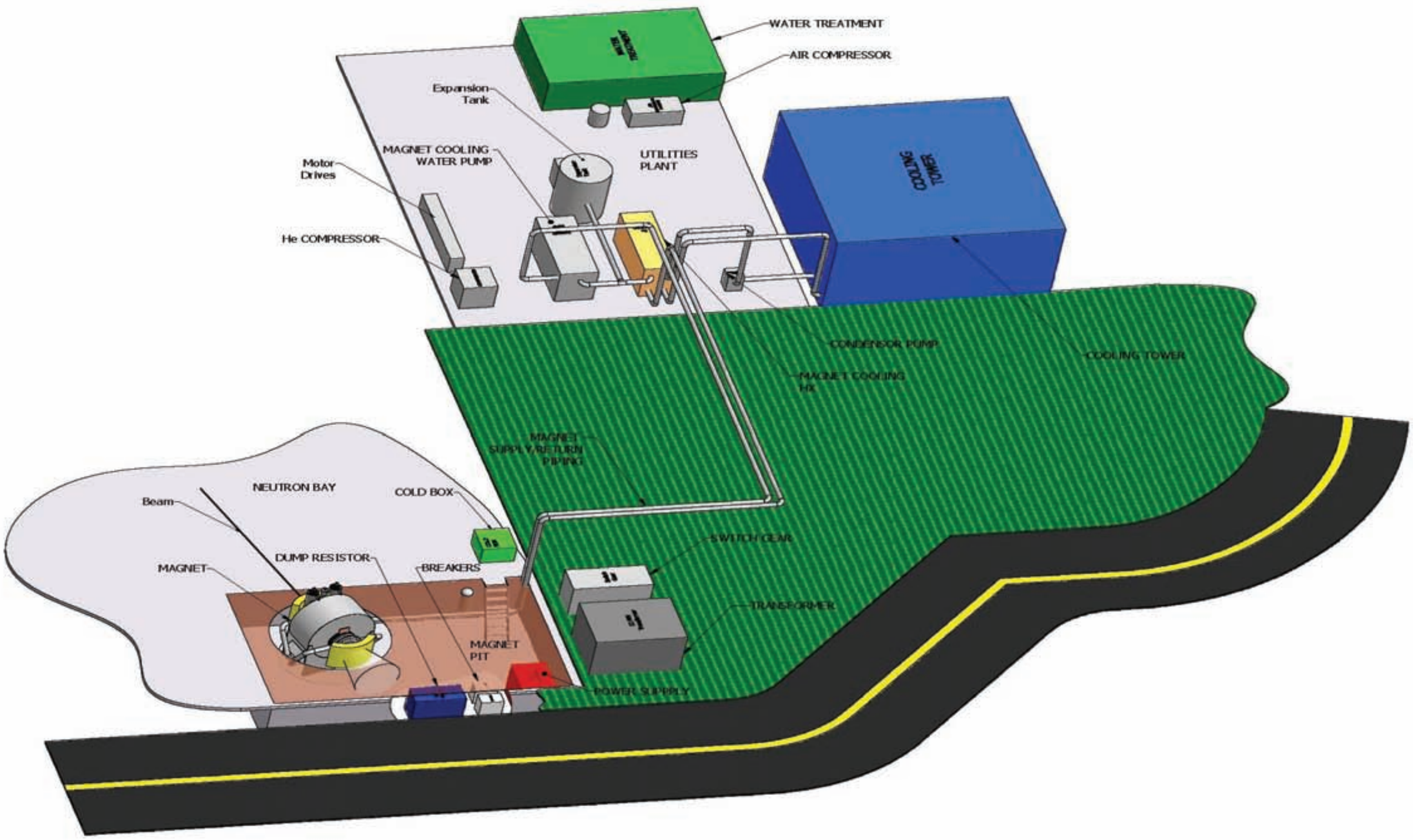


Figure 9. Layout of SCH neutron scattering at HMI-BENSC, including all subsystems essential for operation.

enter into a contract to support HMI in the detailed design and construction of the complete system beginning in 2006. The magnets with cryostat/housing would be assembled and tested at the NHMFL prior to delivery to HMI.

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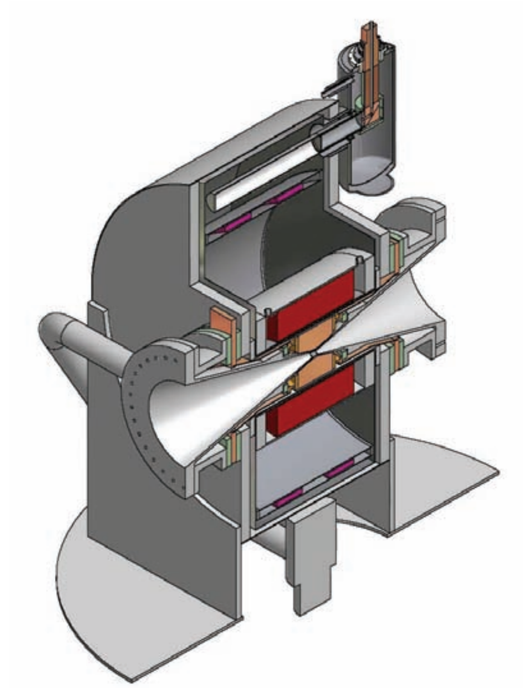


Figure 10. Cross-sectional view of the horizontal-axis SCH with conical entry/exit ports for HMI-BENSC.

CHAPTER 5
IN-HOUSE RESEARCH PROGRAM

The National Science Foundation charged the National High Magnetic Field Laboratory (NHMFL) with developing an in-house research 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.

To this end, the NHMFL established in 1996 an in-house research program that stimulates magnet and facility development and provides intellectual leadership for experimental and theoretical research in magnetic materials and phenomena. The NHMFL In-House Research Program (IHRP) 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
- initial seed support for new faculty and research staff, targeted to magnet laboratory enhancements.

The IHRP 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.

Ten IHRP solicitations have now been completed with a total of 340 pre-proposals being submitted for review. Of the 340 proposals, 175 were selected to advance to the second phase of review, and 72 were funded (21% of the total number of submitted proposals).

2005 Solicitation and Awards

The NHMFL IHRP has been highly successful as a mechanism for supporting outstanding projects in the various areas of research pursued at the laboratory. Since 2001, the submission and reviewing have been handled by means of a Web-based system. Also since then, there have been two review stages.

Of the 22 pre-proposals received, the committee recommended that 14 pre-proposals be moved to the full proposal state. Of the 14 full proposals, 6 proposals were awarded. A breakdown of the review results is presented in Tables 1 and 2.

Table 1. IHRP Proposal Solicitation Results, 2005

Research Area	Pre-Proposals Submitted	Pre-Proposals Proceeding to Full Proposal	Projects Funded
Condensed Matter Science	9	7	3
Biological & Chemical Sciences	7	5	3
Magnet & Magnet Materials Technology	5	2	0
Cross Disciplinary	1	0	0
Total	**22**	**14**	**6**

Table 2. IHRP Funded Projects from 2005 Solicitation

Lead P.I.	NHMFL Institution	Project Title	Funding
Ho Bun Chan	UF	*Micromechanical Devices for Magnetometry in Pulsed and Continuous Magnetic Fields*	$126,512
Irinel Chiorescu	FSU	*Time-Resolved, High Field Studies of Spin Relaxation Processes in Molecular Magnets and Organic Conductors*	$158,281
Gail Fanucci	UF	*Double Electron-Electron Resonance (DEER) Spectroscopy of Biological Macromolecules*	$170,778
Timothy Logan	FSU	*Glycoprotein and Glycoconjugate NMR at 900 MHz*	$247,709
Eric Palm	FSU	*Development of a SQUID Magnetometer for Use at Low Temperatures and High Magnetic Fields*	$228,225
Steven Van Sciver	FSU	*High-Resolution Separation of Micro- and Nano-Particles by Density and Size Using the Magneto-Archimedes Effect in Liquid Oxygen*	$167,952

2006 Solicitation

The 2006 Solicitation Announcement will be released March 16, 2006. Awards will be announced by the end of the year.

Results Reporting

To assess the success of the IHRP, reports were requested in April, 2005, on grants issued from the solicitations held in the years 2000 through 2003, which had start dates respectively near the beginnings of years 2001 through 2004. 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 IHRP. Since IHRP 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 IHRP grant had made possible, even if these were obtained after the term of the IHRP grant was complete.

Tables 3, 4, and 5 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 5 articles in *Nature*, 10 *Physical Review Letters*, and an article 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 3. Reporting results summary, by first year of grant. (The solicitations were issued in the prior calendar year.) The last three columns show the percentage of reports from the year that indicated publications, NHMFL facility enhancement, or external funding.

First Year of Grant	Total Reports	In Progress %	Publications %	Enhancement %	External Funding Generated %
2001	4	0	100	50	50
2002	6	33	83	67	50
2003	6	50	50	67	50
2004	6	100	33	50	17

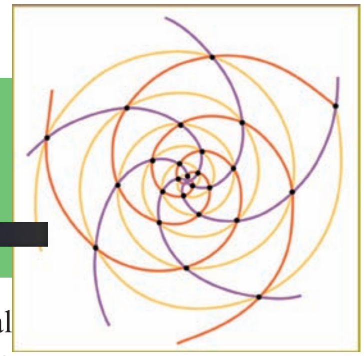
Table 4. List of Reported Facility Enhancements

- Essential, "digital lock-in" type data acquisition instrumentation for pulsed magnets
- NMR instruments for 45 T Hybrid
- High-resolution, magic-angle spinning (HRMAS) NMR probe for the 25 T Keck magnet
- Pressure cells, tunnel diode oscillator measurement capability
- NMR probes for 900 MHz
- Femtosecond spectroscopy for NHMFL magnets
- Cryogenic deformation process for making materials for magnets
- Ultralow temperature ultrasound measurement setup, and work toward kapton-based capacitance thermometer
- EPR spectrometer (170-880 GHz)
- Point contact spectroscopy set up
- Rf amplitude modulation calorimeter
- Development of resonant ultrasound capability
- ^{1}H ^{19}F double resonance NMR probe development

Table 5. Publications (including accepted for publication) as of April 2005

Acta. Materialia	2	*Mat. Science Forum*	1
Appl. Phys. Lett.	2	*Nature*	5
IEEE Trans. Appl. Supercond.	6	*Phil. Mag.*	2
Chem. Phys. Lett.	1	*Physica B*	7
Int. J. Mod. Phys. B	7	*Physica E*	4
J. Am. Chem. Soc.	1	*Phys. Rev. B*	6
J. Low Temp. Phys.	3	*Phys. Rev. B Rapid Comm.*	4
J. Magn. Reson.	3	*Phys. Rev. Lett.*	10
J. Physics – Condens. Mat.	1	*Solid State Commun.*	1
Macromolecule	1	Conference proceedings	6
Mat. Science Eng.	1		

CHAPTER 6
EDUCATION



The Center for Integrating Research and Learning continues to expand its national presence as a science education resource with new programs, new national networking possibilities, and new ways of delivering educational outreach to students, teachers, and the general public. **Pat Dixon, director, Jose Sanchez, assistant director, and Carlos Villa, outreach coordinator**, keep up with current local, regional, state, and national educational policy initiatives to provide the best in enhancement of classroom science education. This includes outreach into the classroom, professional development, curriculum development, new partnerships, educational research to support Center activities, encouraging undergraduates to pursue graduate work in the sciences, and other programs that address current needs in science.

With the addition of expertise from **Ryan Wilke, graduate research assistant**, 2005 saw a reinvigorated educational research agenda that has resulted in several presentations at national conferences. A second study was completed that examined how teachers make changes as a result of participating in the Research Experiences for Teachers program, and two new studies are planned.

Recent increased attention to math and science education underscores the importance of Center programs and challenges all of us to adapt programs to meet national and state mandates in science education. In addition, the well publicized "leaky pipeline" of American students into the sciences places an even greater burden on educational outreach programs from national laboratories to reach students early and encourage their participation in science.

K12 Programs

Over 9,000 students, teachers, and members of the general public took advantage of Magnet Lab programs either at the laboratory or at remote locations. **Carlos Villa**, outreach coordinator, made 263 visits to schools in three states and 9 counties, conducting a wide variety of outreach programs for 6,636 K12 students. The total number of people who toured the Magnet Lab, up from 2004, was 1,184, not including the Annual Open House. The eleventh Annual Open House, held in March 2005, attracted over 4,300 people to the facility to participate in interactive exhibits designed to translate the research conducted at the laboratory.

In addition to outreach and tours, Center educators and scientists and researchers from the laboratory took part in 22 community events ranging from Focus on Physics at the public library to conducting science fair workshops. In addition, scientists routinely serve as science fair judges for local and regional competitions. The Center hosted 17 middle school students in a semester-long mentorship during which seventh graders conducted research alongside Magnet Lab researchers (see ***http://education/K12/middle_mentor/***). Talented high school students participating in Florida Agricultural and Mechanical University's RIMS program shadowed Research Experiences for Undergraduates participants in a 2-week research experience of their own. CIRL outreach programs were disseminated to the broader science education community at the Florida Association for Science Teachers and the National Association for Science Teaching national conferences.

Undergraduate Programs

Research Experiences for Undergraduates remains a significant part of the Center's work attracting qualified students from across the nation. In 2005, the Magnet Lab received 183 applications for 20 positions in research laboratories in Tallahassee, Gainesville, and Los Alamos.

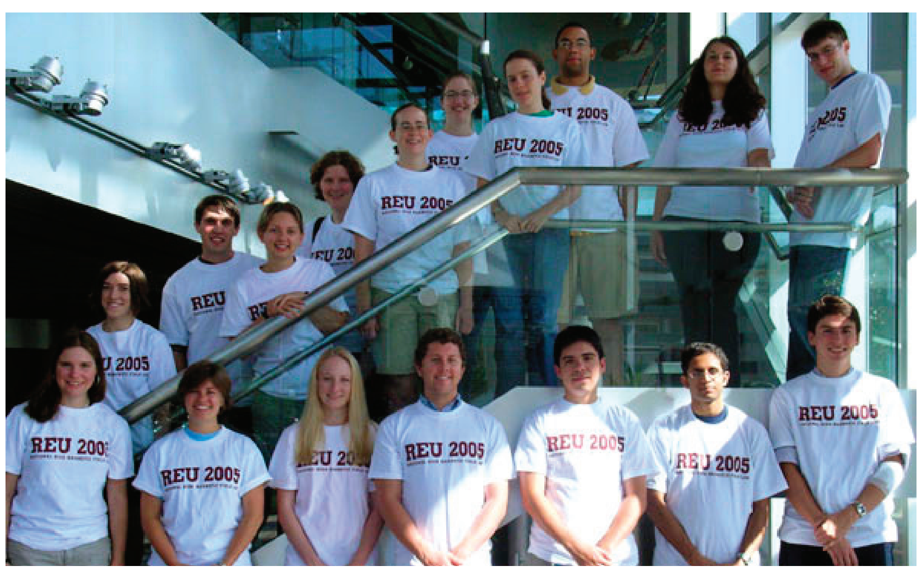


Table 1. Research Experiences for Undergraduates, Class of 2005

Tallahassee Research Location		
Intern	**University**	**Mentor**
Emily Carpenter	University of Wisconsin	Justin Schwartz, Ulf Trociewitz and Sastry Pamidi
Lindsey Channels	Bowling Green State	James Brooks
Brian Chapler	San Diego State University	Stan Tozer
Tim Chiocchio	Florida State University	William Brey
Kristen Downs	University of Florida	Michael Davidson
Sanjiv Goli	Princeton University	Alexei Souslov
Tomi Herceg	Princeton University	Arneil Reyes
Andrew Korinda	University of Delaware	Yan Xin
Stephanie Law	Iowa State	Steve Van Sciver
Andrea Luber	Clarkson University	Tim Logan
Francisco Luongo	Stanford University	Ke Han
Kelly McKirahan	Colorado School of Mines	Dragana Popovic
Evelyn Mervine	Dartmouth College	Roy Odom and Vincent Salters
Claudia Niculas	University of Georgia	Luis Balicas
Elizabeth “Liz” Olhsson	University of Oregon	Justin Schwartz, Ulf Trociewitz and Sastry Pamidi
Kathleen Schwarz	Washington University	Peter Fajer
Charles Stein	Texas Southern University	Irinel Chiorescu

Gainesville Research Location		
Intern	**University**	**Mentor**
Obioma Odionyenma	Xavier University of Louisiana	Art Edison
Kimberly Wadelton	Sweet Briar College	Mark Meisel
Marianna Worczak	Clarkson University	Mark Meisel

Center Director, Pat Dixon, served on the Steering Committee and participated in a **pan-REU workshop held at NSF headquarters in Arlington, Virginia, in September 2005**, the first such gathering in the program’s history. Sixty REU sites participated, representing all of the NSF divisions and directorates that fund REU programs. The workshop was initiated by the REU Chemistry Leadership group, a committee of nine site directors that works to strengthen the chemistry REU program. Committee chairs were **Randy Duran**, University of Florida, and **Mary Boyd**, Georgia Southern University. The purpose of convening the workshop was to bring attention to diverse REU programs nationwide, accomplished through a poster session held in the U.S. House of Representatives Science Committee room and sponsored by AAAS. The workshop was organized around (1) the impact of REU at the national level; (2) the impact of REU programs on students; and (3) strategies for running and assessing REU sites.

In September 2005, two REU participants, **Kristen Downs** and **Tim Chiocchio**, presented their research at the University of Florida Research Experiences for Undergraduates poster session in Gainesville, Florida. This opportunity also facilitated publishing their research posters on the REU On-line Poster Session.

Professional Development

The Center works on a regular basis with local schools and the local school district to provide quality professional development for area teachers. In addition, the Center continues to support national workshops to disseminate curriculum products developed at the Magnet Lab. Forty teachers attended a 4-day summer institute on **Literacy and Literature in Science**. Supported by the local school district, Center educators helped teachers use research-based strategies to support hands-on inquiry based science in the classroom.

The Center’s signature Research Experiences for Teachers program hosted eleven teachers in an intensive 6-week internship with Magnet Lab researchers. Two teachers returned for a second year in the program; one participant was a pre-service teacher; and three teachers were in years 1-5 of their teaching careers.


pan-REU workshop held at NSF headquarters in Arlington, Virginia

Table 2. Research Experiences for Teachers, Class of 2005

Teacher	School	Mentor
Ann Marie Bissoo	Sabal Palm Elementary	Bob Goddard
Margaret (Margy) Callaghan	Hawks Rise Elementary	Jim Walker
Melvin C. Figueroa-Mateo	New River Middle School	Johan Van Tol
Helen Follis	Roberts Elementary School	Bob Goddard
Jonathan Hamilton	Buck Lake Elementary	Johan Van Tol
Soon Young Kim	Moanalua High School	Michael Davidson
Bronislava Lawhorn	Flagler College	William Brey
Jose Sanchez	Belen Jesuit Prep	William Brey
Donna Steele	Oak Grove Middle School	Alexei Souslov
Marcy Steele	Ruediger Elementary	Jim Walker
Amanda Witters	Gilchrist Elementary	Alexei Souslov

Ryan Wilke, graduate research assistant, **Farrell Rogers**, RET participant, and **Pat Dixon**, center director, attended a Teacher Research Experiences conference at the University of Rhode Island and participated in intense discussions on program improvement, research, and evaluation being conducted currently on RET/TRE programs, and on possible partnerships among the varied programs.

The Research Experiences for Teachers program has resulted in a number of "spin-offs," including teachers continuing to participate in outreach activities. One of the most successful of these activities is the recent **American Geophysical Union Geophysical Information for Teachers workshop** that was conducted by two former RET participants, **Richard McHenry**, Leon High School, Tallahassee, Florida, and **David Rodriguez**, Swift Creek Middle School, Tallahassee, Florida. For the first time, the GIFT workshop was designed and facilitated by practicing high school and middle school teachers, the target audience for AGU at their annual national conference. In addition, RET participants from around the country were invited to apply for additional funding to support travel to the conference. The Magnet Lab RET program was represented by five teachers. The workshop panel consisted of research scientists from various fields that related to the overall theme: **Journey to the Center of the Earth**. The other component was made up of hands-on presentations that related to the topics of the research scientists.

The Magnet Lab's long-running **Ambassador Program** evolved this year to include a professional development component that has been extremely well received by area teachers. The program continues to be the primary pipeline for information from the Magnet Lab and the Center to area schools.

Partnerships

Partnerships between the Center and other informal science education sites, partnerships with **other universities** that facilitate REU and RET programs, and partnerships with **other Florida State University departments** have led to the submission of three proposals designed to extend the RET program. In addition, **partnerships with cultural, historical, and scientific entities in north Florida and south Georgia** have led to opportunities to further enhance science education across platforms.

On a smaller scale, the Magnet Lab entered a partnership with two local schools to enhance students' capabilities to gather data and to mentor one another through complex chemistry labs. In the fall of 2005 the Center provided a high school chemistry classroom and a sixth grade middle school classroom with eight laptop computers each. The classes are divided into eight cooperative learning groups, with each group having access to one of the laptops that they use for writing lab reports that include experimental data tables. Because of this partnership, the school equipped both classrooms with wireless access points, so groups are able to access the internet to obtain information related to their lab. The groups also access tutorial web sites to get added instruction on the concepts they are learning in class. Communication is encouraged between the high school students and the middle school students in hopes that the middle school students will be encouraged to take upper level chemistry courses when they reach high school.

The Magnet Lab participates in a partnership with a local fifth grade teacher through which "science totes" were created to promote science outside of the classroom. Each Friday five students take home the totes with an experiment to complete with their family. The Center supplied this classroom with the materials needed to create exciting scientific opportunities for these students and their families, including science experiments, journals, and children's literature.

An ongoing partnership with the Department of Astronomy and Physics Professor Diandra Leslie-Pelecky resulted in Center participation in the Broader Impacts Workshop held at NSF. Education outreach professionals gathered to address ways in which scientists can meet the Broader Impacts criterion through a variety of educational programs. This intensive 2-day workshop resulted in a larger conference planned for 2006-2007.

Educational Research

Graduate Research Assistant Ryan Wilke and Center Director Pat Dixon, completed a **second RET study, The Influence of a Teacher Research Experience on Elementary Teachers' Thinking and Instruction**. The purpose of this study was to investigate whether and how elementary teachers' thinking and instruction changed as a result of a teacher research experience. Four elementary teachers participated in a six-week professional development program designed to promote changes in scientific thinking and instructional practices. Each teacher worked with a scientist conducting research and collaborated with other teachers in translating their experiences into lessons. Data in the form of classroom observations and interviews were collected both before and after the research experience. Document analysis was also conducted on laboratory notebooks, reflective journals, and lesson plans that were collected during the research experience. Discussed are the specific changes to thinking and instruction that resulted from the research experience and how such changes differed between beginning and experienced elementary teachers. An article based on the study has been accepted by *The Journal of Elementary Education.*

CHAPTER 7
COLLABORATIONS

In accordance with one of the laboratory's mission objectives "to engage in the development of future magnet technology," NHMFL researchers and staff work aggressively to engage the private sector, other federal agencies and institutions, and international organizations to advance a wide variety of magnet-related technologies and projects. These important external collaborations are an excellent means of fulfilling this laboratory's mission to advance magnet related technologies and promote U.S. economic competitiveness while enhancing user facilities.

NHMFL Private Sector Activities in the United States

Advanced Technology Group, Stewart, FL. Advanced Technology Group in collaboration with the NHMFL has been developing two-phase mass flow metering technology for liquid oxygen and liquid hydrogen. Multiphase flow is of interest to **NASA** for future space missions. The mass flow meter is being developed as a prototype for determining flow conditions in microgravity. The NHMFL Cryogenics group is providing the cryogenic test facility and instrument calibration.
(NHMFL contact: Steve Van Sciver, MS&T)

Alabama Cryogenic Engineering, Inc., Huntsville, AL. Alabama Cryogenic Engineering, Inc. is a small business specializing in fabrication of materials via hydrostatic extrusion. The company and the Magnet Lab are currently developing joint proposals to fabricate both high-strength conductors for pulsed and resistive magnets and low-temperature superconductors for next-generation superconducting magnets. Because of the high efficiency of the fabrication approach, conductors can be fabricated in an inexpensive manner. Hydrostatic extrusion also has the potential to make homogeneous deformation, which provides uniform microstructure in the materials so that materials will have better performance than those fabricated by conventional approaches.
(NHMFL contacts: John Miller and Ke Han, MS&T)

Bioptechs, Butler, PA. The NHMFL 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.
(NHMFL contact: Mike Davidson, Optical Microscopy)

Bruker Biospin, Billerica, MA. The NHMFL NMR instrumentation program, AMRIS, and Bruker Biospin collaborated on the development of a high temperature superconducting probe for liquid-state NMR applications. The 600 MHz triple resonance probe is now in use at the McKnight Brain Institute at the University of Florida. The work is supported by NIH through grant number 1P41RR016105-01. Bruker Biospin also is supporting the development of static probes for biological solid state NMR of aligned membrane proteins in the NHMFL NMR program.
(NHMFL contacts: William Brey and Peter Gor'kov, NMR)

ADVANCED COVANCE. THE DEVELOPMENT SERVICES COMPANY BIOPTECHS

Chroma, Rockingham, VT. A major supplier of Interference filters for fluorescence microscopy and spectroscopy applications, Chroma is collaborating with the NHMFL to build educational tutorials targeted at fluorescence microscopy. Working in conjunction with **Nikon**, engineers from Chroma and scientists from the NHMFL are examining the characteristics of a variety of filter combinations.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Covance Research Products, Berkeley, CA. Covance is a biopharmaceutical company involved with research and diagnostic antibody production. NHMFL 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.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Diagnostic Instruments, Sterling Heights, MI. Scientists at the NHMFL are working with applications specialists at Diagnostics to field test the company's new line of cooled scientific "charge-coupled device" (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.

(NHMFL contact: Mike Davidson, Optical Microscopy)

ExxonMobil Corp., Irving, TX. The FT-ICR Facility at the NHMFL has an ongoing collaboration with this oil company to explore new mass spectrometric techniques for characterization of petroleum crude oil and its products. Current efforts involve application of field desorption/field ionization (FD), atmospheric pressure photoionization (APPI), electron ionization, and chemical ionization. FD and APPI provide access to non-polar components (e.g., hydrocarbons, thiophenes, etc.) not accessible by conventional electrospray ionization.

(NHMFL contact: Ryan Rodgers, ICR)

Foveon, Santa Clara, CA. An innovative corporation exploring true color "complementary metal-oxide semiconductor" (CMOS) image sensor technology, Foveon is involved with developing educational tutorials with the NHMFL that explain its cutting-edge technology in image sensor design. Scientists at the NHMFL are developing image galleries using a variety of optical contrast-enhancing techniques in the microscope.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Hamamatsu Photonics, Bridgewater, NJ. Scientists at the NHMFL 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.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Haynes International, Inc., Kokomo, IN. This manufacturer of specialty alloys is collaborating with the NHMFL Materials Development and Characterization Group in researching one of its superalloys (Haynes 242) for use in Cable-in-Conduit Conductor (CICC) superconducting magnets. The company has supplied samples of Haynes 242 in production form that can be directly processed into conduit for CICC magnets being built at the NHMFL. Metallurgists from the company are assisting our materials scientist in the selection of processing variables and the analysis of performance tests. The alloy's superior properties make it likely to be a direct replacement for conventional 316LN. The improved properties will allow increased superconductor performance along with a decrease in overall magnet size and cost.

(NHMFL contact: Bob Walsh, MS&T)

H.C. Starck, Inc., Cleveland, OH. H.C. Starck produces an assortment of refractory metal powders and super-alloys that is unique. This collaboration focuses on production of high strength MP35N nickel cobalt alloy sheet for reinforcement in support of the pulsed magnet program.
(NHMFL contact: Chuck Swenson, MS&T)

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

Molecular Probes/Invitrogen, Eugene, OR. A major supplier of fluorophores for confocal and widefield microscopy, Molecular Probes is collaborating with the NHMFL to develop educational tutorials on the use of fluorescent probes in optical microscopy.
(NHMFL contact: Mike Davidson, Optical Microscopy)

Nikon USA, Melville, NY. The NHMFL 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 NHMFL is field testing new Nikon equipment and developing new methods of fluorescence microscopy.
(NHMFL contact: Mike Davidson, Optical Microscopy)

Olympus America, Melville, NY. The NHMFL 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 NHMFL in Tallahassee. This activity will involve biologists at the NHMFL and will feature Total Internal Reflection Fluorescence microscopy.
(NHMFL contact: Mike Davidson, Optical Microscopy)

Omega Optical, Brattleboro, VT. The NHMFL 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 NHMFL scientists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission.
(NHMFL contact: Mike Davidson, Optical Microscopy)

Oxford Instruments America, Concord, MA. The Cryogenics group of the NHMFL and Oxford Instruments are collaborating on a project to use liquid helium as a separation medium for micron and sub-micron size particles. The technique uses the unique properties of superfluid helium (He II).
(NHMFL contact: Steve Van Sciver, MS&T)

Oxford Superconductor Technologies, Carteret, NJ. The manufacturer of Nb_3Sn superconducting wire is collaborating with NHMFL Materials Development and Characterization Group in researching its latest advanced low temperature superconductors. The laboratory's superconductor wire test facility is designed for testing the critical current vs. strain behavior of low temperature Nb_3Sn superconductors. Materials scientists at Oxford are assisting by providing the latest high performance superconductors and consultation with respect to test methodology and data analysis.
(NHMFL contact: Bob Walsh, MS&T)

HAMAMATSU OXFORD INSTRUMENTS MediaCybernetics Molecular Probes invitrogen detection technologies Nikon OMEGA OPTICAL Raytheon Semrock

Pfizer Global Research & Development, San Diego, CA. Dr. Michael Greig at Pfizer is collaborating with the NHMFL ICR program in a novel application of supercritical fluid chromatography (SFC) to separate peptides following hydrogen-deuterium exchange experiments, thereby essentially eliminating deuterium-hydrogen back-exchange, which had been the primary drawback to such analyses. This idea was a specific aim of the recently funded NIH project for which Dr. Greig is a contributor.

(NHMFL contact: Mark Emmett, ICR)

Photometrics (Roper Scientific, Inc.), Tucson, AZ. The microscopy research team at the NHMFL 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.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Raytheon, Tucson, AZ. We have been working with Abram Young and Delmar Barker at Raytheon to perform GHz frequency transmission studies of three dimensional photonic band gap structures. This collaboration is beneficial to Raytheon's research program, providing feedback to the design of photonic structures, and to the development of pulsed field GHz frequency apparatus at the NHMFL-Los Alamos.

(NHMFL contact: Ross McDonald, Pulsed Field Facility, LANL)

Semrock, Rochester, NY. The NHMFL 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 NHMFL scientists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission. In addition, NHMFL scientists produce images of living cells with Semrock filter combinations.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Stereotaxis, Inc., St. Louis, MO. Stereotaxis is leading in the development of intravascular navigation systems for heart and brain surgery and drug delivery. The catheters are magnetically guided. Stereotaxis has teamed with the NHMFL to develop a new generation of catheters that are flexible to ease the navigation around sharp corners or for large bending angles. The heat treatment of the CoPt wire, which constitutes the flexible catheter tip, has been optimized to maximize coercivity. An improvement of 50% has been achieved. Stereotaxis also supports the development of new magnetic materials. We are investigating a nanostructured $Nd_2Fe_{14}B$/a-Fe-type system with the goal to achieve very high energy products through high temperature annealing in a magnetic field.

(NHMFL contact: Ke Han, MS&T)

Toyobo, New York, NY. Toyobo supplies ultra-high-strength fiber and sample materials for composite development in support of the pulsed magnet program.

(NHMFL contact: Chuck Swenson, MS&T)

Training Solutions Interactive, Inc., I4Learning, Atlanta, GA & Tallahassee, FL. TSI and the Center for Integrating Research & Learning (CIRL) 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 and dynamic business relationship. Anticipated projects include an update of *Science, Tobacco, & You* and physics curriculum materials for high school students and teachers.

(NHMFL contact: Pat Dixon, Educational Programs)

Inter-Agency & Inter-Institutional Activities

Advanced Photon Source at the Argonne National Laboratory, Argonne, IL. The NHMFL is under contract to develop and test a Nb_3Sn undulator demonstration magnet, with the intent of developing magnet technology for a planar Nb_3Sn undulator at the IXS beam line of the Advanced Photon Source in Argonne, IL.
(NHMFL contact: H. Weijers, MS&T)

Columbia University, Stanford University, University of California Santa Barbara. 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. In 2005, the Center expanded its collaboration with the network to include the **University of Rhode Island**.
(NHMFL contact: Pat Dixon, Educational Programs)

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. (NHMFL contact: Pat Dixon, Educational Programs)

Los Alamos National Laboratory, Los Alamos, NM. The MS&T division in Los Alamos National Laboratory developed a new technique in casting eutectic Cu-Ag materials with refined structures. We are collaborating in fabrication of high strength conductors by further refining the microstructure. Los Alamos National Laboratory is casting and extruding the materials to various strains, and we are drawing them to the final sizes. Both parties are testing the materials. Some preliminary results were presented in a conference.
(NHMFL contact: Ke Han, MS&T)

Pacific Lutheran University, Tacoma, WA. The NHMFL completed a contract to provide two static biological solids NMR probes to be used in the lab of Professor Myriam Cotten.
(NHMFL contact: Peter Gor'kov, NMR)

Princeton Plasma Physics Laboratory (PPPL), Princeton, NJ. Researchers in the NHMFL Materials Development and Characterization Group have collaborated with engineers at PPPL to evaluate the fatigue crack growth rate of stainless steel components in the National Compact Stellarator Experiment (NCSX). Large-thick complex castings of a modified CF 8M steel used in the NCSX are susceptible to inherent flaws (voids) that act as crack initiation sites in the fatigue stressed structural components. The fatigue crack growth rate and the microstructure of the castings were evaluated and reported in a joint publication at the International Cryogenic Materials Conference, Keystone, CO.
(NHMFL contact: Bob Walsh, MS&T)

Sandia National Laboratories, Albuquerque, NM. The NHMFL collaborates with Sandia on the development of electromagnetic launch technology.
(NHMFL contact: Chuck Swenson, MS&T)

Scripps Florida, Boca Raton, FL. The NHMFL ICR program is collaborating with Scripps Florida in automation of data acquisition and data reduction for hydrogen-deuterium exchange as a means to map the surface of a drug:receptor complex. The first journal publication (in February, 2006) between Scripps Florida and an external institution resulted from this collaboration. Dr. Patrick Griffin of Scripps Florida is a contributor to a recently funded NIH project from the NHMFL ICR program.
(NHMFL contact: Alan Marshall, ICR)

University of Massachusetts, Amherst, MA. The NHMFL completed a contract to provide a static, biological solids NMR probe to be used in the lab of Professor Lynn Marie Thompson.
(NHMFL contact: Peter Gor'kov, NMR)

University of Nebraska-Lincoln, Lincoln, NE. In collaboration with Diandra Leslie-Pelecky, Department of Astronomy and Physics, the Center is working to assist scientists and researchers with meeting NSF Criterion II, Broader Impacts. The effort, with support from NSF, expands the role of the educational outreach professional.
(NHMFL contact: Pat Dixon)

NHMFL International Activities

A.A. Bochvar Institute of Inorganic Materials, Moscow, Russia. The NHMFL collaborates with the institute on the development of a high-strength high-conductivity conductor in support of the NSF 100 T insert program.
(NHMFL Contact: Chuck Swenson, MS&T)

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 NHMFL 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.
(NHMFL contact: Mike Davidson, Optical Microscopy)

Göteborg University, Göteborg, Sweden. Currently, the Swedish and NHMFL groups use electrospray FT-ICR MS to determine the structures of gangliosides, an important class of biomolecules containing both lipid and oligosaccharide components. A Swedish Foundation for International Cooperation in Research and Higher Education grant funds the exchange of students and researchers between the facilities.
(NHMFL contact: Carol Nilsson, ICR)

Grenoble High Magnetic Field Laboratory, Grenoble, France. Since the start of the NHMFL, the cooperation between the two high-field laboratories has been very successful and productive. Accomplishments include the 20 T, 50 mm bore magnets at the NHMFL and the joint development of the 20 T, 200 mm bore magnet at the NHMFL along with a similar magnet in Grenoble. The two labs also cooperated in the development of a model Repetitively Pulsed Magnet suitable for neutron scattering experiments.
(NHMFL contact: Mark Bird, MS&T)

Hahn-Meitner Institute, Berlin, Germany. HMI and the NHMFL have collaborated for several years on a proposal for a major resistive magnet facility installation in Berlin. In 2005 the NHMFL performed a feasibility study for a novel conical series-connected hybrid suitable for neutron scattering experiments. We concluded that a 25 T system with 15° half-angle would be feasible. In late 2005 a plan was developed to start a magnet development project.

(NHMFL contact: John R. Miller, MS&T)

High Field Magnet Laboratory, Radboud University, Nijmegen, The Netherlands. The NHMFL has been collaborating with the Nijmegen lab for several years in various activities, primarily the development of high-field resistive magnets. During 2005 we collaborated on the design of new high-field resistive solenoids of two different sizes to be built at Radboud University. In early 2006, the government of The Netherlands committed to the funding of a new 45 T-class hybrid magnet at Radboud University.

(NHMFL contact: Mark D. Bird, MS&T)

Korea Basic Science Institute, Daejeon, South Korea. Magnet Science and Technology is collaborating with the Korea Basic Science Institute (KBSI) to advance very high field superconducting solenoid technology through collaborative technology development. The present collaboration includes development of 1.8 K cryogenic technology with the goal of minimizing or eliminating cryogen refills. The 1.8 K operational temperature enables the use of higher superconducting current carrying capacities available at the lower temperature. The higher current capacities are used to create higher fields and/or higher operating margins, which in turn reduce risk. The present collaboration also includes a preliminary design study for a superconducting system that will advance very high field superconducting solenoid technology.

(NHMFL contact: Tom Painter, MS&T)

Korea Basic Science Institute, Daejeon, South Korea. Dr. Hyun Sik Kim heads a group of several KBSI scientists who are spending two years at NHMFL with the ICR program to modify a commercial 7 T FT-ICR mass spectrometer for ultimate installation in 2007 with a 15 T superconducting magnet at KBSI. The first stage is complete: replacement of the commercial data system with an NHMFL homebuilt system that controls data acquisition and data reduction and display. The second stage is underway: modification of the modules for ion introduction, ion accumulation, ion transmission, ion trapping and excitation/detection of the ICR signal. The project is funded by KBSI, separately from another joint KBSI/NHMFL project to build a 21 T superconducting magnet for FT-ICR mass spectrometry.

(NHMFL contact: Christopher Hendrickson, ICR)

Linkam, Surrey, United Kingdom. Scientists at the NHMFL collaborate with Linkam engineers to design heating and cooling stages for observation of liquid crystalline phase transitions in the optical microscope. In addition, NHMFL researchers are assisting Linkam in introducing a new heating stage for live-cell imaging in fluorescence microscopy.

(NHMFL contact: Mike Davidson, Optical Microscopy)

National Institute of Chemical Physics and Biophysics, Tallinn, Estonia. The NHMFL NMR program is sponsoring the development of cryogenic magic angle spinning (MAS) probes for NMR under the direction of Professor Ago Samosan.

(NHMFL contact: Zhehong Gan, NMR)

Olympus Corp., Tokyo, Japan. Investigators at the NHMFL have been involved in a collaboration with engineers at Olympus, Tokyo, to develop and test new optical microscopy systems for education and research. In addition to pacing the microscope prototypes through basic protocols, the NHMFL is developing technical support and educational Web sites as part of the partnership.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Qimaging, Burnaby, British Columbia, Canada. High resolution optical imaging is the focus of the NHMFL collaboration with Qimaging, a Canadian corporation that specializes in CCD digital cameras for demanding 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.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Tsukuba Magnet Laboratory, Tsukuba, Japan. In past years, the Tsukuba lab purchased a 30 T resistive magnet from the NHMFL including a spare set of coils under separate contract. The NHMFL will continue to provide coils as needed in the future. Preliminary discussions have begun regarding a new insert for the lab's 40 T class hybrid magnet.

(NHMFL contact: Mark D. Bird, MS&T)

Université de Reims, France. The collaboration between the NHMFL and the Université de Reims is related to the characterization of nanostructure materials. The materials are mainly Cu-Nb composites suitable for pulsed magnet development.

(NHMFL contact: Ke Han, MS&T)

CHAPTER 8
CONFERENCES & WORKSHOPS

5th North American FT-ICR Mass Spectrometry Conference

April 17-20, 2005
Key West, Florida
Meeting Site & Hotel Headquarters: Double Tree Grand Key Resort Hotel
Conference Chair: Mark Emmett

This biennial conference has become a primary forum for presentations of the latest and best developments in FT-ICR. The 2005 meeting attracted 115 leading researchers from the United States, Austria, China, Croatia, England, Denmark, Germany, Hungary, Korea, Russia, Sweden, and The Netherlands.

The technical program featured 44 posters and 25 invited speakers, concluding with a plenary lecture by the Magnet Lab's **Alan G. Marshall** on "Connections and Luck: The Basis of FT-ICR Mass Spectrometry." The invited presentations ranged from instrumentation to technique development in the biological/biomedical sciences ranging from pharmaceutical metabolism to proteomics, environmental analysis, and petroleomics, with special emphasis on new developments.

Generous sponsorship by Advion BioScience, Bruker Daltonics, Florida State University Department of Chemistry and Biochemistry, IonSpec, Oxford Instruments, Siemens, and ThermoElectron Corp. made it possible to provide registration and four nights lodging for all invited speakers as well as 19 student awards for poster presentations.

A Workshop on a 30 T High Resolution Magnet for NMR Spectroscopy and Imaging

July 28, 2005
Tallahassee, Florida
Meeting Site: NHMFL
Workshop Chair: Tim Cross

A very successful workshop was held at the NHMFL in the afternoon following the celebration for the opening of the Ultra-Wide Bore 900 MHz User Facility. This workshop on the prospects for a 30 T or 1.3 GHz NMR magnet was inspired by the laboratory's success with the new high resolution 900 MHz magnet, the 5 T High Temperature Superconducting (HTS) coil that was tested to 25 T using a 20 T background field, and the Report by the Committee on Opportunities in High Magnetic Field Science (COHMAG) commissioned by the National Academy of Science. The workshop comprised three short sessions focusing on the scientific justification for such a magnet, a technological justification for this magnet, and a justification for citing the project at the NHMFL, along with a brief outline for the implementation of this vision.

The scientific vision was delivered by **Prof. Gerhard Wagner from Harvard Medical School**, who spoke about advancing solution NMR spectroscopy of biological macromolecules and macromolecular complexes. **Dr. Paul Ellis from Pacific Northwest National Laboratory** spoke about observation of metals and quadrupolar nuclei in biological complexes, while **Prof. Stanley Opella from UC San Diego** discussed advantages of high fields for structural characterization of membrane proteins through solid state NMR. Finally **Prof. Andrew Webb from Penn State University** discussed the advantages and challenges of doing magnetic resonance microscopy at 30 T.

Denis Markiewicz, the project leader for the NHMFL's Ultra-Wide Bore 900 MHz Magnet, initiated a discussion of the technical justification that represented initial efforts toward a conceptual design, evaluation of both low and high temperature superconductors, cryogenic options, persistence, and a range of other topics. **Justin Schwartz**, the NHMFL project leader for the world record 5 T HTS magnet expanded on a description of state-of-the-art high temperature superconductors. **Thomas Painte**r presented a preliminary timeline for the design and construction of a 30 T magnet and **John Miller** discussed the diversity of skills present at the NHMFL that would be brought to bear on such a project.

A diverse audience representing funding agencies (the National Science Foundation and the National Institute of General Medical Sciences) and wire, magnet, and NMR manufacturers was present. Following advice in the COHMAG report mentioned above, the NHMFL is interested in pursuing prospects for building several magnets to distribute development costs, to enhance opportunities for working with the private sector, and to distribute and expand user facilities originating from this technological development.

Probing Matter at High Magnetic Fields with X-Rays and Neutrons

May 10-12, 2005
Tallahassee, Florida
Meeting Site: NHMFL
Workshop Chairs: G. Srajer (ANL/APL), F. Klose (ORNL/SNS), A. Lacerda (NHMFL)

This workshop was held as a next step beyond the questions posed in 2003 to the Committee on Opportunities in High Magnetic Field Science (COHMAG) of the National Research Council in the United States. They were asked to (1) assess the current state and future prospects of high magnetic field science and technology in the United States; (2) assess the position of the United States in this area in the international context; (3) identify promising multidisciplinary areas for research and development, and (4) review and prioritize major magnet construction initiatives for the next decade.

In conjunction with the COHMAG report, this workshop highlighted grand challenges in science at high magnetic fields that should be addressed using neutron and x-ray scattering techniques. Participants also worked on a roadmap for development of the next generation of instrumentation at major x-ray and neutron user facilities that will enable these challenges to be met, and the supporting R&D to achieve this goal.

Stage-setting for this workshop included two days of invited and contributed talks addressing the new scientific challenges at the forefront of materials research in high magnetic fields. Topics included hard core condensed matter research subjects such as high T_c materials and correlated metals; metallurgy science such as materials processing in very high magnetic fields; and chemistry-related research such as molecular magnets. In addition, overviews were presented about existing capabilities at x-ray and neutron facilities as applied to research in high magnetic fields and preliminary ideas for next generation high-field magnet beamlines at synchrotron and neutron research centers.

This workshop was jointly organized and sponsored by Argonne National Laboratory/Advanced Photon Source (G. Srajer), Oak Ridge National Laboratory/Spallation Neutron Source (F. Klose), and the National High Magnetic Field Laboratory (A. Lacerda).

Physical Phenomena at High Magnetic Fields-V (PPHMF-V)

August 5-9, 2005
Tallahassee, Florida
Meeting Site: FSU University Center
Hotel Headquarters: Tallahassee Double Tree
Conference Chair: Nick Bonesteel

The Physical Phenomena at High Magnetic Fields conference was founded by the NHMFL at Florida State University in 1991 and is held about every three years. It provides a significant international forum for assessing and discussing current research and promising new directions in high magnetic field science and applications. PPHMF-V attracted approximately 130 participants, with attendees coming from Canada, Europe, Japan, Korea, and Taiwan, as well as the United States.

The scientific program provided a "snapshot" of some of the most exciting current developments in a broad range of magnetic field related research, including magnetism and magnetic materials; superconductivity in oxides, heavy fermions and organic materials; semiconductors and the quantum Hall effect; spintronics and quantum computing; and chemical and biological systems.

PPHMF-V was held as one of the satellite conferences of LT 24, which was hosted by NHMFL-University of Florida colleagues.

24th International Conference on Low Temperature Physics (LT24)

August 10-17, 2005
Orlando, Florida
Meeting Site & Hotel Headquarters: Hilton Hotel at Walt Disney World
Conference Chair: Gary Ihas

LT24 is the premiere gathering of the low temperature community held every three years and sponsored by the International Union of Pure and Applied Physics. The first conference was in Cambridge, Massachusetts in 1949. The last LT—LT23—was held in Hiroshima, Japan and LT22 was held in Helsinki, Finland. The University of Florida was pleased to host LT24 in Orlando. About 1,000 participants enjoyed 196 oral presentations and 1,100 posters during the week on subjects ranging from cosmology (it's all in the superfluid ^3He) and dark matter detectors to superconductivity, the quantum Hall effect, and super solid ^4He (or is it?).

For the first time, both the London and Simon Prize lectures were on the opening day of the conference. Very enlightening and entertaining talks were given by award winners **Richard Packard**, **Sebastien Balibar**, **J.C. Seamus Davis**, and **Grigory Volovik**.

The entire conference was in the Hilton at Walt Disney World, with mid-morning breakfast, lunch, and afternoon drinks and snacks provided to the participants free of charge. The biggest commercial exhibit (25 booths) ever assembled for an LT conference included companies from all over the world. The Friday night outreach lectures were by **Nobel laureate Doug Osheroff**, on the Columbia disaster, and **Chief NASA Engineer Rex Geveden**, on the Year of Einstein Gravity Probe B experiment. About 300 people went to Kennedy Space Port on Sunday and many had lunch with an astronaut. At the banquet, there was dancing to the Frank Sullivan sextet with vocalist, a Gainesville group with Grammy Award roots.

International Conference on Ultra-Low Temperature Physics (ULT-2005)

August 18-20, 2005
University of Florida, Gainesville
Meeting Site: New Physics Building, UF Campus
Conference Chairs: Yoonseok Lee, NHMFL-UF & Eric Palm, NHMFL-FSU

About 140 physicists from 12 countries gathered in Gainesville to discuss their latest results at ULT-2005. The NHMFL was a major supporter of ULT-2005, which was held as one of the satellite conferences to the International Conference on Low Temperature Physics (LT-24).

Participants were greeted at an evening reception on August 17 at the Florida Museum of Natural History, which is on the university campus. More than 100 papers were presented in 11 oral and 2 poster sessions and lively discussions were exchanged in and out of the sessions.

The scientific program covered unusually broad research areas in ultra-low temperatures. Quantum phase transitions, low temperature particle detectors, and quantum devices were new topics presented during the conference, along with the traditional ULT topics such as superfluids, quantum solids, and nuclear magnetism. In addition to the regular program, a special discussion session on supersolids was held on August 18. Various theoretical ideas and details of recent experimental results on this subject were discussed until 9:30 p.m.! ULT-2002 was held in Kanazawa, Japan, and the next ULT will be held in London in 2008 right after LT-25 in Amsterdam, Netherlands.

Sixth International Symposium on Crystalline Organic Metals, Superconductors, and Ferromagnets (ISCOM 2005)

September 11-16, 2005
Key West, Florida
Meeting Site & Hotel Headquarters: Wyndham Casa Marina Resort
Conference Chair: Jim Brooks

ISCOM 2005 attracted nearly 200 participants from 17 countries, including Australia, Canada, Denmark, Germany, Italy, Japan, Korea, The Netherlands, Poland, Portugal, Russia, Spain, Switzerland, Tunisia, the United Kingdom, and the United States. This conference is the pre-eminent forum for interdisciplinary discussions of the chemistry, physics, materials science, and technology of crystalline molecular solids, including: synthesis of new molecules; molecular materials and crystal engineering; molecular magnetism; physics of low dimensional metals and superconductors; magnetic field-induced phenomena; organic thin films and devices; phase transitions and charge ordering; theory, modeling, and computation; and organic molecular nanoscience.

High magnetic fields continue to reveal new, fundamental phenomena in organic metals, insulators, magnets, and superconductors. Theoretical and computational methods have also advanced considerably, giving new insight into subjects such as low dimensional superconductors and magnetic systems. The topic of single molecule magnets made a strong debut in the ISCOM program, and the areas of charge ordering, electron correlations, and coherent/in-coherent electrical transport in organic materials were well represented.

The program was divided into 83 oral, 4 tutorial, and 119 poster presentations. **An effort was made to highlight younger researchers and also underrepresented groups for oral presentations. There were 15 women speakers.**

An interdisciplinary theme was emphasized with synthesis, devices, theory, measurement, and materials systems intertwined as much as possible in the program. Invited speakers were encouraged to address an interdisciplinary audience.

Several highlights of the conference deserve special mention:

Tutorials. After each lunch period a senior researcher gave a tutorial to advance student understanding in important ISCOM areas. **Marc Fourmigue** discussed chemical design and synthesis, **Ross McKenzie** presented a theoretical perspective, **Marshal Luban** gave an overview of molecular magnets, and **Janice Musfeldt** discussed optical probes of molecular systems. **Sergei Brazovskii** provided a prospective of the impressive professional career and fine personality of **Prof. Anatoly Larkin**, who passed away earlier in the year. **Patric Batail** and **Ross McKenzie**

closed the conference with perspectives on the importance of interdisciplinary collaborations in this equally interdisciplinary field of science.

Teacher and Undergraduate Research. The NSF support allowed the invitation of NSF-funded Research Experience for Teachers-RET (2) and Research Experience for Undergraduates-REU (6) participants to attend the conference and to present posters of their work done this summer at their host institutions. One REU, **Mariannna Worczak from Sweet Briar College** said she "was amazed at the number of scientists attending the conference who offered encouraging words…they were very eager to encourage young minds to enter research."

Banquet Address and Crow Prize. At the banquet on Thursday night, **Prof. Diane Roberts, Professor of English from the University of Alabama**, well-known author, National Public Radio Commentator, and 8th generation Floridian, gave perspectives of the history of Florida and the arrival of Jack Crow and the National High Magnetic Field Laboratory in Tallahassee.

After the banquet, **Dr. Madoka Tokumoto from AIST, Tsukuba Japan**, was awarded the first Crow Prize for his many contributions to the careers of young researchers working in the area of high magnetic field studies of organic conductors. Tokumoto is from the National Institute of Advanced Industrial Science and Technology (AIST), Japan. As a result of long-term collaborations for over 15 years, Tokumoto has published over 80 joint papers and additional proceedings papers with many Ph.D. students, postdocs, and young researchers, both within and outside Japan. **The prize is given in honor of the late Jack E. Crow, the founding director of the National High Magnetic Field Laboratory.**

The meeting was supported in part by the National Science Foundation through DMR-0508574. The National High Magnetic Field Laboratory, the Florida State University through the Dean of Arts and Sciences, the Vice President for Research, and its Departments of Physics and Chemistry also provided partial support. The Crow Prize was supported by the Florida State Chapter of the Scientific Research Organization Sigma Xi. The next ISCOM will be held in Spain in 2007.

CHAPTER 9
MANAGEMENT & ADMINISTRATION

The National High Magnetic Field Laboratory is operated for the National Science Foundation by a consortium of three institutions: Florida State University, the University of Florida, and Los Alamos National Laboratory. The groups work together under a cooperative agreement that sets forth the laboratory's goals and objectives. FSU has the responsibility for establishing and maintaining the appropriate administrative and financial oversight, and ensuring that the operations are in line with the objectives as outlined in the cooperative agreement. More information about the organizational structure can be found online at *www.magnet.fsu.edu*.

Organization

In 2005, the Magnet Lab added to its preeminence in magnet technology by joining forces with the Applied Superconductivity Center, which will relocate to FSU from the University of Wisconsin-Madison in the summer of 2006. The Center is widely seen as the world leader in the research of practical superconducting materials.

Led by National Academy of Engineering member David C. Larbalestier, the ASC will be housed across the street from the Tallahassee facility in the renovated Shaw Building and will become part of the laboratory's materials research division.

Also in 2005, the Government and Public Relations group was renamed Public Affairs to better reflect a shift in the group's focus. In line with NSF's goal to increase science understanding among laypeople, the group is focused on regularly disseminating timely news and information about the lab and its research to a broader audience in a way that informs, educates, entertains, or motivates change.

Staffing & Management

Implementation of the laboratory's formal diversity plan was a driver of the lab's staffing and management efforts in 2005. Since development of the formal diversity plan in 2004, the results are encouraging and show how building relationships with other research universities can accelerate our diversity goals.

Here is just one example: In 2005, the Visiting Scientist Program offered summer support for Kevin Storr, an assistant professor at Prairie View A&M University who completed his Ph.D. in experimental physics at FSU, spending many hours at the Magnet Lab. Most historically black colleges and universities (HBCUs) are not able to adequately fund the labs of their young faculty, and as such the professors' undergraduates and graduate students are unable to gain valuable experiences—the kind of experiences afforded Storr at the lab when he was a graduate student.

Storr and colleagues at the lab wanted to change that. The result of their efforts was a $1.5 million grant from the National Nuclear Security Agency to increase the involvement of minority scientists and their students in cutting-edge research.

The award, for which Storr is the principal investigator, will establish and enhance strong experimental and theoretical research opportunities at Prairie View A&M University in Prairie View, Texas, and North Carolina A&T University in Greensboro, N.C., while extending and expanding the currently funded research of the Magnet Lab's Extreme Conditions Group, led by principal investigator Stan Tozer working with Eric Palm and Tim Murphy.

Many minority students will benefit from the grant. It will support two graduate and five undergraduate students at Prairie View A&M and a postdoctoral position at North Carolina A&T, all of whom will be provided travel support to do collaborative research at Magnet Lab facilities in Tallahassee and Los Alamos, N.M. In addition, the grant will support four HBCU students in the 2006 Research Experiences for Undergraduates (REU) program administered by the lab's Center for Integrating Research and Learning (CIRL).

The management of the lab shares the NSF's strategic goal of increasing the number of minority and underrepresented students who pursue careers in science, and is confident that ongoing efforts and partnerships will help groom the next generation of scientists by giving them experiences that they would not be able to get otherwise.

Highlights of CO-WIN Effort

As part of the College Outreach – Workforce Initiative (CO-WIN), the Magnet Lab diversity committee in 2005 launched its college lecture series. Lab scientists and engineers traveled to HBCUs and other minority-serving institutions to present the wide range of Magnet Lab-related career development opportunities directly to undergraduates (Table 1).

Table 1. 2005 CO-WIN Lecture Series

Date	Magnet Lab Representative	Institution Visited	State
February 25	Eric Palm, Research Associate and Instrumentation Physicist	Prairie View A&M University	Texas
March 14	William Brey, Assistant Scholar/Scientist, CIMAR, NMR	North Carolina A&T State University	North Carolina
March 30-31	Greg Boebinger, Lab Director	Florida A&M University	Florida
March 20	Arthur Edison, Magnet Lab/UF Advanced Magnetic Resonance Imaging and Spectroscopy Facility	Dillard University	Louisiana
March 21	Arthur Edison, Magnet Lab/UF Advanced Magnetic Resonance Imaging and Spectroscopy Facility	Xavier University	Louisiana
October 5-6	Ross McDonald, staff member, LANL Pulsed Field Facility	University of New Mexico	New Mexico
October 14	Johan van Tol, Associate Scholar/Scientist, CIMAR, EMR	Claflin University	South Carolina
October 20-21	Eric Palm, Research Associate and Instrumentation Physicist	Alabama A&M University	Alabama

As part of the lecture series, Obioma Odionyenma, an undergraduate at Xavier University in New Orleans was recruited to take part in the laboratory's 2005 Research Experiences for Undergraduates (REU) program. In addition, support for summer 2005 research was provided to three Florida State University graduate students from underrepresented groups, apart from the REU program. Two of those students continued to be supported through the fall.

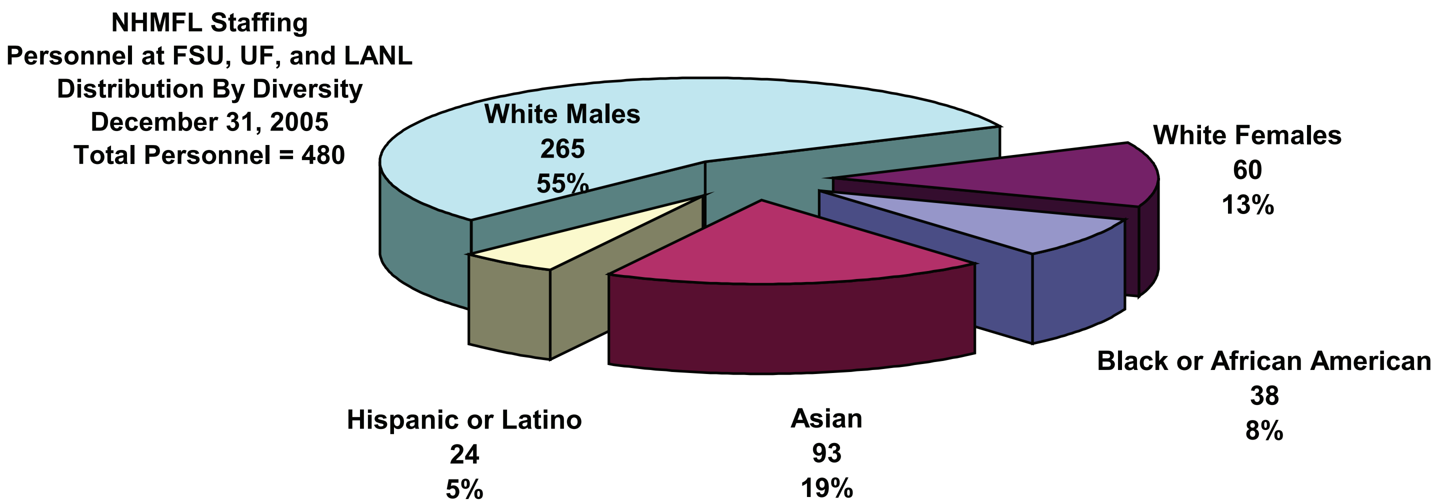
Other successes include:

- Bettina Roberson, the lab's human resources coordinator, and two graduate students presented information about the Magnet Lab at the 2005 Florida-Georgia Louis Stokes Alliance for Minority Participation Expo. The Expo serves as a catalyst for increasing the production of minorities in science, engineering, and math at the undergraduate and graduate level.
- Youn Jung Jo was named the winner of the NHMFL Schuler Postdoctoral Prize. Jo was a graduate student with Prof. Woun Kang at the Ewha Womans University in Korea.
- NMR Director Tim Cross and Prof. Michael Chapman spoke in the Biophysics Session at the 2005 Joint Annual Conference of the National Society of Black Physicists and Black Physics Students and the National Society of Hispanic Physicists in Orlando.
- The lab awarded Lateefah Stanford, a Ph.D. student, a student travel stipend to attend and present a paper at the American Society for Mass Spectrometry Sanibel conference.
- Starting in December 2005, the NHMFL began broadcasting its condensed matter physics seminars to faculty and students at Prairie View A&M University via videoconferencing.

A review of the Magnet Lab staff distribution by diversity provides a comparison of staffing levels over a three-year time frame.

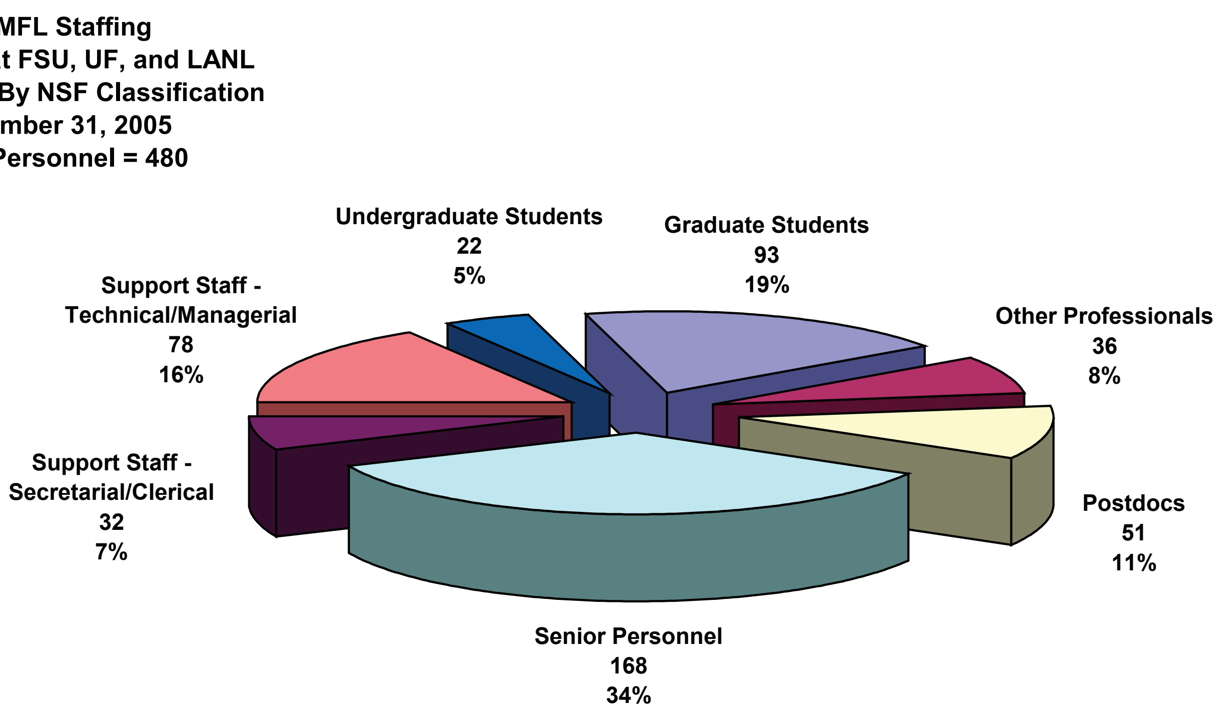
Table 2. Diversity Distribution of Magnet Lab Staff

	2003	2004	2005
White	344 (74%)	337 (71%)	325 (68%)
Hispanic or Latino	21 (4%)	25 (5%)	24 (5%)
Asian	76 (16%)	80 (17%)	93 (19%)
Black or African-American	30 (6%)	34 (7%)	38 (8%)
Total	471	476	480



Significant Recruitments

During 2005, the lab played a major role in the hiring of two new promising faculty members at FSU. Chris Wiebe, who will join the physics faculty in early 2006, will lead the Quantum Materials Group. Sam Grant, already familiar to the lab family through his postdoctoral work in neuroscience at the McKnight Brain Institute at the University of Florida, will join the FAMU-FSU College of Engineering Department of Chemical and Biomedical Engineering faculty early in 2006.



Budget

The National High Magnetic Field Laboratory operates with funding provided by federal, institutional, and industry sources. In addition, the lab faculty and staff have been successful in securing individual research funding for specific areas of research from a variety of sources, including federal and private sectors. While the lab receives funding from numerous sources, the primary funding source for operation of the Magnet Lab remains the National Science Foundation and funds provided through the participating institutions.

NSF Core Budget

The National Science Board approved the NHMFL renewal award of the third five-year research grant in the amount of $117,500,000 at their meeting on October 19, 2000, plus subsequent amendments.[1] The renewal period is from January 1, 2001, through December 31, 2007 (in 2004 the NSF approved two additional years of funding). The following table provides a comparison of the current seven-year NSF award with the previous five-year award:

Table 3. NHMFL NSF Budget Comparison (with overhead distributed to programs)

Division/Program	1996 – 2000 5-Yr NSF Summary	% of BGT	2001 – 2007 7-Yr NSF Summary	% of BGT
Director	$2,912,811	3.33%	$7,364,278	4.28%
Unassigned Budget	0	0.00%	(798,308)	-0.46%
Facilities & Admin	5,698,737	6.51%	12,889,598	7.50%
Instruments & Operations	18,366,654	20.99%	31,053,979	18.07%
Instruments & Operations – Electrical Power for DC Facility	7,918,471	9.05%	21,031,567	12.24%
Magnet Science & Technology	22,122,487	25.28%	32,173,407	18.72%
FSU - IHRP	7,343,739	8.39%	8,563,536	4.98%
LANL	20,838,959	23.82%	37,121,926	21.60%
LANL – IHRP[1]			904,021	0.53%
CIMAR – NMR -FSU	361,550	0.41%	6,164,614	3.59%
CIMAR - EMR	248,902	0.28%	1,632,250	0.95%
CIMAR – ICR[2]	175,650	0.20%	6,812,783	3.96%
CIMAR –NMR -UF - AMRIS	812,414	0.94%	3,118,522	1.81%
UF - High B/T	699,626	0.80%	1,589,817	0.92%
UF – IHRP[1]			2,261,256	1.31%
Total NSF Cooperative Agreement[3]	**$87,500,000**	**100.00%**	**$171,883,246**	**100.00%**

[1] IHRP (In-House Research Program) for LANL and UF is now being reported separately instead of including it in the Science Department's budget as has been done in the past.

[2] ICR Facilities budget does not include the NSF Chemistry Division award in the amount of $5,808,433, which is for 1/1/2000 through 12/31/2004.

[3]

Baseline budget	$117,500,000
Amendments:	
Eglin AFB	49,917
Electricity	1,470,000
RET Program	501,272
Additional 2 years funding	52,500,000
Less 2005 NSF budget reduction	(260,000)
Amended Budget	$171,883,246

The following table presents the NSF funding for the seven-year period.

Table 4. NHMFL - NSF Budget by Program (with overhead separate from programs)

Division/Program	2001	2002	2003	2004	2005	2006	2007	Total Budget
Director	$407,208	$313,320	$115,223	$478,672	$686,216	$791,125	$898,236	$3,690,000
CIRL[1]	225,379	198,611	142,872	329,769	161,213	284,188	185,412	1,527,444
Unassigned Budget[2]	(2,780,994)	(596,653)	2,071,302	1,441,535	714,162	(554,643)	(429,580)	(134,871)
Facilities & Admin	1,374,631	1,253,506	960,122	1,314,968	1,392,666	1,381,603	1,432,560	9,110,056
Instruments & Operations	2,771,403	3,888,227	2,326,974	2,913,482	2,962,497	3,164,019	3,740,235	21,766,837
Instruments & Operations - Electricity for DC Facility	1,900,000	1,600,000	3,020,000	3,074,000	3,606,809	3,907,126	3,922,154	21,030,089
Magnet Science & Technology[3]	4,130,929	4,906,176	3,650,610	3,312,840	1,469,308	2,931,864	2,945,372	23,347,099
Science	880,889	1,037,627	813,047	874,041	968,710	1,191,924	[7]1,273,464	7,039,702
LANL[4]	4,575,655	6,436,905	5,083,545	5,164,502	5,382,012	5,129,415	5,349,892	37,121,926
LANL IHRP[5]	397,107		209,802	92,000	90,000	115,112	[7]	904,021
CIMAR – NMR - FSU	338,597	595,990	501,271	832,097	902,429	884,837	572,469	4,627,690
CIMAR – EMR	81,473	95,650	135,388	221,880	244,347	216,771	167,322	1,162,831
CIMAR – ICR[6]	1,533,358	49,248	46,311	370,541	1,084,812	1,068,633	1,065,338	5,218,241
CIMAR – NMR-UF-AMRIS	303,110	312,202	320,288	291,161	628,890	581,275	499,722	2,936,648
UF – High B/T[4]	182,527	188,003	597,352	(147,833)	218,879	267,151	212,040	1,518,119
UF IHRP[5]	148,199	219,090	434,810	572,470	547,963	338,724	[7]	2,261,256
Overhead	3,686,446	4,578,098	3,677,083	3,547,147	4,439,087	4,162,933	4,665,364	28,756,158
Total	$20,155,917	$25,076,000	$24,106,000	$24,683,272	$25,500,000	$25,862,057	$26,500,000	$171,883,246

1 CIRL includes RET funding as follows: $106k in 2001, $106k in 2002, $106k in 2003, and $183k in 2004.

2 Projected negative budget balance in Unassigned Budget will be eliminated by either transferring expenses off this grant and onto our state funds, or we will reduce the budget in 2007 in an amount sufficient to eliminate this balance.

3 In 2005, the MS&T budget allocation was reduced due to carry-forward budget from previous years.

4 LANL and UF funding is distributed through subcontracts. LANL also contributes funds to the Pulsed Magnet Program, in the amount of $3.6 million in 2001, $3.8 million in 2002, $3.6 million in 2003, $5 million in 2004, and $2.6 million in 2005. UF contributes funds to the High B/T Magnet and the AMRIS Program; the High B/T contributions were $60 K in 2001, $131K in 2002, $195K in 2003, $494K in 2004, and $923K in 2005, and the AMRIS contributions were $895 K in 2003, $321K in 2004, and $166K in 2005 (2001 and 2002 AMRIS contributions are not available).

5 LANL and UF IHRP (In-House Research Program) funding is distributed from the Science Program.

6 ICR Facilities budget does not include the NSF Chemistry Division award in the amount of $5,808,433, which is for 1/1/2000 through 12/31/2004, although all of the funding was received by 12/31/2003.

7 LANL and UF IHRP in 2007 not yet allocated

NHMFL Matching Commitment

The NSF grant includes a matching commitment by the State of Florida through Florida State University, which is $6,783,400 annually. In addition to this, the State of Florida also provides institutional funds to the laboratory above the NSF matching requirement. The NHMFL utilizes these additional state resources as cost sharing funds for other funding opportunities, as well as to help support some of the NSF core activities. Table 5 presents the State of Florida matching requirements and contribution provided through Florida State University.

Table 5. Fiscal Year 2005/2006 State of Florida Matching and Contribution

	State Matching	State Contribution	Total State Funding
State of Florida recurring funds cost sharing	$4,492,318	2,719,712	$7,212,030
State of Florida infrastructure funding Indirect Cost (51%)	2,291,082	1,387,053	3,678,135
Total	**$6,783,400**	**4,106,765**	**$10,890,165**

Program Budget Discussion

Calendar year 2005 is the fifth year of the current grant award from the National Science Foundation, in the amount of $25,500,000. This includes the National Science Board approved allocation of $24,000,000 plus $1,500,000 for ICR that was formerly granted through the Chemistry Division of NSF. The laboratory also receives an annual operating budget from the State of Florida through Florida State University. In fiscal year 2004/2005, the State budget was $16,947,119, and was $7,212,030 for fiscal year 2005/2006 (excluding overhead).

Table 6. NHMFL Program Budget by Source (budget allocation by program)

Program	NSF Budget Calendar Year 2005	State Matching Fiscal Year 2005/2006	State Contributed Fiscal Year 2005/2006	Total Budget
Director	$686,216	$1,898,509	$980,467	$3,565,192
CIRL	161,213	119,014	61,464	341,691
Unassigned Budget	714,162			714,162
Facilities & Admin	1,392,666	300,396	155,137	1,848,199
Instruments & Operations	2,962,497	372,265	192,253	3,527,015
Instruments & Operations – Electrical Power for DC Facility	3,606,809			3,606,809
M S & T	1,469,308	303,609	465,051	2,237,968
Science	968,710	517,988	267,510	1,754,208
LANL (Subcontract)[1]	5,382,012			5,382,012
LANL IHRP	90,000			90,000
CIMAR – Administration		33,829	17,471	51,300
CIMAR – NMR	902,429	420,873	308,796	1,632,098
CIMAR – EMR	244,347	239,356	123,614	607,317
CIMAR – ICR Facilities	1,084,812	230,386	118,981	1,434,179
CIMAR – Geochemistry		56,092	28,968	85,060
CIMAR – NMR @ UF – AMRIS[2]	628,890			628,890
UF- High B/T[3]	218,879			218,879
UF IHRP	547,963			547,963
Infrastructure Overhead[4]	4,439,087	2,291,083	1,387,053	8,117,223
Total	**$25,500,000**	**$6,783,400**	**$4,106,765**	**$36,390,165**

1 LANL's contribution to the Pulsed Magnet Program was $2.643 million in 2005
2 UF's contribution to AMRIS was $0.2 million in 2005
3 UF's contribution to the High B/T program was $0.9 million in 2005.
4 The NSF Budget includes overhead, and the equivalent overhead is included in the state budget to reflect the total state support. FSU's federally negotiated overhead rate is 51%.

The following table summarizes the NHMFL budget position as of 12/31/2005. The budget balance represents deferred capital and expense items, such as resistive magnets maintenance and upgrade; split magnet equipment purchases; In-House Research Program time lag between 2005 awards and actual incurred expenses; and equipment for the 900 MHz.

Table 7. Cumulative NSF Budget and Expenses (1/1/2001 – 12/31/2005)

Expense Classification	Budget	Spent and Encumbered	Balance 12/31/2005
Salaries, Wages & Benefits	$27,753,297	$27,062,509	$690,788
Subcontracts	33,319,848	32,426,299	893,549
Capital Equipment	11,850,976	10,470,372	1,380,604
Other Direct Cost	26,646,163	24,596,756	2,049,407
Subtotal	**99,570,284**	**94,555,936**	**5,014,348**
Overhead	19,950,905	19,281,387	669,518
Total	**$119,521,189**	**$113,837,323**	**$5,683,866**
Program Income	$336,048		

Program Budgets

Director's Office

The Director's Office includes the Director, Associate Director, Budget Administration, Public Affairs, Computer Support Group (transferred from Instrument and Operations), and the Visiting Scientist Program. The Budget Administration Office is responsible for the budget, accounting, and financial analyses functions for the lab. The development and maintenance of an internal budget management system provides greater cost accounting and control over the many different funding sources and projects supported by those funds. The Office of Public Affairs is responsible for the laboratory's public relations and support, including monitoring legislative issues and publication support. The Visiting Scientist program provides funding for scientists to conduct research utilizing the NHMFL facilities. Proposals requesting support through the Visitors Program are internally peer reviewed, and awards are made based on input provided through the internal review process.

Table 8. Director's Office Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
Director - Admin	603,902	1,360,700
Budget Administration	70,995	131,997
Visitors Program	0	253,072
Director's Research	(7,348)	60,366
Unallocated Budget	714,162	
Total	**1,381,711**	**1,806,135**
State Contribution		932,761

Center for Integrating Research and Learning (CIRL) and Optical Microscopy Resource Center (OMRC)

CIRL supports programs in outreach to students, teachers, and the general public, curriculum development and teacher education with the primary focus on enhancing science education at all levels and promoting public awareness. CIRL administers the Research Experiences for Undergraduates (REU) program and has been extremely successful. The REU has, in fact, been around at the NHMFL since 1994. CIRL took over administration of the program in 1999. The Research Experiences for Teachers (RET) is also coordinated and run by the Center. In 2004, the Center received a supplemental grant of $183,272 to support the RET program for summers 2004 and 2005. In 2003 the NSF provided a supplemental allocation in the amount of $106,000, for the RET program. The RET program continues to fit very effectively with the summer REU students. All mentorships for middle school and high school students are organized by CIRL. CIRL is also the focal point for the organization of the NHMFL Annual Open House and outreach and tour activities for K-12 groups and the public.

OMRC is another program operated as part of the NHMFL research and learning efforts. The OMRC has been hugely successful in its educational efforts and continues to receive world-wide recognition. In addition to establishing an in-house Magneto-Optical Imaging Facility, the OMRC has developed a state-of-the-art live-cell imaging center that collaborates with outside users and is available to scientists who wish to study the dynamics of living organisms in magnetic fields. Distance learning efforts of the OMRC are highlighted by the international use of the educational websites in middle, high, undergraduate, and graduate curricula around the world. The OMRC is responsible for web application development and upgrades, and media graphics.

Table 9. Center for Integrating Research and Learning (CIRL) and Optical Microscopy Resource Center (OMRC) Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
Education	92,234	119,014
REU Program	68,979	
Optical Microscopy	18,668	92,374
Total	**179,881**	**211,388**
State Contribution		109,170

Facilities and Administration

Facilities and Administration provides general administrative functions for the lab including the UBA (University Business Administrators) Program. The UBA is responsible for accounts payable, accounts receivable, payroll, procurement, receiving, and other accounting activities. The Facilities staff is responsibilities for maintenance of the NHMFL building and facilities including magnet power supplies and cooling systems, helium systems, and the remainder of the facilities except grounds, janitorial, and some HVAC and plumbing preventative maintenance. The NHMFL Safety Program is also housed within this group. The Facilities group also handles small interior renovations and modifications needed to support research activities. Funding for the Facilities group is split between NSF and institutional funds. NSF funding is used for core-related activities, while institutional funds are used for general facility maintenance and modifications required to support research and other activities related to the mission of the NHMFL.

Table 10. Facilities and Administration Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
UBA	626,841	106,651
Facilities	657,680	151,840
Safety	108,145	41,905
Total	**1,392,666**	**300,396**
State Contribution		155,137

Instrumentation and Operations

This unit, headed by the director of DC Field Facilities, is responsible for the operation of the DC magnet systems at Tallahassee, including the Millikelvin Facility. This unit also provides machine shop, electronics shop, and cryogenic systems support. Two thirds of the staff is dedicated to supporting user activities, and the other one third provides mechanical and electronic instruments for all the groups in Tallahassee. This group focuses on keeping abreast of cutting edge instrumentation specialties, improving the performance of user instrumentation, and developing new measurements. The Instrumentation and Operations group also helps coordinate annual meetings of the NHMFL Users Committee and interfaces with other activities within the user community.

Table 11. Instrumentation and Operations Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
Administration	231,213	19,783
Computer Services	2,882	
Cryogenics	523,470	
Electronics	202,026	
Magnet Operations	292,693	
Electrical Power for DC Magnets	3,606,809	
Mechanical Instruments	282,593	
User Services	1,427,619	352,482
Total	**6,569,305**	**372,265**
State Contribution		192,253

Magnet Science and Technology

The Magnet Science and Technology (MS&T) group is responsible for the design, engineering, fabrication, and maintenance of a broad variety of powered-DC, pulsed, and advanced superconducting magnets, along with the development of the advanced materials, components, and subsystems critical for all high-performance magnet applications. MS&T has broad interactions with the private sector, with other national laboratories, and with the international community involved in high-field magnet research and development. Future advances in magnet technology are heavily dependent on advancements made in materials, especially: high-strength, high-conductivity conductors; high-strength, high-performance superconductors; high-temperature superconductors; and high-strength, high-modulus reinforcement materials, which are critical to overcome the enormous forces intrinsic to high-field magnet design.

Table 12. Magnet Science & Technology Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
Admin/Operations	1,089,715	303,609
Pulsed Magnets	100,222	
Powered Magnets	262,053	
Persistent Magnets	49,052	
Work for Others	(31,733)	
Total	**1,469,309**	**303,609**
State Contribution		465,051

Condensed Matter Science Program

The NSF funding for the science and facilities development program are primarily distributed through the In-House Research Program (IHRP). A small amount of funding is utilized to cover the administration of the program, travel by reviewers, visitors, and speakers, and to provide assistance for the director of the IHRP, who serves a two-year term that rotates among the three institutions. During the current period, the program is headed by Dr. Lloyd Engel of the FSU-NHMFL. The Condensed Matter Science group in Tallahassee assists and provides administrative support with proposal solicitations and reviews. IHRP proposals must include an internal investigator from one of the three participating institutions as principal investigator, but participation from external users as co-principal investigators or collaborators is strongly encouraged by the NSF and NHMFL. The proposed research work must utilize and advance facilities, and support is restricted to two years or less. Proposals that support young scientists and/or support bold new research areas that have the possibility of opening new frontiers are strongly encouraged.

Table 13. Condensed Matter Science Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
Administration	127,545	197,832
In-House Research Program	841,165	
Condensed Matter Theory		185,570
Condensed Matter Experimental		134,586
Total	**968,710**	**517,988**
State Contribution		267,510

Pulsed Field Facility - Los Alamos National Laboratory

The NHMFL Pulsed Field Facility is located at Los Alamos National Laboratory and operated under a subcontract agreement between Florida State University and the Department of Energy. Funding for the Pulsed Field Facilities and Administration includes the facility overhead charges. The Pulsed Field Facility provides technical and instrumentation support for the user community. The staff of the Pulsed Field Facility, in cooperation with the user community, also devotes considerable attention to the development of new research capabilities and instrumentation responding to the unique requirements imposed by the rapidly changing magnetic fields and vibrations characteristic of these systems. The NHMFL Pulsed Field Facility staff works closely with members of the NHMFL Magnet Science and Technology group in Tallahassee to advance pulsed magnet technology and materials for these unique systems. Special staffing is also required to maintain the 1.2 MJ and 4.0 MJ capacitor bank and the 1.4 GVA generator used to power the magnets available at the facility.

Table 14. Pulsed Field Facility Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
Facilities & Administration	2,635,540	
User Operations	1,970,470	
Pulsed Magnets	776,002	
IHRP	90,000	
Total	**5,472,012**	
LANL Contribution		2,643,000

Center for Interdisciplinary Magnetic Resonance

CIMAR represents all areas of magnetic resonance techniques and has made significant advances in building a user program that involves interdisciplinary activities with physics, geochemistry, chemistry, biology, and engineering. The program focuses on nuclear magnetic resonance (NMR), electron magnetic resonance (EMR), ion cyclotron resonance (ICR) mass spectrometry, and magnetic resonance imaging and spectroscopy. A portion of the NMR spectroscopy and imaging activities are pursued at the Advanced Magnetic Resonance Imaging and Spectroscopy Facility (AMRIS) located at the McKnight Brain Institute at the University of Florida. The facilities within CIMAR provide unique instrumentation and capabilities to support a wide variety of research areas and are open to all qualified users.

Table 15. Center for Interdisciplinary Magnetic Resonance Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
Administration		33,829
NMR Program	902,429	420,873
ICR Program	1,084,812	230,386
EMR Program	244,347	239,356
Geochemistry		56,092
AMRIS (UF)	628,890	
Total	**2,860,478**	**980,536**
State Contribution		597,829
UF Contribution		166,000

High B/T Facility – University of Florida

The High B/T Facility is located at the University of Florida and is housed in the existing Microkelvin Laboratory. A special bay has been retrofitted in the laboratory, using a specially designed $PrNi_5$ nuclear refrigerator and a separate 14/15.5 T magnet to conduct experiments at both high magnetic fields and low temperatures (a few 100 microkelvin) simultaneously. Additionally, users may request access to Bay #2 in the Microkelvin Laboratory that uses copper nuclear demagnetization refrigerators and can reach below 100 microkelvin.

This specialized facility is operated as an NHMFL user facility and is open to all qualified users who wish to explore new phenomena that require experimental conditions of high spin polarization or high initial magnetization, and thus a high ratio of applied magnetic field to temperature. Recent examples include studies of solid helium four for possible supersolid states, the fractional quantum Hall effect, transport in polarized Fermi liquids, and superfluid helium three. The high cooling capacity of the facility enables users to maintain experiments below a fraction of a millikelvin for extended periods of time (beyond several weeks for nanowatt heating rates), following a single demagnetization of the refrigerator. These long observation times are often needed to explore properties over a range of parameter space where the thermal equilibration times can be very long.

Specialized instrumentation is available for thermometry, pressure measurements and heat capacity studies, pulsed NMR techniques up to UHF frequencies, electrical conductivity, and transport studies. The facility is enclosed in a tempest-quality, ultra-quiet environment.

Table 16. High B/T Program Budget

Program	NSF Budget 2005	State Matching Budget 2005/2006
High B/T User Support	218,879	
IHRP	547,963	
Total	**766,842**	**0**
UF Contribution		923,454

Program Budget

The program budgets were prepared in accordance with the following criteria:

Budget Units:

The NSF and Institutional budgets are allocated to the NHMFL programs. There are subcontracts for facilities and activities at Los Alamos National Laboratory, Los Alamos, New Mexico, as well as at the University of Florida in Gainesville. The overall operations of the NHMFL are governed by the Executive Committee, which is responsible for developing recommendations to the director for allocation of budget dollars to programs.

Wage and Salary Rates:

Where possible, actual salary rates have been used in the cost calculation. In some instances, the average salary rate may have been used for vacant and OPS positions.

Overhead Rates:

The Florida State University's federally negotiated overhead rate is 51% for 2005. The institutional overhead rate used for costs at University of Florida is 45.5%, and for Los Alamos it is 96.5% (which includes infrastructure tax, division tax, and general and administrative tax).

Overhead Base:

At FSU and UF, overhead is applied to modified direct costs, which include payroll, payroll fringe benefits, materials and supplies, services, travel, and the first $25,000 of subcontracts. The following categories of expenditures are excluded from the overhead base:

- Permanent Equipment (equipment in excess of $1,000)
- Undergraduate, Graduate, and Ph.D. Programs (CIRL)
- Electric Power for magnet operations
- Subcontracts in excess of $25,000
- Tuition Waivers and Student Fees

UF also excludes charges for patient care, rental costs for off-site facilities, scholarships, and fellowships from the overhead base.

At LANL, full overhead is applied to all costs other than capital project costs. Capital projects designated as capital construction have a reduced overhead rate of 5%, and all other capital projects have a reduced overhead rate of 13%.

Fringe Benefits:

Fringe benefits for Florida personnel are based on actual costs of fringe benefits for permanent employees (averaging 29.6%) and temporary employees (1.75% average). Fringe benefit costs for LANL employees are included in the average salary rates for each class.

Administrative and Facility Maintenance Costs:

Certain administrative and facility maintenance costs are accrued solely for the benefit and function of the NHMFL. These costs are included as direct costs in the budget estimates as allowed by the OMB regulations.

In-House Research Program Awards:

The designated budget for the IHRP is inclusive of institution overhead. Since the actual overheads vary depending on the nature of the program and the institution involved, actual overheads are determined at the time of award within the total IHRP budget.

CHAPTER 10
SCIENCE & RESEARCH PRODUCTIVITY

The laboratory continued its strong record of publication, presentations, and related activities. The table below summarized these activities; the citations follow in this chapter. For additional information, to search the laboratory's publication database, and to read many articles online, refer to the Magnet Lab's Web site: www.magnet.fsu.edu (/search/publications/). Grant information, received from the Florida State University and the University of Florida's respective Offices of Sponsored Research, is also presented in this chapter beginning on page 129.

2005 NHMFL Activities

	Number Reported	Page Number for List of Citations
Publications in Peer-Reviewed Journals	386	104
Presentations, Posters & Other Publications	463	114
Books & Book Chapters	11	127
Internet Disseminations	20	128
Patents	6	128
Awards	17	128
Dissertations, Ph.D.	15	128
Theses, Master	3	129

Of the 386 publications reported by NHMFL-affiliated faculty and users, 178 appeared in some of the most prominent science and major disciplinary journals:

2	*Acta Materialia*
2	*Analytical Chemistry*
2	*Applied Physics Letter*
2	*Cryogenics*
1	*Europhysics Letters*
25	*IEEE Transactions on Applied Superconductivity*
15	*Journal of Applied Physics*
2	*Journal of Biological Chemistry*
4	*Journal of Magnetic Resonance*
1	*Journal of Molecular Biology*
5	*Journal of the American Chemical Society*
3	*Journal of the American Society for Mass Spectrometry*
1	*Magnetic Resonance in Medicine*
1	*Nature*
1	*Nature Physics*
1	*Nature Structural & Molecular Biology*
64	*Physical Review B*
41	*Physical Review Letters*
1	*Proceedings of the National Academy of Sciences of the United States of America*
2	*Science*
2	*Superconductor Science and Technology*

2005 Peer-Reviewed Publications

Abbott, K.L.; Renfrow, M.B.; Chalmers, M.J.; Nguyen, B.D.; Marshall, A.G.; Legault, P. and Omichinski, J.G., *Enhanced Binding of RNAP II CTD Phosphatase FCP1 to RAP74 Following CK2 Phosphorylation,* Biochemistry, **44** (8), 2732-2745 (2005)

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Crooker, S.A., *Imaging electrical spin injection and spin flow in ferromagnet/semiconductor devices*, Solid State and Optics Seminar, Yale University, New Haven, CT, USA, October 5 (2005)

Crooker, S.A., *Imaging spin flows in semiconductors in the presence of electric, magnetic, and strain fields*, Exciton-Electron Interactions in Semiconductor Nanostructures, Bad Honnef, Germany, May 29-June 2 (2005)

Crooker, S.A., *Imaging spin flows in semiconductors in the presence of electric, magnetic, and strain fields*, Radboud University, Nijmegen, The Netherlands, May 27 (2005)

Crooker, S.A., *Imaging spin flows in semiconductors*, 35th Winter Colloquium on the Physics of Quantum Electronics (PQE-2005), Snowbird, UT, USA, January 2-6 (2005)

Crooker, S.A., *Imaging the flow of electron spins in semiconductors in the presence of electric, magnetic, and strain fields*, 16th Int. Conf. on Elec. Prop. of 2-D Systems (EP2DS-16), Albuquerque, NM, USA, July 10-15 (2005)

Crooker, S.A., *Measuring random spin fluctuations for perturbation-free probes on spin dynamics and magnetic resonances*, 3rd SPIE Int. Symposium on Fluctuations and Noise, Austin, TX, USA, May 24-25 (2005)

Crooker, S.A., *Spectroscopy of spontaneous spin noise for probes of spin dynamics and magnetic resonance*, 2005 American Physical Society March Meeting, Los Angeles, CA, March 21-25 (2005)

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Deshmukh, A.P.; Kim, S.; Marshall, A.G. and Myeni, S.C.B., *Organohalogens in Soils: Anthropogenic or Natural?*, 230th American Chemistry Society National Meeting, Washington, DC, August 28-September 1 (2005)

Desrochers, P.J., *Controlling the Reactivity of Cysteine and Borohydride at Nickel*, University of North Carolina, Charlotte invited seminar, Department of Chemistry, UNC Charlotte, September 26 (2005)

Desrochers, P.J., *Methane Activation Using Cheap Chemicals*, Midsouth Inorganic Chemists Association, Fall meeting, University of Central Arkansas, October 1 (2005)

Dixon, I.R.; Bird, M.D. and Miller, J.R., *Mechanical Design of the Series Connected Hybrid Magnet Superconducting Outsert*, 19th Int. Conf. on Magnet Technology, Genoa, Italy, September 19-23 (2005)

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Dobrosavljevic, V., *2D-MIT as a Wigner-Mott Transition*, Lorentz Center Workshop (invited talk), Leiden, The Netherlands, August 1-19 (2005)

Dobrosavljevic, V., *Disorder-Driven Metalic Behavior in Dirty Mott Systems*, invited talk at the "Workshop on Novel Electronic Materials", University of Kentucky, Lexington, KY, April 25-27 (2005)

Dobrosavljevic, V., *Non-Ohmic dissipation in electronic Griffiths phases*, invited talk at the "Quantum Critical Phenomena" conference at the Kavli Institute of Theoretical Physics, University of California, Santa Barbara, CA, January 19-22 (2005)

Dobrosavljevic, V., *Quantum Fluctuations and Anderson Localization in Coulomb Glasses*, Aspen Center for Physics Workshop (invited talk), Aspen, CO, July 27-August 18 (2005)

Dobrosavljevic, V., *Quantum Glassines in Coulomb Systems: From Field-Effect Transistors to High Tc Cuprates*, Condensed Matter Seminar, Florida A&M University, Tallahassee, FL, April 14 (2005)

Dobrosavljevic, V., *Quantum Glassines in Coulomb Systems: From Field-Effect Transistors to High Tc Cuprates*, Physics Colloquium, University of Central Florida, Orlando, FL, March 11 (2005)

Dobrosavljevic, V., *Quantum Melting of the Wigner Solid and the 2D-MIT*, invited talk at the workshop "Physics of Ultra Thin Films near the Metal-Insulator Transition II", Brookhaven National Laboratory, Brookhaven, CN, January 6-7 (2005)

Dorsey, A.T., *Electronic Liquid Crystals: Novel Phases of Electrons in Two Dimensions*, Condensed Matter Physics seminar, Universiteit Utrecht, Utrecht, Netherlands, May (2005)

Dorsey, A.T., *Electronic Liquid Crystals: Novel Phases of Electrons in Two Dimensions*, Indiana University Condensed Matter seminar, Bloomington, IN, January (2005)

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Dorsey, A.T., *Fingering, Fronts and Patterns in Superconductors*, Lorentz Center, Universiteit Leiden, Leiden, Netherlands, May (2005)

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Dorsey, A.T., *Phenomenology of Supersolids*, Condensed Matter Physics seminar, University of Pennsylvania, Philadelphia, PA, December (2005)

Dotson, V.M.; Bugos, J. and Perlstein, W.M., *Cumulative effects of aging and depression on overriding prepotent response tendencies*, Society for Neuroscience, Washington, DC, November 12-16 (2005); Published in J. Neurosci. (0)

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Reyes, A.P., *NMR in High Temperature Superconductors*, Physics Department, University of the Philippines in Los Banos, Laguna, Philippines, July 28 (2005)

Reyes, A.P., *NMR Spectroscopy at high magnetic fields*, Physics Department Colloquium, University of South Alabama, December 8 (2005)

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Akhmeteli, A.M. and Gavrilin, A.V., *"Layered shell vacuum balloons"*, US patent application No. 11/127,613; application status: docketed new case - ready for examination; filing date: May 12 (2005)

Bird, M.D.; Brooks, J. and Eyssa, Y.M., *"Superconducting Levitation Magnet"*, Patent No. 6,850,137 B2; February 1 (2005)

Eyssa, Y.M., *"Apparatus and Method for Controlling Movement of an Object Through a Medium Using a Magnetic Field"*, Patent No. 6,842,324,B2; January 11 (2005)

Gavrilin, A.V. and Bird, M.D., *"Transverse Field Bitter-Type Magnet"*, U.S. Patent No. 6,876,288, Awarded April 05 (2005)

Morley, G.W.; Hao, L. and Macfarlane, J., *"A Double-SQUID for Sensitive Magnetic Field Measurements"*, US patent filed October 7 (2005)

Singleton, J.; Ardavan, H. and Ardavan, A., *"Invention disclosure: countermeasure-resistant radar source based on oscillating, accelerated, superluminal polarization currents"*, (2005)

Awards, Honors & Service

Adams, Dwight, American Physical Society Keithley Award (2005)

Brooks, James S., Distinguished Research Professor Award by FSU (2005)

Gor'kov, Lev P., Elected to National Academy of Sciences (2005)

Graf, David E., First recipient of the NHMFL Jack E. Crow Postdoctoral Fellowship (2005)

Harrison, Neil, 2005 Los Alamos Fellows' Prize for Outstanding Research

Hebard, Arthur, Fellow, American Association for the Advancement of Science (2005)

Jo, Younjung, Second recipient of the NHMFL Schuler Postdoctoral Fellowship (2005)

Lee, Yoonseok, University of Florida College of Liberal Arts and Sciences, 2005/2006 Advisor of the Year

MacDonald, Weldon, "Best Poster Award" 2005 Fall MRS Meeting (2005)

Moore, Jacob, Ruth L. Kirschstein National Research Service Award; Individual Fellowship from the U.S. Public Health Service (2005)

Nguyen, Hau T B, American Heart Association Predoctoral Fellowship (2005-2007)

Schwartz, Justin
Editor in Chief, IEEE Transactions on Applied Superconductivity (2005-present)
Engineering Research Award, Florida A&M University-Florida State University College of Engineering, In Appreciation of Exceptional Research Productivity (2005)
Named the Jack E. Crow Professor of Engineering by FSU (2005)

Showalter, Scott, NIH Postdoctoral Fellowship (2005-present)

Singleton John, Los Alamos Laboratory Fellow (2005)

Tanner, David, Honored with 3-day symposium: *Tannerfest 2005*, University of Florida

Ph.D. Dissertations

Carlsohn, Elisabet, *"Mass Spectrometry-based Proteomic Strategies Applied to Helicobacter pylori"*, Goteborg University, Goteborg, Sweden, Medical, advisor: Carol L. Nilsson (2005)

Cason, A.C., *"Sex Differences and the Role of Ovarian Steroids in the Behavioral and Neural Effects of High Strength Static Magnetic Fields"*, Florida State University, Program in Neuroscience, advisor: T.A. Houpt (2005)

Gangadhariah, S., *"Interacting Fermions in Two Dimensions: Singularities in the Perturbation Theory, Non-Analyticities, and Anomalous Effective Mass"*, University of Florida, Physics, advisor: Dmitrii Maslov (2005)

Hu, Jun, *"Structure-Function Correlation of the M2 Proton Channel Characterized by Solid-State Nuclear Magnetic Resonance Spectroscopy"*, Florida State University, Chemistry and Biochemistry, advisor: Timothy A. Cross (2005)

Klironomos, F.D., *"Tunneling between Two-dimensional Electron Systems in a High Magnetic Field and Crystalline Phases of a Two-dimensional Electron System in a Magnetic Field",* University of Florida, Physics, advisor: Alan T. Dorsey (2005)
Lingyin, Zhu, *"Quasiparticle Interference and the Local Electronic Structure of Disordered d-Wave Superconductors",* University of Florida, advisor: Peter Hirschfeld (2005)
Marin, V., *"Domain-domain Interactions on the Pathway of Activation of Diphtheria Toxin Repressor Protein (DtxR)",* Florida State University, Chemistry & Biochemistry, advisor: Timothy M. Logan (2005)
Morley, G.W., *"Designing a Quantum Computer Based on Pulsed ESR",* University of Oxford, Department of Physics, advisors: A. Ardavan and G.A.D. Briggs (2005)
Nyarko, Afua, *"Structure and Interactions of Subunits of Cytoplasmic Dynein",* Ohio University, Chemistry and Biochemistry, advisor: Elisar Barbar (2005)
Song, Likai, *"Conformation of Troponin and Myosin in Muscle Contraction",* Florida State University, Biology, advisor: Peter Fajer (2005)
Stepanenko, D., *"Symmetry and Control in Spin-Based Quantum Computation",* Florida State University, Physics, advisor: Nicholas E. Bonesteel (2005)
Takahashi, S., *"Angle-dependent High Magnetic Field Microwave Spectroscopy of Low Dimensional Conductors and Superconductors",* University of Florida, Physics, advisor: Stephen Hill (2005)
Tanaskovic, D., *"Anomalous Metallic Behavior in Strongly Correlated Electron Systems with Disorder",* Florida State University, Physics, advisor: V. Dobrosavljevic (2005)
Walton, W.J., *"Isotopic Enrichment and Receptor Binding Analysis of Recombinant Avian Thy-1",* Florida State University, Molecular Biophysics, advisor: Timothy M. Logan (2005)
Wilke, R.H.T., *"Tuning the Superconducting Properties of Magnesium Diboride",* Iowa State University, Department of Physics and Astronomy, advisor: Paul C. Canfield (2005)

Master Theses

Berret, Antoine, *"Morphologic Influence of High Magnetic Fields on the in-situ Synthesis of Xylene-Ferrocene Nanotubes and Structures.",* Florida State University, Mechanical Engineering, advisor: Hamid Garmestani (2005)
Cason, Angela A., *"Female Rats Show Greater Sensitivity to High-strength Magnetic Field Exposure: Role of Vestibular System and Estrogen",* Florida State University, Department of Biological Sciences, advisor: Dr. Thomas A. Houpt (2005)
Kasprczak, Agnieska, *"Increasing the Yield of Thy1-EGFP Expression in Insect and Mammalian Cells",* Florida State University, Chemistry & Biochemistry, advisor: Timothy M. Logan (2005)

Grants Awarded to NHMFL-Affiliated Faculty at Florida State University

As reported by the FSU Office of Sponsored Research for calendar year 2005

PI: Bird, Mark
Grant Title: Series Connected Hybrid
Agency: National Science Foundation
Project Dates: 7/15/04-6/30/06
Award: $894,654.00

PI: Boebinger, Gregory
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/02-3/31/12
Award: $8,106.00

PI: Boebinger, Gregory
Grant Title: Program Income for Mag Lab
Agency: Various Sources (Royalties/Other)
Project Dates: 12/2/95-6/30/05
Award: $35,778.70

PI: Boebinger, Gregory
Grant Title: National High Magnetic Field Laboratory
Agency: National Science Foundation
Project Dates: 1/1/01-12/31/07
Award: $25,500,000.00

PI: Boebinger, Gregory
Grant Title: IMR-MIP: Concept and Engineering Design of a Free Electron Laser Light Source for High Magnetic Field Research
Agency: National Science Foundation
Project Dates: 9/1/05-8/31/07
Award: $1,842,219.00

PI: Bonesteel, Nicholas
Grant Title: Correlated Electrons in Reduced Dimensions
Agency: U. S. Department of Energy
Project Dates: 6/1/97-7/31/06
Award: $55,000.00

PI: Brandt, Bruce
Grant Title: Series Connected Hybrid
Agency: National Science Foundation
Project Dates: 7/15/04-6/30/06
Award: $894,654.00

PI: Brooks, James
Grant Title: Request for Partial Support to Hold 6th International Conference on Sixth International Symposium on Crystalline Organic Metals, Superconductors, and Ferromagnets
Agency: National Science Foundation
Project Dates: 6/15/05-5/31/06
Award: $10,000.00

PI: Brunel, Louis Claude
Grant Title: IMR-MIP: Concept and Engineering Design of a Free Electron Laser Light Source for High Magnetic Field Research
Agency: National Science Foundation
Project Dates: 9/1/05-8/31/07
Award: $1,842,219.00

PI: Bruschweiler, Rafael
Grant Title: George Matthew Edgar Professorship
Agency: Florida State University Research Foundation
Project Dates: 12/22/04-12/31/11
Award: $20,000.00

PI: Bruschweiler, Rafael
Grant Title: Direct NMR Methods for Protein Structures and Assignments
Agency: National Institute of General Medical Sciences
Project Dates: 1/1/05-4/30/06
Award: $55,187.00

PI: Bruschweiler, Rafael
Grant Title: George Matthew Edgar Professorship
Agency: Florida State University Research Foundation
Project Dates: 12/22/04-12/31/11
Award: $20,000.00

PI: Bruschweiler, Rafael
Grant Title: Direct NMR Methods for Protein Structures and Assignments
Agency: National Institute of General Medical Sciences
Project Dates: 1/1/05-4/30/06
Award: $182,500.00

PI: Bruschweiler, Rafael
Grant Title: Direct NMR Methods for Protein Structures and Assignments
Agency: National Institute of General Medical Sciences
Project Dates: 1/1/05-4/30/05
Award: $45,678.00

PI: Bruschweiler, Rafael
Grant Title: NMR/MD Studies f Human MDM2 Interaction with P53
Agency: National Cancer Institute
Project Dates: 7/1/05-6/30/06
Award: $42,068.00

PI: Cao, Jianming
Grant Title: The Study of Ultrafast Structural Dynamics in Solid Materials With Femtosecond Electron Diffraction
Agency: National Science Foundation
Project Dates: 6/1/03-5/31/06
Award: $103,956.00

PI: Chapman, Michael
Grant Title: Membrane Protein Structural Genomics: M. Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/01-8/31/06
Award: $880,349.00

PI: Chapman, Michael
Grant Title: Membrane Protein Structural Genomics: M Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/01-8/31/06
Award: $134,089.00

PI: Chapman, Michael
Grant Title: Bess Ward Fellowship and Honors Thesis Awards
Agency: University Honors Program
Project Dates: 5/1/05-6/30/06
Award: $12,000.00

PI: Chapman, Michael
Grant Title: Structural Studies of AAV Serotypes 3b and 6
Agency: American Heart Association
Project Dates: 7/1/05-6/30/07
Award: $42,000.00

PI: Chapman, Michael
Grant Title: Mapping Adeno-Associated Virus-2 Cellular Receptor Binding Sites Using Cryo-Electon Microscopy
Agency: American Heart Association
Project Dates: 7/1/05-6/30/07
Award: $42,000.00

PI: Chapman, Michael
Grant Title: Structure-Function of AAV-A Viral Gene Therapy Vector
Agency: National Institute of General Medical Sciences
Project Dates: 12/16/02-1/31/06
Award: $259,539.00

PI: Cross, Timothy
Grant Title: Membrane Protein Structural Genomics: M. Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/01-8/31/06
Award: $181,200.00

PI: Cross, Timothy
Grant Title: Membrane Protein Structural Genomics: M. Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/01-8/31/06
Award: $880,349.00

PI: Cross, Timothy
Grant Title: Membrane Protein Structural Genomics: M. Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/1/03-8/31/06
Award: $119,955.00

PI: Cross, Timothy
Grant Title: Series Connected Hybrid
Agency: National Science Foundation
Project Dates: 7/15/04-6/30/06
Award: $894,654.00

PI: Cross, Timothy
Grant Title: Structural Analysis of Integral Membrane Proteins
Agency: American Heart Association
Project Dates: 7/1/05-6/30/07
Award: $42,000.00

PI: Cross, Timothy
Grant Title: Tuberculosis Pericarditis: Alpha Helical Membrane Protein Backbone Structure Determination
Agency: American Heart Association
Project Dates: 7/1/05-12/21/05
Award: $10,500.00

PI: Cross, Timothy
Grant Title: Membrane Protein Solid State NMR: PISEMA Development and the M2 Tetramer Structure
Agency: National Science Foundation
Project Dates: 2/1/03-1/31/07
Award: $177,195.00

PI: Cross, Timothy
Grant Title: Correlations: Structure-Dynamics-Functions in Channels
Agency: National Institute of Allergy & Infectious Diseases
Project Dates: 3/1/05-2/28/06
Award: $348,238.00

PI: Dalal, Naresh
Grant Title: Undergraduate Education in Chemistry
Agency: Various Sources (Business/Industry)
Project Dates: 6/13/95-6/30/07
Award: $2,864.00

PI: Dalal, Naresh
Grant Title: Direct NMR Methods for Protein Structures and Assignments
Agency: National Institute of General Medical Sciences
Project Dates: 1/1/05-4/30/06
Award: $55,187.00

PI: Dalal, Naresh
Grant Title: Development of a New Class of Refrigerants for the Mk-20K Range Based on the Cr(V) Tetraperoxides
Agency: National Aeronautics & Space Administration
Project Dates: 9/15/05-9/14/06
Award: $24,977.00

PI: Dalal, Naresh
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/05-3/31/12
Award: $3,520.00

PI: Dalal, Naresh
Grant Title: Direct NMR Methods for Protein Structures and Assignments
Agency: National Institute of General Medical Sciences
Project Dates: 1/1/05-4/30/06
Award: $182,500.00

PI: Dalal, Naresh
Grant Title: Nano-FRET: Analysis of Nucleoprotein Complexes
Agency: Nat'l Institute of Biomedical Imaging and Bioengineering
Project Dates: 11/16/03-3/31/06
Award: $221,589.00

PI: Dalal, Naresh
Grant Title: Direct NMR Methods for Protein Structures and Assignments
Agency: National Institute of General Medical Sciences
Project Dates: 1/1/05-4/30/05
Award: $45,678.00

PI: Dalal, Naresh
Grant Title: NMR/MD Studies f Human MDM2 Interaction with P53
Agency: National Cancer Institute
Project Dates: 7/1/05-6/30/06
Award: $42,068.00

PI: Dalal, Naresh
Grant Title: Quantum Spin Dynamics In Molecule-Based Nanomagnets
Agency: New York University
Project Dates: 8/1/05-7/31/09
Award: $252,050.00

PI: Dalal, Naresh
Grant Title: New Zero-Dimensional Quantum Systems Based on Heteronuclear Clusters
Agency: U. S. Civilian Research & Development Foundation
Project Dates: 8/1/05-7/31/07
Award: $6,000.00

PI: Davidson, Michael
Grant Title: Construction of Interactive Media
Agency: Olympus America
Project Dates: 4/1/00-8/15/06
Award: $150,000.00

PI: Davidson, Michael
Grant Title: Construction of Interactive Tutorials
Agency: Nikon, Inc.
Project Dates: 4/1/00-3/31/06
Award: $150,000.00

PI: Engel, Lloyd
Grant Title: Microwave/Rf Spectroscopy of 2D Electron Solids/Stripes
Agency: U. S. Department of Energy
Project Dates: 7/1/05-6/30/08
Award: $279,764.00

PI: Fajer, Piotr
Grant Title: EPR Studies of Protein-Protein Interactions: Distances, Orientation and Molecular Modeling
Agency: National Science Foundation
Project Dates: 3/1/04-2/28/07
Award: $199,584.00

PI: Fajer, Piotr
Grant Title: EPR Studies of Protein-Protein Interactions: Distances, Orientation and Molecular Modeling
Agency: National Science Foundation
Project Dates: 3/1/04-2/28/07
Award: $199,584.00

PI: Fajer, Piotr
Grant Title: Tnl and Tnc Structural Behavior
Agency: American Heart Association
Project Dates: 7/1/05-6/30/07
Award: $42,000.00

PI: Froelich, Philip
Grant Title: Francis Eppes Professorship
Agency: Florida State University Research Foundation
Project Dates: 8/8/03-12/31/08
Award: $40,000.00

PI: Froelich, Philip
Grant Title: The Acquisition of a Multi-Collector Inductively Coupled Plasma Mass Spectrometer and Laser Ablation System for Earth and Ocean Sciences at Florida State University
Agency: National Science Foundation
Project Dates: 9/1/05-8/31/07
Award: $287,294.00

PI: Fu, Riqiang
Grant Title: Membrane Protein Solid State NMR: PISEMA Development and the M2 Tetramer Structure
Agency: National Science Foundation
Project Dates: 2/1/03-1/31/07
Award: $177,195.00

PI: Fu, Riqiang
Grant Title: Correlations: Structure-Dynamics-Functions in Channels
Agency: National Institute of Allergy & Infectious Diseases
Project Dates: 3/1/05-2/28/06
Award: $348,238.00

PI: Gaffney, Betty
Grant Title: Effect of Vascular Protectants on Lipoxygenase
Agency: AtheroGenics, Inc
Project Dates: 9/20/05-9/19/06
Award: $2,000.00

PI: Gaffney, Betty
Grant Title: Reactive Intermediates in Lipoxygenase Pathways
Agency: National Institute of General Medical Sciences
Project Dates: 4/10/03-3/31/06
Award: $180,064.00

PI: Gaffney, Betty
Grant Title: Reactive Intermediates in Lipoxygenase Pathways
Agency: National Institute of General Medical Sciences
Project Dates: 4/10/03-3/31/06
Award: $180,064.00

PI: Gao, Fei
Grant Title: Correlations: Structure-Dynamics-Functions in Channels
Agency: National Institute of Allergy & Infectious Diseases
Project Dates: 3/1/05-2/28/06
Award: $348,238.00

PI: Greenbaum, Nancy
Grant Title: Structural Studies of RNA Elements in Pre-mRNA Splicing
Agency: National Institute of General Medical Sciences
Project Dates: 8/5/03-7/31/06
Award: $209,257.00

PI: Greenbaum, Nancy
Grant Title: Metal Ion-Dependent Folding of the Spliceosomal U2-U6 snRNA Complex
Agency: National Science Foundation
Project Dates: 8/1/03-7/31/06
Award: $129,716.00

PI: Greenbaum, Nancy
Grant Title: IMR-MIP: Concept and Engineering Design of a Free Electron Laser Light Source for High Magnetic Field Research
Agency: National Science Foundation
Project Dates: 9/1/05-8/31/07
Award: $1,842,219.00

PI: Hendrickson, Christopher
Grant Title: FT-ICR Development Research Agreement Between the Korea Basic Science Institute and the Florida State University Research Foundation, Inc. and Florida State University
Agency: Korea Basic Science Institute
Project Dates: 2/1/05-8/31/06
Award: $221,032.00

PI: Humayun, Munir
Grant Title: Siderophile Element Microanalysis by Laser Ablation ICP-MS
Agency: National Aeronautics & Space Administration
Project Dates: 8/15/04-6/30/06
Award: $156,000.00

PI: Humayun, Munir
Grant Title: Siderophile Element Microanalysis by Laser Ablation ICP-MS
Agency: National Aeronautics & Space Administration
Project Dates: 8/15/04-6/30/06
Award: $84,000.00

PI: Humayun, Munir
Grant Title: Analysis of GENESIS Wafers by ICP-MS
Agency: National Aeronautics & Space Administration
Project Dates: 2/16/05-2/15/10
Award: $163,900.00

PI: Humayun, Munir
Grant Title: Siderophile Element Microanalysis by Laser Ablation ICP-MS
Agency: National Aeronautics & Space Administration
Project Dates: 8/15/04-6/30/06
Award: $82,000.00

PI: Humayun, Munir
Grant Title: Platinum Group Element Geochemistry of High Mgo Lavas
Agency: National Science Foundation
Project Dates: 7/1/04-6/30/06
Award: $84,791.00

PI: Humayun, Munir
Grant Title: The Acquisition of a Multi-Collector Inductively Coupled Plasma Mass Spectrometer and Laser Ablation System for Earth and Ocean Sciences at Florida State University
Agency: National Science Foundation
Project Dates: 9/1/05-8/31/07
Award: $287,294.00

PI: Humayun, Munir
Grant Title: Development of an ICP Dual Mass Spectrometer for the Analysis of Discovery Mission Samples
Agency: National Aeronautics & Space Administration
Project Dates: 8/15/05-8/14/06
Award: $300,000.00

PI: Kalu, Peter
Grant Title: Cummins IUCRC Membership
Agency: Cummins Engine Co., Inc.
Project Dates: 8/1/02-4/30/06
Award: $50,000.00

PI: Kalu, Peter
Grant Title: Production of Seamless Superconducting Radio Frequency Cavities From Ultra-Fine Grained Niobium
Agency: Black Laboratories, L.L.C.
Project Dates: 10/10/05-8/31/07
Award: $30,000.00

PI: Landing, William
Grant Title: Assessment of Environmental Pollution
Agency: University of West Florida
Project Dates: 5/1/05-4/30/07
Award: $49,970.00

PI: Landing, William
Grant Title: Supplement to Collaborative Research: Global Ocean Survey of Dissolved Iron and Aluminum and Aerosol Iron and Aluminum Solubility Supporting the Repeat Hydrography (CO2) Project
Agency: National Science Foundation
Project Dates: 2/1/03-8/31/06
Award: $30,486.00

PI: Landing, William
Grant Title: Assessment of Environmental Pollution
Agency: University of West Florida
Project Dates: 5/1/05-4/30/06
Award: $24,985.00

PI: Landing, William
Grant Title: REU Supplement: NSF Collaborative Research
Agency: National Science Foundation
Project Dates: 2/1/03-8/31/06
Award: $5,000.00

PI: Landing, William
Grant Title: Apalachicola NERRS Nutrient Analysis Project: 2005-2006
Agency: Florida Department of Environmental Protection
Project Dates: 3/1/05-2/28/06
Award: $18,675.00

PI: Landing, William
Grant Title: The Acquisition of a Multi-Collector Inductively Coupled Plasma Mass Spectrometer and Laser Ablation System for Earth and Ocean Sciences at Florida State University
Agency: National Science Foundation
Project Dates: 9/1/05-8/31/07
Award: $287,294.00

PI: Logan, Timothy
Grant Title: Caspar Research Fund
Agency: Florida State University Foundation
Project Dates: 9/1/05-12/31/10
Award: $20,000.00

PI: Logan, Timothy
Grant Title: Glycoprotein Structural Biology
Agency: Florida State University Research Foundation
Project Dates: 4/20/05-6/30/07
Award: $100,000.00

PI: Logan, Timothy
Grant Title: Peptide Activators of Diphtheria Toxin Repressor, DtxR
Agency: Boston Medical Center
Project Dates: 2/1/05-3/31/06
Award: $201,388.00

PI: Luongo, Cesar
Grant Title: Computer Simulation of Quench
Agency: Office of Naval Research
Project Dates: 6/1/02-5/31/07
Award: $9,034.57

PI: Marshall, Alan
Grant Title: Unocal-Analysis of One Petroleum Sample
Agency: Various Sources (Business/Industry)
Project Dates: 12/23/03-7/19/06
Award: $2,000.00

PI: Marshall, Alan
Grant Title: Contract for Services with Aramco Services Company to Provide Sample Analysis
Agency: Various Sources (Business/Industry)
Project Dates: 12/23/03-7/19/06
Award: $50,000.00

PI: Marshall, Alan
Grant Title: Membrane Protein Structural Genomics: M. Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/01-8/31/06
Award: $880,349.00

PI: Marshall, Alan
Grant Title: Contract with Baker Petrolite Corp.
Agency: Various Sources (Business/Industry)
Project Dates: 12/23/03-12/31/05
Award: $15,000.00

PI: Marshall, Alan
Grant Title: Exxon Mobil Unrestricted Grant
Agency: Exxon Chemical Company
Project Dates: 9/20/02-12/31/07
Award: $25,000.00

PI: Marshall, Alan
Grant Title: Contract with Oilphase DBR
Agency: Various Sources (Business/Industry)
Project Dates: 12/23/03-12/31/05
Award: $42,000.00

PI: Marshall, Alan
Grant Title: Contract with the Aramco Services Company
Agency: Various Sources (Business/Industry)
Project Dates: 12/23/03-12/31/05
Award: $6,000.00

PI: Marshall, Alan
Grant Title: FT-ICR Analysis
Agency: Various Sources (Business/Industry)
Project Dates: 12/23/03-12/31/05
Award: $1,500.00

PI: Marshall, Alan
Grant Title: Contract with ExxonMobil Research and Engineering Co.(EMRE)
Agency: Various Sources (Business/Industry)
Project Dates: 12/23/03-12/31/05
Award: $20,000.00

PI: Marshall, Alan
Grant Title: Program Income for 007232
Agency: Various Sources (Royalties/Other)
Project Dates: 1/1/00-12/31/05
Award: $69,700.00

PI: Marshall, Alan
Grant Title: Program Income for Project 007232
Agency: Various Sources (Royalties/Other)
Project Dates: 11/26/03-12/31/05
Award: $63,700.00

PI: Miller, John
Grant Title: A Study of the Feasibility and Design Principles of a Horizontal Series-Connected Hybrid (SCH) Magnet System for Use with Neutron Scattering Experiments in the Field of Structural Research at the Berl
Agency: Hahn-Meitner-Institute Berlin
Project Dates: 7/15/05-10/31/05
Award: $25,000.00

PI: Miller, John
Grant Title: Series Connected Hybrid
Agency: National Science Foundation
Project Dates: 7/15/04-6/30/06
Award: $894,654.00

PI: Miller, John
Grant Title: KBSI-NHMFL Collaboration on FTICR Conceptual Design
Agency: Korea Basic Science Institute
Project Dates: 3/1/05-3/1/06
Award: $100,000.00

PI: Miller, John
Grant Title: FSU Support of Sandia LDRD Year 2
Agency: Sandia National Laboratories
Project Dates: 10/1/03-11/30/05
Award: $130,005.43

PI: Miller, John
Grant Title: Sandia DARPA
Agency: Sandia National Laboratories
Project Dates: 2/10/05-9/30/05
Award: $295,844.80

PI: Miller, John
Grant Title: MTECH STTR
Agency: MTECH Laboratories, LLC
Project Dates: 12/1/04-7/31/05
Award: $30,000.00

PI: Miller, John
Grant Title: Feasibility Demonstration For Superconducting Undulator
Agency: Argonne National Laboratory
Project Dates: 7/14/05-5/12/06
Award: $319,715.00

PI: Miller, John
Grant Title: Large Bore Superconducting Magnet
Agency: Jet Propulsion Lab
Project Dates: 4/11/05-10/7/05
Award: $35,369.00

PI: Miller, John
Grant Title: Superconducting Undulator Study
Agency: Argonne National Laboratory
Project Dates: 8/19/04-12/20/04
Award: $27,542.00

PI: Moerland, Timothy
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/02-3/31/12
Award: $2,714.00

PI: Moerland, Timothy
Grant Title: Cold Body Temperature as an Evolutionary Shaping Force in the Physiology of Antarctic Fishes
Agency: University of Maine
Project Dates: 9/1/03-8/31/06
Award: $6,081.00

PI: Painter, Thomas
Grant Title: KBSI-NHMFL Collaboration on FTICR Conceptual Design
Agency: Korea Basic Science Institute
Project Dates: 3/1/05-3/1/06
Award: $100,000.00

PI: Popovic, Dragana
Grant Title: Study of Correlated Insulators and Metals in Two Dimensions
Agency: National Science Foundation
Project Dates: 5/1/04-4/30/06
Award: $100,000.00

PI: Quine, John
Grant Title: Membrane Protein Structural Genomics: M. Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/01-8/31/06
Award: $880,349.00

PI: Quine, John
Grant Title: Membrane Protein Structural Genomics: M Tuberculosis
National Institute of General Medical Sciences
Project Dates: 9/28/01-8/31/06
Award: $134,089.00

PI: Quine, John
Grant Title: Membrane Protein Solid State NMR: PISEMA Development and the M2 Tetramer Structure
Agency: National Science Foundation
Project Dates: 2/1/03-1/31/07
Award: $177,195.00

PI: Rikvold, Per
Grant Title: COFRS: Biological Evolution by Statistical Physics
Agency: Florida State University Council on Research Creativity
Project Dates: 5/9/05-8/5/05
Award: $8,000.00

PI: Rikvold, Per
Grant Title: Computational Studies of Dynamical Phenomena in Nanoscale Ferromagnets
Agency: Mississippi State University
Project Dates: 4/1/05-2/28/06
Award: $82,137.00

PI: Salters, Vincent
Grant Title: Support for Teachers for Teachers (GIFT) Workshop
Agency: National Science Foundation
Project Dates: 9/15/05-8/31/06
Award: $12,000.00

PI: Salters, Vincent
Grant Title: Collaborative Research: Isotopic Constraints on the Mineralogy of the MORB Source
Agency: National Science Foundation
Project Dates: 3/1/03-2/28/06
Award: $90,329.00

PI: Salters, Vincent
Grant Title: The Acquisition of a Multi-Collector Inductively Coupled Plasma Mass Spectrometer and Laser Ablation System for Earth and Ocean Sciences at Florida State University
Agency: National Science Foundation
Project Dates: 9/1/05-8/31/07
Award: $287,294.00

PI: Schlottmann, Pedro
Grant Title: Correlated Electrons
Agency: U. S. Department of Energy
Project Dates: 8/15/98-8/14/06
Award: $50,000.00

PI: Schwartz, Justin
Grant Title: AC Conductors
Agency: American Superconductor
Project Dates: 8/16/05-8/14/07
Award: $153,954.00

PI: Schwartz, Justin
Grant Title: High Field Magnets for MRI Applications
Agency: Supercon, Inc.
Project Dates: 9/14/04-8/31/05
Award: $15,000.00

PI: Schwartz, Justin
Grant Title: Quench Behavior of YBCO Coated Conductors
Agency: University of Wisconsin
Project Dates: 7/1/04-12/31/05
Award: $45,826.00

PI: Schwartz, Justin
Grant Title: Quench Behavior of YBCO Coated Conductors
Agency: University of Wisconsin
Project Dates: 7/1/04-3/31/05
Award: $29,164.00

PI: Swenson, Charles
Grant Title: FSU Support of Sandia LDRD Year 2
Agency: Sandia National Laboratories
Project Dates: 10/1/03-11/30/05
Award: $130,005.43

PI: Swenson, Charles
Grant Title: Sandia DARPA
Agency: Sandia National Laboratories
Project Dates: 2/10/05-9/30/05
Award: $295,844.80

PI: Tozer, Stanley
Grant Title: Electron Interactions in Actinides and Related Systems Under Extreme Conditions
Agency: U. S. Department of Energy
Project Dates: 11/15/02-11/15/06
Award: $159,771.00

PI: Van Sciver, Steven
Grant Title: Particle Separation Using Superfluid Helium Technology
Agency: Oxford Instruments Superconductivity Ltd
Project Dates: 11/15/05-8/14/06
Award: $90,000.00

PI: Van Sciver, Steven
Grant Title: Thermal Conductivity of Powder Insulations
Agency: University of Central Florida
Project Dates: 2/1/05-5/30/06
Award: $46,500.00

PI: Van Sciver, Steven
Grant Title: Particle Separation Using Superfluid Helium Technology
Agency: Oxford Instruments Superconductivity Ltd
Project Dates: 3/30/05-7/31/05
Award: $30,000.00

PI: Van Sciver, Steven
Grant Title: Liquid Helium Fluid Dynamics Studies
Agency: U. S. Department of Energy
Project Dates: 1/1/96-12/31/05
Award: $205,000.00

PI: Van Sciver, Steven
Grant Title: Integration of Magnetic Actuation Using VOST Design
Agency: Big Horn Valve, Inc.
Project Dates: 8/1/02-7/31/05
Award: $31,455.00

PI: Van Sciver, Steven
Grant Title: Densified LH2 and LO2: Transport Properties, Density and Flow Studies of Subcooled Liquids and Solid Particles
Agency: University of Central Florida
Project Dates: 6/1/02-12/31/05
Award: $570,000.00

PI: Van Sciver, Steven
Grant Title: Thermal Conductivity of Powder Insulations
Agency: University of Central Florida
Project Dates: 2/1/05-2/1/06
Award: $53,500.00

PI: van Tol, Johan
Grant Title: IMR-MIP: Concept and Engineering Design of a Free Electron Laser Light Source for High Magnetic Field Research
Agency: National Science Foundation
Project Dates: 9/1/05-8/31/07
Award: $1,842,219.00

PI: Yang, Kun
Grant Title: ITR: Study of Complex Nanoclustered States Using Novel Efficient
Agency: University of Tennessee at Knoxville
Project Dates: 9/17/04-1/31/06
Award: $51,005.00

Grants Awarded to NHMFL-Affiliated Faculty at the University of Florida

As reported by the UF Office of Sponsored Research for calendar year 2005

PI: Abernathy, C.
Grant Title: Magneto-Optical Behavior of II-Tm-N Materials & Devices
Agency: U.S. Army
Project Dates: 10/1/04-9/30/06
Award: $89,000.00

PI: Abernathy, C.
Grant Title: Acquisition of XPS/UPS System for Study of GAN Device Surfaces
Agency: U.S. Navy
Project Dates: 5/1/05-4/30/06
Award: $180,000.00

PI: Abernathy, C.
Grant Title: Magneto-Optical Behavior of II-Tm-N Materials & Devices
Agency: U.S. Army
Project Dates: 10/1/04-9/30/06
Award: $47,000.00

PI: Angerhofer, A.
Grant Title: NHMFL In-House Research Program
Agency: Florida State University
Project Dates: 1/1/05-12/31/06
Award: $82,500.00

PI: Angerhofer, A.
Grant Title: Smoking as a Novel Risk Factor for Progression of Renal Disease
Agency: Dept. of Health
Project Dates: 7/1/05-6/30/07
Award: $10,792.00

PI: Angerhofer, A.
Grant Title: NHMFL In-House Research Program
Agency: Florida State University
Project Dates: 1/1/05-12/31/06
Award: $82,500.00

PI: Blackband, S.J.
Grant Title: NMR Microscopy of Single Neural Cells and Brain Slices
Agency: National Institutes of Health
Project Dates: 3/1/02-1/31/06
Award: $276,325.00

PI: Blackband, S.J.
Grant Title: High Field Magnetic Resonance Research and Technology
Agency: National Institutes of Health
Project Dates: 5/1/01-4/30/06
Award: $358,309.00

PI: Blackband, S.J.
Grant Title: Hippocampal Shape Recovery & Analysis in Epileptics
Agency: National Institutes of Health
Project Dates: 5/1/05-4/30/09
Award: $12,663.00

PI: Blackband, S.J.
Grant Title: Core 2:High Field Magnetic Resonance Research and Technology
Agency: National Institutes of Health
Project Dates: 5/1/01-4/30/06
Award: $169,322.00

PI: Blackband, S.J.
Grant Title: The National High Magnetic Field Laboratory
Agency: Florida State University
Project Dates: 1/1/05-12/31/07
Award: $594,531.00

PI: Blackband, S.J.
Grant Title: High-Field MRI: Limitations and Solutions
Agency: Pennsylvania State University
Project Dates: 9/3/02-8/31/06
Award: $133,816.00

PI: Brennan, A.B.
Grant Title: Reduced Creep in Ultra High Molecular Weight Polyethlene Fiber
Agency: Lockheed Martin
Project Dates: 8/1/05-11/28/05
Award: $200,000.00

PI: Brennan, A.B.
Grant Title: Revenue from Endowed Professorship
Agency: U.F. Foundation
Project Dates: 9/1/05-6/30/10
Award: $13,125.00

PI: Cheng, H.P.
Grant Title: Interfacial Phenomena in Nobel Metal-C60 Interactions
Agency: U.S. Department of Energy
Project Dates: 12/1/03-11/30/06
Award: $57,604.00

PI: Christou, G.
Grant Title: Quantum Spin Dynamics in Molecular Nanomagnets
Agency: New York University
Project Dates: 8/1/05-7/31/09
Award: $252,050.00

PI: Christou, G.
Grant Title: Transition Metal Clusters as Single-Molecule Magnets
Agency: National Science Foundation
Project Dates: 8/1/04-7/31/07
Award: $158,000.00

PI: Constantinidis, I.
Grant Title: A Study of Model B-Cells in Diabetes Treatment
Agency: National Institutes of Health
Project Dates: 5/15/02-2/28/06
Award: $261,694.00

PI: Douglas, E.P.
Grant Title: Design Guidelines for Durability of Bonded CFRP Repair/ Strengthening of Concrete
Agency: University of Wyoming
Project Dates: 3/7/05-3/6/08
Award: $116,567.00

PI: Edison, A.S.
Grant Title: Discovery of *Caenorhabditis Elegans* Chemical Ecology
Agency: Human Frontier Science Program Org.
Project Dates: 7/1/05-6/30/06
Award: $190,000.00

PI: Edison, A.S.
Grant Title: National High Magnetic Field Laboratory - Special Projects AMRIS Facility
Agency: Florida State University
Project Dates: 11/1/04-4/30/05
Award: $40,000.00

PI: Edison, A.S.
Grant Title: Characterization of Endogenous G-Protein Coupled Receptor Antagonists
Agency: National Institutes of Health
Project Dates: 4/1/03-2/28/07
Award: $15,735.00

PI: Edison, A.S.
Grant Title: Core 3:High Field Magnetic Resonance Research and Technology
Agency: National Institutes of Health
Project Dates: 5/1/01-4/30/06
Award: $223,809.00

PI: Fitzsimmons, J.R.
Grant Title: Dental Fear and Anticipation of Pain: Imaging the Brain
Agency: National Institutes of Health
Project Dates: 4/15/01-3/31/06
Award: $9,212.00

PI: Fitzsimmons, J.R.
Grant Title: Core 1:High Field Magnetic Resonance Research and Technology
Agency: National Institutes of Health
Project Dates: 5/1/01-4/30/06
Award: $175,420.00

PI: Fitzsimmons, J.R.
Grant Title: Center for the Study of Emotion and Attention
Agency: National Institutes of Health
Project Dates: 7/1/05-6/30/10
Award: $19,120.00

PI: Fitzsimmons, J.R.
Grant Title: Center for the Study of Emotion and Attention
Agency: National Institutes of Health
Project Dates: 7/1/05-6/30/10
Award: $30,380.00

PI: Hebard, A.F.
Grant Title: Simultaneous Multiple Wavelength, Multiple Field of View Imaging System
Agency: U.S. Army
Project Dates: 1/1/04-5/16/07
Award: $142,722.00

PI: Hebard, A.F.
Grant Title: Surface Plasmon Coupling for Enhanced Transmission in Diffractive Optics
Agency: Raytheon Company
Project Dates: 3/22/04-12/31/05
Award: $45,000.00

PI: Hebard, A.F.
Grant Title: Magnetic Phenomena in Ultra-Thin Films and at Thin-Film Interfaces
Agency: National Science Foundation
Project Dates: 9/1/04-8/31/07
Award: $119,250.00

PI: Hebard, A.F.
Grant Title: Synthesis and Characterization of Self-Assembled Ordered Nano Arrays for Magnetic & Superconducting Applications
Agency: North Carolina A&T University
Project Dates: 7/15/04-6/30/06
Award: $29,993.00

PI: Hill, S.O.
Grant Title: Career: Magnetic Resonance - From Materials Research to Science Education
Agency: National Science Foundation
Project Dates: 5/1/03-4/30/08
Award: $90,000.00

PI: Hill, S.O.
Grant Title: Quantum Spin Dynamics in Molecular Nanomagnets
Agency: New York University
Project Dates: 8/1/05-7/31/09
Award: $252,050.00

PI: Hill, S.O.
Grant Title: Development of a Pulsed Broadband High-Field/High-Frequency EPR Spectrometer
Agency: Florida State University
Project Dates: 6/1/04-3/31/06
Award: $92,395.00

PI: Hirschfeld, P.J.
Grant Title: Grains, Wires and Interfaces of Cuprate Superconductors
Agency: U.S. Department of Energy
Project Dates: 9/1/05-8/31/08
Award: $99,983.00

PI: Hirschfeld, P.J.
Grant Title: Theory of Defects in Cuprate Superconductors
Agency: U.S. Navy
Project Dates: 10/1/03-9/30/06
Award: $49,172.00

PI: Ihas, G.G.
Grant Title: 24th International Conference on Low Temperature Physics (LT24)
Agency: National Science Foundation
Project Dates: 4/15/05-3/31/06
Award: $20,000.00

PI: Ihas, G.G.
Grant Title: Hydrogen Research for Spaceport and Space Based Applications
Agency: NASA
Project Dates: 8/1/03-8/2/05
Award: $20,000.00

PI: Lee, Y.
Grant Title: Nature of Pure & Dirty Liquid ^{3}He-Fundamental Investigations and Educational Activities
Agency: National Science Foundation
Project Dates: 2/15/03-1/31/06
Award: $90,133.00

PI: Liu, Y.
Grant Title: fMRI Analysis of a Neural Network Involved in Depression
Agency: National Institutes of Health
Project Dates: 9/1/05-8/31/07
Award: $71,702.00

PI: Liu, Y.
Grant Title: Functional MRI Investigation of Impaired Leptin Regulation Due to Secondband Smoking
Agency: Flight Attendant Med. Res. Inst.
Project Dates: 7/1/04-6/30/06
Award: $108,500.00

PI: Liu, Y.
Grant Title: fMRI of Serotonergic Genetic Variation in Autism
Agency: National Institutes of Health
Project Dates: 1/1/06-12/31/06
Award: $47,296.00

PI: Long, J.R.
Grant Title: Protein Structure-Function Relationships in Lung Surfactants
Agency: National Institutes of Health
Project Dates: 1/7/05-12/31/08
Award: $287,815.00

PI: Long, J.R.
Grant Title: Solid State NMR Studies of a Membrane-Associate Peptide: The Role of Membrane Composition on Ion Channel Structure,...
Agency: American Heart Association
Project Dates: 1/1/04-12/31/07
Award: $65,000.00

PI: Long, J.R.
Grant Title: Protein Structure-Function Relationships in Lung Surfactants
Agency: National Institutes of Health
Project Dates: 1/7/05-12/31/08
Award: $230,070.00

PI: Long, J.R.
Grant Title: Development of Techniques for Solid State NMR Structural Measurements at High Magnetic Fields
Agency: Florida State University
Project Dates: 8/1/04-3/31/06
Award: $33,627.00

PI: Mareci, T.H.
Grant Title: *In Vivo* Evaluation of Spinal Cord Injury Neuroprotection Algorithms for Automatic Fiber Tract Mapping in the CNS
Agency: National Institutes of Health
Project Dates: 4/1/02-3/31/06
Award: $39,035.00

PI: Maslov, D.
Grant Title: Interactions and Disorder in One, Two, and Three Dimensions
Agency: National Science Foundation
Project Dates: 7/15/03-6/30/06
Award: $80,000.00

PI: Meisel, M.W.
Grant Title: Magnetism of Quantum Spins Systems in Low Dimensions
Agency: National Science Foundation
Project Dates: 7/15/03-6/30/06
Award: $95,000.00

PI: Pearton, S.J.
Grant Title: Remote Power Transmission Using High Power GAN HEMTS and Diodes for Regenerative Fuel Cells
Agency: NASA
Project Dates: 9/30/04-8/2/06
Award: $64,000.00

PI: Pearton, S.J.
Grant Title: Highly Stable and Reliable Uncooled Lightweight Hydrogen Sensors for Fuel Cells
Agency: NASA
Project Dates: 9/30/04-8/2/06
Award: $35,000.00

PI: Pearton, S.J.
Grant Title: Use of Ion Implantation to Synthesize Wide Bandgap Ferromagnetic Semiconductors and Oxides
Agency: U.S. Army
Project Dates: 10/1/02-1/31/06
Award: $75,000.00

PI: Pearton, S.J.
Grant Title: High Density Three-Dimensional Packaging Technology for Rf Devices
Agency: International Technology Corp.
Project Dates: 5/18/04-9/18/06
Award: $128,000.00

PI: Pearton, S.J.
Grant Title: Revenue for Alumni I Endowed Professorship
Agency: U.F. Foundation
Project Dates: 9/1/05-6/30/10
Award: $16,153.00

PI: Pearton, S.J.
Grant Title: Nanoscale Arrays for Direct RNA Profiling in Single Cells and Their Compartments
Agency: National Science Foundation
Project Dates: 9/1/03-11/30/07
Award: $21,750.00

PI: Pearton, S.J.
Grant Title: ZNO PN Junctions for Highly-Efficient, Low-Cost Light Emitting Diodes
Agency: U.S. Department of Energy
Project Dates: 10/1/04-9/30/07
Award: $91,895.00

PI: Pearton, S.J.
Grant Title: 1.55 µm Sub-Micron Finger, Interdigitated MSM Photodetector Arrays with Low Dark Current
Agency: U.S. Army
Project Dates: 8/1/05-7/31/08
Award: $12,500.00

PI: Pearton, S.J.
Grant Title: Highly Stable and Reliable Uncooled Lightweight Hydrogen Sensors for Fuel Cells
Agency: NASA
Project Dates: 9/30/04-3/31/07
Award: $35,000.00

PI: Pearton, S.J.
Grant Title: Remote Power Transmission Using High Power GAN HEMTS and Diodes for Regenerative Fuel Cells
Agency: NASA
Project Dates: 9/30/04-3/31/07
Award: $70,000.00

PI: Reitze, D.H.
Grant Title: Ultrafast Coherent Control in High Magnetic Fields
Agency: Florida State University
Project Dates: 1/1/05-12/31/06
Award: $14,851.00

PI: Reitze, D.H.
Grant Title: Prototype Advanced Ligo Diagnostics and Optical Components: *In Situ* Measurements and Control of Thermo-Optical Effects
Agency: National Science Foundation
Project Dates: 7/1/05-6/30/08
Award: $82,500.00

PI: Reitze, D.H.
Grant Title: Ultrafast Coherent Control in High Magnetic Fields
Agency: Florida State University
Project Dates: 1/1/05-12/31/06
Award: $65,208.00

PI: Reitze, D.H.
Grant Title: Prototype Advanced Ligo Diagnostics and Optical Components: *In Situ* Measurements and Control of Thermo-Optical Effects
Agency: National Science Foundation
Project Dates: 7/1/05-6/30/08
Award: $27,500.00

PI: Reitze, D.H.
Grant Title: Ultrafast Coherent Control in High Magnetic Fields
Agency: Florida State University
Project Dates: 1/1/05-12/31/06
Award: $11,339.00

PI: Reitze, D.H.
Grant Title: Ultrafast Coherent Control in High Magnetic Fields
Agency: Florida State University
Project Dates: 1/1/05-12/31/06
Award: $69,602.00

PI: Richards, N.G.
Grant Title: Biochemical Studies of Oxalate Decarboxylase
Agency: National Institutes of Health
Project Dates: 4/1/03-1/31/07
Award: $163,564.00

PI: Richards, N.G.
Grant Title: Measuring Asparagine Synthetase Expression in Leukemia
Agency: National Institutes of Health
Project Dates: 6/1/04-5/31/06
Award: $29,827.00

PI: Rinzler, A.G.
Grant Title: Carbon Nanotube-Based Transparent Electrodes for Polymer…
Agency: Nanoholdings LLC
Project Dates: 7/15/05-6/14/07
Award: $274,899.00

PI: Schmalfuss, I.M.
Grant Title: Phase IIIB, Double-Blind, Multicenter, Randomized Crossover Study To Compare 0.10 Mmol/Kg of Multi-Hance
Agency: Bracco Diagnostics Inc
Project Dates: 10/1/03-10/1/05
Award: $28,125.00

PI: Schmalfuss, I.M.
Grant Title: Phase IIIB, Double-Blind, Multicenter, Randomized Crossover Study To Compare 0.10 Mmol/Kg of Multi-Hance
Agency: Bracco Diagnostics Inc
Project Dates: 10/1/03-10/1/05
Award: $16,875.00

PI: Stanton, C.J.
Grant Title: Optical Control in Semiconductors for Spintronics and Quantum Information Processing
Agency: National Science Foundation
Project Dates: 9/15/03-7/31/08
Award: $197,841.00

PI: Stanton, C.J.
Optical Control in Semiconductors for Spintronics and Quantum Information Processing
Agency: National Science Foundation
Project Dates: 9/15/03-7/31/08
Award: $23,752.00

PI: Steindler, D.A.
Grant Title: Study of Adult Brain Neuropoiesis
Agency: National Institutes of Health
Project Dates: 9/30/99-2/28/07
Award: $336,469.00

PI: Steindler, D.A.
Grant Title: Altering Fate of Hematopoietic and Neural Stem Cells
Agency: National Institutes of Health
Project Dates: 7/1/03-6/30/07
Award: $327,375.00

PI: Sullivan, N.S.
Grant Title: The National High Magnetic Field Laboratory
Agency: Florida State University
Project Dates: 1/1/05-12/31/07
Award: $218,879.00

PI: Takano, Y.
Grant Title: Bose-Einstein Condensation of Magnon in Quantum Magnets
Agency: Florida State University
Project Dates: 10/1/03-10/1/06
Award: $91,552.00

PI: Takano, Y.
Grant Title: Experimental Studies of Quantized Hall Effects at he NHMFL High-B/T Facility
Agency: Florida State University
Project Dates: 12/8/05-3/31/06
Award: $5,500.00

PI: Talham, D.R.
Grant Title: Fabrication and Magnetism of Coordinate Covalent Networks Assembled at Interfaces
Agency: National Science Foundation
Project Dates: 4/1/05-3/31/08
Award: $125,000.00

PI: Talham, D.R.
Grant Title: Metal Phosphonate Surfaces for Bioarray Applications
Agency: National Science Foundation
Project Dates: 8/15/05-7/31/08
Award: $150,000.00

PI: Tanner, D.B.
Grant Title: UF Participation In ADMX, the Axion Dark-Matter Experiment
Agency: U.S. Department of Energy
Project Dates: 3/1/05-2/28/06
Award: $35,000.00

PI: Tanner, D.B.
Grant Title: Time-Resolved Far-Infrared Experiments: Implications for Nanotechnology
Agency: U.S. Department of Energy
Project Dates: 5/15/02-5/14/06
Award: $125,000.00

PI: Tanner, D.B.
Grant Title: Agile Response Coatings
Agency: Wake Forest University
Project Dates: 4/1/05-3/31/06
Award: $20,003.00

PI: Tanner, D.B.
Grant Title: Infrared Studies of Cuprate Superconductors
Agency: National Science Foundation
Project Dates: 8/15/03-7/31/06
Award: $50,358.00

PI: Tanner, D.B.
Grant Title: Infrared Studies of Cuprate Superconductors
Agency: National Science Foundation
Project Dates: 8/15/03-7/31/06
Award: $48,396.00

PI: Vala, M.T.
Grant Title: Laboratory Studies of Gas-Phase Polycyclic Aromatic Hydro- Carbon Cations and Fragments
Agency: NASA
Project Dates: 1/1/03-12/31/05
Award: $130,000.00

PI: Vala, M.T.
Grant Title: Prebiotic Molecules in Intersteller Space
Agency: University of Central Florida
Project Dates: 5/19/05-10/31/05
Award: $3,000.00

APPENDIX A
RESEARCH REPORTS BY CATEGORY

NHMFL users and affiliated faculty submitted 416 brief research reports describing activities in 2005. All reports are available on the Web at *http://www.magnet.fsu.edu/publications/2005 annual report/*. The following table lists the reports by category and provides essential information.

BIOCHEMISTRY - 54 Reports

Facility	PI Name	Title
DC Field Facility	Telser, J.	High field and frequency EPR of a magnetically coupled model for dinuclear hydrolase enzyme active sites: [FeCo(BPBPMP)(μ-OAc)2]ClO4
EMR Facility	Fajer, P.G.	Activation Of Anhtracis Repressor Protein By Mn(II) Binding
EMR Facility	Redding, K.E.	Use of high-field/high-frequency EPR to investigate the effect of environment upon the g-tensor of P700+, the oxidized primary electron donor of Photosystem I
EMR Facility	Telser, J.	High field and frequency EPR studies of a model for phosphatase enzyme active sites: [FeZn(BPBPMP)(μ-OAc)2]ClO4
EMR Facility	Thomas, D.D.	DEER Measurements on the Actomyosin Complex
ICR Facility	Bendiak, B.	Discrimination of isomeric disaccharides using variable wavelength infrared multiple photon dissociation/Fourier transform ion cyclotron resonance mass spectrometry
ICR Facility	Colmer, S.A.	Assigning Product Ions from Complex MS/MS Spectra: The Importance of Mass Uncertainty and Resolving Power
ICR Facility	Cooper, Helen	The Role of Electron Capture Dissociation in Biomolecular Analysis
ICR Facility	Marshall, A.G.	Structural Characterization of GM1-Ganglioside by Infrared Multiphoton Dissociation, Electron Capture Dissociation, and Electron Detachment Dissociation FT-ICR Mass Spectrometry
ICR Facility	Marshall, A.G.	Identification of Mycobacterium tuberculosis H37Rv Integral Membrane Proteins by One-Dimensional Electrophoresis and Liquid Chromatography Electrospray Ionization Tandem Mass Spectrometry
ICR Facility	Marshall, A.G.	Fourier Transform Ion Cyclotron Resonance Mass Spectrometry for the Analysis of SUMO Modifications of Proteins
ICR Facility	Marshall, A.G.	A Combined Top-Down and Bottom-Up Mass Spectrometric Approach to Characterization of Biomarkers for Renal Disease
ICR Facility	Marshall, A.G.	Bayesian Error Analysis of LC FT-ICR Mass Spectra of Peptides
ICR Facility	Meijer, G.	Charge-State Resolved Mid-IR Spectroscopy of a Gas-Phase Protein
ICR Facility	Novak, J.	Determination of Aberrant O-Glycosylation in the IgA1 Antibody Hinge Region by Electron Capture Dissociation FT-ICR Mass Spectrometry
MBI-UF AMRIS	Barbar, E.	NMR Studies on Folding Coupled to Binding of the Intrinsically Unfolded Domain of Cytoplasmic Dynein Intermediate Chain
MBI-UF AMRIS	Constantinidis, I.	13C Isotopomer Studies of Insulin Secreting Cells: The Role of Anaplerosis
MBI-UF AMRIS	Constantinidis, I.	NMR Studies of Insulin Secreting Cells: Biochemical Consequences of Cell Encapsulation
MBI-UF AMRIS	Hanson, A.D.	Identification of Two Novel Pterin Glucosides in Tomato Fruit

MBI-UF AMRIS	Haskell-Luevano, C.	Conformational analysis of Agouti-related Protein (AGRP)-melanocortin chimeric peptides
MBI-UF AMRIS	Long, J.R.	Structural Studies of the M2 Helix of NaChr in Varying Lipid Environments
MBI-UF AMRIS	Silverman, D,N	Structural Mobility in Human Manganese Superoxide Dismutase
MBI-UF AMRIS	Thelwall, P.E.	T2-labelling of phosphate with 17O – a method with potential for in vivo studies of phosphorus metabolism
MBI-UF AMRIS	Thelwall, P.E.	H2[17O] as a T2 contrast agent with relaxivity sensitive to tissue metabolic status
NMR Facility	Blaber, M.	Triple Resonance Assignments of Highly Symmetric Core Mutant of FGF-1, Sym6DD
NMR Facility	Bruschweiler, R.	Covariance DOSY NMR
NMR Facility	Bruschweiler, R.	Structural Dynamics of Free and Peptide-Bound MDM2
NMR Facility	Bruschweiler, R.	Application of Indirect Covariance NMR to Water Suppression
NMR Facility	Chapman, M.S.	Functional dynamics of arginine kinase
NMR Facility	Cotten, M.	Investigating Molecular Recognition and Biological Function at Interfaces Using Antimicrobial Peptides
NMR Facility	Cross, T.A.	17O Residual Quadrupole Couplings as a Probe of Membrane Hydration
NMR Facility	Cross, T.A.	Electrophysiology Studies of M2 Protein from Influenza Virus A
NMR Facility	Cross, T.A.	Two Molecular Mechanisms Toward Influenza A Virus Resistant to Antiviral Drug: Amantadine-An Solid-state NMR Study
NMR Facility	Cross, T.A.	Structural Characterization Of M2 Proton Channel From Influenza A Virus
NMR Facility	Cross, T.A.	Effect of Detergent on NMR Spectral Quality
NMR Facility	Cross, T.A.	Ion Solvation by Channel Carbonyls Characterized by 17O Solid State NMR at 21T
NMR Facility	Cross, T.A.	Towards 17O solid-state NMR spectroscopy of ion-selective channels at ultra-high magnetic fields
NMR Facility	Cross, T.A.	Flow-through Nanotube Arrays for Structure-function Studies of Membrane proteins by Solid-state NMR Spectroscopy
NMR Facility	Cross, T.A.	Structural Characterization of Cytoplasmic Domain Of M2 Protein From Influenza A Virus
NMR Facility	Cross, T.A.	Rubidium-87 NMR Study of Ion Interactions with KcsA Channel
NMR Facility	Cross, T.A.	Selective Amino Acid Labeling of Various Integral Membrane Proteins from Mycobacterium tuberculosis
NMR Facility	Cross, T.A.	Effect of Sample Preparation and Paramagnetic Relaxation on Rv0008c – An Integral Membrane Protein from Mycobacterium Tuberculosis
NMR Facility	Fu, R.F.	19F solid-state NMR spectroscopy studies of M2TMD protein, structure and molecular dynamics investigation
NMR Facility	Greenbaum, N.L.	Interaction of p14 with the pre-mRNA branch site duplex
NMR Facility	Greenbaum, N.L.	Interaction of U2 snRNP proteins SF3b155 and p14
NMR Facility	Greenbaum, N.L.	Investigation of RNA duplexes at supercooled temperatures
NMR Facility	Greenbaum, N.L.	Examining Structural Features of the Larger Components of the Spliceosomal Branch Site
NMR Facility	Kern, D.	Structural rearrangements of the Pin1 prolyl isomerase during catalysis
NMR Facility	Lim, K.H.	Investigations of Amyloidogenic Intermediate States
NMR Facility	Logan, T.M.	Glycoprotein Structural Biology

NMR Facility	Logan, T.M.	Backbone Dynamics of an Intramolecular Peptide-Protein Complex from the Diphtheria Toxin Repressor
NMR Facility	Logan, T.M.	Sequence of Metal Binding and Activation of the Diphtheria Toxin Repressor and the Hyperactive E175K Mutant
NMR Facility	Veglia, G.	Protein-Protein Interactions By Solid-State NMR Spectroscopy
NMR Facility	Wu, G.	Solid-state 25Mg NMR of chlorophyll a at natural abundance

BIOLOGY - 27 Reports

Facility	PI Name	Title
DC Field Facility	Meisel, M.W.	Effects of High Magnetic Fields on in vitro Transcription
DC Field Facility	Valles Jr., J.M.	Studying the effects of strong magnetic fields and forces on the swimming of protozoa
EMR Facility	Bonora, M.	FT-EMR Structural Study of Biomolecules with Double Electron-Electron Resonance Experiments at 94 GHz
EMR Facility	Fajer, P.G.	Myosin cleft closure in muscle contraction by pulsed EPR
EMR Facility	Fajer, P.G.	Determination of the head conformation in smooth muscle heavy meromyosin and myosin filament by CW dipolar EPR and DEER
EMR Facility	Fajer, P.G.	Conformational Change of TnI in Reconstituted Fibers upon Ca2+ Binding
ICR Facility	Tuma, R.	Functional Visualization of a Viral Molecular Motor by Hydrogen-Deuterium Exchange Reveals Transient States during RNA Packaging
MBI-UF AMRIS	Bowers, D.	Aging, Emotional Memory and the Amygdala-Hippocampus
MBI-UF AMRIS	Carter, C.S.	ACE inhibition and Angiotensin Receptor Blocker Treatment on Skeletal Muscle Fat Content in Aged Rats.
MBI-UF AMRIS	Forder, J.R.	Diffusion Tensor Imaging of Cardiac Tissue: Understanding Diffusion Sources and Compartmentation
MBI-UF AMRIS	Forder, J.R.	First report of Diffusion Tensor Imaging of the Murine Eye
MBI-UF AMRIS	Forder, J.R.	In vivo Tracking of Endothelial Progenitor Cells in a Mouse Model of Choroidal Neovascularization
MBI-UF AMRIS	Gamcsik, M.P.	Non-Invasive Monitoring of Glutathione Metabolism and Heterogeneity in Rat Tumor Tissue
MBI-UF AMRIS	Goldstone, A.P.	Phenotyping a mouse model of Prader-Willi Syndrome using MRI
MBI-UF AMRIS	Kaan, E.	Discourse processing in the brain: Setting up new discourse referents
MBI-UF AMRIS	Petersen, B.E.	Cellular Origins of Hepatocellular Carcinoma
MBI-UF AMRIS	Price, C.C.	Examining Changes in Mediate Temporal Lobe Diffusivity and Metabolite Function among Older Adults with Mild Cognitive Impairment Undergoing Knee Replacement Surgery.
MBI-UF AMRIS	Price, C.C.	Pre-Operative White Matter Abnormalities Predicting Post-Operative Cognitive Decline in Healthy Older Adults
MBI-UF AMRIS	Sambanis, A.	Non-Invasive Monitoring of Oxygen Availability within Pancreatic Substitutes
MBI-UF AMRIS	Thelwall, P.E.	Unilateral common carotid artery occlusion: a transient ischemia model well suited to MR studies
MBI-UF AMRIS	Vandenborne, K.	A longitudinal study of skeletal muscle following spinal cord injury and locomotor training
MBI-UF AMRIS	Vandenborne, K.	Changes in muscle T2 relaxation properties following spinal cord injury and rehabilitation
MBI-UF AMRIS	Vandenborne, K.	Noninvasive monitoring of muscle damage during reloading following limb disuse

MBI-UF AMRIS	Vandenborne, K.	A quantitative study of bioenergetics in skeletal muscle lacking carbonic anhydrase III by 31P magnetic resonance spectroscopy
MBI-UF AMRIS	Yezierski, R.P.	Use of MRI to Study Spinal Cord Injury
NMR Facility	Cross, T.	Production of Membrane proteins in the Form of Tubular Structures
Pulsed Field Facility at LANL	Usheva, A.	Detection of Bubble Formation in DNA with Heat Capacity Measurements

CHEMISTRY - 37 Reports

Facility	PI Name	Title
CMT/E	Rikvold, P.A.	Enhanced Reaction Rate in Heterogeneously Catalyzed CO Oxidation under Oscillating CO Pressure
CMT/E	Rikvold, P.A.	Effects of Lateral Diffusion on Adsorbate Morphology and Dynamics in a Lattice-gas Model of Metal Electrodeposition
DC Field Facility	Desrochers, P.J.	High-Frequency and -Field EPR of High-Spin C3v Nickel(Ii) Halides
DC Field Facility	Minteer, S.D.	Magnetic Field Effects on a Laboratory Size Chlor-Alkali Cell
DC Field Facility	Ozarowski, A.	High-Field, High-Frequency EPR Study On Iron(Ii) Hexafluorosilicate Hexahydrate, FeSiF6•6H2O
DC Field Facility	Telser, J.	Tunable-frequency high field EPR of a series of cobalt(II) “scorpionate” complexes
EMR Facility	Benmelouka, M.B.	High frequencies EPR study of frozen solutions and magnetically dilute powders of GdIII complexes: straightforward determination of the Zero Field Splitting parameters.
EMR Facility	Borel, A.	Electron spin relaxation in two polyaminopolypyridinecarboxylate complexes of Gd(III)
EMR Facility	Kokozay, V.	High-Field EPR and Magnetic Studies on a Hexa-Copper Complex [Cu3CdI2(TeaH)3]2
EMR Facility	Kokozay, V.N.	EPR Studies On A Weakly Magnetically Coupled Copper(II) System [Cu(en)2I]2[Cu(en)2{CdI4}2]
EMR Facility	Kokozay, V.N.	High-Field EPR and Magnetic Susceptibility Studies on a heterometallic complex [Cu2CoPbCl4(L)4]2 where HL is 2-(dimethylamino)ethanol
EMR Facility	Krzystek, J.	Concentration sensitivity of CuII complex solutions at different EPR frequencies
EMR Facility	Ozarowski, A.	High-Field High-Frequency EPR Studies On Metal-Metal Interactions In Binuclear Oxygen-Bridged Iron(III) Compounds
EMR Facility	Ozarowski, A.	A Cu-Zn-Cu-Zn Heterometallomacrocycle Shows Significant Antiferromagnetic Coupling Between Paramagnetic Centres Mediated By Diamagnetic Metal
EMR Facility	Smirnov, A.I.	Nanoporous Sample Holders For Multifrequency/High-Frequency EPR Of Fully Hydrated Macroscopically Aligned Spin-Labeled Membrane Proteins
EMR Facility	Smirnova, T.I.	Resolving polarity and hydrogen bond environment at protein lipid-binding sites using high field EPR
EMR Facility	van Tol, J.	The Triplet Excited State of C60 Investigated by Transient Electron Magnetic Resonance At High Field: Evidence of Significant Non-Axiality
ICR Facility	Groenewold, G.S.	IRMPD of cationic U(VI), U(V), and Ce(III) complexes in the gas phase
ICR Facility	Kortz, U.	Magnetism, EPR, Electrochemistry, and Mass Spectrometry of the Penta-Copper(II) Substituted Tungstosilicate [Cu5(OH)4(H2O)2(A-a-SiW9O33)2]10-
ICR Facility	Marshall , A.G.	Comparative Compositional Analysis of Untreated and Hydrotreated Oil by Electrospray Ionization FT-ICR Mass Spectrometry
ICR Facility	Marshall, A.G.	Electrospray Ionization FT-ICR Mass Spectral Analysis of Coal Liquefaction Products
ICR Facility	Marshall, A.G.	Compositional Characterization of the Microbial Degradation of Petroleum by Electrospray Ionization FT-ICR Mass Spectrometry

ICR Facility	Marshall, A.G.	Speciation of Aromatic Compounds in Petroleum Refinery Streams by Continuous Flow Field Desorption Ionization FT-ICR Mass Spectrometry
ICR Facility	Mazurek, U.M.	Protonated Serine Octamer Cluster: Structure Elucidation by Gas Phase H/D Exchange Reactions
ICR Facility	Oomens, J.	Infrared Spectroscopy of Gas Phase Complexes of Fe+ and Polycyclic Aromatic Hydrocarbons
ICR Facility	Polfer, N.C.	Infrared Fingerprint Spectroscopy Of Potassium Ion-Tagged Amino Acids And Peptides In The Gas Phase
ICR Facility	Polfer, N.C.	Spectroscopic Evidence For Oxazolone Ring Formation In Collision-Induced Dissociation Of Peptides
ICR Facility	Talyzin, A.V.	Selective Synthesis of the C3v Isomer of C60H18
ICR Facility	Talyzin, A.V.	Composition of Hydrofullerene Mixtures Produced by C60 Reaction with Hydrogen Gas, Revealed by MALDI-TOF and Field Desorption Ionization FT-ICR Mass Spectrometry
MBI-UF AMRIS	Angerhofer, A.	EPR and Hyscore Studies on Mn(Ii)-Imidazole6 in a Single Crystal
MBI-UF AMRIS	Duran, R.S.	High Magnetic Gradient Studies of Multi-Component Core-Shell Particle Dynamics
NMR Facility	Duxson, P.	17O 3QMAS-NMR of Synthetic Alkali Aluminosilicate Gel
NMR Facility	Fu, R.F.	High Resolution 15N of Ferroelectric Phase Transition in a Single Crystal of Ammonium Sulfate, (NH4)2H2SO4
NMR Facility	Hayes, S.E.	Se-77 NMR Spin-Lattice Relaxation Investigations of Hexarhenium Chalcogenide Cluster Analogues
NMR Facility	Sen, S.	A 73Ge MAS NMR study of Ge anomaly in oxide glasses: preliminary results
NMR Facility	Stiegman, A.E.	Characterization of Reactive Sites in Supported Catalysts by 51v/15n Rotational Echo Double Resonance NMR Spectroscopy: Formation of Phenylimido Groups at Surface-Bound Oxovanadium Sites
Pulsed Field Facility at LANL	Gaunt, A.	EPR studies of Homoleptic Uranium (III) imidodiphosphinochalcogenides

CRYOGENICS - 5 Reports

Facility	PI Name	Title
MS & T	Van Sciver, S.W.	PIV Measurements of He II Counterflow around a Cylinder
MS & T	Van Sciver, S.W.	Solid H2/D2 Particle Seeding and Injection System for Particle Image Velocimetry (PIV) Measurement of He II
MS & T	Van Sciver, S.W.	Steady Background Turbulence Level on Second Sound Thermal Shock in He II
MS & T	Van Sciver, S.W.	Thermal conductivity measurement of powder insulation
UF Physics	Van Sciver, S.W.	Transport Property Measurements of Subcooled Liquid Propellants

ENGINEERING MATERIALS - 8 Reports

Facility	PI Name	Title
DC Field Facility	Ludtka, G.M.	Effect of 30 T Magnetic Field on Phase Transformations in a Bainitic High Strength Steel
DC Field Facility	Molodov, D.A.	Magnetically Affected Recovery and Recrystallization in Aluminum Alloy 3103
DC Field Facility	Molodov, D.A.	A Novel High Magnetic Field Polarization Microscopy Probe
DC Field Facility	Putatunda, S.K.	A Novel Heat Treatment Process
DC Field Facility	Souslov, A.	Elastic tensor of Gd5(Si2Ge2)

EMR Facility	Angerhofer, A.	High-Field EPR of Metal-Doped Sodium Alanates
EMR Facility	Eichel , R.A.	High-Frequency EPR On Functional Centers In Ferroelectric Ceramics
MS & T	Han, K.	Texture, Twins and Electrical Properties of Copper by Pulsed Electron Deposition

GEOCHEMISTRY - 17 Reports

Facility	PI Name	Title
Geochemistry	Das, R.	Nd-Sr Isotope Systematics Of The Bimodal Volcanic Suite Of Eastern Blue Ridge, Southern Appalachian.
Geochemistry	Das, R.	Usefulness Of La-Icpms Single Zircon Analysis: Crystallization Age Of Tres Piedras Granite -- A Case Study.
Geochemistry	Das, R.	Evidence Of Ordovician Volcanic Arc In The Southern Appalachian From U-Pb Ages Of Zircon.
Geochemistry	Humayun, M.	Progress in analysis of samples returned by the NASA GENESIS mission
Geochemistry	Humayun, M.	Laser ablation microanalysis of trace metals in silicate glasses.
Geochemistry	Humayun, M.	Metal-carbide elemental partitioning in iron meteorites.
Geochemistry	Landing, W.M.	Trace element analysis by high-resolution ICP-MS and isotope dilution HR-ICP-MS
Geochemistry	Odom, A.L.	A Mercury Isotopic Standard
Geochemistry	Odom, A.L.	The Hillabee Volcanic Complex, Southern Appalachians: Radiogenic Pb-Pb Ages of Zircons
Geochemistry	Salters, V.J.M.	Determining the Source Mineralogy of Basalts Through Neodymium Isotope Compositions
Geochemistry	Salters, V.J.M.	Speciation of Tetravalent Metals Thorium, Hafnium, and Zirconium by Capillary Electrophoresis Inductively Coupled Plasma Mass Spectrometry (CE-ICP-MS) and Equilibrium Dialysis Ligand Exchange (EDLE)
Geochemistry	Salters, V.J.M.	Isotope and trace element evidence for depleted lithosphere in the source of enriched Ko'olau basalts
Geochemistry	Sen, G.	Hafnium-Neodymium isotopes on early Deccan flood basalts: Implications for the composition and structure of a starting plume
Geochemistry	Sen, G.	The Hawaiian plume is replacing the Pacific lithosphere: Evidence from peridotite xenoliths from Oahu and Kauai.
Geochemistry	Wang, Y.	Ancient diets indicate significant uplift of southern Tibet after 7 million years ago
Geochemistry	Wang, Y.	Evidence For A Plio-Pleistocene Strengthening Of The Asian Monsoon And Its Importance To The Understanding Of Mammalian Evolution In Northwest China
Geochemistry	Wise, S.	Cause of the Middle/Late Miocene Carbonate Crash: Dissolution or Infertility?

INSTRUMENTATION - 11 Reports

Facility	PI Name	Title
DC Field Facility	Brooks, J.S.	Evolution Of The Fermi Surface Of (Per)2au(Mnt)2 Using Hydrostatic Pressure
DC Field Facility	Fortune, N.A.	Primary and secondary millikelvin thermometry in magnetic fields
DC Field Facility	Nagel, U.	Far infrared transmission measurement on the Hybrid
DC Field Facility	Souslov, A.	Contactless Generation of Ultrasound
ICR Facility	Marshall, A.G.	Evaluation and Optimization of Electron Capture Dissociation Efficiency in FT-ICR Mass Spectrometry

ICR Facility	Marshall, A.G.	Instrumentation and Method for Ultrahigh-Resolution Field Desorption Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry of Non-Polar Species
Pulsed Field Facility at LANL	Betts, J.B.	Calibration of a Cernox thermometer magnetoresistance using a pulsed magnetic field.
Pulsed Field Facility at LANL	McDonald, R.D.	Faraday rotation measurements of TGG to calibrate field production in the singleturn magnet system.
Pulsed Field Facility at LANL	Migliori, A.	Digital ultrasonic pulse-echo overlap system and algorithm for unambiguous determination of pulse transit time
Pulsed Field Facility at LANL	Sharma, P.A.	Calibration of Cernox Thermometers at Low Temperatures and High Magnetic Fields using the Pulsed Field Facility at Los Alamos
Pulsed Field Facility at LANL	Smirnova, E.I.	W-Band Transmission Studies

KONDO/HEAVY FERMION SYSTEMS - 23 Reports

Facility	PI Name	Title
CMT/E	Gor`kov, L.P.	Antiferromagnetism and hot spots in CeIn3
CMT/E	Schlottmann, P.	Spinless Fermion Model With Quantum Criticality
DC Field Facility	Andraka, B.	High Magnetic Field Investigation Of Selected Filled Skutterudite Compounds
DC Field Facility	Andraka, B.	Magnetic Properties Of CeNi9Ge4, A Single-Impurity Type Non-Fermi Liquid System
DC Field Facility	Balicas, L.	Pressure Effects On The Magnetic Induced Phase Transitions Of URu2Si2
DC Field Facility	Bernal, O.O.	First Report of a Homogeneous Internal Field in Hidden-Ordered URu2Si2
DC Field Facility	Goodrich, R.	Metamagnetism and non-Fermi Liquid Behavior in CeIrIn5
DC Field Facility	Maple, M.B.	Angle Dependent De Haas-Van Alphen Effect In PrOs4As12
DC Field Facility	Pagliuso, P.G.	Thermal-expansion experiments on Sm2IrIn8
DC Field Facility	Stewart, G.R.	Non-Fermi Liquid Behavior Down TO 0.05 K and in Fields up to 30 T
DC Field Facility	Tozer, S.W.	Low-temperature magnetovolume studies on CeCoIn5
DC Field Facility	Tozer, S.W.	High-magnetic field thermal-expansion and magnetostriction of Uru2Si2
Pulsed Field Facility at LANL	Bauer, E.D.	Possible Crystalline Electric Field Excitations in New Cubic UX2Zn20 (X=Co, Rh, Ir) Heavy-Fermion Compounds
Pulsed Field Facility at LANL	Bud'ko, S.L.	Complete Elastic Constants of the Heavy Fermion YbAgGe
Pulsed Field Facility at LANL	Bud'ko, S.L.	Field-dependent anisotropic Hall effect in single crystal heavy fermion YbAgGe
Pulsed Field Facility at LANL	Ebihara, T.	Non-local quantum criticality in high-symmetry systems CeIn3-xSnx
Pulsed Field Facility at LANL	Ebihara, T.	Quantum Criticality in CeIn3 at High Magnetic Fields
Pulsed Field Facility at LANL	Kim, K.H.	Hall Effect Evolution Across A Field-Induced Phase In U(Ru0.95rh0.04)2si2
Pulsed Field Facility at LANL	Lawrence, M.J.	Suppression Of Antiferromagnetism In Pr3in
Pulsed Field Facility at LANL	Maple, M.B.	Pulsed-Field De Haas-Van Alphen Studies Of PrOs4As12, NdOs4Sb12, And SmOs4Sb12

Pulsed Field Facility at LANL	Mydosh, J.A.	Thermodynamic Similarities Between YbInCu4 And U(Ru0.96Rh0.04)2Si2
Pulsed Field Facility at LANL	Pham, L.	Hall Resistivity In Heavy-Fermion Superconductor CeCoIn5 Up To 50 T
UF Physics	Ingersent, K.	Stable Non-Fermi-Liquid Phase in a Kondo Trimer System

MAGNET TECHNOLOGY - 4 Reports

Facility	PI Name	Title
DC Field Facility	Miller, J.R.	Current Lead Development
MS & T	Miller, J.R.	Simulated Thermal Performance Of The Superconducting Outsert In The Series Connected Hybrid Magnet System
MS & T	Miller, J.R.	Mechanical Design Of The Series Connected Hybrid Magnet Superconducting Outsert Conduit
MS & T	Miller, J.R.	Nb3Sn Undulator Development

MAGNETIC RESONANCE TECHNIQUES - 45 Reports

Facility	PI Name	Title
DC Field Facility	Hill, S.	Development of a high-frequency mvna-based EPR spectrometer (170-670 GHz) for the national high magnetic field laboratory
EMR Facility	Fajer, P.G	Movement Of The Switch Peptide Of TnI In Cardiac Troponin
EMR Facility	Lenahan, P.M.	An Approach to Spin Based Quantum Computing: Spin Dependent Recombination at Very High Magnetic Fields
EMR Facility	Morley, G.W.	Pulsed Electrically Detected Magnetic Resonance of Silicon Heterostructures
EMR Facility	Morley, G.W.	Designing Nano-SQUIDs for Readout of Spin Qubits
EMR Facility	Morley, G.W.	Dynamic Nuclear Polarization of N@C60 for Quantum Computing
EMR Facility	van Tol, J.	An Electron Spin Resonance Study Of The Free Radicals Formed In Corn After Food Irradiation
MBI-UF AMRIS	Benveniste, H.	A 3D Digital Atlas Database of the C57BL/6J Brain by MR Microscopy
MBI-UF AMRIS	Benveniste, H.	MRI of a Mouse Model of Attention-Deficit-Hyperactivity Disorder
MBI-UF AMRIS	Byrne, B.J.	Characterization of and AAV2/9 Mediated Gene Therapy for the Cardiac Phenotype in a Mouse Model of Pompe Disease
MBI-UF AMRIS	Byrne, B.J.	AAV SDF-1 Augmented Myoblast Therapy For Cardiac Failure
MBI-UF AMRIS	Byrne, B.J.	Cardiac MRI Evaluation In A Rat Model Of Pulmonary Hypertension
MBI-UF AMRIS	Constantinidis, I.	Alginate Assessment by NMR Microscopy
MBI-UF AMRIS	Constantinidis, I.	Implanted Magnetic Resonance Coil System for In Vivo Imaging and Spectroscopy of a Bioartificial Pancreas
MBI-UF AMRIS	Constantinidis, I.	Distinction Between Islet and Acinar Cells in Pancreatic Tissue Via MRI
MBI-UF AMRIS	Couch, J.A.	Pilot Studies in Cognitive Flexibility and Set Shifting Using fMRI
MBI-UF AMRIS	Edison, A.S.	Development of Microsolenoidal Coils for Biological NMR
MBI-UF AMRIS	Edison, A.S.	Ultra High Sensitivity NMR: 1-mm HTS Triple Resonance Probe

MBI-UF AMRIS	Fitzsimmons, J.R.	Comparison of Microstrips and Surface Coils at 11.1T as Building Blocks for Phased Array Surface Coils
MBI-UF AMRIS	Forder, J.R.	Robust interpolation of DT-MRI data using Tensor Splines
MBI-UF AMRIS	Grant, S.C.	MR Microscopy at 21.1 T: An Evaluation of Contrast and Sensitivity
MBI-UF AMRIS	Sadleir, R.J.	Magnetic Resonance Electrical Impedance Tomography at 11 and 17 T
MBI-UF AMRIS	Shaw, C.A.	Comparison of Genetic & Environmental Models of ALS Using MRI
MBI-UF AMRIS	Vandenborne, K.	31P Magnetic Resonance Spectroscopy of Calpain 3 Knockout Mouse Skeletal Muscle
MBI-UF AMRIS	Walter, G.A.	Evaluation of Exogenous MR Contrast Agents at High Magnetic Fields
MBI-UF AMRIS	Weiss, M.D.	MRI of Labeled Stem Cells Applied to a Neonatal Murine Mode of HIE
MBI-UF AMRIS	White, K.D.	Comparisons Of Signal Change From In vivo Smartphantom And Human Bold fMRI Of Language And Motor Systems
NMR Facility	Alamo, R.G.	Crystallization In Precision Polyolefins. The Role Of Halogen And Oxygen Substituents
NMR Facility	Brey, W.W.	Reduction of Temporal Magnetic Field Variations in Resistive Magnets using Digital Feedback Control
NMR Facility	Cross, T.A.	The Alignment, Location and Motion of Antiviral Drug- Amantadine in DMPC Lipid Bilayers Studied By Solid-state NMR
NMR Facility	Cross, T.A.	Solid State NMR Investigation for Membrane Protein Nanocrystals
NMR Facility	Cross, T.A.	Application of Site Directed Nitroxide Spin Labels and Paramagnetic Ion Binding Tags to Solution NMR Paramagnetic Relaxation Enhancement
NMR Facility	Cross, T.A.	Comparison of Gradient-Enhanced HSQC versus TROSY Pulse Sequences for Solution NMR Characterization of Helical Integral Membrane Proteins
NMR Facility	Cross, T.A.	Comparison of MscL, Rv2719c, and Rv1761c HSQC Spectra on 900 MHZ Spectrometer at University of Georgia, and 900, 720 and 600 MHZ Spectrometers at the NHMFL
NMR Facility	Fu, R.	Solid State ¹H/¹⁵N Chemical Shift Correlation Experiments of Aligned Samples at 900 MHz
NMR Facility	Gan, Z.	High-resolution 14N/13C correlation for measuring 14N quadrupolar coupling
NMR Facility	Gan, Z.	Extracting orientational information from two-dimensional 27Al/17O correlation pattern under magic-angle spinning
NMR Facility	Gor'kov, P.L.	1H-BB Transmission Line Probe for 900 MHz Solid State NMR Spectroscopy
NMR Facility	Gor'kov, P.L.	Large Sample Low-E Probes for Biological SS NMR at 600 and 900 MHz
NMR Facility	Lin, Y.	Control of Spin Turbulence AT ULTRA-High Magnetic Fields
NMR Facility	Locke, B.	21 Tesla MRI Micro-Imaging Method Of Rat Skin
NMR Facility	Quine, J.R.	A Study of Mosaic Spreads in Membrane Protein Structure Determination by Solid State NMR
NMR Facility	Bertram, R.	PIPATH: An Optimized Algorithm for Generating Alpha-Helical Structures from PISEMA Data
NMR Facility	Witter, R.	Structure Refinement of 6F-TRP-M2-TMD
Pulsed Field Facility at LANL	Crooker, S.	Measurement of Spin Noise Coherences in 41K via Faraday Rotation: Experiment & Theory

MAGNETISM & MAGNETIC MATERIALS - 72 Reports

Facility	PI Name	Title
CMT/E	Chiorescu, I.	Development Of A New Physical Laboratory For Studies On Quantum Spin Dynamics In Molecular Magnets

CMT/E	Hoch , M.J.	Evolution of the ferromagnetic and non-ferromagnetic phases with temperature in phase separated La1-xSrxCoO3 by high field 139La NMR
CMT/E	Kuhns, P.L.	Evolution with composition of the d-band density of states at the Fermi level in highly spin polarized Co1-xFexS2
CMT/E	Pankov, S.P.	Low temperature solution of the Sherrington-Kirkpatrick model
CMT/E	Rikvold, P.A.	Simulations of Magnetization Switching in Iron Nanopillars
CMT/E	Schlottmann, P.	Charge, Spin And Orbital Degrees Of Freedom In Manganites
CMT/E	Spinu, L.	Switching Dynamics In Nanostuctured Magnetic Materials Using Susceptibility Experiments
CMT/E	Yang, K.	Collective Excitations In Random Quasi One-Dimensional Antiferromagnetic Spin-1/2 Systems
DC Field Facility	Balicas, L.	Shubnikov de Haas Effect in High Quality Single Crystals of Sr4Ru3O10
DC Field Facility	Cao, G.	Colossal Magnetoresistance by Avoiding a Ferromagnetic State in the Mott System Ca3Ru2O7
DC Field Facility	Cao, G.	Observation of oscillatory magnetoresistance periodic in 1/B and B in Ca3Ru2O7
DC Field Facility	Doerr, M.D.	Magnetostriction of 4f and 5f antiferromagnets
DC Field Facility	Fisher, I.R.	Measurement of Magnetic Phase Transition in BaCuSi2O6 Using TDO
DC Field Facility	Guertin, R.P.	High pressure and high resolution magnetization of GdBaCo2O5.5
DC Field Facility	Harrison, N.	Dimensional Reduction At A Quantum Critical Point
DC Field Facility	Jin, R.	Magnetization of K_2V_3O_8 Under High Magnetic Fields
DC Field Facility	Kim, K.H.	Dielectric Constant And Ferroelectric Polarization Studies Of Multiferroic TbMn2O5 And YMn2O5 Up To 33 Tesla
DC Field Facility	Kono, J.	Magnetic brightening of dark excitons in carbon nanotubes
DC Field Facility	Kosaka, M.K.	Magnetic phase diagram of quadrupolar ordering compound YbAl3C3
DC Field Facility	Kosaka, M.K.	Devil's staircase in Ce3PbC
DC Field Facility	Krzystek, J.	Novel approach to zero-field splitting treatment of binuclear complexes of Ni(II)
DC Field Facility	Lacerda, A.	Magnetostriction in the BEC compound NiCl2-4SC(NH2)2
DC Field Facility	Landee, C.P.	Magnetization of a Novel 2D Spin Singlet Lattice (5FAP)2CUCL4
DC Field Facility	Lee, Y.S.	Low Temperature Susceptibility Measurements on a Spin-Frustrated Quantum Magnet
DC Field Facility	Liu, J.P.	Alignment of Nano-sized Permanent Magnets
DC Field Facility	Long, V.C.	Magnetic Field-Dependent Electronic Absorptions Of Ni(N2c3h10)2(No2)2
DC Field Facility	Mackenzie, A.P.	Discovery of quantum oscillations in a new ternary rhodate
DC Field Facility	Mao, Z.M.	Studies Of Metamagnetic Quantum Phase Transitions In Bilayer Ruthenate Sr3Ru2O7
DC Field Facility	Meisel, M.W.	Resonance Study of Nonlinear Excitations in a S = 1 Heisenberg Planar Ferromagnet CsNiF3
DC Field Facility	Mitrovic, V.F.	Magnetic induced phases in the frustrated quantum AF Cs2CuCl4
DC Field Facility	Musfeldt, J.L.	Magneto-dielectric effect in the S = 1/2 quasi-two dimensional antiferromagnet K2V3O8
DC Field Facility	Musfeldt, J.L.	Understanding the field driven semiconducting paramagnetic to ferromagnetic metallic transition in (La0.4Pr0.6)1.2Sr1.8Mn2O7
DC Field Facility	Nagel, U.	Coupling of optical phonons to the gapped spin state: FIR study of chain magnetism in Sr14Cu24O41
DC Field Facility	Nagler, S.	Field Dependent Phase Diagram and Low Temperature Magnetic Susceptibility of Ferromagnetic – Antiferromagnetic Alternating Quantum Spin Chain: (CH3)2NH2CuCl3

DC Field Facility	Nagler, S.	Field Dependent Phase Diagram and Low Temperature Specific Heat of Ferromagnetic – Antiferromagnetic Alternating Quantum Spin Chain: (CH3)2NH2CuCl3
DC Field Facility	Paduan-Filho, A.	Torque Magnetometry in the Quantum Magnet NiCl2-4SC(NH2)2
DC Field Facility	Reyes, A.P.	Hysteretic Behavior Of 55Mn NMR In Multiferroic TbMn2O5
DC Field Facility	Rollett, A.D.	Microstructural Evolution Of Fe-1%Si In The Presence Of A High Magnetic Field
DC Field Facility	Stern, R.	NMR Measurements At 3He Temperatures On Hybrid: 11B NMR Study Of The Magnetization Plateaus In SrCu2(BO3)2
DC Field Facility	Stern, R.	NMR Measurements on a Potential BEC of Triplons: 29Si NMR Study of the Transition Behavior in BaCuSi2O6
DC Field Facility	Takano, Y.	Tomonaga-Luttinger Liquid in the Quasi-One-Dimensional S=1 Antiferromagnet NTENP
DC Field Facility	Takano, Y.	Magnetic-Field-Induced Second Transition of the Haldane-Gap Antiferromagnet NDMAP
DC Field Facility	Tokumoto, M	Angle-Dependent Investigation Of Magnetic Phase Diagram Of Molecular Conductors
DC Field Facility	Tozer, S.W.	Possible Bose-Einstein Condensation of spin degrees of freedom in NiCl2-4SC(NH2)2
DC Field Facility	Wosnitza, J.W.	Magnetic Quantum Oscillations in YNi2B2C
DC Field Facility	Zvyagin, S.	Magnetic excitations in Na5RbCu4(AsO4)4Cl2 , a novel cluster system with a mixed covalent-ionic bonding
DC Field Facility	Zvyagin, S.A.	Electron Spin Resonance In S=1/2 Antiferromagnetic Chains With Alternating G-Tensor And The Dzyaloshinskii-Moriya Interaction: In The Perturbative Spinon Regime
EMR Facility	Arcon, D.	High-Field ESR Study Of A Novel Two-Dimensional S=1 Spin System Ni5 (Teo3)4x2 (X=Cl, Br)
EMR Facility	Brooks, J.S.	Multiple Spin Sites In An Organic Conductor Without Magnetic Ions
EMR Facility	Krzystek, J.	High-frequency and -field electron paramagnetic resonance investigation of a square heteronuclear Co(II) - Mn(II) complex
EMR Facility	Zorko, A.Z.	ESR Study Of Layered And Porous NaxMnO2 Compounds
EMR Facility	Zvyagin, S.A.	Spin-Triplet Excitons In Han Purple Pigment BaCuSi2O6: Electron Paramagnetic Resonance Studies.
NMR Facility	Reyes, A.P.	NMR studies of magnetic fluctuations in quantum antiferromagnet LiCuVo4
Pulsed Field Facility at LANL	Bauer, E.D.	Thermal Conductivity of Quadrupolar System UPd3
Pulsed Field Facility at LANL	Blundell, S.J.	Phase Diagram Of The Layered Triangular Magnet NaNiO2
Pulsed Field Facility at LANL	Bobev, S.	Magnetic Order In CaMn2Sb2
Pulsed Field Facility at LANL	Cheong, S-W.	Elasticity at the “Strain Glass” Transition in La5/8-xPrxCa3/8MnO3
Pulsed Field Facility at LANL	Coldea, R.	Pulsed Magnetic Field Studies Of The Triangular Magnet AgNiO2
Pulsed Field Facility at LANL	Cox, S.	Transport Measurements Of Charge Order In La1-xCaxMnO3
Pulsed Field Facility at LANL	Fisher, R.A.	Strongly Correlated Spins: GeCo2O4 And GeNi2O4 In High Magnetic Fields
Pulsed Field Facility at LANL	Fritsch, V.	Magnetization Steps in Nanowires
Pulsed Field Facility at LANL	Kim, K.H.	Dielectric constant and Magnetization studies of RMn2O5 (R=Dy, Bi, and Y) Crystals up to 45 T

Pulsed Field Facility at LANL	Kouprine, A.	Unusual Groundstates In Cobaltites
Pulsed Field Facility at LANL	Loram, J.	Heat Capacity And Magnetization Measurements Of Manganites
Pulsed Field Facility at LANL	Morosan, E.	Layered Antiferromagnets And The Crystalline Electric Field - A High-Field, Angle-Dependent Study Of TmAgGe
Pulsed Field Facility at LANL	Paduan-Filho, A.	Angle-dependent Properties of NiCl2-4SC(NH2)2
Pulsed Field Facility at LANL	Paduan-Filho, A.	Thermodynamic Measurements of Ni(Cl1-xBrx)2-4SC(NH2)2
Pulsed Field Facility at LANL	Paduan-Filho, A.	Bose-Einstein Condensation of Magnons in NiCl2-4SC(NH2)2
Pulsed Field Facility at LANL	Ronning, F.	Thermal Conductivity of 1-D Organic Spin Chains
UF Physics	Hebard, A.F.	Evidence For An Anomalous Hall Insulating State In Highly Disordered Thin Films Of Iron
UF Physics	Hill, S	Analysis Of The EPR Spectrum Of A Ni4 Single-Molecule Magnet Through Direct Diagonalization Of The Four-Spin Hamiltonian
UF Physics	Hill, S.	Magnetic Quantum Tunneling in a Mn12 Single-Molecule Magnet Measured With High Frequency Electron Paramagnetic Resonance (HFEPR)

METAL INSULATOR TRANSITIONS - 9 Reports

Facility	PI Name	Title
CMT/E	Aguiar, M.C.O.	Effects Of Disorder On The Non-Zero Temperature Mott Transition
CMT/E	Aguiar, M.C.O.	Scaling behavior of an Anderson impurity close to the Mott-Anderson transition
CMT/E	Grigoriev, P.D.	The phase diagram and the structure of charge-density-wave state in high magnetic field
CMT/E	Moulton, W.G.	Nuclear spin-lattice relaxation in n-GaAs close to the metal-insulator transition
CMT/E	Popovic, D.	Nanoscale clusterization at the metal-insulator boundary in diluted magnetic 2D quantum wells
CMT/E	Popovic, D.	Nonexponential relaxations in a 2D electron system in silicon
CMT/E	Popovic, D.	Low-temperature resistance noise study in underdoped cuprates
DC Field Facility	Balicas, L.	Severe Fermi Surface Reconstruction In CA2-XSrXRuO4 (FOR 0.2 < x < 0.5)
DC Field Facility	Yoon, J.	Magnetic field-induced non-superconducting states in tantalum films

MOLECULAR CONDUCTORS - 16 Reports

Facility	PI Name	Title
CMT/E	Brooks, J.S.	Field-effect transistor made by functionalized pentacene with logic gate application
CMT/E	Brooks, J.S.	Nano-patterning of TIPS-pentacene and its optical properties
CMT/E	Gor`kov, L.P.	New soliton-wall phase near antiferromagnetic quantum critical points in the Bechgaad salts
DC Field Facility	Ardavan, A.	The Role Of Charge Density Wave Fluctuations In Stabilizing The Ground State Of Quasi-Two Dimensional Charge-Transfer Salts, b”-(BEDT-TTF)4[(H3O)M(C2O4)3].Y
DC Field Facility	Ardavan, A.	Yamaji Oscillations Due To Magnetic Breakdown In An Organic Superconductor Submitted To Large Hydrostatic Pressures And High Fields

DC Field Facility	Brooks, J.S.	Stark Oscillations In (PER)2AU(MNT)2 Under Pressure
DC Field Facility	Brooks, J.S.	Resonant Nernst effect in the field-induced spin density wave states of (TMTSF)2ClO4
DC Field Facility	Brooks, J.S.	Pressure-temperature phase diagram of beta-(BDA-TTP)2FeCl4 investigated by the magnetization measurement under high pressure
DC Field Facility	Clark, W.G.	Proton NMR study of electron motion in the conducting polymer poly-3-methyl-thiophene-PF/ sub 6/
DC Field Facility	McDonald, R.D.	Electrodynamics of the charge density wave system Per2Pt(mnt)2 in high magnetic fields.
DC Field Facility	Naughton, M.J.	Commensurate-Incommensurate Crossover And Magnetoresistance Of Quasi-One-Dimensional Superconductors, (TMTSF)2ClO4 and (DMET)2I3
DC Field Facility	Park, Y.W.	Magnetotransport in quasi-one dimensional polymer nanofibers
DC Field Facility	Uji, S.	Possibility of FFLO State in Organic Superconductor lambda-(BETS)2FeCl4
EMR Facility	Brooks, J.S.	Observation Of The Exchange Narrowing In The Pi-D Correlated Organic Conductors
Pulsed Field Facility at LANL	McDonald, R.D.	GHz-frequency measurements of the magnetoconductivity of the charge density wave system Per2Pt(mnt)2.
Pulsed Field Facility at LANL	Singleton, J.	Multi-Functional Molecular Materials Combining Chirality And Magnetism

OTHER CONDENSED MATTER - 11 Reports

Facility	PI Name	Title
CMT/E	Bonesteel, N.E.	Quantum Computing with Nonabelian Quantum Hall States
CMT/E	Cao, J.	Ultrafast electron shadow imaging for sub-ps synchronization of femtosecond laser and electron pulses
CMT/E	Cao, J.	Investigation of electron-phonon interactions using femtosecond electron diffraction
CMT/E	Cao, J.	Electronic thermal expansion and its role in the generation of coherent acoustic phonons
CMT/E	Schlottmann, P.	Gd3+ and Eu2+ local environment in Ca1-xRxB6 (R=Gd,Eu): An ESR study
CMT/E	Sergey Pankov, V.	Nonlinear screening theory of the Coulomb glass
DC Field Facility	Brooks, J.B.	Electric Field Effect of quantum oscillations in a few-layer graphene
DC Field Facility	Suslov, A.	Ultrasonic Studies of the Fermi Surface in AuZn Single Crystal
High B/T Facility at UF	Lee, Y.	Magneto-transport measurements on Ca1.5Sr0.5RuO4 at low temperatures and high fields
Pulsed Field Facility at LANL	Migliori, A.	Unusual compressibility in the negative-thermal-expansion material ZrW2O8
Pulsed Field Facility at LANL	Planes, A.	Electrons And Martensites: Exploring The Martensitic Phase Diagram With Magnetic Fields

QUANTUM FLUIDS & SOLIDS - 5 Reports

Facility	PI Name	Title
DC Field Facility	Fisher, I.R.	High Field Thermal Transport in BaCuSi2O6
DC Field Facility	Mydosh, J.A.	Thermal Transport at the High Magnetic Field Quantum Critical Phase Region of URu2Si2
High B/T Facility at UF	Dorsey, A.T.	Phenomenology of Supersolids

Pulsed Field Facility at LANL	Mydosh, J.A.	Thermal Transport in U(Ru,Rh)2Si2 at the "Hidden Order" transition
Pulsed Field Facility at LANL	Paduan-Filho, A.	Thermal Transport at 3He Temperatures up to 15 T in NiCl2-4SC(NH2)2

SEMICONDUCTORS - 34 Reports

Facility	PI Name	Title
CMT/E	Bonesteel, N.E.	Coherent Manipulation of Spins in Quantum Dots through Control of Spin-Orbit Coupling
CMT/E	Bonesteel, N.E.	Composite Fermion Pairing in Bilayer Quantum Hall Systems
CMT/E	Brooks, J.S.B	Pressure Dependence Study of FETs and Time Characteristics of Photoconductivity
CMT/E	Yang, K.	Effects Of Disorder On Transport Gap In Fractional Quantum Hall States And Fractional Quantum Hall – Insulator Transition
DC Field Facility	Ashkinadze, B.M.	Magneto-photoluminescence of two-dimensional electron gas at low filling factors
DC Field Facility	Baranov, A.	Intersubband Magnetophonon Resonance In InAs/AlSb Quantum Cascade Structures
DC Field Facility	Drichko, I.L.	Acoustoelectric Effects in p-type Si/SiGe Heterostructures in the Extreme Quantum Limit
DC Field Facility	Drichko, I.L.	High-frequency Transport in GaAs/AlGaAs Heterostructures in the Extreme Quantum Limit: Acoustic Study
DC Field Facility	Engel, L.W.	Resonance in insulating phase re-entrant around 1/3 fractional quantum Hall effect
DC Field Facility	Engel, L.W.	Melting of pinned Wigner solid in high magnetic field
DC Field Facility	Kim, P.	Spin and Valley Splitting of Two-Dimensional Electrons in Graphene in the High Magnetic Field Limit
DC Field Facility	Kuskovsky, I.L.	Magneto-optical properties of ZnTe/ZnSe type II nano-structures fabricated by migration-enhanced epitaxy
DC Field Facility	Pan, W.	Electronic Transport Studies in a Lateral Quantum Dot Array Sample
DC Field Facility	Reitze, D.H.	Ultrafast optics in high magnetic fields: cooperative recombination of a quantized, dense electron-hole plasma
DC Field Facility	Reitze, D.H.	Many-Body Interaction in the Shift of Fermi-Energy in Quantum Wells Containing More Than One Occupied Subband
DC Field Facility	Shayegan, M.	Spin-dependent peak shift and resistivity spikes in AlAs two-dimensional electrons in the integer quantum Hall regime
DC Field Facility	Sirtori, C.	Electronic Scattering Mechanism Spectroscopy In Two-Levels Quantum Cascade Structures Submitted To High Magnetic Fields
DC Field Facility	Smirnov, D.	Electron Scattering Spectroscopy By High Magnetic Fields In GaAs/AlGaAs And GaInAs/AlInAs Mid-Infrared Quantum Cascade Lasers
DC Field Facility	Smirnov, D.	Development Of ODR Spectroscopy With THz Quantum Cascade Lasers
DC Field Facility	Stormer, H.L.	Anisotropic Electronic Transport in Two-dimensional Hole Systems
DC Field Facility	Tsui, D.C.	Pinning mode resonance of bilayer hole systems
DC Field Facility	Tsui, D.C.	Valley Splitting of Two-Dimensional Electrons in Silicon in Tilted Magnetic Fields
DC Field Facility	Tsui, D.C.	Far infrared cyclotron resonance of two-dimensional electron systems with short-ranged alloy disorder
DC Field Facility	Wang, W.K.L.	Magneto-Noise In Carbon Nanotube Field Effect Transistor

DC Field Facility	Wang, Y.J.	Infrared Optical study of new magnetic modes in dilute Cd1-xMnxTe/Cd1-yMgyTe quantum well structure at high magnetic fields
DC Field Facility	Woo, J.C.	Magneto-Subband Separation Of Zeeman Splittings Observed In Narrow Quantum Wire Array
DC Field Facility	Ye, P.D.	Microwave Photoresistance Spectroscopy Of Single-Walled Carbon Nanotubes
High B/T Facility at UF	Tsui, D.C.	Disorder and quantum Hall Plateau-to-plateau transition at ultra-low temperatures
Pulsed Field Facility at LANL	Crooker, S.A.	Modeling Spin Flows In Semiconductors
Pulsed Field Facility at LANL	Crooker, S.A.	Imaging Spin Transport In Lateral Fe/GaAs Structures
Pulsed Field at LANL	Crooker, S.A.	Spin- and Time-Resolved Fluorescence Line Narrowing in CdSe Colloidal Nanocrystal Facility Quantum Dots
Pulsed Field Facility at LANL	Crooker, S.A.	Measuring Spin Lifetimes in n-Type GaAs Using Magneto-Optical Kerr Rotation Spectroscopy
Pulsed Field Facility at LANL	Cumings, J.	A Tunable Anomalous Hall Effect In A Non-Ferromagnetic System
Pulsed Field Facility at LANL	Kim, Y.K.	Magneto-Photoluminescence Of Diluted Magnetic Semiconductors

SUPERCONDUCTIVITY, APPLIED - 13 Reports

Facility	PI Name	Title
DC Field Facility	Hong, S.	Characterization Of Superconducting Strands For High Field Magnet Applications Over 20 T
DC Field Facility	Larbalestier, D.C.	Upper Critical Field Of High-Field Intermetallic Superconductors
DC Field Facility	Miller, J.R.	In-field transport properties of lts conductors under strain
DC Field Facility	Minervini, J.	Characterization of Nb3Sn Superconducting Wires under Strain
DC Field Facility	Nachtrab, W.T.	High Field Magnets for MRI Applications
DC Field Facility	Schwartz, J.	Bi2212 Superconductors In High Field Applications
DC Field Facility	Sumption, M.D.	Variations In Hc2 And Hirr Of Doped MgB2 Strands with T AND J
DC Field Facility	Thieme, C.L.H	Small Double Pancake Coils Made with Second Generation HTS Wire Tested in High Magnetic Fields
MS & T	Han, K.H.	New Manufacture Process Of Nb3Sn Wire
MS & T	Merritt, G.A.	Development of a React-Wind-Sinter Process of Ag alloy clad Bi2Sr2CaCu2O8+x Conductors
MS & T	Schwartz, J.	Quench Behavior of Y-Ba-Cu-O Coated Conductors
MS & T	Schwartz, J.	Statistical Analysis of Electro-Mechanical Properties of Ag/Mg Sheathed Bi2Sr2CaCu2Ox Tapes Using Weibull Distribution
Pulsed Field Facility at LANL	Serquis, A.	HC2 Of C-Doped MgB2 Superconductor

SUPERCONDUCTIVITY, BASIC - 25 Reports

Facility	PI Name	Title
CMT/E	Gor`kov, L.P.	Electron-hole symmetry and phase separation in electron doped cuprates
CMT/E	Gor`kov, L.P.	Phonon superconductivity and Kondo screening in mixed valence and heavy fermion superconductors

DC Field Facility	Balicas, L.	Observation Of Small Fermi Surface Pockets In NaXCoO2 (FOR X = 0.3 And 0.75)
DC Field Facility	Biswas, A.	Normal state density of states of the electron-doped cuprate Pr2-xCexCuO4 measured using point contact spectroscopy in fields of up to 32 tesla
DC Field Facility	Clark, W.G.	Critical field and NMR measurements of the local magnetic field in the electron-doped high-T/sub c/ superconductors Pr/sub 2-x/Ce/sub x/CuO/sub 4-y/
DC Field Facility	Dagan, Y.	High Field Transport As A Function Of Disorder In PCCO
DC Field Facility	Deutscher, G.	Tunneling Into Over-Doped YBCO Films At High Magnetic Fields
DC Field Facility	Dordevic, S.V.	Magneto-optical studies of high-Tc superconductors
DC Field Facility	Gasparov, V.A.	The Upper Critical Magnetic Field Of ZrB12 Single Crystal
DC Field Facility	Greene, R.L.	Low Temperature, High Field Transport In Pr(2-x)Ce(x)CuO(4+/-y)
DC Field Facility	Hussey, N.E.	Temperature Dependent Polar Amro In Tl2Ba2CuO6 (Tc ~ 15K)
DC Field Facility	Krusin-Elbaum, L.	Universal Scaling of the Pseudogap Tunneling Resistivity in Cuprates
DC Field Facility	Maple, M.B.	Dimensionality of vortex fluctuations in Y[1-X]Pr[X]Ba[2]Cu[3]O[6.97] AND YBa[2]Cu[3]O[6.5]
DC Field Facility	Ong, N.P.	Torque Magnetometry on High-Tc Superconducting Cuprates in Intense Fields
DC Field Facility	Singleton, J.	The Coherence Conundrum In BEDT-TTF Superconductors; The Prolonged Death Of Interlayer Transport As Temperature Rises
DC Field Facility	Tanner, D.B.	Magneto-Optical Response Of Electron Doped Cuprates Pr2-XCexCuO4
DC Field Facility	Tanner, D.B.	Infrared Study Of YBCO In High Magnetic Fields
DC Field Facility	Yeh, N.-C.	Experimental study of the effect of competing orders on cuprate vortex dynamics via DC cantilever magnetometry
DC Field Facility	Yomo, S.	Hall Effect of a Single Crystal of La2-xSrxCuO4 (x = 0.090) under Pressure
High B/T Facility at UF	Hirschfeld, P.J.	Dopant -Modulated Pair Interaction in Cuprate Superconductors
Pulsed Field Facility at LANL	Balakirev, F.F.	Normal-State Hall Effect In High-Tc La2-XSrxCuo4 At Low Temperatures
Pulsed Field Facility at LANL	Li, P.	Resistivity And Hall Effect Measurements In Pr2-XCexCuO4-Y Up To 60T
Pulsed Field Facility at LANL	Meingast, C.	Elastic Constants Of Untwinned Y1Ba2Cu3Ox Single Crystals
Pulsed Field Facility at LANL	Yeh, N.C.	Pulsed-Field Tunnel Diode Oscillator Measurements of the Hg-based Cuprates
UF Physics	Hirschfeld, P.J.	0-pi Transitions in Josephson Junctions with Antiferromagnetic Interlayers

APPENDIX B
PUBLICATIONS INDEX BY AUTHORS

A

Abbott, K.L., 114
Abdel-Jawad, M., 114
Abdel-Malek, C., 122
Abou Hamad, I., 114
Abrahams E., 114
Achey, R., 115, 117
Acree, W., 118
Adams, E.D., 115, 119
Adams, M.A., 122
Adelmann, C., 115
Adhyaru, B.B., 118
Adroja, D., 122
Affleck, I., 117
Agosta, C.C., 119
Aguiar, M.C.O., 114
Akhmeteli, A.M., 114
Akutso-Sato, A., 115
Akutsu, H., 114-115
Akutsu-Sato, A., 114
Alber, D., 114
Alexander, C.S., 114
Aliouane, N., 114
Allwood, D.A., 114
Almeida, M., 117
Al-Naggar, I.M., 121
Alsmadi, A.M., 114, 117
Alvarez, G., 114, 119
Amitsuka, H., 118, 121
Anders, A.G., 117
Andersen, B.M., 114, 119
Anderson, N., 117
Ando, Y., 116
Andraka, B., 118, 120, 122
Andrearczyk, T., 117
Andreev, A.V., 114
Andronikov, D., 114, 118
Anthony J.E., 122
Anzai, H., 121
Aoki, Y., 120
Araki, C., 118
Ardavan, A., 114-115, 119
Ardavan, A., 114-115, 119
Ardavan, A., 114-115, 119
Ardavan, A., 114-115, 119
Argyriou, D.N., 114
Aromi, G., 114,123
Astakhov, G.V., 114
Attfield, J.P., 118
Au, G., 123
Awwadi, F.F., 122

B

Babu, S.S., 117
Bacon Moore, A., 115
Bagwe, R.P., 121
Balatsky, A.V., 115
Baldwin, K.W., 116, 119
Baldwin, T.L., 118
Balicas, L., 114-116, 121
Balkanda, M., 117
Baney, R.H., 118
Bangura, A., 114-116, 119
Barash, Y.S., 114
Barberon, F., 114, 116
Baroghel-Bouny, V., 114
Barr, M.C., 115
Barranco, J.M., 117
Barrick, T., 114, 116
Baruah, T., 120
Barzykin, V.V., 114
Bassil, B.S., 114
Batista, C.D., 117, 121
Bauer, E.D., 114, 117
Bauzo, J.W., 122
Beck, B.L., 118
Beck, R., 114-115, 122
Behr, G., 117
Benveniste, H., 118
Berens, S., 114
Bernado, P., 114
Bernal, O.O., 120
Bernstein, N., 120
Bertet, P., 114-115
Berthier, C., 117
Beth, A.H., 123
Betts, J.B., 115, 117
Beyer, A.D., 123
Bhadeshia, H.K.D.H., 117
Bhatt, R.N., 122
Bhattacharya, N., 123
Bi, Li-Hua, 114, 119
Bianchi, A., 120, 122
Biasiol, G., 120
Bienkiewicz, E.A., 120, 123
Billups, W.E., 121
Bird, M.D., 114
Bishop, N.C., 122
Biskup, N., 122
Biswas, A., 115
Bizimis, M., 114, 117, 121
Blaber, M., 118
Blackband, S.J., 117-119, 122
Blackledge, M., 114
Blakney, B.T., 122
Blatter, G., 118
Blichert-Toft, J., 116
Blov, D., 122
Blue, A., 116
Blumer, N., 118
Bobkova, I., 114
Boebinger, G.S., 116, 121
Bolch, W.E., 121
Bona, J., 117
Bonesteel, N.E., 114
Borges, P.D., 118
Bosco, D.A., 116
Boudgil, B.M., 121
Bouvignies, G., 114
Bowers, C.R., 114-115, 118, 120
Bowtell, R.W., 119
Boyet, M., 116
Bozzolo, N., 119
Bradley, M.M., 117, 120
Brandon, A.D., 114, 120
Brandon, S., 123
Breschi, M., 122
Bresson, B., 114
Brey, W.W., 115-117
Briggs, G.A.D., 119
Briggs, R.W., 115
Broholm, C., 122
Brooks, J.S., 114-115, 117, 119, 122-124
Brown, C., 115
Brown, G., 114, 122
Brown, S., 115
Bruger, M., 121
Brunel, L.C., 114-116, 119-120, 122

Bruschweiler, R., 114, 116, 123
Brych, S.R., 118
Bubb, M.R., 121
Bud'ko, S.L., 115, 123
Buendia, G.M., 119
Burkard, G., 114-115
Burnette, D.J., 118
Burrell, A.K., 118
Butch, N.P., 114-115, 117
Butler, J.E., 123
Butt, D.P., 118
Buvaylo, E.A., 115
Byczuk, K., 118

C

Caldwell, J.D., 114-115, 120
Caleriu, C., 123
Calvo, M.G., 115
Campbell, A.J., 115, 120
Canfield, P.C., 115, 119, 123
Cao, G., 114-115, 118
Cao, J., 115, 120-121
Capan, C., 120
Capotondi, F., 120
Carrington, A., 115
Caruso, A.R., 122
Cason, A.M., 115
Cassell, J.A., 117
Celik, D., 115, 122-123
Celper, S., 117
Chakov, N., 116-117
Chalmers, M.J., 114, 119, 123
Chandrasekhar, V., 117
Chang, S., 117
Chapman, M.S., 116
Chapon, L.C., 114
Charmant, J.P.H., 115
Chavez, C., 118
Chekmenev, E.Y., 115-117
Chen, C.-T., 123
Chen, J., 115
Chen, Y.P., 115, 118
Cheng, C.-Y., 118
Cheng, H.-P., 122
Cheng, S., 115
Chenseddine, A., 114
Cheong, S.W., 122
Chi, X., 119
Chikara, S., 115
Chiorescu, I., 114-115
Cho, K., 114
Cho, Y.D., 115, 118
Choi, E.S., 114-115, 117, 119, 122-123
Choi, H.C., 122
Choi, J., 123
Choi, K.-Y., 115
Chou, F.C., 114
Christianen, P.C.M., 114
Christou, G., 116-117
Chubukov, A.V., 116
Ciobanu, L., 122
Claridge, R.F.C., 122
Clark, S.A., 116
Clausen, M., 118
Clinite, R., 120
Cobb, C.E., 123
Coffey, T., 117
Coldea, A.I., 114-115
Cole, M.A., 121
Colvin, D., 114
Comment, A., 117
Constantinidis, I., 117, 119, 121
Conway, T.W., 115
Cooper, H.J., 119-120
Cooper, J.R., 115
Cordier, L., 122
Corgne, A., 117
Cormier, L., 118
Correa, V., 115-117, 121
Cox, S., 114-115, 118
Craciun, V., 118
Crooker, S.A., 114-116, 118, 121, 123
Cross, T.A., 115, 117-118, 123
Crosson, B., 115
Crow, J.E., 114
Crowell, P.A., 115
Crozier, S., 118
Crozier, S., 118
Csathy, G.A., 115
Cui, B.Z., 115
Cui, H., 119
Cwernak, J., 117

D

D'yakonov, A.M., 116
Dabkowska, H.A., 117
Daemen, L.L., 120, 123
Dagan, Y., 114-115
Dagotto, E., 114, 119
Dahm, T., 116
Dai, D., 123
Dalal, N.S., 114, 116-117, 119-120, 124
Daniels, B.C., 120
Darling, T.W., 119
Davidson, M.W., 122
Davidsson, P., 121
Davulcu, O., 116
Day, P., 114-115
De Chatel, P.F., 114
De la Caillerie, J.-B.D., 114
De Poortere, E.P., 122
DeKamp, J.C., 114
Del Barco, E., 116-117, 120
DeMarse, T.B., 120
Demery, J.A., 121
Denbleyker, M., 115
Deng, T., 116, 122
Dennis, T.J.S., 119
DeSensi, S.C., 123
Deutscher, G., 114
Dhakal, T., 115
Dhalle, M., 122
Dias, J.C., 117
Dietl, T., 117
Dinse, K.P., 116
DiVincenzo, D.P., 114-115
Dixit, N., 123
Dixon, I., 116
Dobrosavljevic, V., 114, 116, 118-121
Dordevic, S.V., 116
Dorsey, A.T., 118
Dotson, V.M., 120
Dressel, M., 121
Drichko, I.L., 116
Drymiotis, F., 116, 119
Du, X., 116
Durairaj, V., 115, 118
Dutta, D., 121
Dziatkowski, K., 119
Dzyubenko, A.B., 114

E

Eaton, D.L., 122
Eckstein, M., 118
Edison, A., 116, 121, 123
Edwards, R.S., 117
Efros, A.L., 116
Eichel, R.A., 116
Eisenmesser, E.Z., 116
El Shawish, S., 117
Elhami, E., 115
El-Khatib, S, 114, 117, 120
Emmett, M.R., 118-120
Engel, L.W., 115-116, 118
Enomoto K., 122-123
Eom, C.B., 121
Esterhai, J.L., 120
Eyler, J.R., 119, 122
Fabrizio, K.R., 115

F

Fajer, P., 120
Fanciulli, M., 120
Farid, A.K., 116
Fei, Y., 117
Ference, K., 115

Feyerherm, R., 124
Finnemore, D.K., 119, 123
Fisher, I.R., 121
Fisher, R. A., 116
Fisher, W.M., 115
Fisk, Z., 114, 116-117, 120, 122
Fistzsimmons, M.R., 117
Fitzsimmons, J.R., 118, 120
Fletcher, J.D., 115
Foltyn, S.R., 118
Forder, J.R., 121
Frank, S., 116
Frederick, N.A., 115, 117
Fredman, P., 119
Freeman, E., 120
Frey, F., 116-117
Frimel, T.N., 116
Frings, P.H., 123
Fu, R., 115-116, 123
Fuchs, R., 121
Fukaya, A., 121
Furdyna, J.K., 119
Furis, M., 115-116, 123
Furukawa, N., 114

G

Gaboardi, M., 116
Gaidosh, G.S., 116
Gaiefsky, M.E., 115
Gal'perin, Y.M., 116
Gamcsik, M.P., 122
Gan, Z., 114, 116-118
Ganapathy, S., 116-117
Gangadharaiah, S., 116
Gangopadhyay, A., 116
Gao, F.P., 118, 123
Gao, X.P.A., 116, 121
Garmestani, H., 115
Gat-Malureanu, I.M., 121
Gauffin-Holmberg, I., 117
Gaulin, B.D., 117
Gautier, R., 116
Gavrilin, A.V., 114
Gedris, T., 115
Geller, O., 119
Gerber, A., 114
Gervais, G., 116
Gibbs, C.P., 120
Gibbs, J.D., 116, 120
Giencke, J.E., 121
Glazman, L.I., 116
Glossop, M.T., 116
Gnatchik, O., 117
Gnezdilov, V., 115
Goddard, P.A., 114, 116, 119
Goldberg, D., 118
Gopinath, K., 115
Gor`kov, L.P., 114, 116
Gor'kov, P.L., 115, 117
Goto, M., 121
Graf, D., 114, 117, 119, 122-123
Grant, S.C., 116, 119-120
Gray III, G.T., 123
Greedan, J.E., 123
Greeff, C.W., 123
Green, J.C., 119
Green, L.A., 121
Greenbaum, N.L., 121
Greene, R.L., 115
Grigoriev, P.D., 116-117
Grzanka, E., 119
Grzesiek, S., 114
Gubicza, J., 119, 122
Gudfinnsson, G.H., 117
Guerrero, L., 120
Guevorkian, K., 117
Guigan, M.D., 118
Gusev, G.M., 115

H

H, S.H., 120
Hagel, J., 117
Haldane, F.D.M., 122
Hall, D., 114
Halperin, W.P., 122
Han, K., 115
Han, Z., 119
Hannahs, S.T., 119, 123
Hanski, E., 116
Hao, Z., 120
Haraldsen, J.T., 115, 123
Harima, H., 116, 119
Harmans, C.J.P.M., 114
Harrison, A., 121
Harrison, N., 116-119, 121, 123
Harter, A.G., 117
Harvey, J.D., 117
Hasegawa, M., 121
Haskell-Luevano, C., 122-123
Hassan, A.K., 119
Hebard, A.F., 116
Hedenstrom, M., 122
Hellstrom, E.E., 121
Hendrickson, C.L., 119, 121-122
Hendrickson, D.N., 116-118, 120, 123
Henriques, R.T., 117
Herbert, B.J., 119
Hiki, Y., 120
Hill, S., 116-118, 120-121, 123
Hilton, D.K., 117
Hirschfeld, P.J., 114, 116, 118-119, 122
Hixson, R.S., 123
Ho, P.C., 114-115, 117
Hoch, M.J.R., 117-118, 123
Hoffmann, M.J., 116
Holcomb, D.F., 117
Holder, R.M., 122
Hollingsworth, J., 116
Holloway, P.H., 121
Honda, F., 114
Honda, Z., 122
Hong, L., 118
Hormozi, L., 114
Horsfield, A.P., 119
Horvatic, M., 117
Houpt, T.A., 117
Hu, J., 115-117
Hua, Y., 118
Huang, Q.Z., 122
Huang, S., 116-117
Hughes, C.R., 123
Humayun, M., 114-115, 120
Hundley, M.F., 120
Huo, K., 120
Huo, S.H., 123
Hur, N., 122
Hussaini, M.Y., 122
Hussaini, Y., 123
Hussey, N.E., 114
Hustedt, E.J., 123

I

Ichihara, T., 121
Igarashi, S., 123
Ingersent, K., 116-117, 120
Ishimoto, H., 117
Isidro, R.M., 117
Ito, K., 118
Ito, S., 118
Ito, T., 121

J

Jäckel, M., 117
Jacobson, N., 117
Jaime, M., 117-118, 121-122
Jansen, M., 117
Jaramillo, R.A., 117
Jaroszynski, J., 117
Jeffries, J.R., 115, 117
Jezierska, J., 115
Jiang, Z., 117
Jiao, Y.L., 120
Jin, R., 120
Jo, Y.J., 115
Jobiliong, E., 117, 119
Johansson, A., 116-117

Johnels, D., 122
Jokish, D.W., 121
Jonckheere, R., 121
Jones, G.E., 120
Jones, T., 118
Jorge, G.A., 117-118, 121
Jung, M.H., 114, 117

K

Kadish, K.M., 118
Kainov, D.E., 118
Kajnakova, M., 117
Kalu, P.N., 115, 122
Kang, H.Y., 115
Kang, W., 115
Kapitulnik, A., 121
Karczewski, G., 114, 117
Karpinski, J., 115
Kasibhatla, M.S., 122
Kasl, C., 117
Kato, Y., 118
Katsumata, K., 122
Kavanagh, Z., 122
Kawabata, S., 121
Kawakami, T., 117
Kawanaka, H., 117
Kawashima, N., 117, 121
Kay, L.E., 116
Kazakov, S.M., 115
Kecskes, L., 115
Keil, A., 117
Keita, B., 114, 119
Kelly, K.G., 120
Kelly, S.M., 117
Kenney, S.J., 114, 119
Kent, A.D., 116-117, 120
Kern, D., 116
Keshav, S., 114, 116-117, 121
Khokhlova, N., 121
Kim, D.S., 118
Kim, J., 118
Kim, K.H., 118, 122-123
Kim, S., 118
Kim, T.S., 120
Kim,C.S., 118
Kimura, T., 116
Kinoshota, T., 119
Kirman, C., 117-118, 123
Kisner, R.A., 117
Klimov, V.A., 116
Klimov, V.I., 116
Klimove, V.I., 116
Klironomos, F.D., 118
Knoll, D.C., 119
Kobayashi, A., 119, 122
Kobayashi, H., 119, 122
Koch, C.C., 115
Kochereshko, V., 114, 118
Koerting, V., 118
Kogerler P., 121, 124
Kojima, K.M., 121
Kokozay, V.N., 115
Kokshenev, V.B., 118
Kolezhuk, A.K., 124
Kollar, M., 118
Komiya, S., 116
Konijnenberg, P.J., 119
Kono, J., 115, 123
Konoike, T., 114, 117, 122-123
Koo, H.-J., 123
Kopp, T., 118
Kopriva, D.A., 119
Korepanova, A., 118
Kortus, J., 115, 120
Kortz, U., 114, 119
Korzhnev, D.M., 116
Kosaka, M., 118
Kotliar, G., 114, 118
Kovalev, A., 114, 120
Kramer, M.J., 123
Kravchyna, O.V., 117
Kroh, H., 123
Krusin-Elbaum, L., 117-118
Krzystek, J., 114-115, 117-119, 121, 123-124
Kuchta, S., 123
Kuhns, P., 116-118, 123
Kulhavy, R., 120
Kumar, P., 116, 118
Kungl, H., 116
Kwon, B., 117
Kwon, O., 120
Kyriakou, P.P., 121
Kyrychenko, F.V., 115

L

Labeikovsky, W., 116
Lacerda, A.H., 114-115, 117, 120-121
Lai, K., 118
Lam, T.K., 118-119
Land, M., 119
Landee, C.P., 122-123
Lang, P.J., 115, 117, 120
Lange, M., 118
Lansky, D.E., 118
Lapina, O.B., 116
Larbalestier, D.C., 121
Larson, M.J., 120-121
Lashley, J.C., 116, 119
Lashley, J.V., 116
Lawes, G., 116
Lawrence, J., 117-118, 120, 123
Le Polles, L., 116
Lee, B.I., 120
Lee, H., 114
Lee, Han-Oh, 117
Lee, J., 118
Lee, P.A., 114
Lee, P.J., 121
Lee, S.-I., 123
Lee, S.M., 119
Lee, S.Y., 118, 120
Lee, Y., 116, 122
Legault, P., 114
Lei, M., 123
Leibovitch, G., 114
Leisure, R.G., 120
Lemmens, P., 115
Lesher, C.M., 116
Lewis, R.A., 118
Lewis, R.M., 115, 118
Leya, I., 114
Li L., 119, 123
Li, B., 120
Li, H., 118
Li, L., 119, 123
Li, Y., 118, 120
Liang, B., 123
Lifshitz, C., 119
Lin, C.T., 123
Lin, L.Z., 120, 123
Lin, X.N., 115, 118
Lin, Y., 118
Lisal, J., 118
Littlewood, P.B., 118
Liu, D., 118
Liu, F., 118
Liu, J.P., 115
Liu, R., 118
Liu, Y., 118
Lockwood, D.R., 117
Logan, T.M., 116, 118, 120-121, 123
Long, J.R., 116
Long, R.C. Jr., 121
Lou, X., 115
Loudon, J.C., 115, 118
Love, J.F., 120, 123
Lu J., 117-118
Lu, B., 118
Lu, J., 117-118
Luban, M., 121
Ludtka, G.M., 117
Ludwig, A.W.W., 117
Luga, D., 118
Luke, G.M., 121, 123
Luongo, C., 118-120
Lyon, S.A., 118
Lyubshin, D.S., 117

M

Ma, E., 115
Ma, Z., 123
Maan, J.C., 114
Macdonald, J.M., 122
MacDougall, G.J, 121, 123
Machado, E., 119
Mackiewicz-Ludtka, G., 117
MacLaughlin, D.E., 120
Maeno, Y., 114
Malosse, L., 114
Mandimutsira, B., 118
Mandrus, D., 120
Mankiewicz, P., 118
Mannhart, J., 118
Manning, T.J., 119
Mansson, J.E., 119
Mao, S., 119
Maple, M.B., 115, 117, 120
Mareci, T.H., 114, 119
Margolies J., 119
Marin, V., 120, 123
Markiewicz, W.D., 115-116, 119
Marques, J.P., 119
Marshall, A.G., 114, 118-123
Marshall, T.A., 123
Marshall, W.S., 114
Martin, C., 118-119
Marzik J.C., 123
Marzik, J.V., 119
Maslov, D.L., 116
Mason, N.J., 114
Massiot, D., 118
Masson, P.J., 119-120
Mathur, N.D., 114-115, 118
Matos, M., 117
Mauron, P., 121
Mayr, M., 119
Mazurek, U., 119
Mbaruku, A., 119, 123
Mcardle, E., 123
McCall,S., 114
McCammon, C.A., 122
McCarty, A.D., 119
McCleskey, T.M., 118
McDonald, R.D., 114, 116, 119
McDonough, W.F., 117
McFarland, M.A., 119
McFarlane, S.S., 121
Meier, S., 114
Meijer, G., 119, 122
Meisel, M.W., 115
Melikyan, A., 119
Menghini, M., 119
Mericle, R.A., 121
Mestecky, J., 120
Mestric, H., 116
Metz, B., 122
Metzner, W., 118
Midgley, P.A., 114, 118
Mielke, C.H., 116, 123
Migliori, A., 115-116, 119-120
Miller, G., 119, 121
Miller, J., 119, 121-122
Millet, O., 116
Mills, A.P., Jr., 116
Milne, C.J., 114
Milner, A., 114
Milstead, C., 115
Minervini, J.V., 121
Mints, R.G., 114
Miranda, E., 116, 119, 121
Mitchell, S.J., 114-115
Mito, T., 121
Mixson, D.J., 118
Modler, R., 121
Molodov, D.A., 119
Mooij J.E., 114-115
Moore, D.T., 119, 122
Morais, C., 118
Moratti, S., 117
Mori, N., 118
Morley, G.W., 119
Morosan, E., 115, 121
Moshchalkov, V.V., 118-119, 121
Moss, P.L., 123
Motome, Y., 114
Moudgil, B.M., 121
Moulton, W.G., 116-118
Mousdis, G.A., 117
Movshovich, R., 120
Mozharivskyj, Y., 121
Mühlberger, M., 118
Mulders, N., 122
Murata, K., 114, 117, 119, 123
Murphy, J.R., 120, 123
Murphy, T., 114, 119-120
Murphy, T.P., 114, 119
Murugananth, M., 117
Murugesu, M., 117
Musfeld, J.R., 115
Mydosh, J.A., 118, 121

N

Nadjo, L., 114, 119
Nagler, S.E., 115
Nakamoto, R.K., 118
Nakanishi, T., 119, 123
Nakanishi, Y., 118
Nakatsuji, S., 114, 122
Nakotte, H., 114, 117
Naveira, L.M., 122
Nellutla, S., 114, 119
Neuville, D., 118
Nguyen, B.D., 114
Nguyen, D.N., 119, 123
Nguyen-Manh, D., 119
Nicholson, D.M., 117
Nie, S., 120
Nikiforov, A.I., 116
Nilsson, C.L., 119, 121
Nishimura, M., 123
Nogami Y., 123
Nojiri, H., 121
North, J.M, 116-117
Novak, J., 120
Novotny, M.A., 120
Nunner, T.S., 119

O

Oca-Cossio, J., 119, 121
Odom, S.A., 122
Oh, E., 118
Oh, S.H., 120
Ohnishi, T., 114
Ohoyama, K., 118
Okerke, E., 120
Okraku, W.E., 115
Olmstead, M.M., 117
Olmstead, W.N., 121
Omichinski, J.G., 114
Oomens, J., 119, 122
Orendac, M., 117
Orendacova, A., 117
Oseroff, S.B., 122
Oshima, Y., 114, 119
Ossau, W., 114
Ostojic, G.N., 123
Ou, Z., 118
Ozarowski, A., 114-118, 121
Ozarslan, E., 119

P

Pagliuso, P.G., 120, 122
Painter, T.A., 119
Palm, E.C., 119
Palmer, R., 114
Palmstrom, C.J., 115
Palosz, B., 119
Pamidi, S.V., 120
Pan, W., 118-119
Panagopoulos, C., 119
Pankov, S., 120
Pantea, C., 119-120, 122-123
Papavassiliou, G., 114, 117, 119, 123
Park M.S., 123
Park, C., 120

Park, H., 120
Park, J.-H., 117
Park, K., 120
Park, M.-S., 123
Patel, A.H., 120
Pathare, N., 120
Patnaik, S., 121
Patton, P.W., 121
Pechan, M.J., 115
Peck, K.K., 115
Pederson, M.R., 120
Peera, A., 121-122
Peled, E., 116
Penner-Hahn, J., 118
Perlstein, W.M., 120-121
Perozo E., 120
Perring, T.G., 122
Petford, N., 120
Petruska, M., 116
Pettifor, D.G., 119
Petukhov, K., 117
Pfeiffer, L.N., 115-116, 118-119
Phillips, D., 119
Pienkos, J.E., 119-120
Pietri, R., 120
Pittman, D.W., 117
Platonov, A., 114
Plichta, E.J., 123
Polfer, N., 119
Porfyrakis, K., 119
Portugall, O., 123
Prati, E., 120
Puchtel, I.S., 114, 120
Punnoose, A., 120
Purcell, J., 119
Pyo, H.C., 120

Q

Qian, J., 120, 123
Qian, K., 118, 121
Qin, H., 118
Qiu, M., 120
Quinn, J.P., 119, 121

R

Rabbani, Z.N., 122
Radaelli, P.G., 114
Radke de Cuba, M.H., 118
Radovan H.A., 119
Raedts, S., 119, 121
Rai, R.C., 120-121
Rajon, D.A., 121
Ramdhanie, B., 118
Ramirez, A., 116, 119
Ramsey, C., 117
Rangachari, V., 120, 123
Redenkov, V.V., 114
Regelous, M., 116-117
Reiff, W.M., 121
Reitze, D.H., 115
Ren, H.I., 120
Renfrow, M.B., 114, 120
Reno, J.L., 114
Rettori, C., 122
Reuben, B.G., 119
Reyes, A.P., 116-118, 123
Rezayi, E.H., 122
Rheingold, A.L., 118, 120, 123
Rhodes, E., 119
Ribas, J., 123
Riccardi, C., 117
Richardson, D.E., 119
Richardson, S.L., 120
Rickel, D., 115, 117, 120
Rigg, P.A., 123
Righter, K., 120
Rikken, G.L.J.A., 123
Rikvold, P.A., 114-116, 119-122
Rindfleisch, M., 119
Robb, D.T., 120
Robbins, P.D., 116
Roberts, B., 117
Roberts, D.E., 116
Robins, D., 121
Rodgers, R.P., 118, 120-121, 123
Rogl, P., 117
Rollett, A.D., 122
Romanenko, K.V., 116
Ronning, F., 120
Rose, M.S., 120
Rosenbaum, R., 120
Rothi, L.J.G., 115
Rotundu, C.R., 120
Rovers, M.T., 121
Rudloe, J., 119
Rumberger, E.M., 116, 120
Rushmer, T., 120
Russo, P.L., 121, 123
Ruuge, A., 115

S

Sabatinelli, D., 117, 120
Sadleir, R., 120
Saha, S., 117
Sale, K., 120
Sales, B.C., 120
Salters, V.J.M., 114
Sambandamurthy, G., 118
Sambanis, A., 121
Sanders, G.D., 115, 118
Santra, S., 121
Sarrao, J.L., 115, 119-120, 122
Sastry, P.V.P.S.S., 119, 123
Sato, H., 120
Savici, A.T., 121, 123
Saxena, A., 116, 119
Sayles, T.A., 115, 117
Scalapino, D.J., 116
Scarborough, M.T., 120
Schäffler F., 118
Schaub, T.M, 120-121
Schehl, T., 122
Schleuter, J., 114
Schlottmann, P., 114-115, 118, 122, 124
Schnack, J., 121
Schneider-Muntau, H.J., 115, 121
Schroeder, K.T., 121
Schulga, Y.M., 122
Schwartz, J., 119, 122-123
Scipioni, R., 119
Scott, J.W., 123
Scott, R., 122
Sebastian, S.E., 121
Sechovsky, V., 114
Seehra, M.S., 120
Seignourel, P.J., 121
Semavina, M., 120
Semba, K., 114
Sen, C., 114, 119
Sen, G., 114, 116, 121
Senkowicz, B.J., 121
Seo, J.K., 120-121
Sevim, V., 121
Shah, A.P., 121
Shahar, D., 116-117
Shapiro, S.M., 116
Sharma, M., 116
Sharma, P.A., 121
Shaver, J., 123
Shaw, G., 121
Shayegan, M., 122
Sheikh-Ali, A.D., 119
Shellock, F.G, 121
Sheng, D.N., 122
Shepherd, T.M., 119
Shetty, K., 116
Shibauchi, T., 117-118
Shkolnikov, Y.P., 122
Shul'ga, Y.M., 121
Sihlbom, C., 121
Silhanek, A.V., 118-119, 121
Silver, X., 120
Simmonds, P.E., 118
Simmons, J.A., 114
Simon, J.D., 118
Simon, S.H., 114
Simpson, C.P., 121
Simpson, N.E., 117, 119, 121-122

Singh, D.J., 114, 120
Singleton, J., 114-116, 119, 121
Skalicky, J.J., 116, 121
Skelton, B.W., 115
Sleno, L., 121
Smirnov, A.I., 115, 122
Smirnov, I.Y., 116
Smith, D.L., 115
Smith, J. L., 116, 119
Smith, J.C., 117
Soban, D.S., 119
Sofin, M., 117
Sohn, J.Y., 121
Solheid, P.A., 116
Soltysik, D., 115
Song, C., 123
Song, L, 120, 123
Souptel, D., 117
Spencer, D.S., 121
Sproule, R.A., 116
Stabler, C.L., 121
Stacpoole, P.W., 119
Standford, L.A., 118
Stanley, T., 121
Stanton, C.J., 118
Stein, R.A., 123
Steiner, M.A., 121
Stern, R., 117
Stevens, J.E., 120
Stewart, G.R., 118, 120
Stiegman, A.E., 115
Stoeckli-Evans, H.-M., 114
Stormer, H.L., 115-116, 119
Stowe, A.C., 114
Stringer, E.A., 117
Strohm, J.J., 123
Su, J.H., 115, 123
Sugawara, H., 120
Sullivan, N.S., 115, 118-119
Sundqvist, B., 121
Suplinskas, R.J., 123
Suslov, A.V., 116
Susuki, M.T., 116, 117, 119
Sweeney, H.L., 120, 122

T

Takahashi, S., 117, 121
Takano, Y., 120, 122
Takasaki, S., 121
Takayasu, M., 121
Talham, D.R., 115
Talyzin, A.V., 121
Tan, W., 121
Tanaka, H., 119, 122
Tanaskovic, D., 118, 121
Tanedo, P., 121
Tang, M., 120
Tapp, H., 121
Taylor, O.J., 115
Tedoldi, F., 117
Teitel'baum, G.B., 116
Telser, J., 114, 117-118, 121
ten Haken, B., 122
Ten Kate, H.H.J., 122
Tennant, W.C., 122
Tenne, R., 117
Terao, Y., 117
Terashima, T., 123
Thelwall, P.E., 122
Thoennessen, M., 114
Thompson, J.D., 120
Thompson, J.R., 115
Thompson, S.H., 122
Thordarson, T., 117
Tichy, G., 122
Todorovic, J.R., 122
Tokumoto, M., 119, 122
Tokumoto, T., 122
Toma, K., 120
Tomana, M., 120
Toplosky, V.J., 122
Torardi, C.C., 115
Toth, J., 114
Tozer, S., 114, 118-119, 123
Trbovic, N., 123
Trociewitz, U.P., 115, 119, 122
Trofimenko, S., 118
Tsai, S.W., 116
Tshepe, T., 123
Tsui, D.C., 115-116, 118-119
Tsujii, H., 120, 122
Tsybin, Y.O., 121-122
Tulenko, J.S., 118
Tuma, R., 118, 123
Turnbull, M.M., 122-123
Turner, S.S., 114-115
Tutuc, E., 122
Twamley, B., 122

U

Uchida, M., 122
Uchida, S., 121
Uchida, T., 120, 123
Uchinokura, K., 117
Uemura, Y.J., 121, 123
Uji, S., 122-123
Ungar, T., 119, 122
Unlusu, B., 122
Upton, E., 119
Urbano, R.R., 122

V

Vakili, K., 122
Valle, J.J., 122
Valles, Jr., J.M., 117
Van Agthoven, M, 123
Van Bael, M.J., 118
Van der Laan, D.C., 122
Van der Meer, A.F.G., 122
Van Dongen, P., 118
Van Duijn, J., 122
Van Eck, H.J.N., 122
Van Look, L., 121
Van Sciver, S.W., 115, 117, 122-123
Van Slageren, J., 121
Van Tol, H., 114, 119
Van Tol, J., 116, 119-120, 122
Vandenborne, K., 116, 120
Vasic, R., 124
Vassilyeva, O.Yu., 115
Veira, J., 114
Velaquez, E., 122
Vemuri, B.C., 119
Vicente, C.L., 115, 119, 122
Vlcek, A., 117
Vollhardt, D., 118
Volmer, D.A., 121
Von Helden, G., 119, 122
Vongtragool, S., 121
Voronin, G.A., 120, 122

W

Waddell, K.W., 122
Wagberg, T., 122
Wakamatsu, K., 118
Walker, P.J., 114
Walker, R.J., 116, 120
Walsh, R.P., 122
Walter, G., 116, 120-122
Walter, G., 116, 120-122
Walters, C.C., 118
Wan, X., 122
Wandlowski, Th., 114
Wang, H., 118, 122
Wang, J., 123
Wang, L., 120, 122-123
Wang, L.-L., 122
Wang, X., 120, 122
Wang, Y., 115-116, 118-120, 122-123
Wang, Y.M., 115
Wang, Zhihai, 115
Warren, E., 123
Waryoba, D.R., 122
Watson, B.C., 115
Webb, A., 122
Wei, X., 115, 120-121, 123

Weijers, H.W., 114, 122
Weisberg, M.K., 115
Wells, B.M., 122
Wenger, L.M., 118
Wernsdorfer, W., 117
Wesolowski, R., 123
West, K.W., 115-116, 118
Whangbo, M.-H., 115, 123
White, K.D., 115
Wiebe, C.R., 121, 123
Wierenga, C.E., 115
Wijngaarden, R., 119
Wilczynski, A., 123
Wilgen, J.B., 117
Wilke, R.H.T., 119, 123
Williams, A.J., 118
Wilson, A., 117
Wilson, K.R., 123
Windham, C.L., 119
Wittebort, R.J., 122
Wojtowicz, T., 117
Wolf-Watz, M., 116
Woo, E.J., 120
Woodward, J.D., 123
Wosnitza, J., 117
Wrobel, J., 117
Wu, J., 123
Wu, Y., 123
Wu, Z., 123
Wylde, R.J., 122
Wylie, G.P., 123

X

Xia, D., 120
Xia, J.S., 115, 119, 122
Xiao, L., 120, 123
Xie, J., 118
Xin, Y., 123
Xiong, Y., 123
Xu, B., 118, 123
Xu, J., 122-123
Xu, K., 121
Xu, Z., 120

Y

Yakimov, A.I., 116
Yakovlev, D.R., 114
Yakushi, K., 114
Yamada, J., 121-122
Yamaguchi, A., 117
Yamamoto, H.M., 123
Yamamoto, T., 114
Yang, E-C., 117-118, 123
Yang, H., 121
Yang, K., 122-123
Yang, M.F., 123
Yang, Y., 123
Yang, Z., 120
Yao, Z.H., 120
Yarmola, E.G., 121
Yasuzuka S., 119, 122-123
Ye, P.D., 115
Yee, K.J., 118
Yeh, N.C., 123
Yemin, A., 122
Yezierski, R., 114
Yhang, J.S., 118
Yin, D., 121
Yomo, S., 123
Yoshino, H., 119, 123
Yoshizawa M., 118
Young, B.-L., 120
Young, R., 114
Youssef, K.M., 115
Yu, C.T., 115
Yu, C-G., 114
Yu, Y., 116, 123
Yu, Y.J., 123
Yuan, Q., 118
Yuhasz, W.M., 115, 117
Yukawa, Y., 123
Yusuf, E., 123

Z

Zakharov, L., 118, 120, 123
Zanni, H., 114
Zapf, V., 114-115, 120, 123
Zaric, S., 123
Zeller, A., 114
Zerda, T.W., 119-120, 122
Zhan, R., 118
Zhang, B., 122
Zhang, D., 118
Zhang, F., 116, 123
Zhang, F.L., 123
Zhang, G., 119-120, 122-123
Zhang, J., 120, 123
Zhang, S.U., 120
Zhang, T., 123
Zhao, S., 120
Zhao, Y., 117, 120, 122-123
Zheng, G-q., 123
Zheng, J.P., 123
Zheng, M.H., 120
Zheng, X.G., 115
Zhigadlo, N.D., 115
Zhoiu, Z.X., 120
Zhou, H.X., 121
Zhou, Z., 114, 118, 123-124
Zhu, B.Y., 121
Zhu, L.-Y., 116
Ziegler, C.J., 117
Ziff, R.M., 119
Zikos, G., 114
Zipse, D., 124
Zolensky, M., 114
Zuttel, A., 121
Zvyagin, S. A., 115, 118-119, 121, 123-124