NATIONAL HIGH MAGNETIC FIELD LABORATORY

2006 ANNUAL REPORT

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2006 NHMFL ANNUAL REPORT

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2006 Year in Review

Renewal…

…defined the past year in many ways, as the year long process of crafting and submitting the proposal to the National Science Foundation has renewed our sense of excitement and optimism about the future of physics, chemistry and biology in high magnetic fields.

The year began with much-welcomed news that the National Science Board (NSB) decided to invite a renewal proposal from the Mag Lab rather than run a competition for the right to operate the National High Magnetic Field Laboratory.

That NSB decision came at the conclusion of a process that began in 2002 with the National Research Council (NRC) commissioning a Committee on Research Opportunities in High Magnetic Fields. The resulting "COHMAG" report expressed the broad scientific merit of high magnetic field research. It makes for great reading and can be found on the NRC Web site: ***www.nationalacademies.org***

Although the renewal decision was welcomed and well-received, the lab decided to compete anyway – to compete against its own record of success, against the research successes of other magnet labs around the world, and against the best science done at any national lab anywhere in the word.

The Mag Lab proposal is an ambitious one, a proposal to support the best science by offering more magnet time, increasingly sophisticated techniques and diverse magnet systems and services…all in service to the Mag Lab's multidisciplinary user community. This community – which includes biologists, chemists, physicists and every conceivable interdisciplinary combination of those disciplines – has and will always set the Mag Lab's mission and focus.

Recognizing that rich scientific diversity, two new principal investigators were added to the lab's core grant proposal: Tim Cross, director of the lab's Nuclear Magnetic Resonance (NMR) user program and professor of chemistry at Florida State University, and Arthur Edison, director of the Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) user program and associate professor of biochemistry and molecular biology at the University of Florida.

The lab enlisted the support and counsel of its new Science Council, chaired by Lev Gor'kov, and its User and External Advisory committees (EAC). Members of the EAC, in particular, flew to Tallahassee twice during a three-month period, in August to help hone the proposal, and in December, to preview the NSF Site Visit presentations.

SCIENCE DRIVERS, MAGNET TECHNOLOGY, LEADING THE WAY

Although it is difficult to capture the breadth of the Mag Lab user programs and future opportunities, the lab's proposal focuses on five science drivers that will characterize the lab's user programs into the next decade. They are:

1. Quantum matter: Understanding the broadly challenging manifestations of quantum phenomena in materials properties;
2. Complex mixtures: Analyzing in detail the chemical constituencies of complicated mixtures as they exist in the natural world;
3. Structure, dynamics and function: Exploiting advantages of magnetic resonance in biological and other organic materials;
4. Materials chemistry: Extending magnetic resonance techniques to electrons and new nuclei, including quadrupolar nuclei; and
5. Materials for magnets: Developing better superconductors, insulators and structural materials, because our magnets are increasingly materials-limited.

DIVERSITY OF SCIENCE REFLECTED IN THIS ANNUAL REPORT

Multi-disciplinary science is a key strength of the Magnet Lab, and this reality was once again demonstrated in 2006: 398 research reports were received in 17 categories, representing the life sciences, chemistry, magnet science and technology, and condensed matter physics.

- Twenty percent of the research activities (78 reports) have already been published in 2006, often in prominent journals: *Science, Nature, Proceedings of the National Academy of Sciences, Physical Review Letters, Applied Physics Letters, Physical Review B, Journal of the American Chemical Society, Biochemistry, Analytical Chemistry, Journal of Magnetic Resonance, Energy & Fuels* and the *IEEE Transactions on Applied Superconductivity.*
- In addition, the research in 6% of the annual reports has now been accepted for publication; 11% is submitted for publication; and 37% is represented by manuscripts in preparation. The remaining 26% represent advanced technique development and ongoing research.
- The majority of research projects were funded by the National Science Foundation, the Department of Energy, and the National Institutes of Health.
- The Magnet Lab's In-House Research Program – which encourages collaborations among internal and external investigators, promotes bold but risky efforts and provides initial seed money for new research programs and facility enhancements – supported 47 of the 398 research activities and was the primary support for 23 projects, an impressive performance, as it represents less than five percent of the Mag Lab budget.

BIG MAGNET PROJECTS COMPLETED


100 T Multi-shot Magnet at LANL

Two major pulsed magnet projects concluded in 2006: The 60-tesla controlled waveform and the 100-tesla multi-shot magnet. Before year's end, excellent data was coming out of the 100 T, which has been accepted for *Physical Review Letters*. These new magnets will be operating at 55 T and a world-leading 85 T to 89 T while we gain operational experience. The peak field will creep up to the 100 T design field as we build trust in the performance of the new materials that are critical to its success.

For pulse durations in the 10-25 millisecond range, the new 100 T multi-shot magnet provides magnetic fields 15 T to 20 T higher than smaller (and less expensive!) pulsed magnets around the world. Millisecond pulsed magnets, compared to explosive microsecond magnets, provide a wider range of techniques to investigate quantum matter, materials chemistry and materials for magnets.

Commissioned last summer, the 60 T long-pulse provides controlled-waveform pulses of two second duration. The pulse shapes can be designed to suit a particular experiment, including linear ramps and 100 msec flat-top at 60 T.

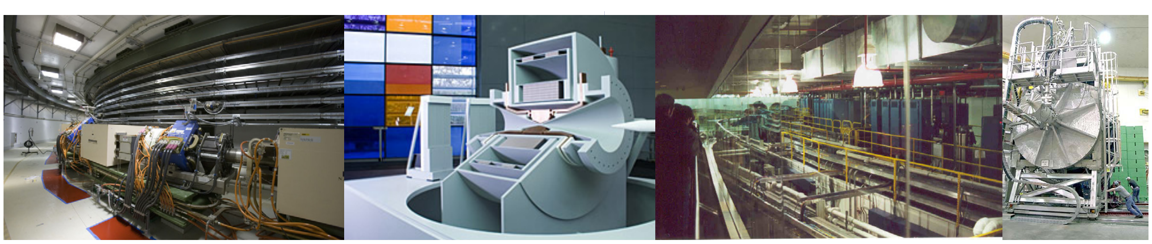
The stage was set in 2006 for the next generation of powered magnet systems. In September, the Magnet Lab began a $11.7 million project to construct the Series Connected Hybrid. This magnet – which will generate 36 T to 40 T magnetic fields – will use only half the power of our existing 31 T to 33 T magnets and one-third the power of our 45 T Hybrid magnet.

PURSUING TRANSFORMATIONAL NEW EXPERIMENTAL REGIMES

While building its vision at home, the Mag Lab is also working to export its magnet expertise in the interest of opening completely new scientific regimes. During the year, the lab made great progress on bringing neutrons and 25 T to 30 T magnetic fields together through collaborations with the Spallation Neutron Source in Oak Ridge and with the Hahn Meitner Institut in Berlin. In addition, users of the Advanced Photon Source at Argonne submitted a collaborative proposal to develop a 25 T to 30 T magnetic-field beamline for X-ray scattering.

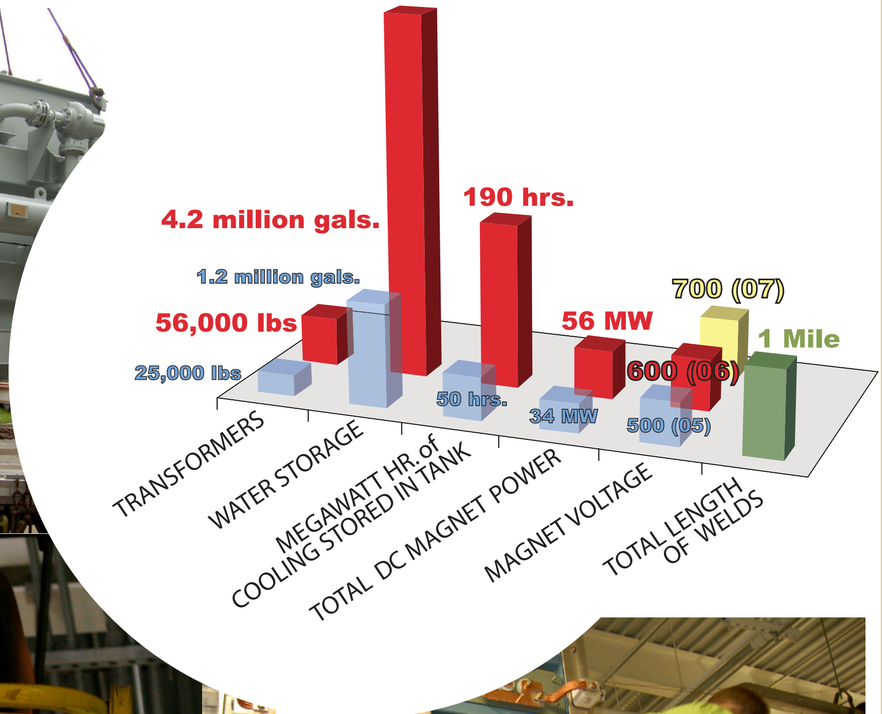
The Free Electron Laser, or "Big Light," project at the Mag Lab built momentum and support during 2006, as the lab and its partners – Jefferson Lab and University of California Santa Barbara – refined the technical specifications and engineering design for building a FEL capable of spanning the THz to infrared regime with intense, tunable, and picosecond-pulsed optical sources. Four separate undulators will provide the first capability for pump-probe experiments with 10-20 fs resolution. Together, these capabilities will provide unprecedented flexibility for condensed matter, chemistry and biology research in this nearly

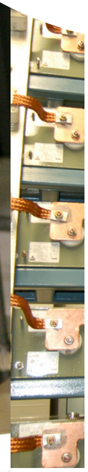
Spallation Neutron Source in Oak Ridge • Hahn Meitner Institut in Berlin • Advanced Photon Source at Argonne • Jefferson Lab



inaccessible regime of the electromagnetic spectrum…the regime that is resonant with many of the energy scales imposed by our magnetic fields. The capability to steer these beams into the Mag Lab magnets will be truly transformational. Success in this project will once again draw on the spectacular collaboration of the State of Florida and federal government agencies that underpins the National High Magnetic Field Laboratory.

INFRASTRUCTURE UPGRADE COMPLETED





In the fall of 2006, DC resistive magnet operations began a two-month shutdown to install equipment purchased with a $7.5 million appropriation from the Florida Legislature. The upgrade today allows users to run the magnets for longer times at peak field with lower ripple and makes possible future upgrades in the Mag Lab's peak DC magnetic fields. The modernization and expansion of our electrical and cooling infrastructure was critically important, as replacement components were becoming increasingly difficult to find and reliability has been one of the hallmarks of the DC user program.

EDUCATION AND OUTREACH

The lab's education, outreach and diversity activities continued to grow in 2006 with the newly enhanced Magnet Lab Web site (***www.magnet.fsu.edu***), the expanded education section of the site, and many new endeavors.

The Center for Integrating Research & Learning added *Comet Tales* to its outreach menu. The two- to three-week unit was created around the NASA Stardust Mission. Activities, including how to build a comet, engage students in learning by research: building the confidence to ask and the tools to answer their own questions.

SciGirls

Open House

Prairie View A&M

Also new in 2006: *SciGirls*. With a grant from Dragonfly TV and through a partnership with WFSU, the Tallahassee PBS station, and the Tallahassee Museum of History and Natural Science, the Mag Lab hosted 15 middle school girls for a two-week summer camp that offered them an opportunity to explore a variety of science experiences and related careers.

The Mag Lab's diversity initiatives gathered steam in 2006, with visitations to Historically Black Colleges and Universities (HBCUs) in 2004 leading to collaborative research in 2005 and now a refurbished Mag Lab laboratory in 2006 that complements new laboratories at Prairie View A&M and North Carolina A&T, welcoming their students for collaborative research using the Mag Lab's unique facilities.

In addition to these new endeavors, the traditionally successful Mag Lab outreach continues to demonstrate its strength. For example, more than 3,600 people visited the annual Open House in just five hours to experience the dozens of hands-on demonstrations throughout the lab. Lab tours throughout the year hosted an additional 1,000 students and members of the general public at the Tallahassee campus in 2006.

Nontraditional outreach efforts were stepped up in 2006 with increased efforts to translate the laboratory's user program science for laypeople. To that end, the lab's Public Affairs group refocused its efforts on placing research and other Mag Lab news in mainstream and online media outlets.

In addition, the lab's Web site was redesigned in 2006 to broaden its appeal to non-experts and to put increased emphasis on education. The education section received an overhaul that includes a new Magnet Academy, containing articles spanning Mag Lab research that might best be described as "science for English majors."

All of these efforts are tied to broader NSF goals to fund transformational science, increase science literacy and direct a more diverse population toward careers in science, technology, engineering and mathematics.

Research Highlights

In November and December of each year, Magnet Lab users and affiliated faculty submit brief abstracts that describe their scientific and R&D activities for the year. For 2006, we received 398 reports in 17 categories, and, following review and approval by facility or department directors, all were presented on the Web site at: ***www.magnet.fsu.edu/mediacenter/publications/annualreport.aspx***

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

	Reports Received	Highlights Selected
Life Sciences *including Biochemistry and Biology*	84	6
Chemistry *including Chemistry, Magnetic Resonance Techniques, Geochemistry*	102	6
Magnet Science & Technology *including Engineering Materials, Instrumentation, Magnet Technology, Superconductivity-Applied*	47	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—Basic*	165	14
Total	*398*	*30*

Strong record of publication continues. At the time of submission at the end of 2006, 20% of the research activities (78 reports) had already been published, many in prominent journals such as the *Analytical Chemistry, Applied Physics Letters, Biochemistry, Energy & Fuels, IEEE Transactions on Applied Superconductivity, Journal of Magnetic Resonance, Journal of the American Chemical Society, Physical Review B and Phys. Rev. Lett., Nature*, and the *Proceedings of the National Academy of Sciences*. In addition, 6% of the reports had been accepted for publication; 11% had been submitted; and 37% had manuscripts in preparation.

For more information on Magnet Lab publications, presentations, theses, and other scientific productivity, see Chapter 10 of this Annual Report (page 127) or refer to the database online: ***www.magnet.fsu.edu/search/publications/search.aspx***

Broad funding support. While most research at the laboratory is funded by the National Science Foundation, the Department of Energy, and the National Institutes of Health, a wide range of other agencies and organizations also support research projects and activities. Details are presented in the following table.

RESEARCH HIGHLIGHTS

2006 PRIMARY FUNDING SOURCE OVERVIEW

FUNDING SOURCE	NUMBER OF REPORTS
American Chemical Society - Petroleum Research Fund	1
Australian Research Council	1
Bioheart Inc.	1
Children's Miracle Network	1
China National Science Foundation	1
Christopher Reeve Paralysis Foundation	1
Colby College Natural Science Division	1
Department of Defense	1
Department of Energy	51
Deutsche Forschungsgemeinschaft (Germany)	2
Engineering and Physical Sciences Research Council (UK)	5
Forschungzentrum Karlsruhe (Germany)	3
FSU Research Foundation	1
German Research Society	3
Grant-in-Aid for Scientific Research of Japan	1
Human Frontier Science Program	3
IBM	1
Industrial R&D	1
INTAS, Ukraine	3
James and Esther King Foundation	1
Korean Ministry of Science and Technology	2
Korean Science and Engineering Foundation	3
Lithuania Ministry of Defence	1
MARCO Focus Center on Functional Engineered Nano Architectonics (FENA)	1
Muscular Dystrophy Association	1
NASA	3
National Institutes of Health	66
National Science Council, Taiwan	1
National Science Foundation	135
National Sciences and Engineering Research Council of Canada	2
NHMFL	48
NHMFL In-House Research Program	23
Queens College	1
Research Assistantship	1
Research Corporation and Dreyfus Foundation	2
Roosevelt University	2
Russian Academy of Sciences	1
Russian Foundation for Basic Research	2
Slovenian Research Agency	1
Tel Aviv University	1
U.S. Air Force Office of Scientific Research	4
U.S. Army	1
U.S. Geological Survey	1
U.S. Navy	1
UF Department of Chemical Engineering	1
UF Department of Radiology	3
UF McKnight Brain Institute	5
UK Government	1
Wroclaw University of Technology	1
TOTAL	**398**

Rapid and reliable recording of multidimensional NMR spectra is of great practical utility. An approach is presented that accomplishes this task by means of a covariance transform followed by a masking procedure that identifies and eliminates potential spectral artifacts. It is demonstrated for a two-dimensional total correlation spectroscopy (TOCSY) dataset of a decapeptide using only 48 increments along the indirect time domain.

This research was published in **Journal of the American Chemical Society**, **128**, 15564 (2006).

COVARIANCE NMR WITH MINIMAL DATASETS

Y. Chen (FSU, Physics & NHMFL), F. Zhang (NHMFL), W. Bermel (Bruker Biospin) and R. Brüschweiler (FSU, Chemistry & Biochemistry, and NHMFL)

INTRODUCTION

Covariance NMR spectroscopy [1] is an alternative method to 2D Fourier transform (2D FT) NMR to establish spin correlations in molecules. The covariance spectrum $\boldsymbol{C}$ is determined using the mixed time-frequency domain data $\boldsymbol{S}$, $\boldsymbol{C}=(\boldsymbol{S}^T\boldsymbol{S})^{1/2}$, where $\boldsymbol{S}$ is the $N_1 \times N_2$ mixed time-frequency domain matrix after Fourier transform along the detection dimension t_2. The matrix square-root can be efficiently determined by singular value decomposition [2].

RESULTS AND DISCUSSION

An advantage of covariance spectroscopy over traditional 2D FT NMR is that the indirect dimension is not required to be sampled with a time increment that fulfills the Nyquist theorem, 1/(spectral width). Importantly, if N_1 is to be minimized to achieve maximal speed up, undersampling in t_1 can be advantageous by probing a wider range of t_1 evolution times. The conventional FT spectrum obtained from the time-domain of the same size (N_1=48) shows severe line broadening along the indirect dimension ω_1, and thus is unsuitable for simple analysis. The covariance spectrum has the same high resolution along both dimensions by definition. Comparison with the 2D FT spectrum with 2048 increments reveals, however, the presence of extra peaks reflecting the onset of poor sampling effects due to the small size of the dataset. These effects can be removed by a masking scheme that uses predicted spurious correlations caused by finite sampling. Application of the resulting mask to the covariance spectrum leads to the spectrum (upper left) that is essentially void of false peaks while most of the true peaks are present [3].

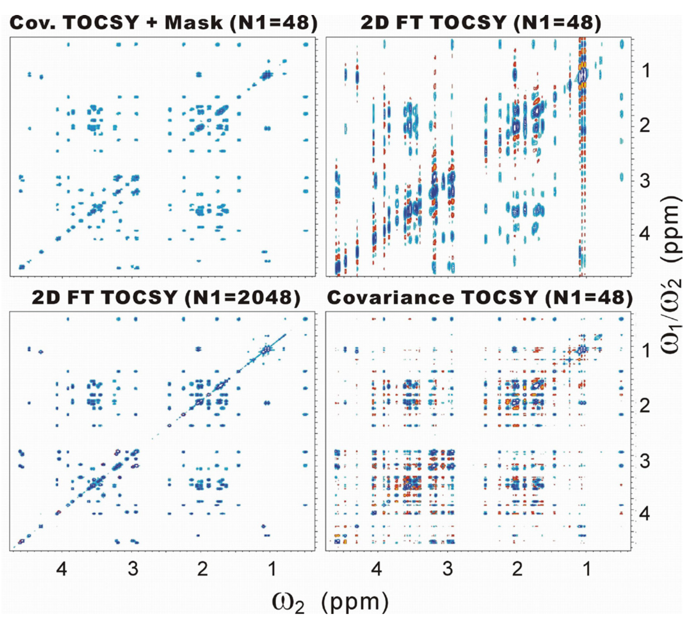


Figure 1.
Aliphatic proton region of TOCSY NMR spectra of 1 mM cyclic decapeptide antamanide in $CDCl_3$ collected at 800 data MHz proton frequency and 300 K.

CONCLUSIONS

The enhanced covariance method presented here provides high-resolution 2D spectra from minimal t_1 datasets. The undersampling and cross-validation schemes represent powerful means to suppress spurious correlations. The scheme, which offers substantial savings of measurement time for TOCSY- and COSY-type spectra, is readily applicable to high-throughput screening such as in metabolomics.

ACKNOWLEDGEMENTS

We thank Dr. David Synder for discussion. This work is supported by NIH (R01-GM066041).

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[3] Chen, Y. *et al.* J. Am. Chem. Soc., **128** (2006) 15564-11565.

Sarcolipin (SLN) is a 31-residue alpha-helical protein that regulates Ca-ATPase, the enzyme that is responsible for calcium trafficking in heart muscle. In order to investigate the interaction between SLN and Ca-ATPase the topology of SLN in a native-like lipid environment was first deduced. From experiments conducted at the MagLab using low-E probe technology developed in-house, it was determined that SLN adopts a tilt of ~23 degrees, relative to the bilayer normal, and that the hydrophobic face of the protein is oriented facing the cytoplasmic surface of the lipid bilayer.

This research was published in **Biochemistry, 45** (36), 10939-46 (2006).

TWO-DIMENSIONAL NMR SPECTROSCOPY OF SARCOLIPIN IN ORIENTED LIPID BILAYERS

J.J Buffy (U. of Minnesota), N.J. Traaseth (U. of Minnesota), and G. Veglia (U. of Minnesota)

INTRODUCTION

Sarcolipin (SLN), a 31 amino acid integral membrane protein, regulates SERCA1a and SERCA2a, two isoforms of the sarco(endo)plasmic Ca-ATPase, by lowering their apparent Ca^{2+} affinity and thereby enabling muscle relaxation. Previous 1D solid-state NMR experiments on selectively ^{15}N-labeled sites showed that SLN crosses the lipid bilayer with an orientation nearly parallel to the bilayer normal. With a view toward the characterization of SLN structure and its interactions with both lipids and SERCA, we started the analysis of SLN in mechanically oriented DOPC/DOPE lipid bilayers as mapped by two-dimensional ^{15}N PISEMA experiments.

EXPERIMENTAL

NMR experiments were performed on a Bruker DMX-600 operating at a frequency of 600.14 MHz for ^{1}H and 60.82 MHz for ^{15}N. Prior to ^{15}N data acquisition, the integrity of the oriented lipid bilayer was verified using ^{31}P NMR. PISEMA experiments [1] were performed on a probe designed and constructed at the National High Magnetic Field Laboratory. In order to reduce sample heating, the probe utilizes a separate, low inductance ^{1}H resonator outside the ^{15}N detection coil. Typical NMR parameters used in the PISEMA experiments include a ^{1}H pulse length of 3.7 us, decoupling field of 50 kHz, rf field strengths of 48 kHz for ^{1}H and 67.6 kHz during the SEMA element, and a recycle delay of 3.5-5 s. PISEMA spectra on selectively ^{15}N-labeled SLN were acquired at 5°C with 9-12 t_1 increments and ~3k scans, while uniformly ^{15}N-labeled SLN samples required 32 t_1 increments and ~2k scans.

RESULTS AND DISCUSSION

PISEMA spectra mapped the structure and topology of SLN in oriented DOPC/DOPE bilayers. Under our experimental conditions, this single-pass membrane protein adopts a helical conformation and crosses the membrane with a tilt angle of ~ 23°. PISEMA spectra obtained with both uniformly and selectively ^{15}N-labeled SLN clearly indicate a preferential orientation of the helix face containing Leu-21, Leu-25, and Ile-14 pointing towards the N-terminal side of the membrane, corresponding to the cytoplasm side in SR. Remarkably, PISEMA spectra suggest a topological interconversion on a slow time scale (i.e., slower that 10^{-4}s) with the presence of a second population of resonances. This additional population exhibits roughly the same tilt angle (θ) of the SLN helix with respect to the membrane bilayer, but a slightly different rotational angle (ρ). These two topologies may represent the two states whose

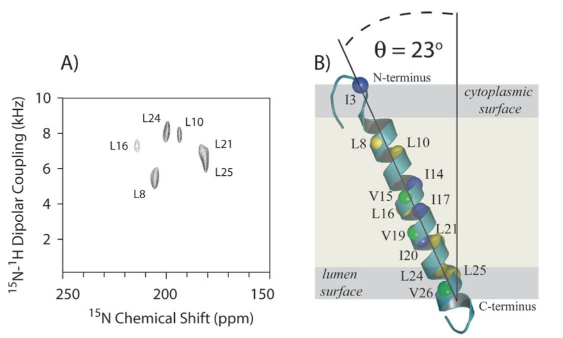

Figure 1.
A) PISEMA assignment for ^{15}N-Leu SLN in oriented lipid bilayers. The Leu spectral pattern follows the PISA wheel of the U-^{15}N SLN PISEMA. B) Proposed structural model of SLN in lipid membranes. The Leu, Ile and Val residues that were assigned in the PISEMA spectra are highlighted in yellow, blue and green spheres, respectively. SLN backbone is rotated around its helical axis so that the face containing Leu-21, Leu-25, and Ile-14 points toward the N-terminal side of the membrane.

information is totally lost in the isotropic micellar environments and may represent a pre-equilibrium state of SLN that constitutes a requirement for SERCA recognition.

CONCLUSIONS

SLN crosses the lipid bilayer with an angle of approximately 23°, echoing the conclusions of a similar investigation carried out with phospholamban (another Ca-ATPase inhibitor) under identical experimental conditions. This result demonstrates that high homologous primary sequences are likely to have the same interactions with lipid bilayers.

ACKNOWLEDGEMENTS

Many thanks to Dr. T. Cross for many helpful discussions. This work was supported by the National Institutes of Health Grant GM64742 and K02HL080081 to GV. J.J.B. is supported by the MinnCResT (NIDCR 5T32-DE007288-10); and N.J.T. pre-doctoral fellowship (AHA 0515491Z). The spectroscopy was performed at the NHMFL supported by NSF through cooperative agreement DMR-0084173 and by the State of Florida.

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More than half of all human proteins are modified by the attachment of sugar chains that modify the biological function and enhance the blood stability compared to non-glycosylated proteins. Structural studies of these glycosylated proteins using high-field magnets such as are available at the National High Magnetic Field Laboratory require large amounts of pure samples that are enriched in stable ^{13}C and ^{15}N isotopes, but preparing these samples is very expensive. The high cost associated with these studies has discouraged researchers from studying these proteins. A broadly applicable strategy is developed for significantly reducing the cost of preparing these samples, which will facilitate structural and functional studies on this important class of proteins.

This research was published in **Journal of Biomolecular NMR, 36** (4) 225-233 (2006) and supported by the **In-House Research Program** (PI, Tim Logan).

ISOTOPE ENRICHMENT IN EUKARYOTIC CELLS AS A PRELUDE TO GLYCOPROTEIN STRUCTURAL BIOLOGY

W.J. Walton (FSU, Molecular Biophysics), D.Q. Ni (Molecular Biophysics) and T.M. Logan (Molecular Biophysics and Chemistry & Biochemistry, Florida State University)

INTRODUCTION

The genetic code in all organisms provides a template for producing proteins and RNA molecules that effectively "run" the cell and control nearly all aspects of the cell's fate. To expand the scope of the genetic code, many of the protein and RNA products are modified during or after biosynthesis. These post-translational modifications are particularly important in modifying or regulating protein and RNA activity. Covalent modification by attaching carbohydrates, either as single sugars or as complex chains, is the most prevalent of these post-translational modifications, being found on more than half of all proteins coded for in the human genome.

Despite the prevalence and importance of glycosylation in protein biochemistry, we know very little about how glycosylation affects protein structure because these proteins typically present more significant challenges to structural biology than even membrane proteins. One of the most daunting challenges is to produce large quantities of isotopically enriched, pure recombinant glycoproteins for NMR spectroscopy. As the foundation for a research program directed towards glycoprotein structural biology, we are focusing our initial studies on how to enhance isotope labeling in recombinant glycoproteins produced in insect cells or in mammalian cells.

EXPERIMENTAL

We use Thy-1 fused to green fluorescence protein (Thy-1-GFP) in these studies. The GFP "tag" provides very sensitive detection, which allows us to work with reasonable amounts of cells. Our approach is to obtain "partial" medium commercially and then supplement these media with isotopically enriched precursors.

RESULTS AND DISCUSSION

We demonstrated that isotopically enriched ammonium chloride can be metabolically incorporated into amino acids, which can then be used to synthesize recombinant glycoproteins produced in cultured insect Sf9 cells [1]. We also found that isotopically enriched glucose is readily incorporated into the sugar moieties of glycoproteins (which was not unexpected) and into several amino acids (which was unexpected).

Thy-1-GFP is produced at significantly higher levels in cultured mammalian cells and we are currently investigating similar approaches to isotope labeling in these cells. Our strategy is to identify growth media that can economically introduce labeled precursors, such as glucose and glutamate, that can be metabolized into amino acids and incorporated into recombinant proteins. Our preliminary experiments indicate that slowing metabolism results in significantly increased recombinant protein yields and are working towards repeating these experiments with isotopically enriched precursors.

CONCLUSIONS

In the past year we completed a study investigating the supplementation of insect cell growth medium with labeled glucose and ammonium chloride. The approach yielded fairly uniform labeling at a fraction of the cost of purchasing complete, isotopically enriched growth medium and should find utility in drug screening, structural studies, and biophysical studies. Labeling in mammalian cells will require additional supplementation of isotopically-enriched essential amino acids, but our preliminary studies are encouraging and should lead to significantly improved methods for producing isotopically enriched glycoproteins for structural biology.

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Membrane proteins are particularly difficult to structurally characterize and yet they represent the majority of all drug targets for today's pharmaceuticals. No matter what structural approach is used, sample preparation is the critical step. Using several examples of membrane proteins, we demonstrate that high quality samples can be prepared for solid-state NMR spectroscopy. This technology has the unique advantage of being able to characterize membrane protein structure in a membrane mimetic environment that is very similar to that of the native membranes.

This research has been accepted to publish in the **Journal of the American Chemical Society** .

UNIFORMLY ALIGNED FULL-LENGTH MEMBRANE PROTEINS IN LIQUID CRYSTALLING LIPID BILAYERS FOR STRUCTURAL CHARACTERIZATION

C. Li; P. Gao; H. Qin; R. Chase; T.A. Cross (FSU, Chemistry and Biochemistry, NHMFL); P. Gor'kov; W. Brey; (FSU, NHMFL)

INTRODUCTION

Progress has recently been made in membrane protein structure determination in lipid bilayer environments using solid state NMR spectroscopy of uniformly aligned samples. From the complete structure of gramicidin in 1993 to the structure of the M2 transmembrane domain with and without the antiviral drug amantadine, the structure of MerF, etc., there are ten membrane protein structures in the Protein Data Bank characterized by aligned sample solid state NMR. Recent improvements in RF probe technology and in sample preparation have made it possible to obtain spectra of uniformly aligned full-length membrane protein samples. Here, we demonstrate the uniform alignment of three such proteins as well as the observation of characteristic resonance patterns for their transmembrane (TM) α-helices.

RESULTS AND DISCUSSION

Fig. 1 shows the PISEMA spectra of KdpF, Rv1861, and DAGK in liquid crystalline lipid bilayer environments. Here PISA wheels reflecting the helical topology are clearly observed for two (KdpF and Rv1861) of the three proteins. The third protein, DAGK has TM helices displaying small tilt angles such that the PISA wheel, which disappears at a 0° tilt angle, is unresolved in the uniformly ^{15}N labeled sample.

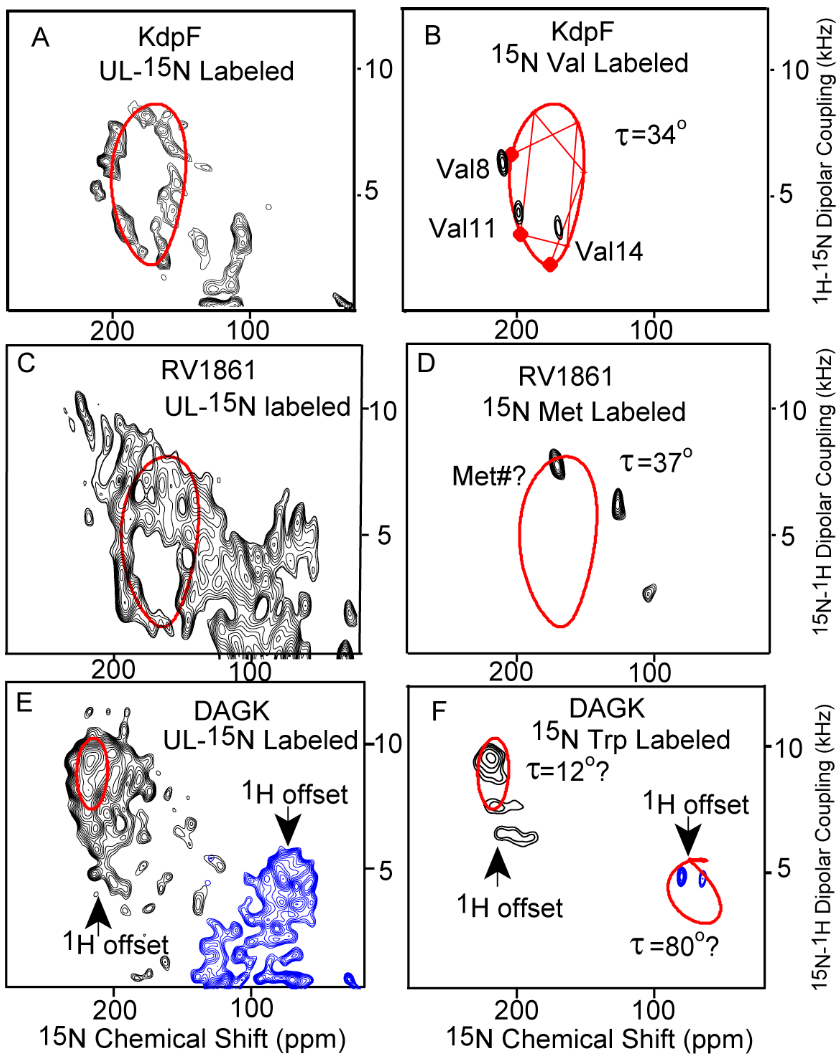

Figure 1.
PISEMA spectra of KdpF (A&B), Rv1861 (C&D) and DAGK (E & F) of uniformly ^{15}N-labeled (A,C&E) and amino acid specific labeled protein (B,D&F) expressed in *E. coli* and reconstituted into a mixture of lipids – dimyristoylphosphatidylcholine (DMPC) and phosphatidyl-glycerol (DMPG) in a 4:1 molar ratio. The samples were aligned between glass slides . Spectra were obtained at 600 MHz except for the ^{15}N UL KdpF spectrum which was obtained in the UWB 900 MHz magnet at the NHMFL using NHMFL Low-E probes. The low-electric field feature was essential for this spectroscopy. 0.8 ms cross polarization contact time, an acquisition time of 4 ms during with SPINAL decoupling was applied, and a recycle delay of 6 s were used. To avoid the limitations of the ^{1}H bandwidth the spectra of DAGK were obtained in two halves with different offset frequencies. The PISA wheels were calculated using motionally averaged dipolar ($\nu_{\parallel}$ = 10.375 kHz) and chemical shift tensors (σ_{11} = 57; σ_{22} = 81; σ_{33} = 228 ppm).

CONCLUSION

Proteins ranging in molecular weight from a 3.5 kDa monomer to a 40 kDa trimer and an 82 kDa octamer have been uniformly aligned between glass slides demonstrating the feasibility of preparing full length membrane protein samples for solid state NMR structural characterization.

ACKNOWLEDGEMENT

This work was supported in part by NIH, GM 64676.

The classical role of carbonic anhydrase (CA) is to maintain tissue pH homeostasis through acid-base reactions. Skeletal muscle contains at least four isozymes of CA (CA II, CA III, CA IV, and CA V). The roles of CA II, CA IV, and CA V are to accelerate the removal of acid as CO_2, transport lactate across the muscle membrane, and to fasten the metabolism of pyruvate, and are all well described. Surprisingly, the function of the most concentrated CA in muscle (CA III) has been a mystery until now. Using noninvasive ^{31}P magnetic resonance spectroscopy, MagLab scientists in collaboration with investigators from the University of Pennsylvania, have monitored muscle bioenergetics in real time from mice lacking muscle CAIII. These studies have uncovered that CA III plays an important role in mitochondrial ATP synthesis in muscle.

This research was published in **Proceedings of the National Academy of Sciences U.S.A, 104,** 371-376 (2007).

A QUANTITATIVE STUDY OF BIOENERGETICS IN SKELETAL MUSCLE LACKING CARBONIC ANHYDRASE III BY ^{31}P MAGNETIC RESONANCE SPECTROSCOPY

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INTRODUCTION

Oxidative slow skeletal muscle contains carbonic anhydrase III in a concentration as high as 2% of wet weight, but its primary function remains in question. In order to determine if the lack of this enzyme handicaps energy metabolism and/or acid elimination under stress, we measured the intracellular pHi and energy phosphates by ^{31}P magnetic resonance spectroscopy (MRS) in hind limb muscles of wild type and CAIII knockout mice during and after ischemia and intense exercise (electrical stimulation).

EXPERIMENTAL

The MR measurements were performed inside an 11T/470 MHz spectrometer. Spectra were acquired using a 6-mm x 12-mm oblong phosphorus (190.5 MHz) surface coil, placed over the belly of the gastrocnemius muscles. Spectra were acquired with a 50 µs square pulse, a pulse repetition time of 2 sec, and data were averaged into 30 second bins. Phosphorus spectra were obtained at rest (5 min), during ischemia (30 min) or electrical stimulation (2 min), and the following recovery (30 min). Intracellular pH was calculated based on the chemical shift of Pi. The Pi and PCr concentrations were determined using area integration.

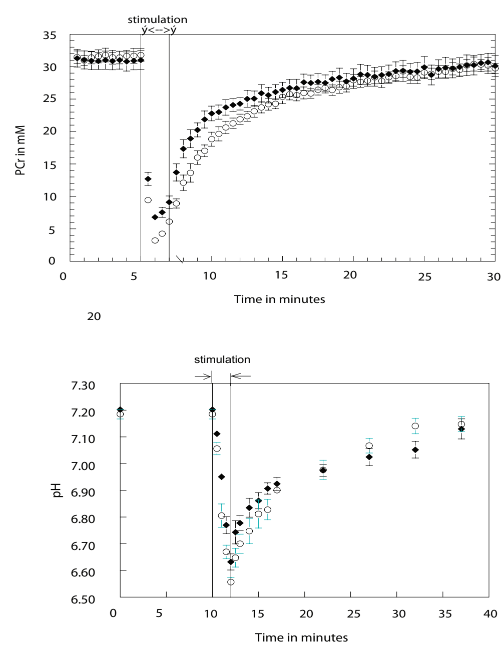

Figure 1.
PCr and pH kinetics in CA III knockout and wild type mice following electrical stimulation.

RESULTS AND DISCUSSION

Thirty minutes of ischemia caused phosphocreatine (PCr) to fall and inorganic phosphate (Pi) to rise, while pH and ATP remained constant in both strains of mice. PCr and Pi kinetics during ischemia and recovery were not significantly different between the two genotypes. From this we conclude that under neutral pH conditions resting muscle anaerobic metabolism, the rate of the creatine kinase reaction, intracellular buffering of protons, and phosphorylation of creatine by mitochondrial oxygen metabolism are not influenced by the lack of CA III. Two minutes of intense stimulation of the mouse gastrocnemius caused PCr, ATP and pH_i to fall and ADP and Pi to rise and these changes, with the exception of ATP, were all significantly larger in the animals lacking CA III. The rate of return of pH_i and ADP to control values was the same in wild type and mutant mice, but in the mutants PCr and Pi recovery were delayed in the first minute after stimulation (Figure 1).

CONCLUSIONS

Our quantitative study of muscle bioenergetics in CA III knockout mice showed a significant decrease in PCr recovery rate following electrical stimulation. We conclude that a lack of CA III impairs mitochondrial ATP *in vivo* synthesis.

ACKNOWLEDGEMENTS

This research was supported by NIH grant AR45394. The mutant mice were obtained from G. Kim and R. L. Levine at NIH. MR data were supported through the National High Magnetic Field Laboratory and obtained at the Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) facility in the McKnight Brain institute of the University of Florida.

Plants, animals, and micro-organisms use chemicals for communication and defense. Learning these chemical languages provides new biological insights that improve our understanding of how biological species interact in their environment. In many cases, chemicals that are used for a specific biological function can be adapted for human medicinal or pesticide applications. About 25% of prescription drugs for humans are directly derived from these natural product chemicals and about another 25% of our drugs are modifications based originally on naturally occurring compounds. The major difficulty in discovering the identity of natural products is the large amount of material needed for NMR analysis. As demonstrated on the analysis of the venom from a single walkingstick insect, the 1-mm HTS NMR probe developed at the NHMFL has about 20x more sensitivity than conventional technology and can provide a significant new tool for natural product discovery.

This research was published in **ACS Chemical Biology, 1** (8), 511-514 (2006).

SINGLE INSECT NMR: TECHNOLOGY LEADING TO NEW SCIENCE

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INTRODUCTION

Due to analytical limitations, multiple animals or plants are typically required to identify natural products. Using a unique 1-mm high-temperature superconducting NMR probe developed at the NHMFL (1), we directly examined the chemical composition of defensive secretions from individual walkingstick insects. We found that the Florida walkingstick *Anisomorpha buprestoides* secretes similar quantities of glucose and mixtures of monoterpene dialdehydes that are stereoisomers of dolichodial. Different individual animals produce different stereoisomeric mixtures, the ratio of which varies between individual animals raised in the same container and fed the same food. Another walkingstick from Peru, *Peruphasma schultei*, also secretes glucose and a single, unique stereoisomer that we named "peruphasmal".

EXPERIMENTAL

Adult A. *buprestoides* were collected at night in Gulf Hammock, Florida during the fall of 2005. Eggs produced by the insects were hatched in captivity. The young phasmids were fed a diet of only variegated *Ligustrum sinense* purchased from a local plant nursery. We were able to collect single milkings from half-grown males consisting of about 1 μL of a whitish fluid by gently touching the secretory duct with a glass pipette. To this we added 10 μL D_2O and without purification or additional preparation, we were able to collect the 1D ^1H NMR spectrum in Fig. 1 within about ten minutes following the milking. Complete assignments were done with standard 2D NMR experiments from the same sample.

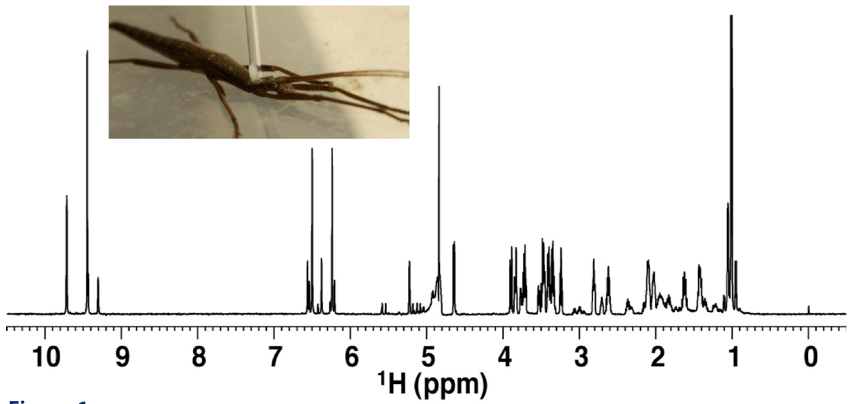

Figure 1.
1D 1H NMR spectrum from the 1-mm HTS probe of a single walkingstick milking as shown in Figure 3. The spectrum was collected in less than 1 minute with 8 scans and less than 10 minutes after the milking.

RESULTS AND DISCUSSION

1) We were able to obtain very high quality NMR data from the milking of a single insect (2). Previous studies on the same insect required over 1000 milkings (3).
2) We observed glucose in the defensive secretions (2). This was not previously observed, because samples were extracted into organic solvents.
3) The active component of the defensive spray is present as three different stereoisomers in the Florida insect but only a single isomer in the Peruvian species. Surprisingly, the composition of the stereoisomers changes between individual insects and as a function of time.

CONCLUSIONS

Traditionally, natural product studies consist of samples collected from hundreds or thousands of individuals. This was the first study to use NMR to analyze natural products from a single insect. The variability in isomers suggests new fertile ground in chemical biodiversity.

ACKNOWLEDGEMENTS

Bill Brey (NHMFL), Saikat Saha (NHMFL, now GE) Rich Withers (Bruker, now Varian), and Rob Nast (Bruker, now Varian) made the 1-mm HTS probe. Funding was from the HFSP, NIH, and NHMFL.

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To our knowledge, this is the first study that elucidates both the chemical and magnetic structure of a complex magnetic compound that would not have been possible without the utility of unique and powerful techniques developed at the NHMFL: high-field electron paramagnetic resonance (EPR) spectroscopy and Fourier transform ion cyclotron resonance (FT-ICR) spectrometry. EPR yielded the desired information on the orientation of the electron spins on the compound, a model five copper cluster, while FT-ICR showed how the various parts of the cluster are bonded together by looking at its fragmentation during infrared multiphoton irradiation. FT-ICR revealed also that the clusters are stable in solution, which is hard to accomplish by other techniques. The results obtained provide fundamentally new information on molecular magnetism, catalysis, and cluster stability, and demonstrate how seemingly diverse techniques provide synergies in solving a complex chemical problem. This work opens up a new window on the design of new molecular solids with desirable magnetic and catalytic properties.

This research was published in **Inorganic Chemistry, 44** (26), 9795-9806 (December 2005).

MAGNETIC AND VARIABLE FREQUENCY EPR STUDIES OF PENTA-NUCLEAR Cu^{2+} POLYOXOMETALATE

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INTRODUCTION

The class of Cu^{2+}-containing sandwich-type polyoxometalates is well-known and to date numerous complexes have been reported, but most of these polyanions are dimeric and contain three or four Cu^{2+}centers [1]. This report presents the magnetic properties and EPR spectroscopy [2] of a new penta-copper substituted polyoxoanion $[Cu_5(OH)_4(H_2O)_2(A\text{-}\alpha\text{-}SiW_9O_{33})_2]^{10-}$ (Cu_5). Cu_5 consists of two A-α-$[SiW_9O_{34}]^{10-}$ Keggin moieties which are linked via two adjacent W-O-W bonds and stabilized by a central $\{Cu_5(OH)_4(H_2O)_2\}^{6+}$ fragment leading to a structure with idealized C_{2v} symmetry (see Fig. 1). The Cu^{2+} ions in Cu_5 are at the corners of a rectangular pyramid.

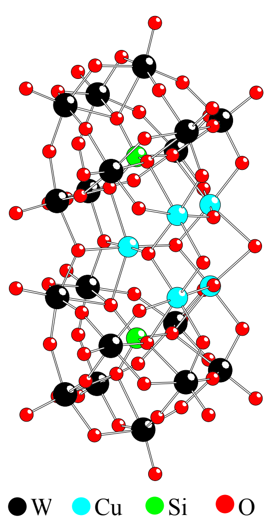

Figure 1.
Ball-and-stick representation of Cu_5.

EXPERIMENTAL

Magnetic susceptibility data were collected on Quantum Design MPMS XL SQUID Magnetometer and Q-band (~35 GHz) EPR data were collected on Bruker Elexsys 500 at the Department of Chemistry and Biochemistry, FSU. EPR measurements at high frequencies were done on a home-built homodyne instrument at the National High Magnetic Field Laboratory, Tallahassee, FL.

RESULTS AND DISCUSSION

Magnetic susceptibility data for Cu_5 is shown in Fig. 2. as a plot of χT vs T. Steady decrease of χT as temperature, T, decreases and suggests the presence of antiferromagnetic interactions between Cu^{2+} ions. Saturation below 50 K at ~0.39 emu-K/mol implies a spin $S_T = 1/2$ ground state, where S_T is the total spin value of the cluster. Analysis of the data according to the exchange spin Hamiltonian shown in Eq.1, provides the exchange constants as: $J_a = -51 \pm 6$ cm^{-1}, $J_b = -104 \pm 1$ cm^{-1}, $J_c = -55 \pm 3$ cm^{-1} and $g = 2.035 \pm 0.002$.

CHEMISTRY

$$\hat{H}_{exch} = -2J_a[\hat{S}_1\cdot\hat{S}_2 + \hat{S}_3\cdot\hat{S}_4] - 2J_b[\hat{S}_1\cdot\hat{S}_3 + \hat{S}_2\cdot\hat{S}_4] - 2J_c[\hat{S}_1\cdot\hat{S}_5 + \hat{S}_2\cdot\hat{S}_5 + \hat{S}_4\cdot\hat{S}_5 + \hat{S}_3\cdot\hat{S}_5] \quad (1)$$

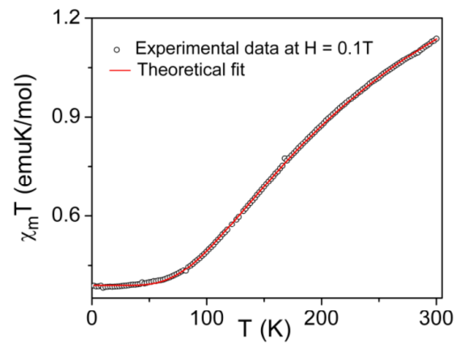

Figure 2. χT vs T for Cu_5.

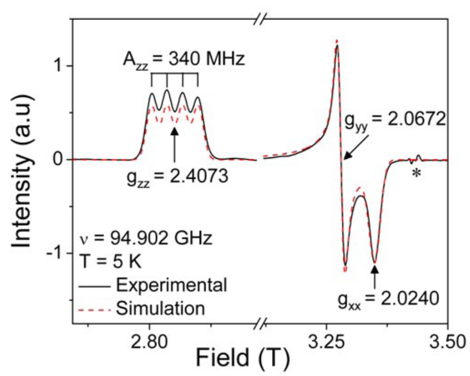

Figure 3. 95GHz EPR of Cu_5.

Figure 3 shows a 95 GHz powder spectrum of Cu_5 at 5 K and it is a typical Cu^{2+} spectrum, with a four line hyperfine structure (A_{zz}) on the low-field Zeeman peak (g_{zz}). The unpaired electron is assigned to the apical copper centre [2]. The spectra at all frequencies were reproduced satisfactorily with the Hamiltonian parameters: $g_{zz} = 2.4073 \pm 0.0005$, $g_{yy} = 2.0672 \pm 0.0005$, $g_{xx} = 2.0240 \pm 0.0005$, $|A_{zz}| = 340 \pm 20$ MHz (0.0113 cm^{-1}) implying that there is no net exchange field on the apical copper. The g-values are consistent with a $3d_{x^2-y^2}$ type molecular orbital ground state, as expected for a Cu^{2+} in an elongated rhombic-octahedral co-ordination with oxygen. A qualitative analysis of the g- and A_{zz} values, using the Crystal field – Molecular orbital theory [3], yields $\alpha^2 = 0.71$, where α is the molecular orbital coefficient of the ground state, indicating a moderate (~ 30%) contribution from the oxygen orbitals.

CONCLUSIONS

Magnetic and EPR measurements reveal that the pentameric copper core of Cu_5 exhibits strong antiferromagnetic interactions resulting in a spin S_T = ½ ground state, with a localized unpaired electron spin density. Cu_5 can therefore be considered as a model system for a 5-spin electronically coupled, spin-frustrated system.

ACKNOWLEDGEMENTS

NSF (NIRT), # DMR 0103290 and CHE-99-09502 for support.

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Membrane-associated proteins hold the secrets to many basic biological processes, as well as to the development of new drugs and vaccines. Because these proteins neither crystallize nor dissolve in water, however, very few of their structures are known. "Low-E" probes recently developed at the MagLab are being combined with new NMR techniques to map the structure of these proteins in their native environment. This study shows that Low-E probes are much less likely to damage the valuable protein sample than conventional probes.

This research was published in **Journal of Magnetic Resonance, 185**, 77-93 (2007) *and was supported by the* **In-House Research Program** (PI, William W. Brey).

COMPARISON OF SAMPLE HEATING IN SOLENOIDAL AND LOW-E NMR PROBES

P.L. Gor'kov, E.Y. Chekmenev, C. Li, W.W. Brey (NHMFL/FSU)

INTRODUCTION

Solid state NMR spectroscopy experiments expose the sample to high levels of high frequency electromagnetic field. Just as in a microwave oven, these fields will heat the sample. Excessive heating may distort the NMR spectrum or even damage the sample. Recently introduced Low-E coil designs may reduce the level of heating [1]. A convenient way to quantify the improvement is to compare the values of RF input power required to produce identical 90° pulse lengths in a lossy biological sample (P_{bio}) and in a non-lossy reference (P_{nl}). The difference in input power $P_{heat} = P_{bio} - P_{nl}$ must then end up heating the biological sample. The same measurement can be done more precisely by comparing 90° pulse lengths (or RF fields $f_1 = \omega_1/2\pi$) measured with a lossy sample (τ_{90bio}) and with a non-lossy reference (τ_{90nl}) at the same power level P_{in}. Holding P_{in} constant eliminates the effect of errors that often accompany measurements of pulsed RF power. In the latter case, the fraction of RF input power diverted to sample heating can be expressed as:

$$\alpha_{heat} = \frac{P_e + P_m}{P_{bio}} = 1 - \frac{\tau^2_{90nl}}{\tau^2_{90bio}} = 1 - \frac{f^2_{1bio}}{f^2_{1nl}}$$

The loss factor α_{heat} alone should not be used to compare sample heating in different probes with different coils, or at different frequencies. A less efficient probe circuit with the same loss factor will deposit more power into the sample while achieving the same RF field f_1. For a heat sensitive sample, a spectroscopist should choose a probe with minimal heat deposition $q_{heat} = P_{heat}/f_{1bio}^2$, which is the cost of producing the required RF field f_1 in terms of power P_{heat} deposited in the sample. The heat deposition coefficient q_{heat} combines sample loss factor α_{heat} with probe circuit power efficiency η in the absence of sample loss:

$$\eta = \frac{f^2_{1nl}}{P_{in}} \qquad q_{heat} = \frac{\alpha_{heat} P_{in}}{f^2_{1bio}} = \frac{\alpha_{heat}}{1-\alpha_{heat}} \frac{P_{in}}{f^2_{1nl}} = \frac{\alpha_{heat}}{(1-\alpha_{heat})\,\eta}$$

Table 1.
Sample heating comparison between ^1H–^{15}N probes with low-E resonator and double-tuned 4-turn solenoid.

Field (MHz)	Probe	τ_{90nl} (µs)	τ_{90bio} (µs)	q_{heat}	η (kHz²/W)	q_{heat} (mW/kHz²)
400	4't solenoid	4.75	7.10	55 %	42.6	28.7
600	4't solenoid	5.05	9.55	72 %	37.7	68.2
600	low-E coil I	5.10	5.48	13 %	37.0	4.0
600	low-E coil II	5.75	6.23	15 %	29.1	6.1
900	low-E coil II	6.88	8.45	34 %	20.3	25.4

EXPERIMENTAL

Tests of sample heating by the ^1H field were conducted in five different probes designed for the same sample size but operating in magnets at three different fields. The results are summarized in Table 1. An applied ^1H power of 65 W was used in all cases. The 90° pulse length was measured for a non-lossy sample of pump oil and a typical biological sample described in [2]. Low-E resonators [1] using gaps of 6.4 (coil I) and 9.9 mm (coil II) were both tested, because the larger gap can produce a somewhat larger f_1 without arcing.

DISCUSSION AND CONCLUSIONS

The reduction in sample heating is illustrated by comparing the low-E probe to a conventional 4-turn solenoid at 600 MHz. RF power deposition in the biological sample has been reduced by 17 times in low-E coil I and by 11 times in low-E coil II. Coil I, with its smaller gap, is more efficient and produces the least sample heating. One might expect the ^1H power efficiency η of the low-E probe to be much worse than that of the solenoid due to the 3.3 times larger volume of the low-E resonator. However, the superior efficiency of the single resonance ^1H circuit in the low-E probe makes up for the difference in filling factor. As shown in Table 1, the low-E probe with coil I has the same ^1H efficiency as the double-tuned solenoid. The low-E probe with coil II is somewhat less efficient, which can be attributed to using more chip capacitors in the gap of the resonator. The amount of ^1H power dissipated in the bilayer sample in a 900 MHz low-E probe is 4 times larger than in its 600 MHz counterpart, yet it is still just 37% of that dissipated in the 4-turn solenoid at 600 MHz. To date, the aligned samples studied in the 900 MHz low-E probe have exhibited no signs of damage after demanding experiments. Yet because of the large rise of RF absorption at 900 MHz, it is important to invest in further refinements to the low-E coil for use at ultra-high NMR fields.

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Asphaltenes are a primary constituent of the residue remaining after the lower-boiling components of petroleum crude oil have been collected by distillation (gasoline, kerosene, lube oil, jet fuel, etc.). In a paper published in 2006 in *Energy & Fuels*, NHMFL's Geoff Klein, Ryan Rodgers, and Alan Marshall used ultrahigh-resolution mass spectrometry to define for the first time the detailed chemical composition (identification of thousands of chemically distinct components) of asphaltenes. They also showed that asphaltenes extracted physically (by temperature and pressure drop as crude oil is pumped out of a reservoir) differ qualitatively from those extracted chemically (by precipitation with heptane, an organic solvent). This paper thus provides the first rational basis for characterizing one of nature's most chemically complex mixtures.

This research was published in **Energy & Fuels, 20**, 1965-1972 (2006).

COMPOSITIONAL DIFFERENCES BETWEEN PRESSURE-DROP AND SOLVENT-DROP ASPHALTENES DETERMINED BY ELECTROSPRAY IONIZATION FT-ICR MASS SPECTROMETRY

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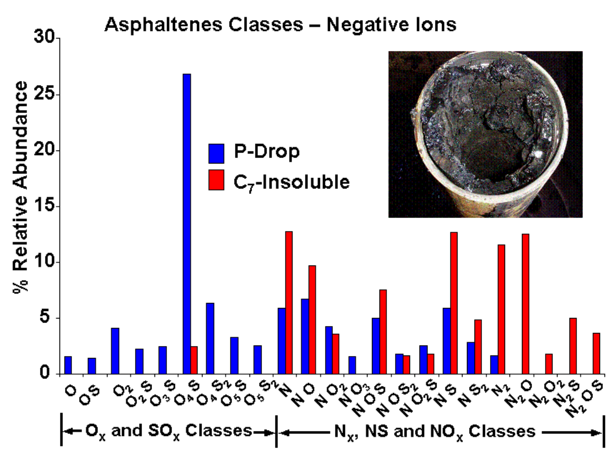
RESULTS AND DISCUSSION



Asphaltenes are typically defined by their solubility in benzene and insolubility in pentane or heptane. They are believed to exist in petroleum crude oil as a colloidal suspension, stabilized by surface-adsorbed resins. Their normal equilibrium under reservoir conditions may be disrupted during production by pressure reduction, crude oil chemical composition changes, introduction of miscible gases and liquids, mixing with diluents and other oils, and by acid stimulation, hot oiling, and other oilfield operations. In this work, we compare the compositional differences between heptane-precipitated asphaltenes and asphaltenes collected by live oil depressurization. Negative and positive ion electrospray yield the acidic and basic species, respectively. We find that the heptane-precipitated asphaltenes contain higher double bond equivalents (number of rings and double bonds) compared to the asphaltenes induced by pressure drop. On the other hand, the pressure drop product exhibits a higher abundance of species containing sulfur. Thus, the solubility criterion for asphaltenes defines a significantly different chemical composition (see Figure) than the (more field-relevant) pressure-drop criterion.

ACKNOWLEDGEMENTS

We thank Christopher L. Hendrickson and John P. Quinn for helpful discussions, and Daniel McIntosh for machining the custom parts required for the 9.4 T instrument construction. This work was supported by the NSF National High-Field FT-ICR Mass Spectrometry Facility (DMR 00-84173), Florida State University, and NHMFL.

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Extinct radionuclides in the early solar system left behind isotope footprints from which a precise chronology of events can be constructed about how our solar system developed. In the report by Humayun et al., the new Plasma Analytical Facility of the Geochemistry group was utilized to study the distribution of the elements hafnium (Hf) and tungsten (W) in selected components of meteorites. A clear post-formation disturbance of the extinct chronometer, Hf-182, was found in the samples on which previous age determinations were based. New samples were identified for subsequent measurements to provide an improved chronology of the formation of the early Solar System by Hf-W dating techniques.

This research has been submitted to **Geochim Cosmochim Acta** *and is under revision.*

THE DISTRIBUTION OF Hf AND W IN INCLUSIONS FROM METEORITES AND CHRONOLOGY OF THE EARLY SOLAR SYSTEM

M. Humayun (FSU, Geological Sciences & NHMFL/Geochemistry); S. B. Simon, L. Grossman (U. Chicago, Geophysical Sciences)

INTRODUCTION

The birth of the solar system is marked by a rapid series of events that occurred within the first100 million years (m.y.) from the collapse of a molecular cloud core. Precise dating of events that occurred 4.56 billion years ago is challenging, and is best accomplished by radiometric clocks based on extinct chronometers, i.e. radionuclides that entirely decayed during the first 100 million years of solar system history. One of these chronometers is based on the beta decay of ^{182}Hf (produced in supernovae) to ^{182}W (stable), one of the five isotopes of tungsten, with a half-life of 9 m.y. (Kleine *et al*., 2005). Application of the ^{182}Hf-^{182}W chronometer requires experimental determination of the initial ratio of ^{182}W/^{184}W in the solar system. The first objects to form as solids in the solar system are the calcium-aluminum-rich inclusions (CAIs) found in the carbonaceous chondrite meteorites. Kleine *et al.* (2005) reported the first ^{182}Hf-^{182}W ages on the CAIs and obtained an initial ^{182}W/^{184}W identical to that obtained from iron meteorites, implying the formation of the iron meteorites contemporaneously with the condensation of the first solids. This result is difficult to understand since individual chondrites accumulated over periods of several m.y., requiring that bodies large enough to form iron cores must have accumulated over longer periods of time. The meteorite from which the CAIs were obtained (Allende) had experienced a protracted history of post-accumulation disturbances which may have affected the ^{182}Hf-^{182}W ages in these CAIs. We explored this by analyzing the distribution of Hf, W and other elements in the individual minerals constituting CAIs using laser ablation ICP-MS at the NHMFL.

EXPERIMENTAL

Analyses of the distribution of Hf, W, and other elements were performed at the Plasma Analytical Facility at the NHMFL, using a New Wave UP213 UV laser ablation system coupled to a magnetic-sector ICP-MS (Thermo Finnigan Element1). Measurements were performed in line scan mode with 12 or 25 µm beam diameters, with the stage moved at 4-5 µm/s, 10 Hz laser repetition rate and 50% power output. The peaks ^{7}Li, ^{25}Mg, ^{27}Al, ^{29}Si, ^{34}S,^{43}Ca, ^{49}Ti, ^{53}Cr, ^{57}Fe, ^{60}Ni, ^{180}Hf, ^{181}Ta, ^{182}W, ^{183}W, ^{193}Ir, ^{195}Pt and ^{197}Au were acquired in low resolution (R=300) at 50 ms/peak (Humayun *et al*., 2006).

RESULTS, DISCUSSION & CONCLUSIONS

CAIs are composed of the minerals melilite (Ca-Al silicate), fassaite (Ca-Mg-Al-Ti silicate), spinel ($MgAl_2O_4$) and Fe-Ni metal. The distribution of the elements in CAIs was studied in two chondrites, Allende which had experienced post-accumulational heating, and Efremovka where these effects are relatively minor. The Efremovka CAIs had fairly simple elemental distribution patterns. All the W occurs in Fe-Ni metal grains (up to 1000 ppm), all the Hf occurs in fassaite (12-15 ppm), while melilite and spinel were found to contain negligible quantities (<0.010 ppm). In Allende, the Hf is hosted exclusively in fassaite, as well, but the W-host metal is absent. All Allende Fe-Ni metal has been altered into secondary oxides, sulfides, etc. W-rich veins were found in fassaite in Allende (Humayun *et al*., 2006). Such mobility is clear evidence for the post-formational disturbance of the ^{182}Hf-^{182}W chronometer in Allende. We find that the ambiguity in the results of Kleine *et al.* (2005) on the ^{182}Hf-^{182}W chronometry of the early history of the solar system could be resolved by new measurements on CAIs from the Efremovka meteorite.

ACKNOWLEDGEMENTS

This research was funded by NASA Cosmochemistry program.

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Diffusion weighted magnetic resonance imaging (MRI) has become a sensitive clinical tool to detect tissue injury. Typically diffusion-weighted MRI is acquired by varying the magnitude and the direction of diffusion sensitizing gradients. However, additional information about tissue microstructure may also be obtained if the diffusion time is varied. In this report, MagLab scientists demonstrate that previously unrecognized structural information is obtainable from time dependent, *q*-space diffusion MR studies of biological tissues.

This research was published in **Journal of Magnetic Resonance, 183** (2), 315-23 (December 2006).

ANOMOLOUS DIFFUSION IN NERVOUS TISSUE AS A NOVEL MRI CONTRAST

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INTRODUCTION

Many biological tissues including the neural tissue have a hierarchical structure that exhibits significant self-similarity. Sensitizing the MR signal to random movements of the molecules makes it possible to probe length scales that can not be resolved by conventional MR imaging methods. Varying the diffusion time provides a means to observe water diffusion at different temporal or spatial scales. A nonlinear dependence of the mean-square-displacements (MSDs) on the diffusion time gives rise to anomalous diffusion, which occurs in systems exhibiting fractal behavior. In fractal environments [2], Brownian motion of particles are restricted in all length scales giving rise to the scaling relations <*r2*>

dw t ∝ 2 / , and *P*(*r* = 0) ∝ *t*–*ds* / 2 where <*r*²> is the mean square displacement and *P*(*r=0*) is the return to origin probabilities for the water molecules undergoing diffusion during time *t*. The scaling exponents *dw* and *ds* are called the fractal dimension of the random walk and the spectral (fraction) dimension respectively. The diffusion process is called "normal" if *dw=2*, where the cases *dw>2* and *dw<2* correspond to sub- and super-diffusion regimes (anomalous diffusion) respectively. These two scaling exponents are related to the fractal dimension, *df*, through the relationship *df=dw ds/2*. In one-dimensional q-space measurements, the projection of the propagator onto the axis is measured. Thus we have a one-dimensional space which can be quantified by the indices *ds'* and *df'*. We have performed experiments on excised rat hippocampi to examine this contrast.

EXPERIMENTAL

A series of diffusion-weighted MR images were acquired from three excised rat hippocampi with varying diffusion gradient strengths and diffusion times. The imaging parameters were: B0=14.1T, TR=1000ms, TE=12.6ms, resolution = (78x78x500)μm_3, matrix size=(64x64x3), δ=2ms. The diffusion gradient strength varied between 0 to 2935mT/m while the q-space acquisition was repeated 10 times with Δ values ranging from 12 to 300ms on a logarithmic scale.

RESULTS AND DISCUSSION

Figure 1 shows images generated of the scaling exponents. Different scaling behavior is observed in regions of the hippocampus. Contrast appears to be influenced by unique cytoarchitectural features of different hippocampal regions. For instance, the densely packed myelinated regions like the fimbria and the dorsal hippocampal commissure appear to be in the subdiffusive regime where the characteristic lengths associated with the diffusion process scales slowly in time.

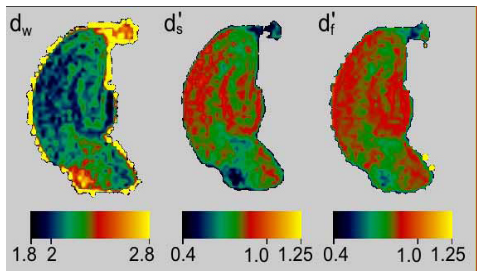

Figure 1.
Scaling exponent maps of isolated hippocampi.

CONCLUSIONS

The formalism developed to characterize diffusional processes in fractal environments was applied to q-space MRI data collected from excised neural tissue. The functional fits were very satisfactory indicating the appropriateness of the approach. This method can be used to understand the variability of data acquired with different values for diffusion time. The method also provides a novel contrast mechanism that may enhance the utility and specificity of diffusion weighted MRI/S to better assess the structural changes that occur during development and various neuropathologies and has been published (1).

ACKNOWLEDGEMENTS

Support was provided by NIH grant P41 RR 16105 and the National High Magnetic Field Laboratory.

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Diffusion tensor imaging with magnetic resonance [1,2] has proven to be a very valuable tool for the study of structured material. This method allows tracking the fiber structure of complex material, like the human central nervous system. However diffusion tensor imaging only allows the resolution of simple structures and fails to accurately map crossing fiber structures in the central nervous system. To overcome this limitation, we have developed an accurate and fast method for fiber orientation mapping using multidirectional diffusion-weighted magnetic resonance data [3]. This new method, called the diffusion orientation transform (DOT), transforms measured diffusivity profiles into displacement probability profiles. Our method is based on the high-angular-resolution diffusion-weighted image (HARDI) acquisition scheme and can be extended to more general acquisition strategies. Our technique can be regarded as a transformation of diffusivity to probability profiles whose peaks correspond to distinct fiber orientations.

This research was published in **Neuroimage, 31** (3), 1086-1103 (2006).

RESOLUTION OF COMPLEX TISSUE MICROARCHITECTURE USING DIFFUSION ORIENTATION TRANSFORM

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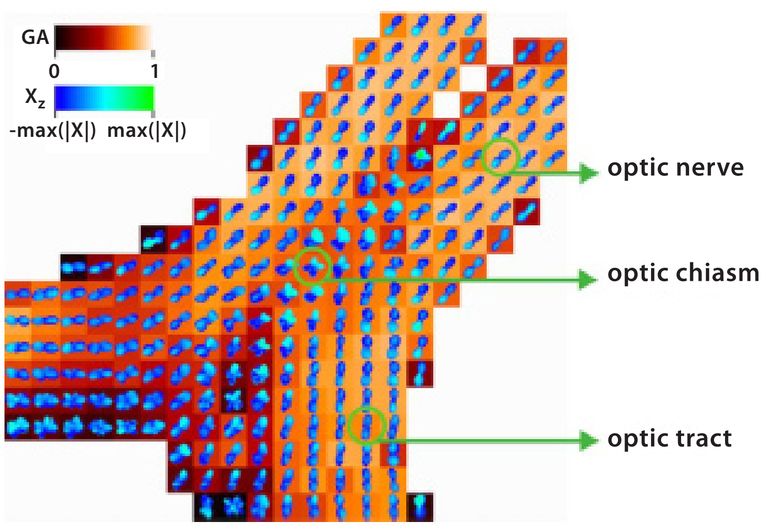
INTRODUCTION

We have developed an accurate and fast method for fiber orientation mapping using multidirectional diffusion-weighted magnetic resonance (MR) data [3]. This new method, called the diffusion orientation transform (DOT), transforms measured diffusivity profiles into displacement probability profiles. Our method is based on the high-angular-resolution diffusion-weighted image (HARDI) acquisition scheme and can be extended to more general acquisition strategies. Our technique can be regarded as a transformation of diffusivity to probability profiles whose peaks correspond to distinct fiber orientations.

EXPERIMENTAL

To test the performance of the DOT, we calculated the orientation probabilities with HARDI data from three anatomical regions of excised, perfusion-fixed rat nervous tissue (optic chiasm, brain and spinal cord). These experiments were performed with the approval of the University of Florida Institutional Animal Care and Use Committee. The images were acquired with either a 17.6 T (brain) or 14.1 T (spinal cord and optic chiasm) magnet



system. A diffusion-weighted spin echo pulse sequence was used. Diffusion-weighted images were acquired along 81 (brain) or 46 (spinal cord and optic chiasm) directions with a b-value of 1500 s/mm^2 (brain and spinal cord) or 1250 s/mm^2 (optic chiasm) along with a single image acquired at b –value of 0 s/mm^2.

RESULTS AND DISCUSSION

Our approach utilizes the Fourier transform relationship between the water displacement probabilities and diffusion-attenuated MR signal expressed in spherical coordinates. The radial part of the Fourier integral is evaluated analytically under the assumption that the MR signal attenuates exponentially. Orientation maps calculated from excised rat nervous tissue data demonstrate this technique's ability to accurately resolve crossing fibers in anatomical regions such as the optic chiasm (see figure). This methodology has a trivial extension to multi-exponential diffusion-weighted signal decay. The developed methods will improve the reliability of tractography schemes and may make it possible to correctly identify the neural connections between functionally connected regions of the nervous system.

CONCLUSIONS

The DOT technique provides a direct estimation of displacement probability surfaces within each voxel from multi-orientational diffusion-weighted MRI data. The method is robust, fast and can be implemented nonparametrically for direct estimation of probability values along desired directions or by using a spherical harmonic transformation that gives the Laplace series coefficients of the probability profile. In either case, high resolution probability surfaces can be reconstructed easily from the signal values. As demonstrated in excised rat nervous tissue, the potential applications of our approach include more accurate estimates of fiber orientations that will improve the existing fiber tractography schemes. This then could enable the reliable mapping of more connections between different parts of fibrous tissues.

ACKNOWLEDGEMENTS

Support provided by the NIH grants R01-NS42075, R01-NS36992 and P41-RR16105, UF Alumni Foundation, and the National High Magnetic Field Laboratory. MRI data were obtained at the AMRIS facility of the UF McKnight Brain Institute.

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[3] Ozarslan E, *et al.*, NeuroImage **31** (2006) 1086-1103

The choice of cable-in-conduit (CIC) conductor for the just approved Fusion Reactor, ITER, points to the need to properly understand one of the consequences of the excellent cooling that CIC conductors (also chosen for the NHMFL Series-Connected Hybrid designs too) possess - namely significant bending strains that can be developed by the Lorentz force in unsupported strand to strand crossovers in the cable. This issue has come to the fore as analysis of the very large ITER test coils has progressed. New designs of Nb_3Sn conductor with higher current density tend to have larger filaments too - the possibility of filament degradation, both reversible and irreversible under cyclic energization of the magnets is an important issue. The experiments of Takayasu enable study of these effects in sub-size cables and in strands under pure bending conditions. The first results already point to big differences in the mechanical behavior of otherwise rather similar conductors.

This research has been accepted for publication by **IEEE Transactions on Applied Superconductivity.**

CHARACTERIZATION OF Nb_3Sn SUPERCONDUCTING WIRES UNDER STRAIN: TRANSVERSE STRESS AND BENDING EFFECTS

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

INTRODUCTION

In order to study degradations due to transverse strain and bending effects on Nb_3Sn superconducting conductors, we continued transverse stress tests on 36-strand cables, and single-strand pure bending tests using the 20 T, 195 mm bore high-field large-bore DC magnet.

TRANSVERSE STRESS EFFECT ON THE CRITICAL CURRENT OF 36-STRAND Nb_3Sn CABLES

We have developed a device to study the effect of transverse stress on a sub-sized Nb_3Sn cable using a mechanical load that simulates the Lorentz loads in ITER conductors. The test sample is a single turn (about 110 mm diameter) circular coil composed of 36 superconducting strands (cabling pattern of 3x3x4). The transverse stress is applied to the cable using a conical wedge that converts a vertical force into a radial (transverse) force. Two samples of IGC wire used for ITER CS model coil and newly developed high-performance wire (Outokumpu) were investigated [1]. The two samples showed quite different behaviors to the applied transverse loads. The high-performance strand cable showed a stronger sensitivity to the applied load than the old CS model coil wire. The transverse load effects of the new high performance wire have been intensively studied taking a sequence of loading and unloading operations at 15 T. The cable is sensitive to the mechanical applied load, showing 5-10% degradation for loads lower than 20 MPa. By 100 MPa stress, the cable critical current was degraded to ~30% of its initial, unloaded value. We will continue the transverse load tests for various Nb_3Sn strand cables to understand operation degradations of Nb_3Sn conductors.

SINGLE-STRAND VARIABLE PURE-BENDING

A variable bending test probe for a single strand was developed last year [2]. This year we modified the bending device to apply pure-bending only without axial strain to a strand sample [3]. This device allows applying pure bending up to 0.9% over the sample of about 100 mm length in liquid helium. Bending properties of new ITER high performance Oxford and Outokumpu wires were tested. The bending was applied first up to 0.2% (-0.2%) and then to the other direction up to 0.8%. The critical currents at 15 T of the Oxford and Outokumpu wires degrade from 175 A to 63 A and from 133 A to 67 A, respectively, by the bending of 0.8%. After the 0.8% bending the critical currents of the Oxford and Outokumpu wires were irreversibly reduced to 114 A and 105 A, respectively. These values were 65% of the initial value for the Oxford wire and 79% of the initial value for the Outokumpu wire. Note that the oxford wire was much more sensitive to the bending than the Outokumpu wire. The initial critical currents of Oxford wire were much higher than that of the Outokumpu wire. However the critical currents at the 0.8% bending and also the reversible values resulted after 0.8% bending of these tested wires were very similar between the Oxford and Outokumpu wires. It is very important to figure out the high sensitivities against bendings and strains which are observed unexpectedly for the newly developed advanced Nb_3Sn wires.

ACKNOWLEDGEMENTS

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

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Solidification is well known to be a process in which many bad things can happen - segregation of alloying elements and impurities, development of porosity and the inhomogeneous distribution of defects. This makes it interesting to develop strategies that minimize such effects by coupling other sources of energy than just withdrawal of thermal energy that can positively homogenize the solidifying material. Evidently very high magnetic fields can be beneficial. In the electromagnetic acoustical treatment described here, a small amount of RF power applied in a 20 Tesla field greatly reduces segregation and avoids top to bottom microstructure differences.

This research has been accepted for publication in the **TMS 2007 Annual Meeting Symposium Proceedings**.

NON-CONTACT ULTRASONIC TREATMENT OF CONDUCTIVE MATERIALS IN A HIGH MAGNETIC FIELD ENVIRONMENT

J. B. Wilgen, R. A. Kisner, R. A. Jaramillo, G. Mackiewicz-Ludtka, and G. M. Ludtka (Oak Ridge National Laboratories)

INTRODUCTION

When induction heating is applied in a high magnetic field environment, the induction heating coil is typically configured in such a way that high intensity ultrasonic treatment occurs naturally. The resulting configuration is that of a highly effective electromagnetic acoustical transducer (EMAT). The synergistic interaction of a high surface current density (induced via induction heating) with the steady-state high magnet field results in an especially effective method for creating a high energy density acoustic environment. The exceptionally high energy efficiency of the resulting electromagnetic transducer is due to the use of a high magnetic field, which greatly reduces the current needed to achieve the same acoustic pressure. This provides an efficient non-contact method for applying high-intensity ultrasonic energy to the processing of conductive materials. Furthermore, the applied ultrasonic excitation can be uniformly distributed over most of the surface of the sample.

EXPERIMENTAL

A high-field EMAT has been used for non-contact ultrasonic processing of aluminum samples (35 mm diameter x 52 mm long) during solidification. The magnetic field for the EMAT was supplied by a 20 Tesla resistive magnet located at the National High Magnetic Field Laboratory, and the drive current was provided by an induction coil. This combination resulted in an EMAT that delivered 0.5 MPa (5 atmospheres) of acoustic drive to the surface of the sample while coupling less than 100 watts of incidental induction heating. In the initial experiment, aluminum samples of A356 alloy were heated to the liquid state and allowed to solidify at a controlled cooling rate while subjected to non-contact ultrasonic stimulation (at 165 kHz) provided by an induction coil located within the bore of the magnet.

RESULTS AND DISCUSSION

Aluminum samples processed ultrasonically with the high magnetic field EMAT were compared with samples processed without EMAT excitation (no-field), but with the same thermal treatment [1]. Based on visual appearance of the small ingots, samples processed with EMAT stimulation showed notably improved smoother surface conditions as compared with samples solidified without EMAT stimulation. Optical micrographs revealed obvious differences in microstructure. Micrographs for a no-EMAT sample exhibited an obvious variation in microstructure from the top to bottom of the ingot, suggesting segregation of Si, which is manifest in different amounts of primary alpha (~pure Al) versus eutectic (alpha plus Si-rich phase). By comparison, similar micrographs for a high-field EMAT processed sample showed no variations in microstructure uniformity.

CONCLUSIONS

A novel high-field EMAT has been developed and demonstrated as an effective non-contact ultrasonic processing methodology for application during the solidification processing of aluminum samples in a high field magnet.

ACKNOWLEDGEMENTS

We acknowledge Dr. Bruce Brandt and the staff at the National High Magnetic Field Laboratory for their support. Research sponsored by the Laboratory Directed Research and Development Program of Oak Ridge National Laboratory (ORNL), managed by UT-Battelle, LLC for the U. S. Department of Energy under Contract No. DE-AC05-00OR22725.

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Pulsed magnets are the most advanced highly-stressed electro-mechanical systems presently in use; the energy-density of and power-flow into the magnetic field are comparable to a combustion chamber inside a rocket engine. The advance to 89 T reported here represents a major breakthrough of long standing barriers. This insert magnet is at the very center of the 100 T magnet objective. The achievement was possible because of the quality and performance of the design and novel state of the art materials developed to reliably reach these field intensities.

PERFORMANCE OF 1ST 90 T INSERT MAGNET FOR DOE-NSF 100 TESLA MULTI-SHOT MAGNET SYSTEM

C.A. Swenson (LANL, MPA-NHMFL), N. Harrison (LANL, MPA-NHMFL), J.B. Schillig (LANL, MPA-NHMFL), J. R. Sims (LANL, AET-1), and D.G. Rickel (LANL, MPA-NHMFL)

INTRODUCTION

The National High Magnetic Field Laboratories 100 T Multi-shot Magnet has completed phase one commissioning to deliver science at 85 Tesla. The US Department of Energy and the National Science Foundation supported the magnet system's development and construction. The magnet system is the culmination of 10 years of efforts by DOE and NSF design teams. The program goals for the first phase of operations are a non-destructive millisecond-scale 90 T pulse magnet system to support scientific research in high magnetic fields. Two magnet subsystems comprise the magnet: a nested array of seven generator-driven coils designed to produce ~ 40T in a 225 mm bore; and a capacitor-driven 15 mm bore "insert" magnet that developed to produce ~ 50 T inside the outer coil set. The US-DOE 100 T Multi-shot (MS) Pulsed Magnet Program is collaboration between US-DOE and US-NSF engineering teams at Los Alamos National Laboratory.

Technology for the 90 T insert evolved from a series of prototype magnets built to access engineering concepts and materials, and gain experience operating insert-like coils at the intensities encountered at 100 T. The insert magnet performance exceeded design specification by almost 15% delivering 53.6 T on a record system pulse of 88.9 T. The field measurement was made using a de Haas van Alphen measurement on pure copper. The magnet system enters the science user program providing the highest magnetic fields ever produced non-destructively.

Figure 1.

Insert magnet in transit to assembly inside 100 T outer magnet assembly

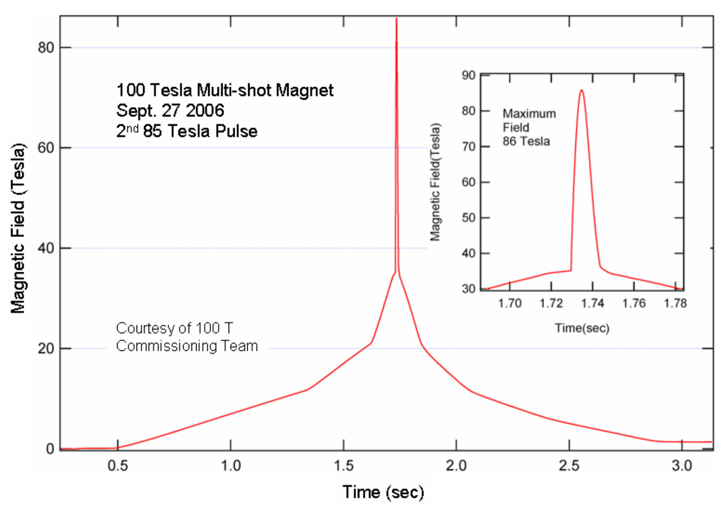

Figure 2.

Second 85 T pulse using insert and outsert magnet systems.

REFERENCES

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The mouse brain image produced by the NHMFL is a very important advance, with a site (*http://nmr.magnet.fsu.edu/facilities/900Demos/MRIDemo.htm*) much visited. The advances described in this work continue to push resolution, important if, for example, MRI images are to be of comparable (and therefore comparable to) two-photon microscopy imaging. The technique reported here is fully functional and uses a three-element coil array that substantially improves signal/noise, and, hence response time and potentially, resolution.

FOCUSED PARALLEL IMAGING ARRAY FOR MOUSE BRAIN IMAGING AT 11.1T

B. Beck (UF, AMRIS), S. Grant (FSU, Chemical Engineering)

INTRODUCTION

In clinical settings, surface coil arrays offer high sensitivity and extended fields of view for human MRI that are crucial for diagnostic coverage. Coupled with parallel imaging (PI) techniques, these coil arrays dramatically decrease the acquisition times of clinical scans. However, for MR research efforts focused on *in vivo* animal models, the exact point of anatomical interest for imaging is often known *a priori* due to a predetermined disease or injury site. Array elements that are focused on a common location can provide the animal image with enhanced signal-to-noise performance, improved B1 field homogeneity at high magnetic fields and accelerated imaging times via PI methods. In this study, we present a receive-only array design for animal MRI at high fields (> 11 T) that focuses each element at a single location. Sample images were acquired at 11.1 T on biologically relevant phantoms and *in vivo* mice.

EXPERIMENTAL

A 3-element array was built on a curvilinear fiberglass half-shell of diameter 3.8 cm (Figure 1). The design consists of two orthogonal butterfly coils centered over a single loop coil. The single loop is 3.2 cm in diameter, built on a Teflon substrate, and has two distributed capacitors. The butterflies, also placed on the Teflon substrate, are 2.8 by 4 cm and have four distributed capacitors. Each coil element contains a passive trap (MA45471Schottky diodes) across one of the distributed capacitors. Small isolation capacitors are added between elements. The coil array was placed in a small transmit-only birdcage and parallel imaging was performed on a 11.1-T, 40-cm Magnex/Varian magnet interfaced with a Bruker Biospec imaging/spectroscopy console and PI algorithms based on GRAPPA. The coil first was evaluated with a tissue equivalent phantom with characteristics of average brain at 470 MHz (ε =48.6, σ =0.6 S/m). *In vivo* brain imaging of a native C57 mouse followed. Fast Spin Echo (FSE) and Gradient-Recall Echo (GRE) images were acquired with acceleration factors of 2 and 3.

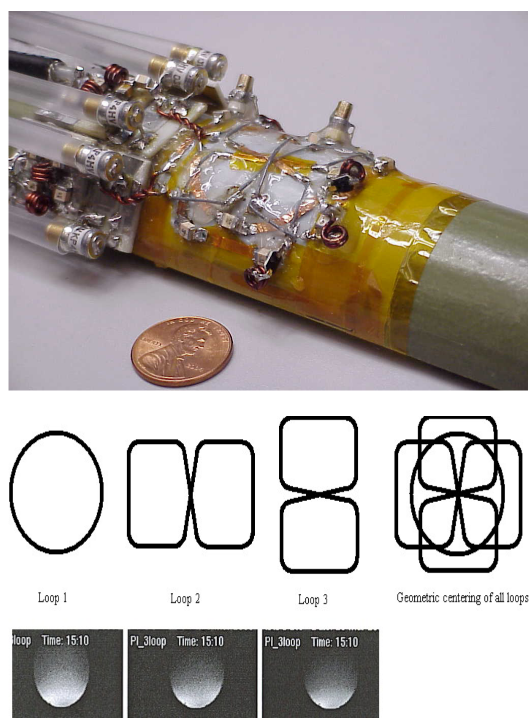

Figure 1.
Coil (left) and element profiles (right) showing focused coverage.

RESULTS AND DISCUSSION

Return loss for all coil elements was ≤ -22 dB, and isolation between all elements was better than 20 dB. The coil and axial profiles of each coil element, all focusing on the same volume, are shown in Figure 1. Figure 2 shows GRAPPA acquisitions of the *in vivo* mouse (with focal location in the cortex) with an acceleration factor of 2.

CONCLUSIONS

We have built, tested and utilized a 3-element surface coil array for mouse brain parallel imaging. Each element of the array is sensitive to the target region, thus maximizing the signal-to-noise in the volume of interest. GRAPPA images indicate good coverage and signal quality in the target volume of the mouse brain.

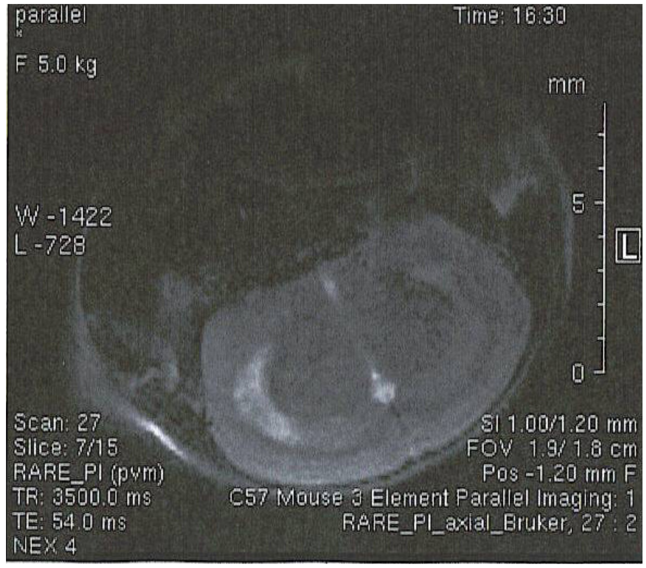

Figure 2.
Parallel Image of mouse brain.

ACKNOWLEDGEMENTS
Support was provided by NIH grant P41 RR 16105 and the National High Magnetic Field Laboratory.

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KONDO/HEAVY FERMION SYSTEMS

For more than twenty years numerous efforts have been concentrated on understanding enigmatic properties of URu_2Si_2. URu_2Si_2 belongs to heavy fermions systems with a moderate mass enhancement. At T_N=17.5K the feature in its specific heat, C(T), reveals a sharp transition, most probably of the second order, into a new state the nature of which still remains unclear. Although the antiferromagnetic (AFM) ordering of the U-spins is confirmed in the neutron scattering experiments, the value of the staggered magnetization moments turns out so small ($\mu \sim 0.02\mu_B$) that the huge entropy loss at transition cannot be ascribed to their formation. Thus, a "hidden order" (HO) parameter of unknown symmetry and nature is hypothesized to account for the entropy changes at T_N.

Further NMR studies have revealed that staggered magnetization increases with applied pressure and reaches values reasonable for an AFM state. The dual interpretation of NMR results is possible. Thus, HO and AFM could coexist in space as sub-phases, and the AFM fraction increases with pressure for the account of the HO phase. Another option is that the order parameter *has two components whose relative weights change with pressure.*

In the report by Y.J. Lo *et al*. evidence is given in favor of this second point of view. The authors provide the (T,H)-phase diagrams for URu_2Si_2 at three different pressures. Their left hand sides correspond to HO/AFM: its shape varies insignificantly. Meanwhile, at the ambient pressure it is HO that is known to prevail, while with the pressure increase HO gets gradually "squeezed", and AFM begins to prevail. Inside, *i.e.*, at T below T_{HO}, changes in electronic properties take place with the field increase at some $T_p(H)<T_{HO}$. T_p itself marks a resistance maximum, but at lower T_p the Shubnikov-de Haas oscillations demonstrate that the increase in the Fermi surface (FS) size occurs at T_p. Abstracting from intermediate field-induced phases that become almost washed away with pressures, the rest of the phase diagram looks merely as a spin-flip transition from AFM into ferromagnetic phase (IV) in strong magnetic fields. No drastic changes are seen in HO/AFM part of the phase diagram with increase of pressure and magnetic field. It looks as a crossover between two components takes place from HO (at low pressure and fields) to AFM (localized spins).

This research was accepted for publication by **Physical Review Letters** *(in press) and was supported by the* **In-House Research Program** (PI, Luis Balicas).

FIELD-INDUCED FERMI SURFACE RECONSTRUCTION AND ADIABATIC CONTINUITY BETWEEN ANTIFERROMAGNETISM AND HIDDEN-ORDER STATE IN URu_2Si_2

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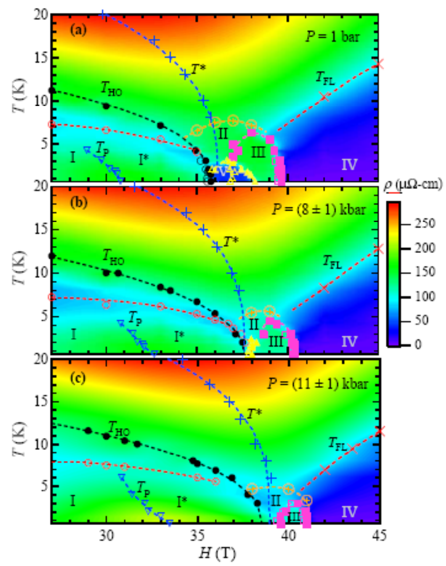
INTRODUCTION

The nature of the phase emerging at $T_0 \sim 17.5$ K which coexists with antiferromagnetism (AFM) in URu_2Si_2 remains elusive and has been called the ``hidden-order" (HO) state. None of the theoretical scenarios proposed can explain satisfactorily all the available data. In this Letter we present high field, low temperature electrical transport measurements in URu_2Si_2 under high hydrostatic pressure in order to gain insight on the interplay between the AFM and HO phases.

EXPERIMENTAL

We performed electrical transport measurement at very low temperatures by using the portable dilution fridge as well as hydrostatic pressure measurements using a ^{3}He insert in conjunction with the hybrid magnet [2].

RESULTS AND DISCUSSION



(a) The resulting *H-T* phase-diagram of URu_2Si_2 at *p* = 1 bar, shown for comparative purposes. The phase-boundary towards the HO state (phase I, following the nomenclature of Ref. [1]) is indicated by black dots. The position of a minimum in ρ within the HO-state is indicated by red circles. The position of the maximum observed in ρ within the HO state at T_p and where the geometry of the Fermi surface changes significantly is indicated by blue triangles. We nominate this new phase as phase I*. The boundary of the reentrant HO state (or phase III) is defined by magenta squares, while the boundaries of phases II and V are defined respectively, by orange circles and yellow triangles. The recovery of a FL state at T_{FL} is indicated by red crosses. Finally, the crossover from positive to negative magnetoresistance within the higher temperature metallic state is indicated by blue crosses. (b) Same as in (a) but under a pressure p = 8 ± 1 kbar. (c) Same as in (a) but for a pressure p = 11 ± 1 kbar.

CONCLUSIONS

Our observations favor a scenario where the evolution from HO to AFM under pressure is a crossover rather than a phase transition with two competing coupled order parameters in the mixed phase, i.e., an adiabatic continuity between HO and AFM with gradual change in their weight with field and pressure. The picture of the HO-state emerging from this study indicates a semi-metallic state containing an intrinsic dipolar component which has Fermi surface pockets enclosing a volume of ~ 1.5 % of the Brillouin zone. It becomes slightly more metallic (in agreement with the Hall effect) under field, as indicated from the increased Fermi surface cross-sections in the SdH oscillations at T_p, then into a sequence of field-induced phases (which are shifted to higher fields and lower temperatures under pressure), and finally into the metallic FL phase IV. This increase in the density of carriers and the coexistence between HO and AFM is difficult to reconcile with a purely local crystalline field picture. Pressure increases the direct overlap between 5*f*-orbitals of nearest neighbor U-ions. This should favor an AFM phase.

ACKNOWLEDGEMENTS

YJJ acknowledges the NHMFL Schuller postdoctoral program while LB acknowledges support the NHMFL In-House Research Program.

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SUPERCONDUCTIVITY—BASIC

Experimental efforts in studying puzzling properties of the so called pseudogap (PG) state for the high temperature (HT_c) superconducting cuprates continue. Besides that the mechanisms of the HT_c superconductivity in cuprates remain unknown, experimental facts show that even the very transition between normal and superconducting states is unusual there. Thus, large diamagnetism is seen by different means in $La_{2-x}Sr_xCuO_4$(LSCO) and other HT_c cuprates, at temperatures that may exceed T_c even by a factor of four. These facts have led to suggestions that condensation of electrons into the Cooper pairs, which in ordinary SCs takes place directly at T_c, in cuprates bears a two-stage character. Namely, initially a formation of incoherent pairs takes place; the *phase coherence* between the latter sets in only with the further temperature decrease down to the SC onset at T_c.

The Princeton group (N.P. Ong) first reported observations of diamagnetism via the Nernst effect studies. The effect, known to be extremely small in metals, turned out to be strong for cuprates at temperatures larger than T_c. This has been ascribed to formation of vortices *above* T_c in strong enough magnetic field on a SC background: the Nernst effect would come about from the vortices' motion perpendicular to the thermal flow. The vortices were also seen in the magnetization experiments.

In the report by Lu Li *et al*. these ideas were further extended. The authors studied low doped LSCO at low temperatures, at x below the optimal doping and, most extensively, in the vicinity of the threshold concentration, x_c=0.055, below which SC was not seen as the bulk phenomenon. Using the magnetometry technique, the phase diagram in the (x, H)-plane was constructed at low enough temperatures. Boundaries between vortex liquid and vortex solid have been measured. The bottom line is that vortices become formed in the presence of applied magnetic field even at $x<x_c$, thus manifesting some incoherent SC background in this strongly underdoped regime. In particular, the critical field, H_{c2} is finite at $x\mapsto 0$. Experiments display peculiarities of the Berezinskii-Kosterlitz-Thouless transition in layered cuprates.

This research is to be published in **Nature Physics** *2007.*

LOW TEMPERATURE VORTEX LIQUID IN SINGLE-LAYERED HIGH T_C CUPRATES

L. Li, Y. Wang, J. G. Checkelsky, N. P. Ong (Princeton Univ., Physics); S. Komiya, S. Ono, Y. Ando (CRIEPI, Tokyo)

INTRODUCTION

High resolution torque magnetometry is a unique method for measuring magnetization in intense field of high T_c cuprates. These measurements uncover diamagnetism above T_c and display unconventional T dependence of H_{c2}. H_{c2} is finite at T_c and remains almost independent of T for T < T_c[1,2,3]. An interesting question is how H_{c2} evolves in the phase diagram, especially as superconductivity disappears as the doping x decreases below the critical doping x_c = 0.055. Lightly doped LSCO (0.03 ≤ x ≤ 0.09) single crystals are measured by using torque magnetometry down to pumped He^3 temperature 0.35 K. [4]

EXPERIMENTAL

Detailed torque magnetometry measurements are carried out in a 33 T resistive DC magnet (cell 9) with a user provided vacuum sealed He^4 probe and in the 31 T 50 mm bore magnet (cell 5) with the He^3 insert at the NHMFL.

RESULTS AND DISCUSSION

The top panel at right displays typical magnetization curves for the measured lightly doped LSCO. Though not superconducting, magnetization curves show a negative "dip" at low field 0 – 10 T, which suggests diamagnetism arising from the vortex liquid state. At higher fields, magnetization tends to saturate, showing the contribution of paramagnetic anisotropic spins. The net result is an interesting oscillating behavior which occurs at 0.5K and 0.75K. After separating the aforementioned paramagnetic contribution, the diamagnetic signal with characteristic "tilted-hill" feature is restored and we are able to determine H_{c2}. The phase diagram in the right panel shows H_{c2} at the lowest achievable temperature 0.35K for different dopings. H_{c2} extends smoothly across the critical doping x_c = 0.055. Blue shading displays the region of spin anisotropy contributing to magnetization. We also measure irreversible MH behavior and detect the field H_{irr} where this hysteresis stops. Since MH hysteresis arises from pinning in the vortex solid state, H_{irr} provides a good probe to study the melting of the vortex solid and additionally approaches the real melting field at the lowest temperatures.

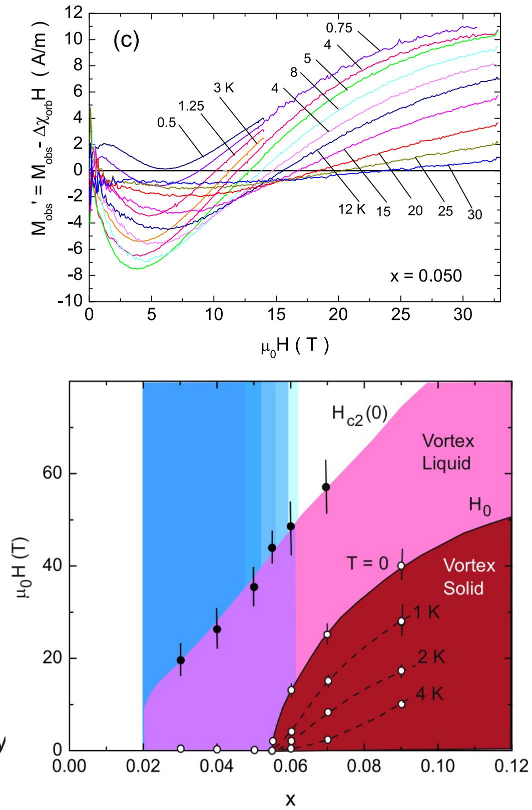

Figure 1.
Top panel: Curves of magnetization M vs. field H up to 32 T in the $La_{2-x}Sr_xCuO_4$ (x = 0.050) at select T; Bottom panel: x-H phase diagram at low temperature showing vortex liquid and vortex solid state [4] .

CONCLUSIONS

Diamagnetic signals of vortices are observed in lightly doped LSCO, even for doping x below the critical doping x_c = 0.055. Doping and temperature dependence are studied with torque magnetometry for two field scales, the upper critical field H_{c2} and the melting field H_{irr}. The results suggest that below x_c, the pair condensate survives as a vortex liquid, though long range phase correlation is absent down to 0.35K.

ACKNOWLEDGEMENTS
This work is supported by a NSF grant (DMR 0213706). The authors wish to thank Dr. Scott Hannahs, Dr. Alexei Souslov and Dr. Eun Sang Choi for their generous assistance during the experiment.

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MAGNETISM AND MAGNETIC MATERIALS

The report by V. R. Fanelli *et al.* deals with the magnetic properties of Pr_3In. The Pr-ion in Pr_3In has a singlet as the ground state. The antiferromagnetic transition at T_N=11.4K is, therefore, due to a weak admixture of the low-lying triplet caused by the exchange interactions between Pr-ions on neighboring sites. The authors investigate the spin-flip transition, i.e., polarization of spins in large magnetic fields. Rather small energy distance between Crystal Field singlet and triplet levels (~6.3 meV) makes possible strong sensitivity of the staggered moments to applied field and other effects that are not fully resolved yet.

This research was supported by the **In-House Research Program** (PI, Marcelo Jaime).

The interest persists in properties of multi-ferroics caused also by potential applications. Symmetry of these materials allows coupling between ferroelectric and magnetic parameters that can be tuned by magnetic fields.

In the report by J.W. Kim *et al*. the magnetic field induced transition is found in $BiMn_2O_5$ with the quantum critical point (QCP) at the critical field 18T providing an example of a ferroelectric QCP. The transition manifests itself also in a spike-like feature for the dielectric constant.

R.C. Rai *et al.* discovered significant high energy magneto-dielectric effects (changes in the dielectric constant with applied magnetic field) in the S = 1 Kagome staircase material $Ni_3V_2O_8$. Here, magnetic frustration and spin-lattice-charge coupling gives rise to a complex H-T phase diagram, the optical properties of which were carefully investigated by the authors. $Ni_3V_2O_8$ is an intermediate gap, local moment band insulator with electronic structure that is particularly favorable for magneto-dielectric coupling. The high energy magneto-dielectric contrast is as large as 16% near 1.29 eV, and it can be positive or negative depending on the energy. This work is reported in Physical Review B **74**, 235101 (2006) and is supported by the DoE.

This work is reported in **Physical Review B, 74**, 235101 (2006).

HIGH FIELD MAGNETIZATION IN THE INDUCED MAGNETIC MOMENT SYSTEM Pr_3In

V.R. Fanelli (UC Irvine, Physics and MPA-NHMFL), M. Jaime (MPA-NHMFL), J. Thompson (MPA-NHMFL), J.M. Lawrence (UC Irvine, Physics), A.D. Christianson (ORNL), N. Harrison (MPA-NHMFL), H.S. Suzuki (Nat. Inst. for Mat. Science, Tsukuba, Japan)

Pr_3In is a compound showing induced moment magnetism in a singlet-triplet system. Neutron diffraction, magnetic susceptibility and specific heat measurements reported by Christianson *et al*. [1] show that Pr_3In exhibits induced moment antiferromagnetic (AF) order with T_N=11.4K. Previous specific heat (C_p) measurements performed at NHMFL-LANL show that the magnetic field causes a strong reduction of C_p and also reduces T_N while magneto-caloric effect (MCE) indicates a phase transition occurs at 1.9 T, below 11K.

In this system, the exchange interaction between Pr sites causes admixture between crystal field levels (inset, Fig.1b) resulting in induced moment magnetic order below T_N. Application of a magnetic field can change the energies of the singlet and triplet in such a manner as to alter the admixture. At high enough fields there should be a transition from the AF phase to a FM-aligned (polarized) phase. At present, we do not know whether the phase above 1.9 T involves a spin rearrangement, e.g. a spin flop, or whether it is a spin polarized phase. It would be surprising for it to be to a spin polarized state in that for T_N =11.4 K, we expect such a transition to take place at values of magnetic field greater than 10 T. In measurements of magneto-caloric effect to 15 T at NHMFL-LANL, we have not observed a second phase boundary for B < 15 T. Our motivation for studying the magnetization was to explore if there is another transition between 20 and 50 T, and to

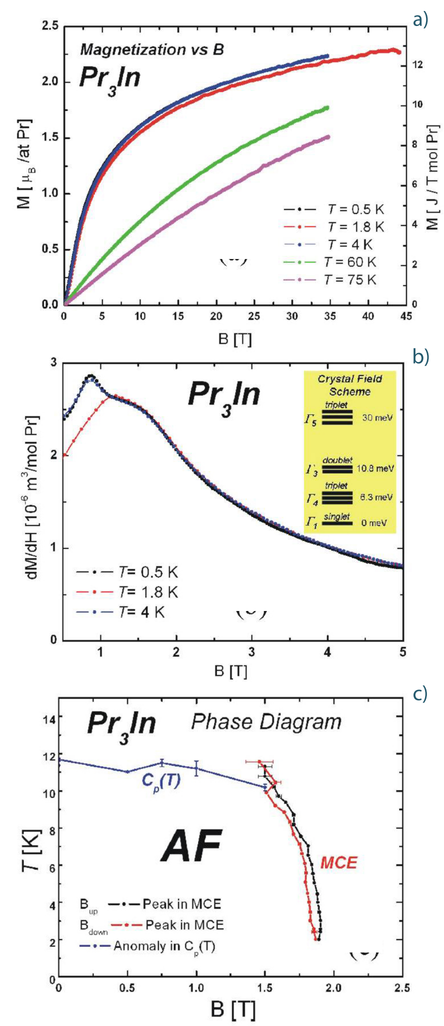

Figure 1.
a) Magnetization versus magnetic field at 0.5 K, 1.8 K, 4 K, 60 K and 75 K. b) Mass Susceptibility (dM/dH) for T=0.5K, 1.8K and 4K. Inset: relevant crystal field scheme. c) Phase diagram determined through the anomalies in C_p/T, peaks in temperature in MCE for both increasing and decreasing B.

find the saturation field B_{sat} for the high-field phase in order to obtain the energy-scale for the exchange interaction between Pr sites.

Magnetization as a function of magnetic field was measured using the 50T pulsed magnet at NHMFL-LANL. No anomaly corresponding to a phase transition was observed in the range $2<B<45$ T, raising the possibility that the 1.9 T transition does indeed involve ferromagnetic polarization. For $T<4$ K, the magnetization was observed to saturate at a field of order of 50T, consistent with the energy required to completely polarize the Γ4 triplet at 6.3 meV. The mass susceptibility (dM/dH) shows two features: one around 1 T and another at 1.5 T. The second one is consistent with the transition observed through MCE (Fig. 1c). Since the first one does not show up consistently for all temperatures, it is likely an artifact originated in the time integration of the raw data.

ACKNOWLEDGEMENTS

This work was performed at NHMFL-LANL, and supported by US DOE Grant No. DE-FG03-03ER46036, by NSF Cooperative Agreement No. DMR-0084173 by the State of Florida and US DOE, and partially supported by NHMFL IHRP.

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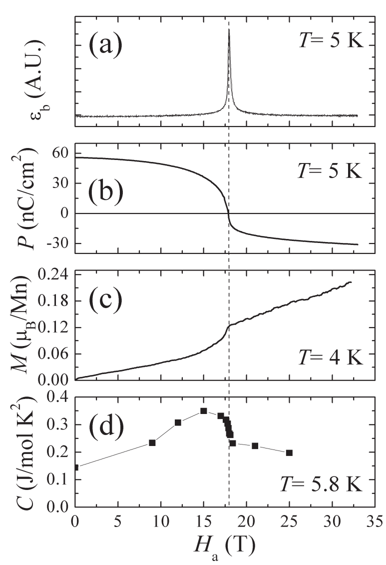
MAGNETIC-FIELD-INDUCED QUANTUM PHASE TRANSITITON IN $BiMn_2O_5$

J. W. Kim, S. Y. Ham, Kee Hoon Kim (Seoul National University, Physics & Astronomy); S. Park, S.-W. Cheong (Rutgers University, Physics & Astronomy); M. Jaime (LANL-NHMFL)

In our previous investigations of magnetic field-temperature phase diagram of multiferroic RMn_2O_5 (R= Tb, Dy, Y, and Bi) compounds [1], we have discovered a common phase boundary with similar shape at high field (>18 T) for all compounds. Particularly for $BiMn_2O_5$, polarization (*P*) change from low field positive to high field negative at the phase boundary. Interestingly, a large peak in dielectric constant (ε) is found at the zero polarization state. This magnetic-field-induced ferroelectric transition has been studied in detail by dielectric constant, electric polarization, magnetization and heat capacity measurements.



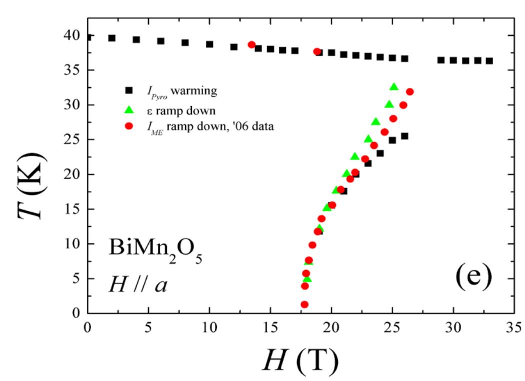


Figure 1.
(Left panel) Magnetic field dependent (a) dielectric constant, (b) electric polarization, (c) magnetization and (d) heat capacity at fixed temperatures. (Right panel) (e) Magnetic field-temperature phase diagram of $BiMn_2O_5$. A single magnetic field induced transition exists down to 0.6 K.

CONDENSED MATTER

A home-made transport stick with 12 coaxial wires and 18 phosphor-bronze wires is used for ε and *P* measurements. Heat capacity is measured with a Si-based heat capacity probe. Magnetization is measured with a compensated coil susceptometer adapted for use in a pulse magnet at LANL-NHMFL. All other measurements are done in a DC resistive magnet in NHMFL, Tallahassee. The electric contacts were made in the *b*-plane and magnetic field is applied along the *a*-axis of the sample.

Fig. 1 (a)-(d) shows the magnetic field dependent dielectric constant, polarization, magnetization, and heat capacity of $BiMn_2O_5$, respectively. The dielectric constant shows a sharp peak at the critical field ~ 18 T. Polarization changes sign from positive to negative, and magnetization shows a sharp increase near the critical field. With increasing field, heat capacity increases up to ~ 15 T. After a maximum value at 15 T, heat capacity decreases steeply near the critical field and decreases slowly up to 25 T. Magnetic field-temperature phase diagram of $BiMn_2O_5$ is plotted in (e). The trajectory of the phase boundary at high field follows the scaling relation $T_c(H)\sim(H-H_c)^{1/2}$, which is similarly found in quantum paraelectrics or incipient ferroelectrics such as $KTaO_3$ and $SrTiO_3$ [2].

These observations support an interesting possibility that $BiMn_2O_5$ can be the first system to exhibit quantum fluctuation of ferroelectricity tuned by magnetic field.

ACKNOWLEDGEMENTS

This work is supported by the National Research Laboratory program (M10600000238) by the Korean Ministry of Science and Technology. The work at NHMFL is performed under the auspices of the National Science Foundation, the State of Florida, and the U.S. Department of Energy.

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DISCOVERY OF HIGH-ENERGY MAGNETO-DIELECTRIC EFFECT IN A FRUSTRATED KAGOME LATTICE MATERIAL

R.C. Rai, J. Cao, S. Brown, J.L. Musfeldt (U. Tennessee, Chemistry); D. Kasinathan (UC Davis); D.J. Singh (ORNL); G. Lawes (Wayne State); N. Rogado, R.J. Cava (Princeton); X. Wei (NHMFL)

INTRODUCTION

$Ni_3V_2O_8$ has attracted attention as a potential high energy magnetodielectric material due to strong spin-lattice coupling, unusual frustration effects, and a complex phase diagram. The ferroelectric phase is particularly interesting because it has coupled magnetic and electric domains. We used a combination of optical spectroscopy, first principles calculations, and energy dependent magneto-optical measurements to elucidate the electronic structure and to study the phase diagram of $Ni_3V_2O_8$. The high energy magneto-dielectric contrast is as large as 16% at 1.29 eV.

RESULTS AND DISCUSSION

The magneto-optical response of $Ni_3V_2O_8$ is very rich, with a remarkable interplay revealing additional high magnetic field phases and an unexpected electronic structure which we associate with the strong magneto-dielectric couplings in this material over a wide energy range. Specifically, we observed several prominent magneto-dielectric effects that derive from changes in crystal field environment around Ni spine and cross-tie centers. This effect is consistent with a field-induced modification of local structure. Symmetry-breaking effects are also evident with temperature. We find $Ni_3V_2O_8$ to be an intermediate gap, local moment band insulator. This electronic structure is particularly favorable for magneto-dielectric couplings, because the material is not subject to the spin charge separation characteristic of strongly correlated large gap Mott insulators, while at the same time remaining a magnetic insulator independent of the particular spin order and temperature.

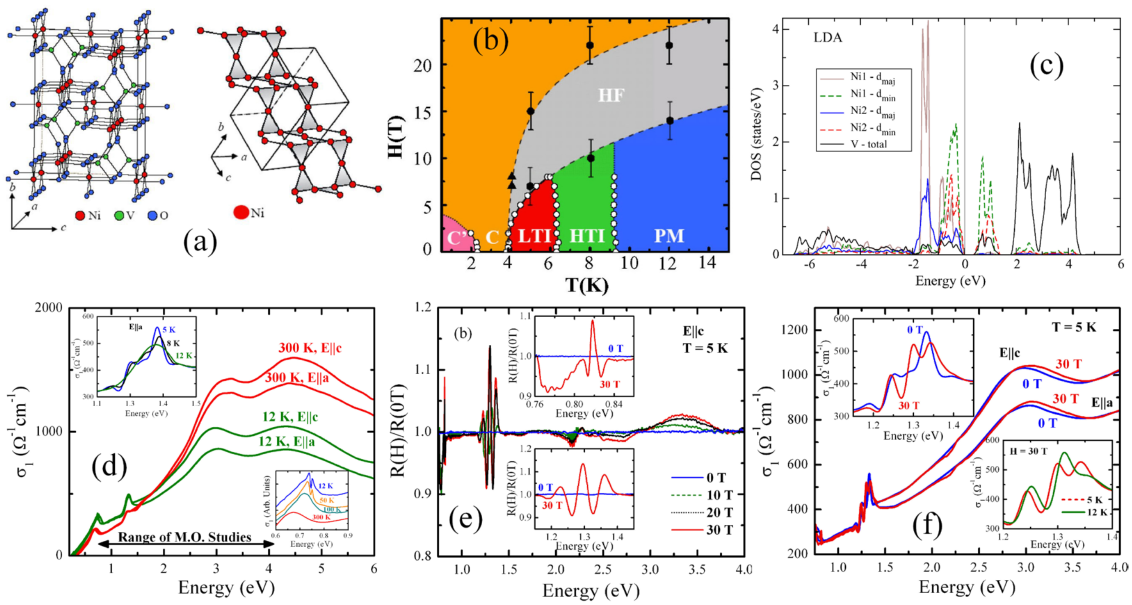

Figure 1:
(a) Crystal structure of $Ni_3V_2O_8$, (b) H-T phase diagram, (c) calculated density of states, (d) variable temperature optical conductivity, (e) magneto-optical reflectance, and (f) optical conductivity in high magnetic field. Note the field-induced splitting of the Ni (spine) d to d on-site excitation (insets, panel (e)).

ACKNOWLEDGEMENTS
We thank the U.S. Department of Energy for support of this work.

OTHER CONDENSED MATTER

Properties of a number of materials with significant potential applications are being studied at NHMFL facilities.

J. Shaver *et al*. investigated the excitonic structure of single-walled carbon nanotubes through photoluminescence excitation spectroscopy. They utilized the Aharonov-Bohm effect to modify the excitonic transitions such to "brighten" an optically inactive state. The high fields available at the Magnet lab allow this team to observe the signature of this optically inactive, "dark exciton" as an increase in photoluminescence intensity at low temperatures and two peaks in spectra at high temperatures.

This research was supported by the **In-House Research Program** (PI, David Reitze).

P. D. Ye *et al*. report preliminary studies on possible applications of the carbon nano-tubes in the area of field-effect transistors.

The report by S.N. Sprunt et al. describes the study of liquid crystals (the systems that have extremely wide technological applications) that relied on birefringence produced in high magnetic fields to obtain the signature of a new state of matter—the tetrahedratic phase with the third-rank tensor as the order parameter.

This research has been submitted to **Phys. Rev. Lett.**

MAGNETO-PHOTOLUMINESCENCE SPECTROSCOPY OF CARBON NANOTUBES

J. Shaver, S. Zaric, T. Searles, J. Kono (Rice U., ECE); Y. D. Jho, X. Wei (NHMFL); R. H. Hauge (Rice U., Chemistry), V. Perebeinos (IBM), Y. Miyauchi, S. Maruyama (U. Tokyo, Mech E.)

Recent theory [1-4] has predicted the existence of optically-inactive, or "dark" excitons in single-walled carbon nanotubes (SWNTs) *below* the first optically-active, or "bright" exciton state. This could trap much of the exciton population and contribute to the low quantum yield. Dark states arise due to the doubly-degenerate conduction and valence bands of SWNTs as well as the characteristic strong Coulomb interactions among charge carriers in low-dimensional systems.

We have measured near-infrared polarized photoluminescence (PL) on micelle-suspended SWNT samples in magnetic fields up to 45 T at room temperature (Fig. 1a) and PL excitation on an aligned gelatin SWNT film at low temperature up to 35 T (Fig. 1b). PL measurements were performed using the 45 T Hybrid Magnet, while PL excitation (PLE) was done in a 35 T resistive magnet.

We demonstrate that a magnetic field can significantly increase the PL of semiconducting SWNTs by "brightening" the dark exciton state. At low temperature, the PL intensity increased, or "brightened", with magnetic field. At high temperature, the PL peaks split into two peaks, the amount of which was proportional to the amount of flux threading the tube.

A magnetic field applied to the tube axis removes the valley degeneracy by lifting the time-reversal symmetry producing two equally-bright excitonic states at high magnetic fields [5,6]. This degeneracy lifting mixes different parity excitonic wave functions providing excitons trapped in the dark state with a radiative recombination pathway, thus brightening the transition. At low temperatures, this is manifest as an increase in PL intensity due to the exciton population being trapped in the lower, dark state, as well as a red shift proportional to the applied field. At high temperature, there is a finite population in the upper, bright state before the field is applied resulting in a two split peaks once the symmetry is broken by a magnetic field. This work clearly demonstrates the existence of dark excitons in SWNTs.

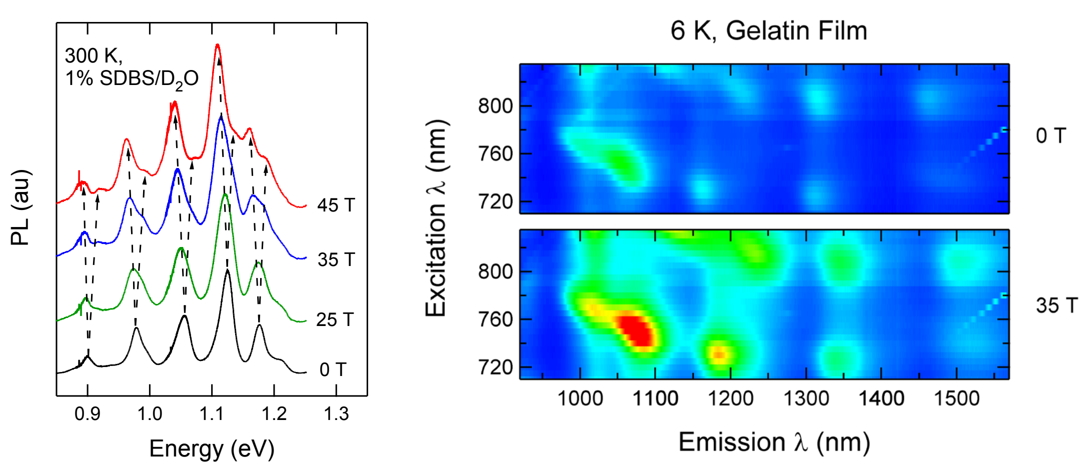

Figure. 1
Magneto-PL data: (a) 725nm excitation light polarized parallel to *B* measured at the fields shown at room temperature for liquid SWNT suspension. Peaks are split by an amount proportional to the applied field. (b) PLE data taken at 0 T and 35 T at 6 K. PL intensity increases with field as peak position red shifts.

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MICROWAVE PHOTORESISTANCE SPECTROSCOPY OF SINGLE-WALLED CARBON NANOTUBES

P.D. Ye (Purdue U., Electrical Engineering), L.W. Engel (NHMFL), S.K. Kim, S. Mohammadi (Purdue U., Electrical Engineering), C.J. Wang, M.S. Shim (UIUC, Material Science and Engineering)

INTRODUCTION

Since their discovery in 1991, carbon nanotubes (CNTs) have been the focus of intensive research for many potential applications, including sensing, textile, chemistry, biology and electronics, to name a few. CNTs are rolled up sheets of graphitic carbon with minimum diameter of 1.2 nm and are available in single-walled and multi-walled forms. Because of its perfect one-dimensional crystalline structure, CNTs exhibit unusual physical, chemical and mechanical properties, i.e., the exotic Luttinger liquid behavior in electrical transport properties. Recently, there has been tremendous interest in using CNTs as channels of field-effect-transistors (FETs) since these have the potential to replace the Si CMOS technology in microelectronic industry. The RF response is of great importance to evaluate this novel nano-device. But it is very challenging to characterize the RF performance of CNT transistors since the impedance of CNTs is mismatched with the standard 50 Ω input of RF instrumentation, hence the present, initial investigation looks at photoresistance of the CNT device under microwave radiation.

EXPERIMENTS

We have successfully developed a novel CNT-FET with a poly-Si bottom gate structure. The device has a gate length of 1 μm and achieves a unity gain frequency f_T of 2.5 GHz and a maximum oscillation frequency f_{max} of > 5 GHz. In this microwave photo-response experiment, we study the quasi-dc electrical transport properties of both metallic and semiconducting single-walled CNTs under high-frequency (RF and microwave) excitations at dilution refrigerator temperatures using NHMFL microwave capability.

RESULTS AND DISCUSSION

Figure 1(a) summarizes our findings on quasi-metallic single-walled CNTs under microwave radiation. The resistance of CNT at B=0 is almost at constant value of 300 KΩ independent on microwave radiation from 50 MHz up to 20 GHz. A negative resistance peak emerges at 5 GHz when B field is a fraction of 1 Tesla and becomes more pronounced with the increase of B field. The $\Delta R/R_0$ is about 5% as B field reaches 18 T. Possible harmonic features are also observable, for example around 10 GHz. The effect becomes more pronounced on increasing microwave power as shown in Fig. 1(b). No resonances were observed in semiconducting CNTs with the same device and measurement configuration. Figure 1(c) shows the impedance-matching equivalent circuit for CNT sample, which explains all the experimental observation. More experiments and theoretical studies are needed to clarify the origin of the sensitivity of the device to microwave radiation.

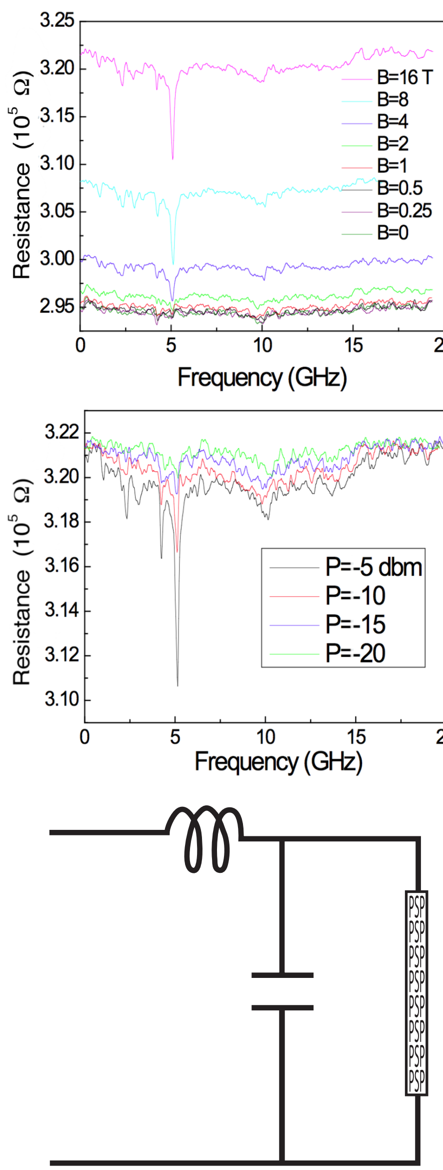


Figure 1.
Single walled CNT under microwave radiation resistance vs microwave frequency (a) at various magnetic fields. and -5 dBm applied at top of cryostat b) at 16 T for various power levels, in dBm at top of cryostat. Only a small fraction of the power applied couples into the sample, which was in mixture at a temperature of about 60 mK. (c) equivalent circuit for the resonator model to explain the experimental results.

HIGH-FIELD MAGNETO-OPTICAL STUDIES OF LIQUID CRYSTALS AND COMPLEX FLUIDS

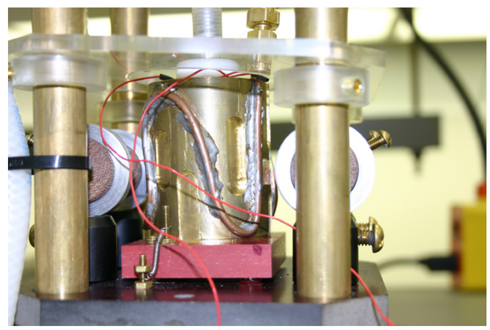
S.N. Sprunt, J.T. Gleeson, A. Jakli, D. Wiant, K. Neupane (Kent State University)

INTRODUCTION

Bent core nematic liquid crystals bring exciting opportunities for both new technological applications and fundamental science. Concerning the latter, one important prediction is the existence of a new state of matter, comprised of such liquid crystals which are tetrahedratically ordered. That is, has the orientational symmetry of a tetrahedron, described by a third-rank tensor order parameter. This state will be particularly difficult to identify because it will be optically isotropic, and therefore not detectable via usual techniques. Our approach was to search for this substance using magnetic field induced optical birefringence. Preliminary experiments at KSU showed promising indications, but we could not produce sufficiently intense fields to make definitive conclusions.

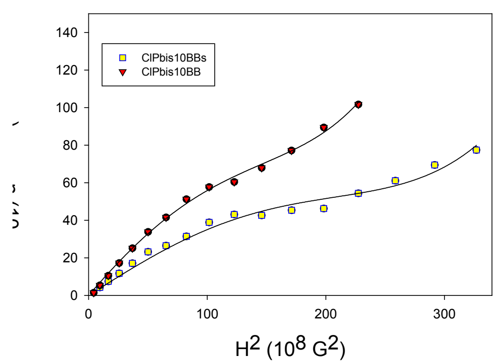
EXPERIMENTAL

We therefore built a custom built oven and stage designed for Cell 4 in Tallahassee. This apparatus folded a laser beam from an optical breadboard on the floor beneath the bore, up to the oven which was held at the bore center, then transverse through the liquid crystal (so that the beam traveled perpendicular to the field) and then back down to the optical breadboard for analysis. These measurements were obtained as functions of both temperature and magnetic field (up to 19T) during May, 2006. A photograph of our oven and tower assembly is at right.



RESULTS AND DISCUSSION

Our high magnetic field results, when taken in conjunction with independent dynamic light scattering and high resolution calorimetry studies, demonstrate convincingly, for the first time, the existence of the tetrahedratic phase. Example data is shown at right; traditional liquid crystals will exhibit a constant Cotton-Mouton coefficient (i.e. a straight line through the origin). The example clearly indicates non-linear behavior, which is a signature of the tetrahedratic phase.[1] Such data could only be obtained using the non-conventional magnetic field capabilities of NHMFL.



ACKNOWLEDGEMENTS

This work has been supported by the National Science Foundation (NSF-DMR-0606160) and Kent State University.

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METAL-INSULATOR TRANSITIONS

The report by J. Huang *et al*. describes transport studies performed on an ultra-clean two dimensional electron gas, at temperatures lower then those ever studied so far. This study is interesting, because the low temperature transport at such low electron densities is believed to be dominated by strong electron-electron interaction, where conventional theory most likely does not apply. Indeed, the experiments observe an insulating-like temperature dependence of the resistivity at the lowest temperatures, which nevertheless seem to saturate to a finite resistance at T=0. This behavior seems at odds with theoretical expectations, and will stimulate further theoretical and experimental work.

DISAPPEARANCE OF THE METAL-LIKE BEHAVIOR IN GaAs TWO-DIMENSIONAL HOLES BELOW T=30 MK

J. Huang (Princeton University); J.S. Xia (NHMFL, High B/T Facility); D. C. Tsui (Princeton University); L.N. Pfeiffer (Bell Labs); K.W. West (Bell Labs)

INTRODUCTION

The discovery of the metal-insulator transition (MIT) in two-dimensional (2D) systems bears fundamental importance towards the understanding the electron-electron interaction effects. The experimental studies have proven to be challenging because the usual disorder present in the system is large enough to overwhelm the Coulomb effects so that the charges are localized. Thus, a clean 2D environment is desired. Despite the large amount of evidence of MIT, there remains a central question on whether the metal-like behavior, observed at finite temperatures *(T)* as low as 30 mK, will survive at even lower *T*. Performing ultra-low *T*-dependence measurement, which demands effective cooling of 2D charges, is therefore essential.

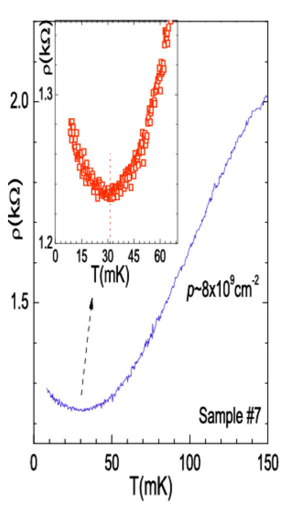

Figure 1. ρ(T) for p=8x10^{9}cm^{-2}.

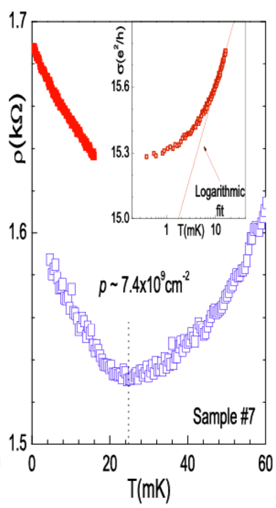

Figure 2. ρ(T) for p=7.4x10^{9}cm^{-2}.

EXPERIMENTAL

We adopt a clean 2D-hole system in a novel *GaAs/AlGaAs* heterojunction insulated-gate field-effect transistor (HIGFET). Without any intentional doping, the device demonstrates exceptional mobility and density tunability (down to 5x10^{8}cm^{-2}). New observations have recently been made in such devices [1,2]. In this work, by utilizing the remarkable cooling techniques developed by Xia *et al.* [3] (who demonstrated a cooling of 2D electrons down to 4 mK), We have performed charge transport measurements on a very high quality p-channel HIGFET device in a nuclear demagnetization refrigerator at the Microcalvin lab at University of Florida, with an ultra-low temperature sweep down to a minimum liquid ^{3}He bath temperature of 0.5 mK.

RESULTS AND DISCUSSION

The *T*-dependence of the resistivity ρ for two different charge densities *(p)* is shown in Fig.1 and 2. Remarkably, for $p=8x10^9cm^{-2}$ [Fig.1], following the metal-like behavior *(dρ/dT>0)* occurring at higher *T*, ρ reaches a minimum around 32mK and rises from 1.22 kΩ to 1.29 kΩ with cooling down to ~9mK, signifying a crossover into an insulator-like regime *(dρ/dT<0)*. The inset is a blow-up of ρ at low-*T*. The same behavior is observed for p=7.4x10^{9}cm^{-2} which corresponds an rs value of 33 [Fig.2]. Notice that the curve in red, obtained after the demagnetization, corresponds to a slightly different density than before. Now, ρ reaches its minimum at a lower *T* of 25 mK, then rises with cooling down to a base *T* of 0.5 mK. The red curve shows an increase of ρ from 1.63 kΩ at 16mK to 1.69 kΩ at 0.5mK. The inset indicates thatthe transport is different than the weak-localization correction.

CONCLUSIONS

For a fixed carrier density around for p=8x10^{9}cm^{-2} for which only the metal-like behavior is anticipated, we have observed a crossover from the metal-like state *(dρ/dT>0)* into an insulator-like state when *T* is lowered below ~30 mK, and this insulator-like behavior *(dρ/dT<0)* prevails down to the lowest bath *T* of 0.5 mK. Despite the possibility of heating, the rising of ρ indicates that the charges are definitely being cooled. This qualitative change, occurring for resistivity much less than the quantum resistance, suggests that the metal-like behavior is likely a finite temperature effect and the ground state is possibly insulating.

ACKNOWLEDGEMENTS

The work at Princeton Univ. is funded by a US NSF MRSEC grant DMR-0213706 and DOE grant DEFG02-98ER45683.

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MOLECULAR CONDUCTORS

The material λ-$(BETS)_2FeCl_4$ is remarkable for the observation few years ago of the Jaccarino-Peter (JP) effect—the field-induced superconductivity. That occurs because the exchange coupling between the irons' spins and those of the conducting electrons of the (BEDT)-skeleton bears antiferromagnetic character. As the result, magnetization of Fe-ions leads to the *internal* magnetic field that acts on the conduction electrons' spins in the direction opposite to the applied external field. Y.J. Jo *et al*. studied the material at elevated pressure (to avoid JP effect) to investigate and measure the internal field through its direct manifestations, such as the spin-splitting of Fermi surfaces (FS). The Shubnikov-de Haas oscillations also revealed the appearance of the new, larger, FS orbit attributed to the magnetic breakdown between the closed-and open trajectories.

This research was published in **Physical Review B, 73**, 214532 (2006).

STUDY OF PRESSURE EFFECT ON THE INTERNAL FIELD OF THE FIELD-INDUCED ORGANIC SUPERCONDUCTOR λ-$(BETS)_2FeCl_4$

Y. J. Jo (Ewha W. Univ. & NHMFL), H. Y. Kang, W. Kang (Ewha W. Univ.); S. Uji, T. Terashima (NIMS); T. Tanaka, M. Tokumoto (AIST); A. Kobayashi (U. of Tokyo), H. Kobayashi (IMS)

INTRODUCTION

Study of BETS compounds containing Fe^{3+} magnetic ions has been of particular interest because the large magnetic moments of Fe^{3+} ions would induce the π-electron spins on donor molecules to develop a π-d coupled antiferromagnetic spin structure. Electrical resistivity and magnetic susceptibility measurements reveal that the π conduction electrons from BETS molecules and the localized magnetic moments of the anions coexist down to very low temperature. Measurement of the Shubnikov–de Haas (SdH) oscillations in λ-$(BETS)_2FeCl_4$ at ambient pressure revealed oscillations with two distinct frequencies of 609 and 737 T. The splitting of the SdH oscillations is attributed to the spin-dependent FS separation due to the internal magnetic field, which is 32 T according to the spin-splitting factor of the Lifshitz-Kosevich formula. We have measured the SdH oscillations at a pressure of 6 kbar. Changes of the Fermi surface topology and the internal field with pressure are explored.

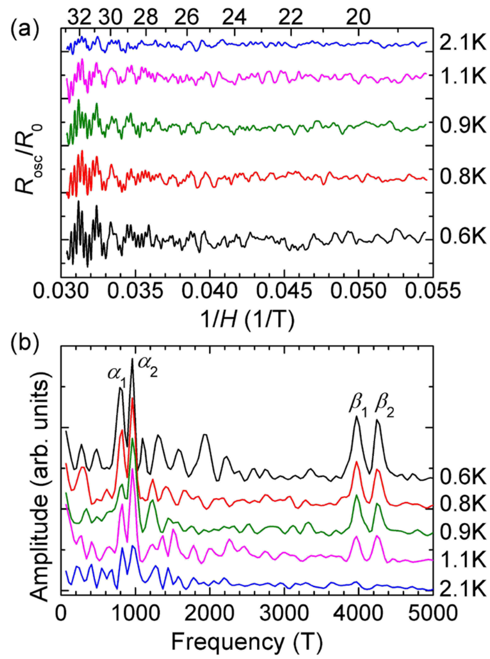

Figure 1.
(a) Oscillatory part of the magnetoresistance at 6 kbar. (b) FFT spectra of the SdH oscillations.

EXPERIMENTAL

Annealed gold wires were attached to the sample surfaces so that the current may flow along the least conducting *b** axis. Pressure was generated with a ultra-miniature BeCu pressure clamp cell. A 1:1 mixture of the Daphne 7373 oil and kerosene was used as a pressure medium. The pressure at low temperature was determined from the change of the superconducting T_c of high-purity lead (Pb). The experiments were performed in a 33 T resistive magnet at the NHMFL.

RESULTS AND DISCUSSION

Fig. 1(a) shows the oscillatory amplitude of the MR as a function of 1/H at several temperatures. The FFT spectra of the SdH oscillations between 18 and 33 T are displayed in Fig. 1(b). The splitting of both the α and β oscillations are observed. α_1, α_2, β_1, and β_2 have values of 803, 957, 3973, and 4255 T, respectively. The average effective masses are $(2.9\pm0.3)m_0$ for the α and $(5.5\pm0.3)m_0$ for the β orbit. For the closed-orbit oscillations, the effective mass falls from $4.1m_0$ to $2.9m_0$ with pressure. As for the MB orbit, the effective mass of $5.5m_0$ is lighter than that in other BETS compounds containing magnetic ions. Hydrostatic pressure will bring the BETS molecules closer together and hence broaden the energy band. So the decrease in effective mass with pressure is strongly related to the suppression of interaction between π electrons which depends critically on the bandwidth. As stated earlier, the internal field H_{int} can be directly calculated from the difference of frequencies, $2\Delta F$. Applying the expression for H_{int} to the α and β orbits, ΔF_α =77 T and ΔF_β=141 T, gives the estimated values for $H_{int,\alpha}$ =53 T and $H_{int,\beta}$=51 T, assuming the *g* factor of 2.

CONCLUSIONS

In λ-$(BETS)_2FeCl_4$ under pressure, new SdH oscillations with frequencies faster than those at ambient pressure, are detected and attributed to the magnetic breakdown orbit. The increase of the SdH frequencies indicates an increase in the size of the closed Fermi surface under pressure. The effective mass becomes smaller under pressure most likely due to the broadening of the bandwidth. The estimated internal field increases from 32 to 52 T under a pressure of 6 kbar.

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QUANTUM FLUIDS

The manifold of Fractional Quantum Hall Effect (FQH) states is currently being investigated from the new viewpoint, namely, as an arena for realizations of some recent ideas related to the theory of quantum computing (QC).Two theoretical reports below address this issue.

Xin Wan *et al*. perform numerical studies for a model realization of the 5/2-FQH state. Fractionally charged quasiparticles for this filling factor are expected to obey the non-Abelian statistics (meaning, to put it simply, that at a permutation between the two quasiparticles in the plane the result depends on whether their rotation with respect to each other is performed in the clock or the counter-clock manner). Experimental methods, by which the non-ordinary properties of such a state should be seen, include tunneling experiments, which should involve chiral edge excitations. The authors find the provisions for observation of the non-trivial properties of the 5/2 filling FQH state in their realistic model for confinement.

This research was published in **Physical Review Letters, 97**, 256808 (2006).

The report of L. Hormozi *et al*. continues the previous work by the NHMFL and the Lucent Technologies group where they suggested a construction for two-quibit gates in the specific case of the so-called Fibonacci anions (see NHMFL Reports, 13 (4), 2006). In the current report the authors provide the mathematical results that also link the FQH effect with the theory of QC.

This research was published in **Physical Review Letters, 96**, 070503 (2006).

EDGE EXCITATIONS AND NON-ABELIAN STATISTICS IN THE MOORE-READ STATE: A NUMERICAL STUDY IN THE PRESENCE OF COULOMB INTERACTION AND EDGE CONFINEMENT

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INTRODUCTION

Fractional quantum Hall (FQH) liquids represent novel states of matter with non-trivial topological order. Consequences of such topological order include chiral edge excitations and fractionally charged bulk quasiparticles that obey Abelian or non-Abelian fractional statistics. It has been proposed that the non-Abelian quasiparticles can be used for quantum information storage and processing in an intrinsically fault-tolerant fashion, in which information is stored by the degenerate ground states in the presence of these non-Abelian quasiparticles, and unitary transformations in this Hilbert space can be performed by braiding the quasiparticles. While many Abelian FQH states have been observed and studied in detail, thus far there have been relatively few candidates for the non-Abelian ones. The most promising candidate is the FQH state at Landau level filling fraction 5/2, discovered two decades ago. The leading candidate for the ground state of this system is the Moore-Read (MR) paired state [1], which has been shown to support fractionally charged, non-Abelian quasiparticles [1]. The MR state received strong support from numerical studies using sphere and torus geometries. However these geometries do not contain any boundary, and are thus not suitable for study of edge states.

NUMERICAL CALCULATION AND RESULTS

In this work [2] we perform detailed numerical studies of edge excitations in the 5/2 FQH state in finite-size systems with disc geometry, taking into account the inter-electron Coulomb interaction and a semi-realistic model of the confining potential due to neutralizing background charge. We use a microscopic model of a two-dimensional electron gas (2DEG) confined to a two-dimensional disk, with neutralizing background charge distributed uniformly on a parallel disk of radius a at a distance *d* above the 2DEG. This distance parameterizes the strength of the confining potential, which decreases with increasing *d*. For filling fraction 5/2, we explicitly keep the electronic states in the first excited Landau level only, while neglecting the spin up and down electrons in the lowest Landau level, assuming they are inert. The amount of positive background charge is chosen to be equal to that of the half-filled first excited Landau level, so the system is neutral.

For a limited and very small range of *d*, we find the ground state does indeed have the same quantum number of, and has substantial overlap (up to 50%), with the MR state. Within this parameter space we are able to identify the existence of chiral fermionic and bosonic edge modes, in agreement with previous prediction. We find the fermionic mode velocity is much lower than that of the bosonic mode. With suitable short-range repulsive potential at the center, we show that a charge +e/4 quasihole can be localized at the center of the system, and its presence changes the spectrum of the fermionic edge mode. This confirms the existence and non-Abelian nature of such fractionally charged quasiparticles.

CONCLUSIONS

- In real system the MR state is likely to suffer from some forms of edge instability.
- A small change in confining potential (say by gating) may lead to qualitative change in edge properties.
- Fermionic mode velocity much lower than that of the bosonic mode; this may dramatically affect the propagation of e/4 quasiparticles at the edge.

ACKNOWLEDGEMENTS

This work is supported NSF grant No. DMR-0225698.

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QUANTUM COMPUTING WITH NONABELIAN QUASIPARTICLES

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

INTRODUCTION

A remarkable recent development in the theory of quantum computation has been the realization that certain exotic states of matter in two space dimensions, so-called nonabelian states, may provide a natural medium for storing and manipulating quantum information. In these states, localized quasiparticle excitations have quantum numbers which are similar to ordinary spin quantum numbers. However, unlike ordinary spins, the quantum information associated with these quantum numbers is stored globally, throughout the entire system, and so is intrinsically protected against decoherence. Furthermore, these quasiparticles satisfy so-called nonabelian statistics. This means that when two quasiparticles are adiabatically moved around one another, while being kept sufficiently far apart, the action on the Hilbert space is represented by a unitary matrix which depends only on the topology of the path used to carry out the exchange. Topological quantum computation can then be carried out by

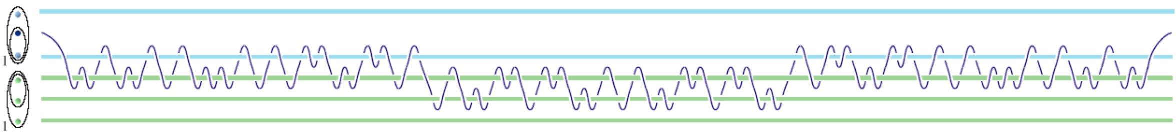

Figure 1.
A two-qubit gate construction for Fibonacci anyons in which a single quasiparticle moves.

moving quasiparticles around one another in two space dimensions. The quasiparticle world-lines form topologically nontrivial braids in three- (= 2 + 1) dimensional space-time, and because these braids are topologically robust (i.e., they cannot be unbraided without cutting one of the strands) the resulting computation is protected against error.

RESULTS AND DISCUSSION

In previous work[1], we showed how to construct two-qubit gates for a particular type of non-Abelian quasiparticles known as Fibonacci anyons (which may exist in the experimentally observed n=12/5 fractional quantum Hall effect) by "weaving" a pair of quasiparticles from one qubit (endoced into three quasiparticles) around the quasiparticles forming a second qubit. We have now given a mathematical proof that similar gate constructions are possible by moving only a *single* quasiparticle [2], and given explicit examples of such constructions [3] (e.g., see Fig. 1). We have also shown that there are fundamental limitations on generalizing these constructions to other kinds of non-Abelian quasiparticles, thus showing that Fibonacci anyons are particularly suited to topological quantum computation.

CONCLUSIONS

A central theme in all of our two-qubit gate constructions is that of breaking the problem of compiling braids for the six quasiparticles used to encode two qubits into a series of braids involving only three objects at a time. While these constructions do not produce the optimal braid of a given length which approximates a desired two-qubit gate, we believe they do lead to the most accurate two-qubit gates which can be obtained for a fixed amount of classical computing power.

Our explicit construction of braids which can used for universal quantum computation provides a direct, and constructive, proof of universality of Fibonacci anyons. This proof compliments the more abstract mathematical proofs of universality and confirms a surprising link between the theory of quantum computation and the physics of the fractional quantum Hall effect.

ACKNOWLEDGEMENTS

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SEMICONDUCTOR PHYSICS

One vigorous activity at the NHMFL in this category is the use of magneto-photoluminescence (PL) to probe nanoscopic and quantum dot systems. Very evident is the increase in high quality, systematic investigations in pulsed field above 50T, where in particular, magneto-optics has played an important role. In this work of D. Andronikov *et al.*, the observation of trions in quantum wells was performed in fields up to 87T.

In the research of B. M. Ashkinadze *et al.*, PL has been used to detect charge fractionalization in the magnetized two dimensional electron at fractional filling.

This research has been accepted for publication by the **International Journal of Modern Physics B.**

TRIONS IN CdTe/CdMgTe QUANTUM WELLS IN HIGH MAGNETIC FIELDS TO 87 T

D. Andronikov and V. Kochereshko (Ioffe Physical-Technical Institute, St-Petersburg, Russia); G. Karczewski (Institute of Physics, Warsaw, Poland); S.A. Crooker (NHMFL, LANL)

INTRODUCTION

Magneto-optical spectroscopy is a powerful tool for studying negatively-charged excitons (trions) – charged three-particle complexes containing two electrons and one hole. Such complexes have two sets of states – singlet, with opposite electron spin alignment, and triplet, with parallel electron spins. It has been shown theoretically (e.g., [1]) and experimentally (e.g., [2]) that both singlet and triplet trion states increase their binding energies in magnetic field. Moreover the triplet state is unbound in the absence of a magnetic field. Thus application of an external magnetic field allows clear observation of the entire set of singlet and triplet trion states in optical spectroscopic experiments.

EXPERIMENTAL

In our earlier experiment [2] we have measured photoluminescence (PL) and reflectivity spectra of a 10 nm wide CdTe/$Cd_{0.7}Mg_{0.3}Te$ modulation-doped single quantum well containing 2D electron gas of a moderate density ($n_e \sim 3 \times 10^{10}/cm^2$) in a magnetic field up to 45T at 1.6K, 4.2K, and 15K. Those measurements allowed us to classify the observed spectral signatures of singlet, as well as dark and bright triplet trion states. In our latest experiment we have performed PL measurements of a similar quantum well structure in magnetic field up to 87 T at liquid helium temperatures. Figure 1 (a) shows a set of PL spectra in magnetic field from 0 to 55 T in σ^- circular polarization, Figure 2 demonstrates a PL spectra in the same polarization at the peak field of 87 T. These data were taken in the 60 T Long-Pulse magnet and the 100T Multi-Shot magnet, respectively.

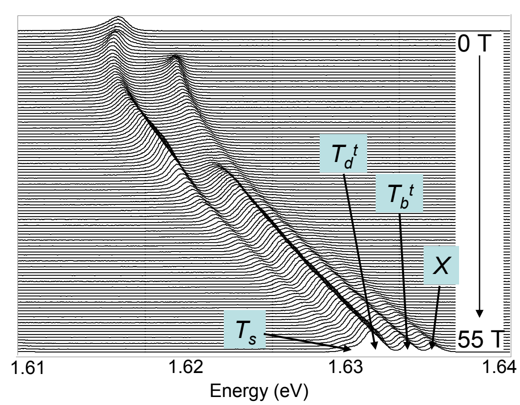

Figure 1.
(a) PL spectra of a CdTe/CdMgTe single quantum well structure taken in magnetic field from 0-55 T in σ^- circular polarization. X indicates the neutral exciton line, T_s is a singlet trion line, T^t_d is the dark triplet trion line, and T^t_b is the bright triplet trion line.

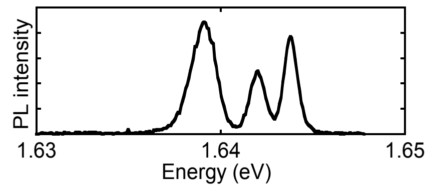

Figure 2.
A PL spectra of the same structure in σ^- circular polarization at 87 T magnetic field.

The acquired PL spectra have confirmed the conclusion about the kinetic nature of the trion states behavior made in our previous study: with increasing magnetic field the singlet trion state T_s is suppressed meanwhile the dark triplet state T^t_d is promoted and becomes one of the dominating lines in the PL spectra due to spin-dependent trion formation mechanism [2]. In our previous research we have been able to observe the bright triplet trion state T^t_b only as a shoulder to the neutral exciton line X. Here, at a very high magnetic field (>50 T) the bright triplet trion state T^t_b is observed as a separate spectral line. This is in agreement with theoretical calculations of the binding energy dependence of this state on magnetic field (e.g. [1]). Measurements of the trionic PL at a magnetic field as high as 87 T have been performed for the first time. Such experiment at an unprecedented magnitude of the magnetic field gives valuable information on the binding energy field dependences of all the observed states and could be used to verify binding energy calculations in the high field limit.

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PHOTOLUMINESCENCE OF A HIGH MOBILITY 2DEG IN THE FRACTIONAL QUANTUM HALL EFFECT REGIME

B.M. Ashkinadze, E. Cohen (Technion, Haifa, Israel); D. Smirnov (NHMFL); L.N. Pfeiffer (Alcatel-Lucent Technologies, NJ)

INTRODUCTION

The electron-electron interaction strongly modifies the energy spectrum of the two-dimensional electron gas (2DEG) under a perpendicularly applied magnetic field (*B*), in the quantum Hall effect regime [1]. Various anomalies were observed in the PL spectrum at integer and fractional electron filling factors ν. However, PL line splitting due to the e-e interaction at ν<1, could hardly be resolved [2]. The reasons are either the photoexcited hole proximity to the 2DEG (in the case of modulation-doped quantum wells), or the broadening of the 2DEG-acceptor PL band in the case of Be-doped heterojunctions (HJs).

EXPERIMENTAL

We measured the magneto-PL spectra of several modulation doped, ultra-high mobility (μ_e> $5{\cdot}10^6$ cm^2/V·sec at 1 K) GaAs/AlGaAs single HJs at T=1.2-0.3 K. The 2DEG density varied in the range of n_{2D}=(0.6-2.7)·10^{11} cm^{-2}. Low-density non-equilibrium electrons and holes were photo-exited at laser energies of 1.58 eV or 1.96 eV. An optical fiber and a polarizer inserted into the He3 cryostat were used for photoexcitation and collection of the circularly polarized PL. The magnetic field varied up to 25T.

RESULTS AND DISCUSSION

All studied HJs show PL peak energy and intensity anomalies at ν =2 and 1, similar to those previously reported for such HJs [3]. An abrupt transfer between free exciton and 2DEG-hole PL is observed at T<2K. It results from the change in the exciton dissociation rate and the appearance of free holes near the magnetized 2DEG for ν < 2.

The strong PL anomalies near ν=2/3 and 1/3 are clearly observed for the HJs with n_{2D}=1.6·10^{11} cm^{-2} (Fig. 1). These anomalies are seen only at the lowest temperature (0.3-0.4 K) and for HJs with n_{2D}>1·10^{11} cm^{-2}. Near ν=2/3, a PL line broadening occurs, and several PL lines can be revealed. The energy separation between the PL lines is ~ 0.1-0.15 meV. In the range of ν=2/5-1/3, the PL line splits into several lines with the energy separation of ~ 0.2-0.3 meV. It is important to notice that several HJs having various n_{2D} show similar PL structure at ν=2/5-1/3 and 2/3.

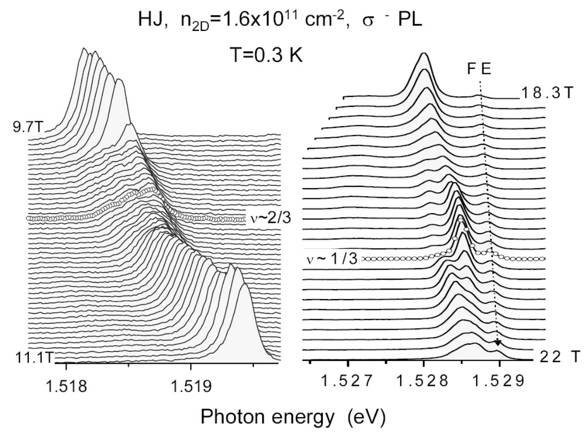

Figure 1.
Waterfall plot of the PL spectra of the HJ near ν=2/3 and 1/3 (n_{2D}= 1.6 ·10^{11} cm^{-2}).

CONCLUSIONS

The obtained PL spectra clearly show splitting of the 2DEG-hole PL into several lines at fractional filling factor. We attribute this effect to a charge fractionalization of the magnetized 2DEG, when a hole can recombine with a quasiparticles and/or generate quasiholes in the incompressible 2DEG condensate.

ACKNOWLEDGEMENTS

B.M.A. acknowledges support from the NHMFL Visiting Scientist Program.

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CONDENSED MATTER

User Programs

The strength and success of NHMFL user programs and facilities are built around the synergies of the highest field magnets, unique instrumentation, and support from 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 2006. 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 ***www.magnet.fsu.edu/usershub/publications/index.aspx.***

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.

Two members of the scientific staff were hired in 2006: Stephen McGill is developing his research program in fast-pulse optics as well as supporting users of fast pulse optics and general optical measurements at visible wavelengths; Jan Jaroszynski uses noise measurements to separate charge phenomena from spin phenomena in a wide variety of systems and helps all users maximize the signal to noise ratio of their measurements.

Four new apartments for NHMFL-FSU users and visitors were renovated in 2006. Each apartment has a fully equipped kitchen, a single bed, and a large chair that unfolds into a bed. All are within walking distance of the lab.

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 ***www.magnet.fsu.edu/scientificdivisions/cms/facilities/dcfield/index.html***

NEW DC MAGNETS

Two new or significantly upgraded magnets were brought on line in 2006. They joined the 35 T magnet, which was commissioned in December, 2005. It performed flawlessly during 2006 and became the resistive magnet of choice for experiments at temperatures below 300 mK.

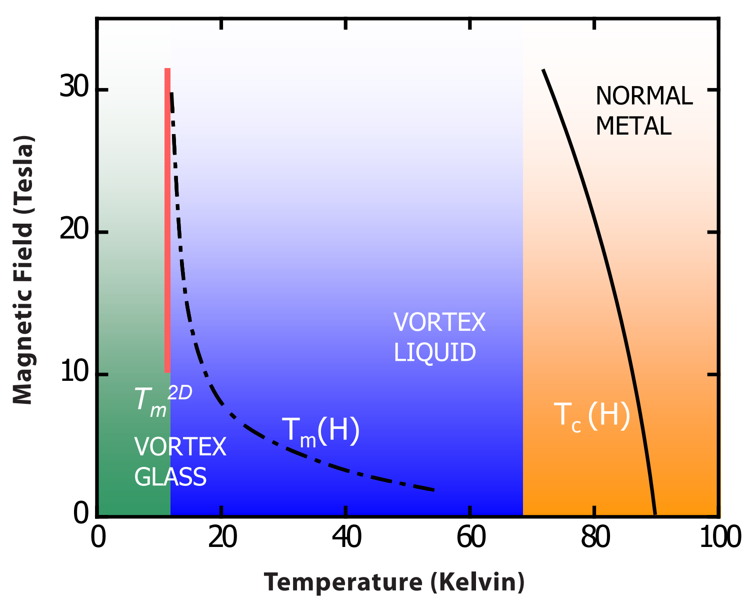

Figure 1.
The magnetic-field–temperature phase diagram for vortex melting in Bi-2212 for H || c, showing the superconducting transition $T_c(H)$ from normal state (solid line), the melting transition, $T_m(H)$, separating the liquid from solid (glass) vortex (dashed line), and the two-dimensional vortex melting transition temperature, Tm2D, (red line). [B. Chen, *et al.*, *Nature Physics*, **540** (2007)].

- A newly designed, 29 T, 32 mm bore, higher homogeneity magnet for condensed matter NMR measurements was installed in Cell 7. In addition to providing higher fields for condensed matter NMR, it is serving as a design test-bed for the water-cooled insert of the Series Connected Hybrid. Halperin's group from Northwestern University, working with NHMFL staff scientists used this magnet to study the vortex solid to liquid transition in BSSCO-2212, a high temperature superconductor (**Figure 1**).
- A new 17.5 T, 34 mm bore, sweepable, superconducting magnet has been purchased for NMR studies of condensed matter systems. It has been mated with a new Janis Research sorption-pumped ^3He refrigerator capable of 24 hour experiments at 350 mK. Probes for this cryostat can be top-loaded. Other cryostats will also be available. This instrument can be run from a remote location so that the user is not limited by geography or time of day.

Table 1. Magnet Systems & Techniques for Users of the Continuous Field Facility, Tallahassee, as of January 2007

FLORIDA-BITTER and HYBRID MAGNETS

Field (T), Bore (mm)	Power (MW)	Supported Research
45, 32, (25 ppm/mm inhomogeneity)	29.3	Magneto-optics – ultra-violet through far infrared; Magnetization; Specific heat; Transport – DC to microwaves; High Pressure; Temperatures from 30 mK to 1500 K; Dependence of optical and transport properties on field, orientation, etc.; Materials processing; Wire, cable, and coil testing. Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.
35, 32	19.2	
33, 32	17.2	
31, 32 to 50[1]	18.4	
29, 32 (~5 ppm/mm inhomogeneity[2])	19.1	
20, 195	18.8	
25, 52, (1 ppm/mm inhomogeneity[2])	19	

SUPERCONDUCTING MAGNETS

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

1 A coil for modulating the magnetic field and a coil for superimposing a gradient on the center portion of the main field are wound on 32 mm bore tubes.
2 Higher homogeneity magnet for magnetic resonance measurements.
3 Special system for optical measurements will be available in May, 2007.

USER-DRIVEN INSTRUMENTATION DEVELOPMENTS

- Resistively detected NMR (RDNMR) provides new information on Skyrmions, ferromagnets, Wigner crystal, phase separation, domain walls, etc. in 2 DES systems. It does not depend on the number of nuclear spins but only on the hyperfine coupling to the carriers and can therefore be used to study systems with too few spins for normal NMR measurements. The 18/20 T superconducting magnet coupled with its dilution refrigerator (20 mK) provides access to the lowest filling factors and highest field phases available (**Figure 2**).
- An IR quasi-direct optical probe was built to the study Landau level (LL) spectroscopy of graphene. This probe reduces the background signal a thousand-fold relative to typical light-pipe measurements and will be a great benefit for all NHMFL users doing transmission measurements on very small samples (less than 100 μm in diameter).

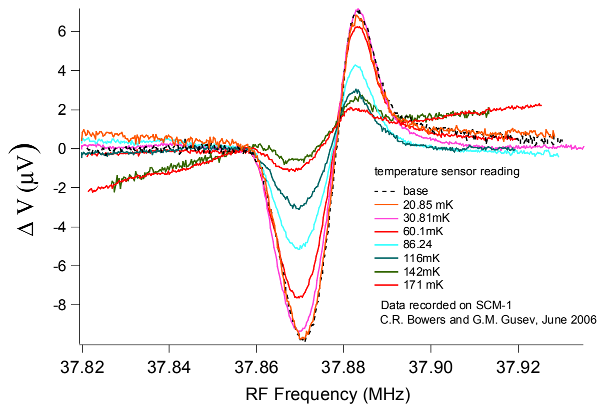

Figure 2.
^{75}As RDNMR near ν=1 in GaAs quantum well.

Graphene, a single atomic layer of graphite, is an intriguing material because of its potential applications in low energy loss nanoelectronics and its importance for fundamental physics. The first IR data obtained with the new probe show that many-particle effects play an important role in the properties of graphene (**Figure 3**).

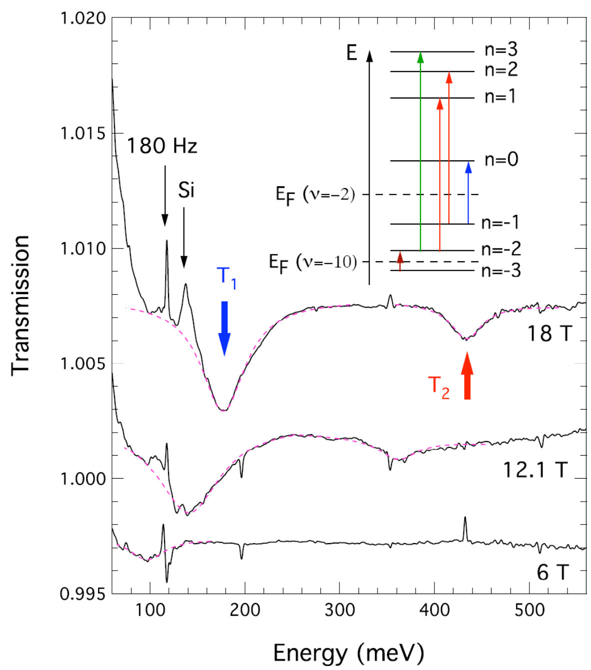

Figure 3.
Normalized IR absorption spectra of holes in graphene at B=18, 12.1, and 6 T. Two LL resonances are denoted by T_1 and T_2. Dashed purple lines are Lorentzian fits to the data. The inset shows a schematic LL ladder with the corresponding transitions indicated by arrows.
[Z. Jiang *et al.*, "Landau Level Spectroscopy of Graphene," Accepted by *Phys. Rev. Lett. (2007)]*

- A two-axis rotator was used for Angular Magneto-Resistance Oscillation (AMRO) measurements to 45 T. The unusual temperature dependence of the resistivity in the cuprates probably originates from two distinct scattering mechanisms. One mechanism arises from conventional electron-electron scattering, while the other is highly anisotropic, has the same symmetry as the d-wave superconducting gap and, most strikingly, exhibits a magnitude that grows approximately linearly with temperature.

- Cryostats similar to the Janis Research cryostats that have been in use since 1992 give increased run time between liquid helium fills. Existing user probes fit in the new cryostats without modification. New, ball-mounted dewar mounting frames provide easier and more accurate alignment of the cryostat in the magnet and thereby reduce sample vibration and related signal noise.

DC MAGNET POWER AND COOLING SYSTEMS IMPROVEMENTS

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 such as NMR of condensed matter systems, high resolution NMR of quadrupole nuclei, heat capacity of heavy fermion systems, studies of phase transitions requiring temperature sweeps at fixed field, and processing materials in high magnetic fields. They will also allow the Magnet Lab to design future magnets with higher fields than are possible now.

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

Schedule

- Scope Development: Complete
- Detailed Design/Engineering: Complete
- Purchasing / Construction: March 1, 2005 – April 15, 2008
- Most of the purchasing and construction is complete.
- Installation: Began 1st quarter, 2006; 80% complete by December 31, 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. All new components, however, have been sized to allow the system to be upgraded to 64 MW operations when additional funds are available.
- The first upgrade step, to 48 MW, was completed in 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. This work will be finished in March, 2008.
- New transformers rated at 16 MW each have replaced the original 8.5 MW transformers.
- New power supply controllers have replaced the original, 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. One heat exchanger remains to be installed.

IMPROVEMENTS SCHEDULED FOR 2007

- The 45 T Hybrid magnet will be redesigned so that the water-cooled insert can be run on three of the recently upgraded power supplies. It will allow running the SCH and 45 T in parallel when the SCH is available and some magnet cooling water system changes have been made.
- 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. Helium three and variable temperature inserts for each cryostat will use the same probes, which the user will be able to insert and remove as needed.

Table 2.

DC Facility User Statistics for 2006 (1/1/06 – 12/31/06)

User and Project Data	Total	Minority	Female
Number of Research Projects	179	6	4
Number of Senior Investigators, U.S.	192	3	10
Number of Senior Investigators, non-U.S.	73	1	4
Number of Students, U.S.	75	4	9
Number of Students, non-U.S.	20	0	7
Number of Postdocs, U.S.	35	0	5
Number of Postdocs, non-U.S.	13	0	3

Table 2a.

DC Facility User Statistics by Discipline for 2006

User and Project Data	Physics	Chemistry	Engineering	Instrument & Magnet Test
Number of Research Projects	151	12	11	5
Number of Senior Investigators, U.S.	138	21	22	11
Number of Senior Investigators, non-U.S.	66	6	1	0
Number of Students, U.S.	66	2	6	1
Number of Students, non-U.S.	16	4	0	0
Number of Postdocs, U.S.	32	2	1	0
Number of Postdocs, non-U.S.	13	0	0	0

Table 3.

DC Facility Operations Statistics for 2006 (1/3/06 – 1/2/07)

Number of Magnet Days	Florida-Bitter & Hybrid	Superconducting
NHMFL, UF, FSU, FAMU, LANL	252	341
U.S. University	162	160
U.S. Govt. Lab.	20	23
U.S. Industry	12	0
Non-U.S.	109	91
Test, Calibration, & Maintenance	46	44
Idle	3	66
Total	**604**	**725**

Table 3a.

DC Facility Operations Statistics by Discipline for 2006

Number of Magnet Days	Physics	Chemistry	Engineering	Instrument & Magnet Test
NHMFL, UF, FSU, FAMU, LANL	540.8	18.6	23.6	9.5
U. S. University	274.4	33.4	13.7	0
U. S. Govt. Lab.	42.5	0	0	0
U. S. Industry	1.9	0	9.6	0
Non-U.S.	196.5	3.2	0	0
Test, Calibration, & Maintenance	0	0	0	90.3
Idle	2.2	0	0.2	66.3
Total	**1058.2**	**55.2**	**47.1**	**166.1**

USER PROGRAMS

NHMFL PULSED FIELD FACILITY

The Pulsed Field Facility (PFF) and the Los Alamos branch of the NHMFL are located in Los Alamos, New Mexico, at the Los Alamos National Laboratory (LANL). The pulsed field users program is designed to provide researchers with a balance of the highest research magnetic fields and robust scientific diagnostics specifically designed to operate in pulsed magnets. The connection with the DC Field Facility is strong and complementary in expertise. Achieving the highest magnetic fields possible is not what this facility 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 (32 mF @ 10 kV) 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 that accommodates approximately 100 users. For additional info, contact Charles H. Mielke, Ph.D. Head of Pulsed Field Facility User Program (***cmielke@lanl.gov***)

The highlight for the PFF in 2006 was the successful commissioning of the 100 tesla multi-shot magnet (100TMS). This project began over ten years ago and was a joint collaboration between the DoE-BES and the NSF. The project has already set a new world record with the highest "non-destructive" pulse ever conducted. The pulse height was recorded at 89.9 T, with a rise time of approximately 5.2 ms in a 15 mm bore with a ^{3}He sample space of 8 mm.

An example of this magnet's ability to provide unprecedented resolution in uncovering scientific phenomena is well represented in a recent experiment by Neil Harrison and co-workers on $CeIn_3$. The data in **Figure 4** shows the discovery of a new Fermi surface orbit, only observable in magnetic fields above 60 T.

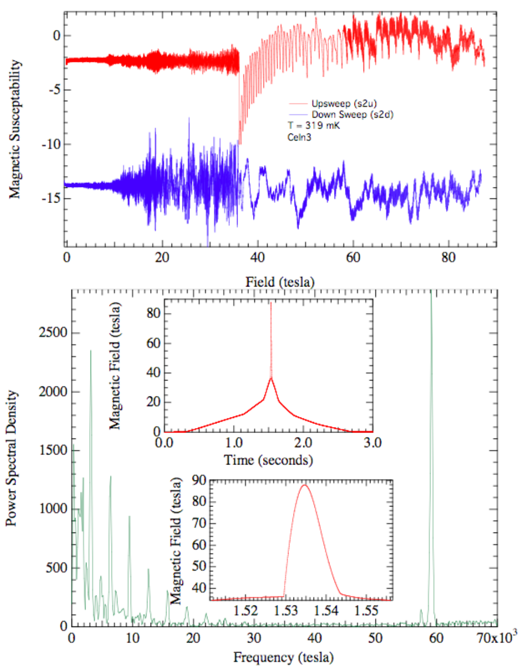

Figure 4.
The upper plot shows the magnetic susceptibility of $CeIn_3$ over the entire magnetic field range, extending to 87.9 T. The insert pulse begins at a field platform of approximately 36 T, shown in the inset below. The power spectral density of the oscillatory deHaas-van Alphen signal is shown in the lower plot.

(Photo) Dwight Rickel inspecting an overpressure flange on the 100T-MS.

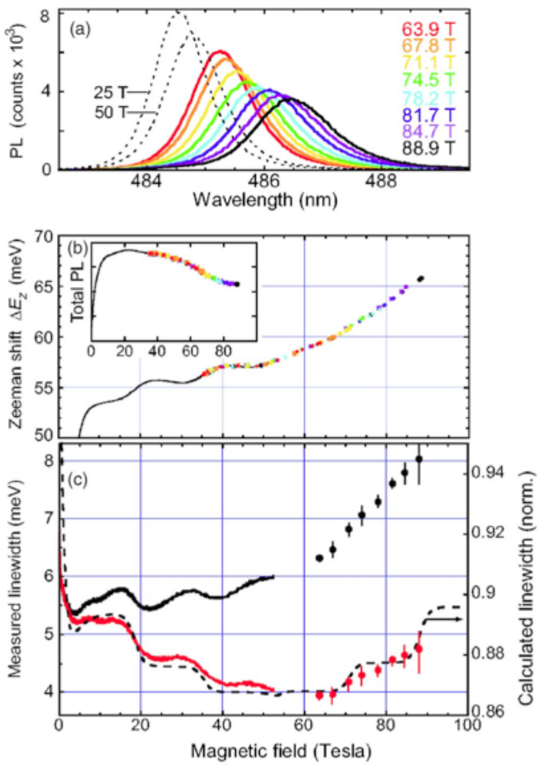

Figure 5.

Photoluminescence (PL) spectrum (a) at 1.5 K from $Zn_{0.70}Cd_{0.22}Mn_{0.08}Se$ quantum well [S. A. Crooker and N. Samarth, *Appl. Phys. Lett.* **90**, 102109 (2007)]. (b) High-Field PL Zeeman shift as a function of applied magnetic field, the black line is data obtained from the 60TLP and the colored points are from the 100T-MS. (c) Measured linewidth from the Long Pulse and 100T-MS.

(Photo) Scott Crooker making final adjustments before a pulse.

In August 2006 the 60 T long pulse magnet (Controlled Waveform) was commissioned. This magnet system is known as the 60T-LP Mark II. Putting this magnet system back into service marks the end of a long process that began on July 28, 2000, when the original 60T-LP catastrophically failed. The problems were fully investigated and found to be related to a metallurgical processing fault that left the reinforcing shells too brittle. Problems corrected and carefully monitored reinforcement material have left the NHMFL with a truly unique and world-class magnet system, once again.

The pulsed magnet winding operation formerly located at the Tallahassee branch of the Magnet Lab has moved to Los Alamos and has been enhanced. A new fabrication area is now operational and the first new magnets will be put into service in 2007. The winding facility now has more coil winders and substantially larger footprint that will help with future expansion as pulsed magnets continue to push to the edge of the materials technology. **Figure 6** is a view of the new operation installed and running in Building 125 at the Pulsed Field Facility. Although the operation was quite successful in Tallahassee, the new close proximity to the pulsed field users, equipment, and staff of the PFF will give the program a more central focus and immediate feedback from operations.

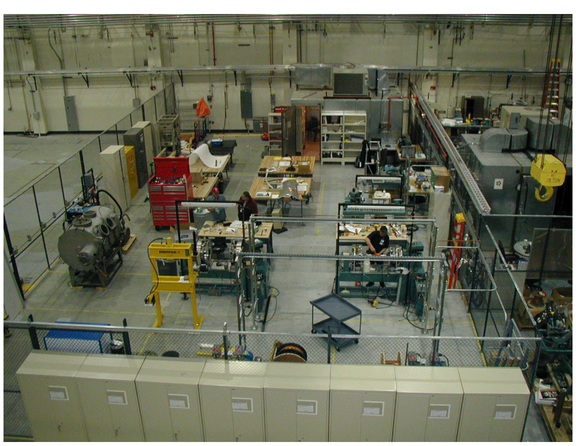

Figure 6.

The newly commissioned pulsed field winding operation located at the PFF in Los Alamos.

Projects in the near future for the PFF include the new User Capacitor Bank, which is in full force construction and should be commissioned in the fall of 2007. The 4 mega-joule capacitor bank will increase the user fields in peak height and duration and allow magnet designs to incorporate multiple cooling channels that reduce their efficiency but greatly increase their cooling times. Faster cooling magnets directly impact user productivity and allow them to record more pulses in a given visit. In addition to the photo-luminescence and magnetic susceptibility probes, a new suite of diagnostic probes for the 100T-MS magnet will include Pulse-Echo Ultra-Sound, Contactless Conductivity, GHz transmission, and sample extraction magnetometry. Other user system improvements include a new pulsed magnet liquid helium cryostat that is designed to have an improved hold time and reduced mechanical impulse from induced eddy currents.

Table 4.

Pulsed Field Facility User Statistics for 2006 (1/1/2006-12/31/2006)

	Total	Minority	Women
Number of Projects	86		
Number of Research Groups	39		
Number of Users	91	1	31
Number of Senior Investigators, U.S.	16	0	3
Number of Senior Investigators, non-U.S.	13	0	1
Number of Students, U.S.	14	2	3
Number of Students, non-U.S.	2	0	0
Number of Postdocs, U.S.	15	0	5
Number of Postdocs, non-U.S.	3	0	0

Table 5.

Pulsed Field Facility Operations Statistics for 2006 (1/1/2006-12/31/2006)

	Short Pulse	Mid-Pulse	Superconducting
		Number of Magnet Days	
NHMFL	72	29	113
U.S. Universities	66	61	183
U.S. Government Labs	20	0	96
Industry	14	0	0
Non-U.S.	53	16	80
Total	**225**	**106**	**472**

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 and at very low temperatures simultaneously. Bay 3 is equipped with a 15.2 T superconducting magnet, to be upgraded to 21 T in 2008, and provides temperatures down to 0.4 mK. Bay 2 provides temperatures down to 0.1 mK in magnetic fields up to 8 T. Faculty members in the facility work with users in the design of experiments when needed. Instrumentation is available for studies of magnetization, magnetic susceptibility, 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.

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.

INCREASED MAGNET TIME

Starting from 2006, the total magnet time of the High B/T Facility has been increased by 50%, by making available one-half of Bay 2 of the UF Microkelvin Laboratory to the NHMFL users. This bay is equipped with two 8 T superconducting magnets, one for a sample and another for the copper nuclear-demagnetization cooling stage capable of reaching temperatures below 100 µK. It is ideal for experiments that require temperatures less than 0.4 mK.

MAGNET UPDATE AND NEW REFRIGERATOR

With funding from the State of Florida, a new superconducting magnet system is being built by Cryomagnetics, Inc. in Oak Ridge, Tennessee, to bring the maximum field from the present 15.2 T to 21 T. The system will comprise a 21 T high field magnet for a sample, as well as an 8.5 T demagnetization magnet for the nuclear-demagnetization cooling stage and a 5 T active-shielded, moderate-field magnet. With a 10 mT Z0 coil that compensates for the current decay, the magnet will be continuously operated in the persistent mode for up to seven weeks, detached from the main power supply. The new magnet system is expected to be delivered by early 2008.

A new dilution refrigerator (KelvinoxMX400 from Oxford Instruments) is scheduled to be delivered by the end of 2007. This refrigerator will be used for testing samples prior to an experiment and for developing new experimental capabilities. The purchase of the new refrigerator was also made possible with funding from the State of Florida.

INSTRUMENTATION UPDATES

- In collaboration with Moses Chan's group from Penn State, a high-precision torsion pendulum has been developed. Employing a beryllium-copper torsion rod to provide a mechanical Q value of 1 million, the pendulum has a state-of-the-art sensitivity of 1 part per 1011. The device is especially suitable for superfluid-density measurements in quantum fluids and solids, as well as for detecting subtle structural transitions and studying dislocations at temperatures down to 2 mK.

- Steve Julian's group from Toronto has collaborated with the Dr. Jian-sheng Xia at the High B/T Facility to develop an AC magnetic susceptometer, incorporating a low-temperature transformer to achieve impedance matching to enhance the signal-to-noise ratio. This susceptometer has been used to carry out de Haas-van Alphen measurements in $CeCoIn_5$ at temperatures down to 0.9 mK, setting the new lowest-temperature record for the de Haas-van Alphen effect (**Figure 7**).

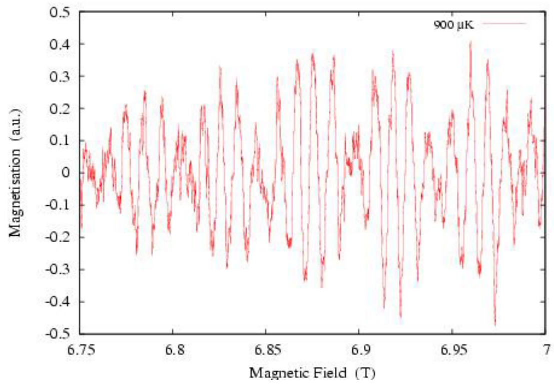

Figure 7.
de Haas-van Alphen (dHvA) oscillations in $CeCoIn_5$ at 0.9 mK—***a new record temperature for dHvA measurements.***

- Resistively-detected nuclear magnetic resonance is being developed in collaboration with the group headed by Horst Stormer (Columbia) and Dan Tsui (Princeton). The technique employs tipping of nuclear spins at 32 MHz and has a sensitivity better than 5 nV using a low-frequency lockin method.

Table 6.
Magnet Systems & Instrumentation for Users of the High B/T Facility at UF, as of January 2007

Equipment	Features	Supported Research
15.2 T SC magnet, 25 mm diameter experimental volume	Temperatures down to 0.4 mK	Magnetization, ac magnetic susceptibility, de Haas-van Alphen effect, thermodynamic quantities, transport measurements, NMR, viscosity, diffusion, ultrasound, torsion pendulum measurements, capacitance, and pressure
21 T SC magnet, 25 mm diameter experimental volume	Temperatures down to 0.4 mK	*Under development*
8 T SC magnet, 25 mm diameter experimental volume	Temperatures down to 0.1 mK	AC magnetic susceptibility, transport measurements, and ultrasound
Miniature sample rotator in liquid ^3He	Temperatures down to 2 mK, 0–100 degrees	Quantum Hall effect, fractional quantum Hall effect, metal-insulator transition, and heavy fermions
Sub-femto ampere current source	Ultra high accuracy, low noise	High resistance, low carrier-density samples
AC magnetic susceptometer	Temperatures down to 0.9 mK, capable of de Haas-van Alphen measurements	Magnetic materials and superconductors
Pulsed NMR spectrometer	Temperatures down to 1.2 mK, frequencies up to 500 MHz	Quantum fluids, magnetic materials, and superconductors
Torsion pendulum	Temperatures down to 2 mK, frequencies 1 kHz–10 kHz, mechanical $Q\sim10^6$	Quantum fluids and solids

Table 7.
High B/T Facility User Statistics for 2006 (1/1/06 – 12/31/06)

	Total	Minority	Female
Number of Research Projects	3		
Number of Senior Investigators, U.S.	4		
Number of Senior Investigators , non-U.S.	3		
Number of Students, U.S.	2		
Number of Students, non-U.S.			
Number of Postdocs, U.S.	2		
Number of Postdocs, non-U.S.	1		1

Table 8.
High B/T Facility Operation Statistics for 2006 (1/1/06 – 12/31/06)

User Affiliations	Number of Magnet Days	Percent of Total
NHMFL, UF, FSU, FAMU, LANL		
U. S. University	215	39%
U. S. Govt. Lab.		
Industry		
Overseas	121	22%
Experiment setup, Maintenance	211	39%
Idle		
Total	**547**	**100%**

CENTER FOR INTERDISCIPLINARY MAGNETIC RESONANCE (CIMAR)

The NHMFL's Center for Interdisciplinary Magnetic Resonance supports 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 (FT-ICR).

Table 9.
CIMAR Facilities in Tallahassee, as of January 2007

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	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 NMR
500 MHz	11.75, 52	1 ppb	Solution NMR, Cryoprobe
400 MHz	9.4, 89	1 ppb	Solid State NMR
300 MHz	7, 52	1 ppb	Developmental NMR
300 MHz	7, 89	1 ppb	Solid State NMR
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
ICR	**Field (T), Bore (mm)**	**Homogeneity**	**Measurements**
	14.5, 104	1 ppm	ESI FT-ICR
	9.4, 220	1 ppm	ESI APPI FT-ICR
	9.4, 155	1 ppm	FD, MALDI FT-ICR
	7, 155	1 ppm	EI, CI, FT-ICR
	7, 150	1 ppm	ESI FT-ICR

+ under development * ECR: Electron Cyclotron Resonance

Table 10.
CIMAR Facilities at the University of Florida, as of January 2007

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
600 MHz	14, 52	1 ppb	1-mm HTS cryoprobe
500 MHz	11.7, 52	1 ppb	Solution/solid state NMR
500 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, 900 (600 mm useable bore)	0.1 ppm	MRI of whole body humans and large animals

NMR Spectroscopy and Imaging Program

Tallahassee Update

Faculty Recruitment. We are pleased to announce that Dr. Victor Schepkin has joined the NHMFL as of June 1, 2006. For the past dozen years Dr. Schepkin has been working on magnetic resonance imaging and comes to the NHMFL to facilitate MRI on the wide bore 600 and ultra-wide bore (UWB) 900 MHz magnets in Tallahassee.

Mr. Kiran Shetty has been part of the RF instrument development group since 2003, but recently accepted a faculty position with us as Assistant in Engineering. He graduated from Florida State University with a master's degree electrical engineering in 2003. His new responsibilities include working on field stabilization for the Series Connected Hybrid project and the building of new NMR probes for specialty applications.

NMR Spectroscopy and Imaging Program in Tallahassee

Prof. Sam Grant and Dr. Victor Schepkin, in collaboration with both the RF development group in Tallahassee and the AMRIS RF group in Gainesville, are rapidly bringing imaging capabilities online. As an example (**Figure 8**), Prof. Susanne Cappendijk of the FSU College of Medicine and Dr. Grant have been studying the influence of nicotine on zebra finch brain morphology using *in vivo* and *ex-vivo* MRI in the UWB 900. In the zebra finch, nicotinic acetylcholinergic receptors are localized in several song nuclei and the hippocampus, and recent *in vitro* research supports the hypothesis that the nicotinic cholinergic mechanism could play a critical role in long-term potentiation in the zebra finch brain. The unique UWB 900 magnet provides high resolution for anatomical identification, as well as improved sensitivity for significantly shortened acquisition times compared to previous studies. With correlation to physiological and histological evaluations, these microimages highlight the effect of nicotine on cognitive processes in the adult male zebra finch brain. [Cappendijk *et al.*, Proceedings of the Society for Nicotine and Tobacco Research: 13th Annual Meeting, RPOS308 (2007); Proceedings of ISMAR: 15th Scientific Meeting and Exhibition, 2355 (2007)].

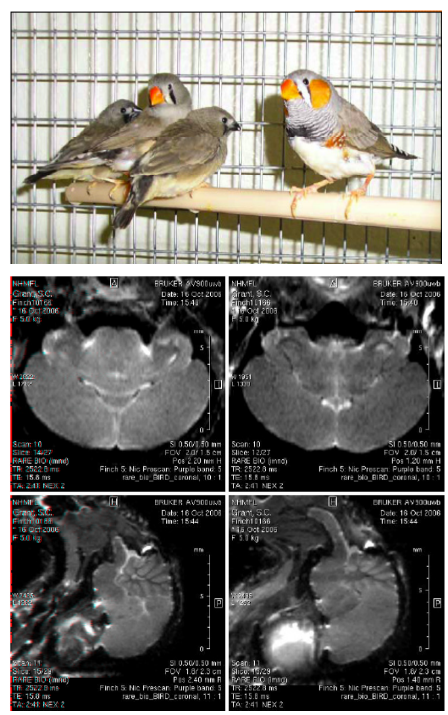

Figure 8.
An *in vivo* 900 MHz MRI study of the influence of nicotine on zebra finch brain morphology. Nicotine affects the development of song, flight, sexual markings and muscle development. Imaging studies have shown a dramatic increase in brain volume for birds exposed to nicotine.

Materials solid-state NMR capabilities on the UWB 900 are advancing with new probe capabilities for Cross Polarization and Magic Angle Sample Spinning over a broad range of temperatures thanks to the efforts of Peter Gor'kov and Dr. Bill Brey in the RF development group. Recent progress by Dr. Riqiang Fu and Prof. Naresh Dalal of FSU [Fu *et al., J. Am. Chem. Soc.,* **129**, 470-471 (2007)] have shown dramatic enhancements in resolution leading to a quadrupling of sensitivity between 600 and 900 MHz for spin ½ ^{15}N spectroscopy of ammonium dihydrogen arsenate (**Figure 9**). The resolution enhancement has been used to obtain nearly baseline resolution between the paraelectric and antiferroelectric phases of this compound coexisting at the phase transition temperature, 215 K.

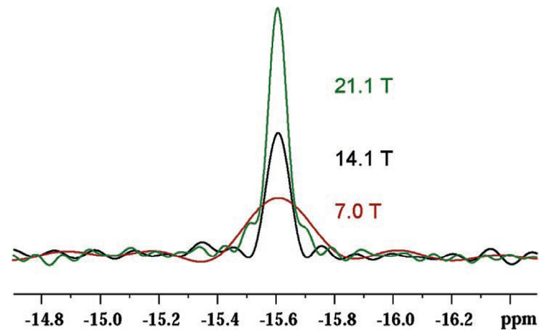

Figure 9.
Field dependence of the ^{15}N CP/MAS spectra of an $NH_4H_2AsO_4$ single crystal illustrating the dramatic improvement in resolution and sensitivity in this antiferroelectric material.

Excellent progress has also been made in the past year in biological solid state NMR structural characterization of membrane proteins using uniformly aligned samples. Gor'kov and others [Gor'kov, *et al., J. Magn. Reson.*, **185**, 77-93 (2007)] developed NMR probes that generate minimal electric fields with the RF coil, while providing a very uniform RF generated magnetic field. Collaborators from the University of Minnesota (Prof. Gianluigi Veglia) and Pacific Lutheran University (Prof. Myriam Cotten) provided superb demonstrations of the probe's capabilities, which were reported in the paper. In addition, Dr. Philip Gao, Conggang Li, and Prof. Tim Cross groupmembers have recently obtained high quality spectra [Li *et al., J. Am. Chem. Soc.*, in press; **Figure 10**) of three full length proteins—two of which are from *Mycobacterium tuberculosis*, the causitive agent of TB that kills 2,000,000 people a year. Dr. Fu and Prof. Cotton are working on the development of a new solid state NMR experiment that correlates the aniosotropic ^{1}H and ^{15}N chemical shift interactions. This experiment will provide important new restraints for the membrane protein structural efforts. Resolution is critically important and, because the ^{1}H anisotropy is small (15 ppm for amide protons), the improvement in resolution with field strength is particularly significant for this spectroscopy. This experiment (**Figure 11**) was developed at 600 MHz and will soon be implemented on the UWB 900.

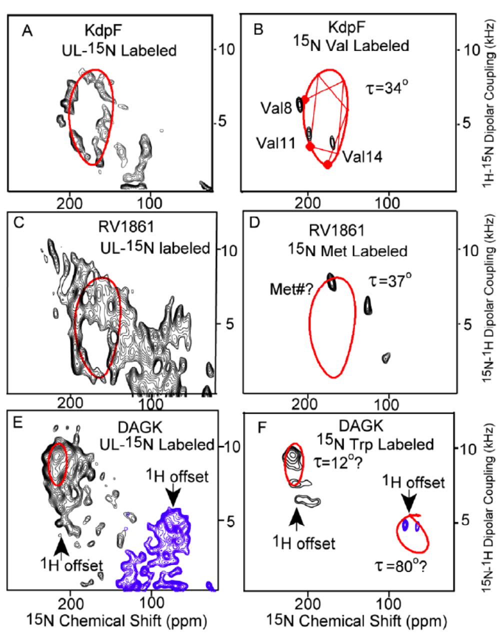

Figure 10.
PISEMA spectra of three proteins (KdpF and Rv1861 from *Mtb* and Diacylglygerol Kinase from *E. coli* uniformly ^{15}N labeled and amino acid specific labeled demonstrating superb alignment of the proteins. The red PISA wheels represent preliminary interpretation of the data for characterizing the tilt of the transmembrane helices with respect to the bilayer normal.

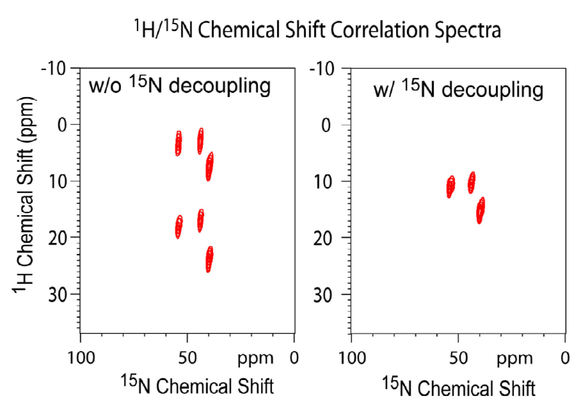

Figure 11.
^{1}H/^{15}N Anisotropic chemical shift correlation spectra of ^{15}N Val10,Gly13,Ile16 labeled Piscidin, an antimicrobial peptide from fish. In addition to the chemical shifts the ^{1}H/^{15}N dipolar interaction is also observed.

Prof. Elisar Barbar at Oregon State University is studying the structure and function of cytoplasmic dynein. Cytoplasmic dynein is a microtubule-based retrograde motor responsible for intracellular transport of membranous vesicles and multiple cargo proteins. **Figure 12**, collected at the Magnet Lab's UWB 900 MHz, shows the positive peaks in the {^{1}H}-^{15}N nuclear Overhauser enhancement (NOE) experiment in the presence of proton saturation. Differences found with respect to the NOE experiment recorded at lower magnetic field (600 MHz), in terms of crosspeak amplitudes and signs, indicate the presence of significant motion on the nanosecond time scale.

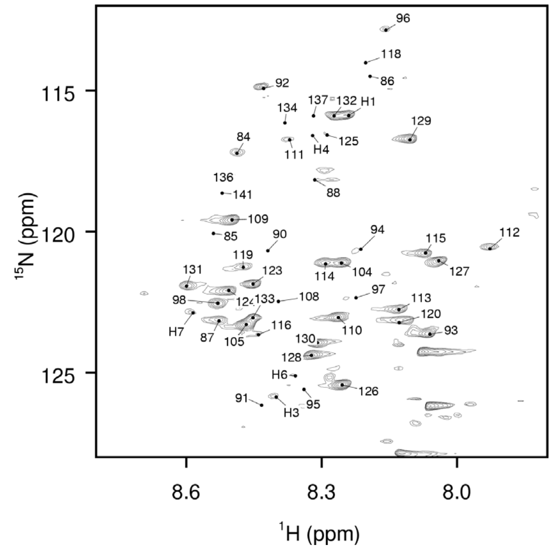

Figure 12.
2D {^{1}H} -^{15}N steady state heteronuclear NOE experiment collected for the light chains and intermediate chain complex using 900 MHz UWB Bruker spectrometer at the NHMFL.

Nitrogen is one of the most important elements in all branches of chemistry, yet the spectroscopy of the naturally abundant nucleus, ^{14}N, is rare. Dr. Zhehong Gan and researchers from the Ecole Polytechnique Federale de Lausanne (S. Cavadini, A. Lupulescu, S. Antonijevic, and G. Bodenhausen) have developed a series of indirect detection methods for observing ^{14}N, the highly abundant, but low-γ spin-1 quadrupolar nucleus. Indirect detection provides not only excellent spectral resolution at high fields, but also the sensitivity needed for measuring ^{14}N electric field gradient tensors as illustrated by the amide nitrogen in polypeptides. Indirect detection can be implemented with second-order quadrupolar-dipolar coupling [Gan, *J. Am. Chem. Soc.* **128**, 6040-6041 (2006); Cavadini *et al., J. Am. Chem. Soc.*, **128**, 7706-07 (2006)], or direct dipolar recoupling [Gan, *J. Magn Reson*, **183**, 247-253 and **184**, 39-43 (2006)]. The double resonance experiment can measure ^{14}N/^{13}C distances (**Figure 13**) as well in natural abundant samples without the need of isotope labeling [Gan, *Chem. Comm*, 4712 (2006)]. These developments open up new opportunities for NMR studies of this important nucleus.

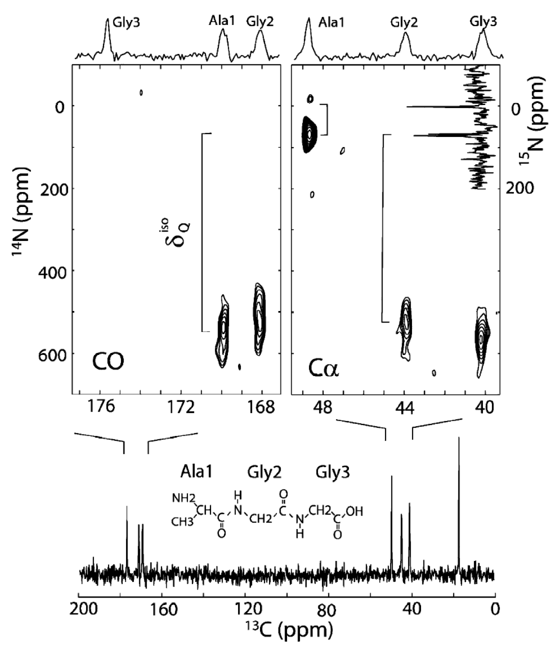

Figure 13.
^{14}N/^{13}C correlation spectrum at 600 MHz of the natural abundant Ala-Gly-Gly. The vertical brackets indicate the isotropic second order quadrupolar shift from the chemical shift measured in a separate ^{15}N MAS experiment.

Since no program is in now place to develop the 30 T NMR magnet based on high temperature superconductors as proposed in the COHMAG report, the only significant near-term advance in NMR field strength must come from DC magnets. The recently funded 36 T series-connected hybrid, with its science program emphasizing biological and chemical applications of solid state NMR, will provide this advance in field strength. Successful use of the 36 T magnet, however, will require significant development in NMR techniques and technology. In a key step forward, a team including Drs. Gan and Brey of the NHMFL and Prof. Jeff Schiano of Penn State University demonstrated for the first time in 2006 sub-ppm linewidths in a resistive magnet (**Figure 14**). The combination of magic angle spinning and inductive feedback ("flux stabilization") used to obtain the sub-ppm spectrum will be employed to improve resolution for NMR applications on the series hybrid.

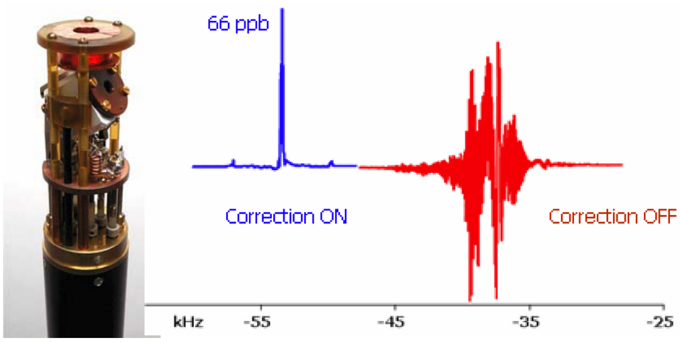

Figure 14.
(L) NMR Probe developed to obtain high-resolution spectra in the inhomogeneous and fluctuating magnetic field of a dc magnet. (R) Single-transients obtained with and without inductive feedback of a H_2O reference sample.

Table 11.
NMR Spectroscopy and Imaging Facility (Tallahassee) User Statistics (1/1/2006-12/31/2006)

	Total	Minority	Women
Number of Projects	71		
Number of Research Groups	40		
Number of Users	135	5	24
Number of Senior Investigators, U.S.	63	3	9
Number of Senior Investigators, non-U.S.	15	0	3
Number of Postdocs, U.S.	14	0	1
Number of Postdocs, non-U.S.	1	0	0
Number of Students, U.S.	42	2	11
Number of Students, non-U.S.	0	0	0

Table 12.
NMR Spectroscopy and Imaging Facility (Tallahassee) Operations Statistics (1/1/2006-12/31/2006)

	900	833 NB	720	600	600WB	600WB2
User Affiliation		Number of Magnet Days				
NHMFL	167	81	235	203	177	194
U.S. Universities	171	90	130	162	112	107
U.S. Government Labs	0	0	0	0	0	0
Industry	0	0	0	0	0	0
Non-U.S.	0	54	0	0	50	45
Development & Maint.	27	45	0	0	5	12
Idle	0	95	0	0	21	7
Total	**365**	**365**	**365**	**365**	**365**	**365**

Gainesville Update

Instrumentation Highlights. Last year, AMRIS (Advanced Magnetic Resonance and Imaging Spectroscopy facility) received $1.3M for infrastructure development as part of the state of Florida $10M enhancement to the NHMFL. We purchased a new 600 MHz Bruker NMR for our 1-mm HTS cryoprobe, a new console with 4 receivers and imaging and 1-mm (warm copper) spectroscopy probes for our 750 MHz wide bore, new broadband and ssNMR probes for the old 600 MHz, and new gradients for improved rodent imaging at 11.1 T. New prototype microsurface coils were also investigated in collaboration with Bruker at 600 MHz, with 750 MHz microcoils being ordered. These new coils offer improved sensitivity for very small samples. All of these have been installed and are working well. Each item has added either additional capabilities or expanded our overall capacity for users.

The 600 MHz 1-mm HTS triple resonance probe reported last year continues to work well. We have added 9 new external users from around the world who have extremely mass limited samples and need the signal to noise (S/N) ratio provided by this unique probe. The S/N per mass of sample of the 1-mm HTS

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probe is about 20-25x greater than a conventional 5-mm probe at the same field strength. This is believed to be the highest S/N per mass in the world. The new 600 MHz system with the probe is expected to be very heavily subscribed.

AMRIS also purchased a new Philips 3 T Achieva whole body scanner that was installed at the end of 2006. This instrument replaced our 3 T Siemens head magnet, and it significantly expands the range of human and large animal MRI studies that can be done at UF and the NHMFL. The system has 32 receiver channels and a large number of coils for studies of brain, heart, and muscle. We also purchased a new fMRI presentation system called Eloquence that interfaces with the 3 T and allows detailed investigations of brain activation in living people.

AMRIS Science Highlights for 2006

***In vivo* spectroscopy:** High field systems for *in vivo* magnetic resonance are often used for imaging. However, the high fields also open up completely new opportunities for studies of metabolism by measuring *in vivo* spectroscopy of metabolites. Liu and coworkers used the AMRIS 11.1 T/40 cm system to discover the effects of defective carbonic anhydrase III (CA III) on muscle function in mice by measuring ^{31}P spectra in mouse legs (**Figure 15**). By monitoring phospocreatine, ATP, and inorganic phosphate, M. Liu *et al.* were able to show that muscles lacking CA III under resting conditions had normal metabolic function but that under stress of exercise, the muscles lacking CA III had significant changes, suggesting defects in mitochondrial ATP synthesis in CA III defective animals. These results could only be discovered with high fields for increased sensitivity and with non-invasive methods allowing mice to be studied over time.

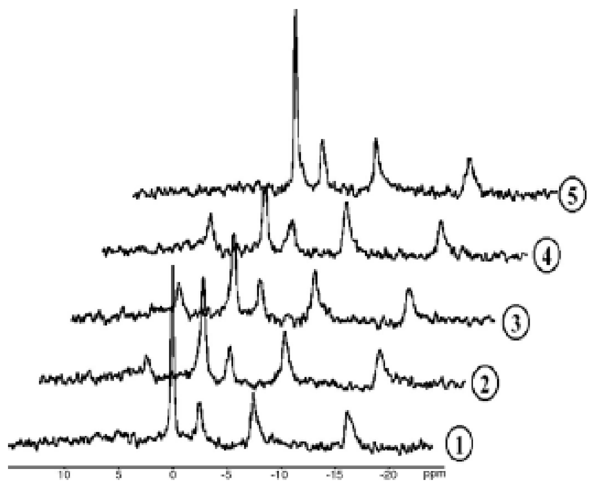

Figure 15.
In vivo ^{31}P spectra from a leg of a mouse lacking CA III. Spectra 1-4 were at 10 minute intervals following ischemia (1=0 min, 2=10 min, 3=20 min, 4=30 min). Spectrum 5 is following recovery. [M. Liu *et al., Proc. Natl. Acad. Sci. U.S.A.* **104**, 371-376 (2007)].

MRI microscopy. Brain slices provide a useful nervous tissue model to investigate the relationships between magnetic resonance imaging (MRI) contrast mechanisms and tissue microstructure. Last year saw further developments in microimaging of isolated perfused brain slices at high field strengths, where diffusion tensor imaging techniques offered new insights in nerve fiber structure in brain (1-4). However these acutely isolated tissues remain viable for only 10-12 hours. Further, when the temperature of the slices is increased to approach physiological temperatures, their viability decreases dramatically to 4 hours or less. This makes it impossible to obtain the high resolution, good SNR data we require for accurate measurement of diffusion, T2 and T1 using our protocols. Thus to study slower biological processes, and to improve slice viability at higher temperatures, we evaluated the MR characteristics for the first time of organotypic rat hippocampal slice cultures, which can be maintained for several weeks (5). A new slice perfusion chamber was designed and constructed and patented. Diffusion-weighted images of slice cultures acquired demonstrated the laminar anatomy of the hippocampus with relatively high signal-to-noise ratios (**Figure 16**). Diffusion data analyzed using a two-compartment model with exchange indicated that cultured slices have a comparable microstructure to acute brain slices and to *in vivo* brain. Immunohistochemistry indicated that slice cultures tolerate the conditions required for MRI study well. Thus these MRI of cultured tissue slices are highly amenable to correlative microscopy techniques and offer great promise for future MRI investigations of pathological tissue reorganization, molecular imaging and stem cell therapies. More importantly they offer a stable model on which to conduct experiments at higher temperatures than feasible with acute slices.

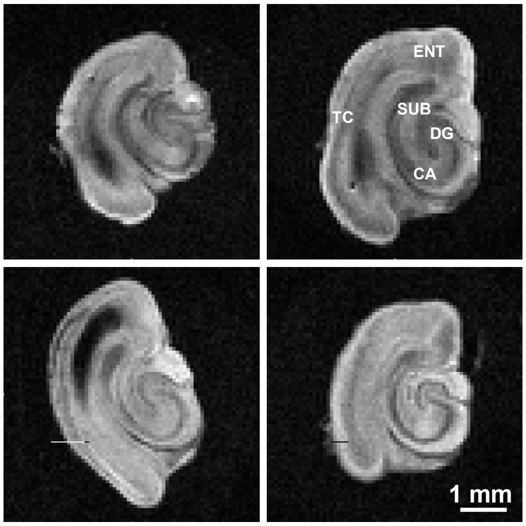

Figure 16.
78-µm in-plane resolution diffusion-weighted images (b = 2028 s/mm²) of 4 axially-cut, P9 rat hippocampal slices after incubation for 2 weeks [100-µm slice thickness, TR/TE = 1500/23.3 ms, 64 averages, scan time = 3.5 hrs]. Despite the limited thickness of these hippocampal slice cultures (~150 µm), there is sufficient MRI signal to clearly demonstrate the laminar anatomy of the hippocampus (CA), dentate gyrus (DG), subiculum (SUB), entorhinal (ENT) and temporal cortex (TC). The region of decreased signal within the slices (arrow) atrophies after slice procurement. Microbubbles noted in the images (arrowhead) were trapped underneath the cell culture membrane inserts during chamber assembly.

1. Ozarslan, E.; Shepherd, T.M.; Vemuri, B.C.; Blackband, S.J. and Mareci, T.H., Observation of anomalous diffusion in excised tissue by characterizing the diffusion-time dependence of the MR signal, *J. Magn. Reson*., **183**(2), 315-323, Dec. (2006).
2. Shepherd, T.M.; Ozarslan, E.; King, M.A.; Mareci, T.H. and Blackband, S.J., Structural insights from high resolution diffusion tensor imaging and tractography of the isolated rat hippocampus, *Neuroimage*, **1:32(4),1499-1509, Oct. (2006).**
3. Ozarslan, E.; Shepherd, T.M.; Vemuri, B.C.; Blackband, S.J. and Mareci, T.H., Resolution of complex tissue microarchitecture using the diffusion orientation transform, *Neuroimage*, **1:31**(3), 1086-103, Jul. (2006).
4. Shepherd, T.M.; Ozarslan, E.; Yachnis, A.T.; King, M.A. and Blackband, S.J., Diffusion Tensor Microscopy Indicates the Cytoarchitectural Basis for Diffusion Anisotropy in the Human Hippocampus, *AJNR*, In Press, 2007.
5. Shepherd, T.M.; Scheffler, B.; King, M.A.; Stanisz, G.J.; Steindler, D.A. and Blackband, S.J., MRI Microscopy of Rat Hippocampal Slice Cultures: a Novel Model for Studying Cellular Processes and Chronic Perturbations to Tissue Microstructure, *Neuroimage*, **30**(3):780-6 (2006).
6. Shepherd, T.M.; Scheffler, B. and Blackband, S.J., Apparatus and method for obtaining magnetic resonance imaging data from live tissue samples, Provisional patent filed, May (2005).

USER PROGRAMS

The 1-mm HTS probe [W.W. Brey *et al., J. Magn. Reson.*, **179**, 290 (2006)] works well for small molecule identification in organic solvents or D_2O. This was initially demonstrated by work by Dr. Aaron Dossey of UF and coworkers where they were able to analyze the defensive secretion from a single walkingstick insect. Previous studies using the same insect required over 1000 milkings of insects to get enough material for NMR, so the new study with the 1-mm HTS probe significantly improves our ability to identify natural biological products. Because Dossey *et al*. were able to achieve single insect resolution, they discovered that the stereochemistry of the components in the secretion changed from insect to insect and also over time. This was an unexpected result and has now led to new investigations examining the population distribution and developmental regulation of these compounds. The work by Dossey and coworkers has also spurred considerable new use in the 1-mm HTS probe, and several new investigations with NHMFL external users are underway.

Figure 17.
Cover from Dossey *et al., ACS Chemical Biology* **1**, 511-514 (2006).

Table 13.
AMRIS User Statistics for 2006 (1/1/2006-12/31/2006)

	Total	Minority	Women
Number of Projects	57		
Number of Research Groups	32		
Number of Users	209	1	22
Number of Senior Investigators, U.S.	54		10
Number of Senior Investigators, non-U.S.	5		
Number of Postdocs, U.S.	15		2
Number of Postdocs, non-U.S.	6		1
Number of Students, U.S.	22		7
Number of Students, non-U.S.	6		2

Table 14.
AMRIS Operations Statistics for 2006 (1/1/2006-12/31/2006)

User Affiliation	500 MHz	600 MHz	600 MHz(2)	750 MHz	4.7 T	11 T	3 T
NHMFL	58	83	86	130	32	22	4
U.S. Universities	270	198	15	174	138	158	145
U.S. Government Labs	3						
Industry							
Non-U.S.							
Development, Maintenance	27	68	14	51 ***	22	26	
Idle	7	16	7	10	63	49	56
TOTAL DAYS	365*	365	122**	365	255****	255	205*****

* The 500, 600, 600(2), and the 750 operate 24/7 52 weeks/year for a total of 365 days.
** The 600(2) did not start operating until September 1.
*** This includes the console upgrade on the 750
**** The 3 T, 4.7 T, and 11 T operate 9 hours/day, 5 days/week for 51 weeks for a total of 255 days due to animal care.
***** The old 3.T was shut down in mid-October.

ELECTRON MAGNETIC RESONANCE PROGRAM

Instrumentation Update. Major instrumentation developments occurred during 2006:

- Two new microwave sources were added to the homodyne and heterodyne instruments.
- A new BWO was added to the Keck based instrument extending its frequency coverage.
- Pulsed EPR capability was developed for the heterodyne instrument allowing Hahn echoes at 340 GHz and pulsed ENDOR at 240 GHz.

EMR Science Highlights for 2006

Internal Rotational Dynamics of TOAC Labeled Phospholamban in Lipid Bilayers Determined by Multifrequency EPR. The group of Y.E. Nesmelov, *et al*. (University of Minnesota Medical School) and L. Song, *et al.* (FSU Institute of Molecular Biophysics and NHMFL) used multifrequency EPR (X- and W-band) to define the rotational dynamics of phospholamban (PLB) protein domains labeled with the unnatural aminoacid, TOAC, which is also a spin label. The frequencies of the two bands differ by factor of 10 and so does the time window of motional sensitivity. X-band is sensitive to nanosecond and tens of nanoseconds motion, W-band is more sensitive to faster, subnanosecond motions. TOAC is coupled directly to the protein backbone with no rotatable single bonds and thus TOAC mobility reflects directly the mobility of protein backbone. The global analysis of X- and W-band EPR spectra of monomeric PLB defined the backbone dynamics of PLB in lipid bilayers. The group resolved two populations of PLB with different dynamics of the cytoplasmic domain: fast ($\tau_C \perp$ =0.68 ns) and nearly unrestricted motion (S = 0.11, corresponding to a cone angle of 79°), in a minor conformation (*R* state, mole fraction 0.16), and slower and more restricted dynamics, probably due to interaction with the membrane surface, in the major conformation (*T* state, mole fraction 0.84). The transmembrane domain of the phopholambam performs slow axial rotation (τ_c|| = 105 ns) and highly restricted wobbling motion ($\tau_c\perp$ = 2 ns, *S* = 0.93, corresponding to a cone angle of 18°), the same in both *R* and *T* conformations. This two-frequency analysis (**Figure 18**) offered insights that were not obtained at either frequency alone: (1) the presence of both slow uniaxial diffusion and fast wobble of the transmembrane domain, and (2) a much more precise analysis of the *T*-to-*R* (order-to-disorder) conformational equilibrium. In particular, the two-frequency analysis permitted a precise determination of the dynamic properties and the mole fraction of the minor *R* conformational state of PLB. Although this dynamically disordered component makes up only about 1/6 of the PLB population, it has been shown to be the conformation of PLB that interacts preferentially with the cytoplasmic domain of its regulatory target, the calcium pump. This interaction has profound implications for cardiac function, pathology, and therapy.

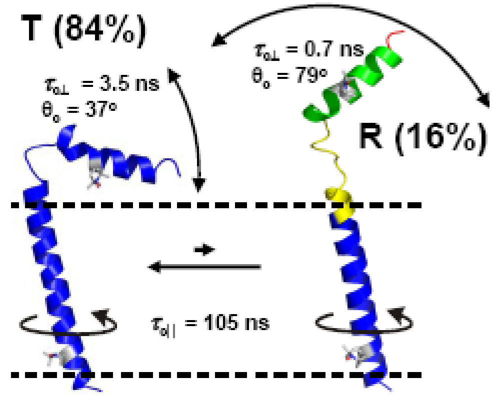

Figure 18.
Two-state model for PLB structural dynamics in a membrane. Dashed lines indicate the membrane surface. Populations of *T* and *R* conformations are 84% and 16%. The transmembrane domain performs slow uniaxial rotation and rapid wobbling motion in both PLB conformations. The cytoplasmic domain moves rapidly and almost unrestrictedly in *R* conformation, but its motion much more restricted in the predominant *T* conformation.

Calculating Slow-Motional EPR Spectra from Molecular Dynamics Using a Diffusion Operator Approach. A number of groups have utilized molecular dynamics (MD) to calculate slow-motional electron paramagnetic resonance (EPR) spectra of spin labels attached to biomolecules. Nearly all such calculations have been based on some variant of the trajectory method introduced by Robinson, Slutsky, and Auteri [*J. Chem. Phys.,* **96**, 2609-2616 (1992)]. A collaboration comprising Budil and Khairy of Northeastern University (Chemistry and Chemical Biology) and Sale and Fajer at FSU (Biological Science and Institute of Molecular Biophysics) has developed an alternative approach that is specifically adapted to the diffusion operator-based stochastic Liouville equation (SLE) formalism that is also widely used to calculate slow-motional EPR line shapes. Specifically, the method utilizes MD trajectories to derive diffusion parameters such as the rotational diffusion tensor, diffusion tilt angles, and expansion coefficients of the orienting potential, which are then used as direct inputs to the SLE lineshape program [**Figure 19**; D.E. Budil *et al., J. Phys. Chem. A*, **110**, 3703-3713 (2006)]. This approach leads to considerable improvement in computational efficiency over trajectory-based methods, particularly for high frequency, high field EPR. It also provides a basis for deconvoluting the effects of local spin label motion and overall motion of the labeled molecule or domain for work at lower frequencies. The method is validated by comparison of the MD predicted lineshapes to experimental high frequency (250 GHz) EPR spectra.

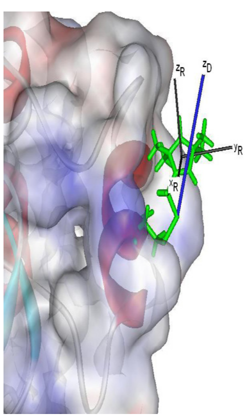

Figure 19.
Orientations of principal diffusion axes (xR,yR,zR) and director axis (zD) relative to molecular structure of the nitroxide label and the T4 lysozyme surface for site 44.

High-Frequency EPR Studies on Isomeric Pair of Binuclear, Oxygen-Bridged Iron(III) Compounds: Green and Red $[Fe(phen)]_2O(SO_4)_2{\bullet}6H_2O$. An unusual case of isomerism was discovered by Dr. A. Ozarowski of the NHMFL in two compounds of formula $[Fe(phen)]_2O(SO_4)_2{\bullet}6H_2O$ that exist in a green and in a red form. (phen = 1,10-phenanthroline). X-Ray investigations revealed that in the red form the two iron(III) ions are joined by a simple μ-oxo bridge, while in the green form there are two μ-sulfato bridges between the iron ions in addition to the μ-oxo bridge. Very large zero-field splitting, particularly in the triplet spin states (S=1) render these two antiferromagnetic complexes unsuitable for traditional EPR. Nicely defined high-field, high-frequency EPR spectra coming from the excited S = 1 and S = 2 spin states were measured at the microwave frequencies 100-400 GHz and fully interpreted.

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Multi-frequency high-field EPR study of iron centers in malarial pigments. An international collaboration comprising researchers from Poland, Switzerland, Canada, and Jurek Krzystek of the NHMFL used multi-frequency high-field electron paramagnetic resonance (HFEPR) to study the magnetic properties of hemozoin, a pigment synthesized by Plasmodium falciparum (a malarial parasite), and its synthetic analogue, β-hematin. (Fe^{III}–protoporphyrin-IX)$_2$ dimers containing five-coordinate high-spin iron Fe^{III}, S = 5/2 are the building blocks of these pigments (**Figure 20**). The fit of EPR spectra that were acquired in an unprecedented wide range of microwave frequencies of 34 and 94 GHz for hemozoin and 27 – 500 GHz for β-hematin yielded a complete set of intrinsic spin Hamiltonian parameters: D = +5.85(1) cm^{-1}, E = 0, g⊥ = 1.95(1), g||= 2.00(1). These results point to the existence of largely axial symmetry of the iron environment in the bulk phase of hemozoin and β-hematin, which is at odds with low-resolution powder x-ray diffraction results [Sienkiewicz *et al., J. Am. Chem. Soc.*, **128**, 4534-4535 (2006)]. Combining structural conclusions deduced from different experimental techniques may eventually solve the problem of the unusual chemical stability of hemozoin, which may result in new, efficient antimalarial drugs.

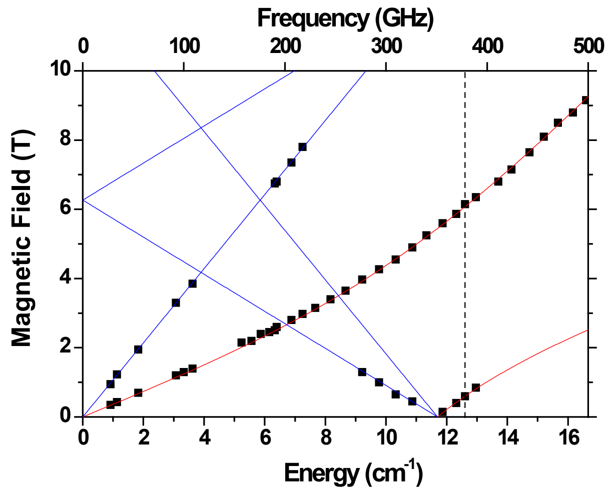

Figure 20.
Resonance field vs. quantum energy (or frequency) dependence of turning points in the powdered sample of β-hematin. Experimental points are marked by squares. Lines were simulated using best-fitted spin Hamiltonian parameters as in text. Blue lines: parallel turning points; red lines: perpendicular turning points. For clarity, only those transition branches are plotted that are actually observed experimentally.

Table 15.
EMR User Statistics for 2006
(1/1/2006-12/31/2006)

Senior Personnel	49
Postdocs	6
Graduate Students	17
Undergraduates	2
Total Users	**74**

Table 16.
EMR Facility Operations Statistics for 2006
(1/1/2006-12/31/2006)

Number of Projects	**34**
Projects by Discipline	
Chemistry	23
Biochemistry	7
Physics	4
Projects Summary	
External Projects	18
Affiliated Labs	7
NHMFL Projects	9
USA-based Projects	27
Non-U.S.-based Projects	7
Projects by Instrumentation	
Keck Magnet	8
Bruker 680	8
Homodyne/heterodyne SPE	18

FOURIER TRANSFORM ION CYCLOTRON RESONANCE (FT-ICR) MASS SPECTROMETRY

During 2006, 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 Program. The facility features six staff scientists who support instrumentation, software, biological applications, environmental applications, and user services as well as a machinist, technician, and several rotating postdocs who are available to collaborate and/or assist with projects.

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 make 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) has been added to improve resolution of small molecules. Simultaneous infrared multiphoton (IRMPD) and electron capture dissociation (ECD) is 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. 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 and instrumentation development. The 9.4 T magnet is currently used for field desorption and elemental cluster analysis. The 7 T magnet is optimized for volatile mixture analysis (*Rev. Sci. Instrum.*, **77** 025102 (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.

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. Sites and nature of post-translational modification (e.g., glycosylation, phosphorylation, etc.) are readily determined. 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.

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. 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.

Table 17.
FT-ICR Mass Spectrometry Facility User Statistics (1/1/2006-12/31/2006)

	Total	Women	Percent Women
Total Number of Projects	90		
Number of Research Groups	83		
Total Number of External Users	141	37	26
Number of Senior Investigators, U.S.	59	13	22
Number of Senior Investigators, non-U.S.	29	6	21
Number of Postdocs, U.S.	7	3	43
Number of Postdocs, non-U.S.	4	1	25
Number of Students, U.S.	23	14	61
Number of Students, non-U.S.	3	1	33
Number of Collaborators, U.S.	4	1	25
Number of Collaborators, non-U.S.	4	0	0
Total Number of Visitors to ICR Facility	70	26	37
Total Number of Users Sending Samples	84	16	19
Remote Users	3	1	33

Table 18.
FT-ICR Operations Statistics, 9.4 T, 220 mm Magnet, for 2006

	9.4 T, 220 mm	Percent
User Affiliation	**Number of Magnet Days**	
NHMFL, UF, FSU, FAMU, LANL	115	32
U.S. Universities	91	26
U.S. Government Labs	2	1
Industry	56	15
International	56	15
Development & Maintenance	21	5
Idle	24	6
Total	**365**	**100**

Table 19.
FT-ICR Operations Statistics, 9.4 T active shield Magnet, for 2006

	9.4 T, active shield	Percent
User Affiliation	**Number of Magnet Days**	
NHMFL, UF, FSU, FAMU, LANL	42	12
U.S. Universities	1	0.3
U.S. Government Labs	0	0
Industry	0	0
International	12	3
Development & Maintenance	63	17
Idle	247	67
Total	**365**	**100**

Table 20.
FT-ICR Operations Statistics, 14.5 T Magnet, for 2006

	14.5 T	Percent
User Affiliation	**Number of Magnet Days**	
NHMFL, UF, FSU, FAMU, LANL	156	43
U.S. Universities	21	6
U.S. Government Labs	0	0
Industry	10	3
International	15	4
Development & Maintenance	63	17
Idle	100	27
Total	**365**	**100**

GEOCHEMISTRY PROGRAM

In 2006 the **Geochemistry program** concentrated on using existing instrumentation for geochemical and environmental research. 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 allows rapid and precise analysis of lithium isotope ratios as well as the elemental concentrations in a large variety of geological materials.

We also acquired a new generation multi-collector ICP-MS with a laser ablation system. The laser ablation is already operational and is used in a number of projects and has attracted some new outside users. The research ranges from trace element analyses of Hawaiian mantle xenoliths to *in-situ* analyses of black corals. A highlight of our research involving laser ablation includes trace elemnt analyses of meteorites. Extinct radionuclides in the early solar system left behind isotope footprints from which a precise chronology of events can be constructed about how our Solar System developed. In the work of Humayun *et al.*, the new Plasma Analytical Facility of the Geochemistry group was utilized to study the distribution of the elements hafnium (Hf) and tungsten (W) in selected components of meteorites. A clear post-formation disturbance of the extinct chronometer, Hf-182, was found in the samples on which previous age determinations were based. New samples were identified for subsequent measurements to provide an improved chronology of the formation of the early Solar System by Hf-W dating techniques.

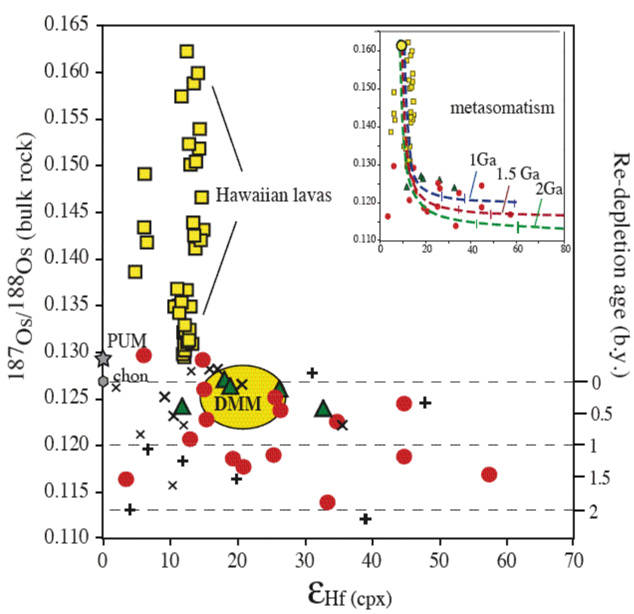

Figure 20.
$^{187}Os/^{188}Os$ vs. ε_{Hf} isotope compositions of the SLC peridotites (circles) compared with Hawaiian lavas (squares). Triangles are peridotites from other Hawaiian localities. Right vertical axis shows the corresponding Re-depletion ages in billion years for a given $^{187}Os/^{188}Os$ ratio. The 0, 1 and 2 billion year depletion ages and corresponding $^{187}Os/^{188}Os$ ratios are connected with dashed lines for clarity). Error bars are smaller than the symbol sizes. The $^{187}Os/^{188}Os$ range of the depleted MORB mantle (DMM) field is defined by the Os isotopic composition of abyssal peridotites and encompasses all previous estimates of DMM ($^{187}Os/^{188}Os=0.126 \pm 0.004$ (1 sd)). Also plotted for comparison are cratonic peridotite xenoliths from Siberia (X) and the Wyoming craton (crosses: Homestead kimberlite, Montana). Inset figure shows the compositions generated by metasomatism of a 1, 1.5, or 2 Ga old depleted peridotite by a Hawaiian-type melt. The calcualations assume a Hawaiian melt with $^{187}Os/^{188}Os = 0.16$, 0.3 ppm Os, $\varepsilon_{Hf} = 10$, and 2.7 ppm Hf. We also assume a peridotite with: 3 ppm Os (in the bulk rock), 0.37 ppm Hf (in cpx), $^{187}Os/^{188}Os = 0.113$, 0.1165 and 0.12 and $\varepsilon_{Hf} = 60$, 81 and 121 for the 1, 1.5 and 2 Ga old ages, respectively.

Another highlight of our research is the discovery of ancient mantle under Hawai'i [Bizimis *et al*, to be published, *Earth Plan. Sci. Lett.* (2007)], based on Salt Lake Crater (SLC) xenoliths. **Figure 20** shows the depleted and correlated Hf and Os-isotope compositions of the peridotites. The extent of the depletion requires a 1 to 2 Ga age. This age is strong evidence that the peridotites are part of the plume component under Hawai'i and are not part of the lithosphere. Mineral equilibria place the pressure and temperature estimates for these samples at less then 70 km depth indicating that the Hawai'ian plume has eroded at least 30 km of the oceanic lithosphere.

In order to make room for the new instrumentation we have retired and dismantled the Isolab. In the place of the Isolab we have now constructed a small laboratory with excellent climate control. The Isolab was retired in May; construction started after an extensive design phase in August and was completed in early December 2006. The new laboratory houses both a multi-collector ICP-MS (Thermofisher Neptune) and a single collector ICP-MS (Thermofisher ELEMENT2). At the end of 2006 both instruments were in the process of being installed.

Table 21.
Mass Spectrometers and Configurations for Geochemical and Environmental Research, as of January 2007

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	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, 1/1/06 through 12/31/06

	Total	Minority	Female
Number of Research Projects	31	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 Magnet Day Statistics 1/1/05 through 12/31/05

Number of Magnet Days	Isolab	262/RPQ	ICP-MS ELEMENT	DELTA XP	Total
NHMFL, UF, FSU, FAMU, LANL	60	170	210	150	590
U.S. University	20	40	30	20	110
U.S. Govt. Lab	-	-	20		20
U.S. Industry	-	-	-		-
Overseas	-	-	-		-
Maintenance	20	20	40	60	140
Total	**100**	**230**	**300**	**230**	**860**

Access to Magnet Lab Facilities

User access to the NSF-funded NHMFL Continuous and Pulsed Field Facilities is controlled by a proposal and review process that is administered by the Directors of the Continuous and Pulsed Field 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 High 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.

USER PROGRAMS

Magnets & Materials

A central enabling feature of the NHMFL's success to-date and its prospects for success in the future is the availability of unique high-performance magnet systems. The magnets built to-date are the product of decades of work developing materials and technologies suitable for high-performance magnet applications. As we move forward, pursuing ever higher fields while controlling costs, continued hand-in-glove developments on these fronts will be essential for success.

2006 was a year of major strategic developments in Magnets and Materials at the laboratory. In the pulsed magnet program, the 60 T long-pulse and the 100 T multi-shot magnets were delivered to the user community. In addition, the capacitor-driven pulsed magnet development activity was relocated to Los Alamos, enabling an increase in floor-space by a factor of 2.5 as well as better integration into user operations and the motor-generator-driven magnet program.

In the cable-in-conduit magnet program, an $11.7M grant was received from NSF to construct a Series-Connected Hybrid (SCH) for the NHMFL. In addition a $1.3M grant was received, also from NSF, for a Conceptual and Engineering Design of a horizontal SCH with a conical bore suitable for neutron scattering experiments at the Spallation Neutron Source. In addition, a contract for $8.7M with the Hahn-Meitner Institute in Berlin for construction of an SCH similar to the SNS version was negotiated and awaits signature.

A major new initiative to develop the technology of superconducting magnets beyond Niobium-based low temperature superconductors was initiated in 2006. This program builds on our earlier 2003 success inserting a 5 T Bi-2212 solenoid into the 20 T Bitter solenoid background field. This High-Temperature Superconducting (HTS) coil used Bi-2212 tape conductors, while the new effort will be initially focused on using Bi-2212 round wires to develop a robust technology capable of achieving the National Research Council panel COHMAG (Committee on High Magnetic Fields) goals of superconducting magnets well beyond the capability of Niobium. An early target aimed at verifying the capabilities of the new technology is the design and construction of conductors and coil prototypes suitable for a 7 T insert coil to operate in an 18 T background field as a demonstration of the materials and magnet technologies required for future 25-30 T general-purpose and NMR-quality superconducting systems.

The materials program for future magnets and superconducting magnets is greatly amplified by the move of the Applied Superconductivity Center (ASC) under the leadership of David Larbalestier from the University of Wisconsin at Madison to the NHMFL at FSU. The ASC brings 2 professors, 5 career scientists, 10 postdocs and students, and 4 other staff positions with more than 200 years of combined experience in superconducting materials development, characterization and understanding, along with ~$2M in a year in outside grants and ~$4M of superconductor fabrication and characterization equipment, to the NHMFL. This intellectual capability, along with 25,000 square feet of new space provided by FSU, is already being employed in the development of the 7 + 18 T HTS insert. The research program of the ASC covers all useful superconducting materials from Nb for SRF cavities through Nb-Ti, Nb_3Sn, MgB_2, $Bi_2Sr_2CaCu_2O_x$ (Bi-2212), $(Bi,Pb)_2Sr_2Ca_2Cu_3O_x$ (Bi-2223) to $YBa_2Cu_3O_{7-x}$ (YBCO coated conductors). In addition to the contributions already made to the HTS development program, members of ASC have joined with NHMFL and ITER staff to work on the strain-sensitivity of Nb_3Sn strands needed for the SCHs. We expect that the addition of the ASC to the NHMFL will create a uniquely synergistic capability for impacting the development of materials for high-performance magnets.

The Shaw building, directly across the street from the NHMFL main building, now houses the Applied Superconductivity Center.

MAGNETS & MATERIALS

PULSED MAGNETS

100 T

The 100 Tesla Multi-Pulse Magnet System was assembled and successfully commissioned in 2006 (**Figure 1** provides a vertical section). This magnet system is the result of a long-term partnership project jointly funded by the U. S. Department of Energy – Office of Basic Energy Science and the National Science Foundation. Milestone non-destructive operation to 88.9 T was achieved in October 2006. This established a world record field for a pulsed magnet that can be operated in a repeatable manner. Repeated, non-destructive operation of the system with original components in the 85 T to 90 T range continued through the year (typical pulse field vs. time shown in **Figure 2**). Science experimentation inside the magnet started in December 2006 at the NHMFL Pulsed Field Science Facility located at Los Alamos National Laboratory. Measures to extend the useful life of the platform field coil set (outer coil set) were studied and will be proven with further fatigue testing of the conductor from the heats/campaign lots used in the outer coil set.

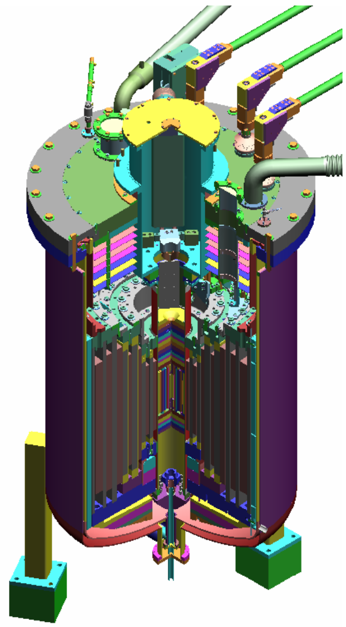

Figure 1. Section of 100 T Multi-pulse magnet.

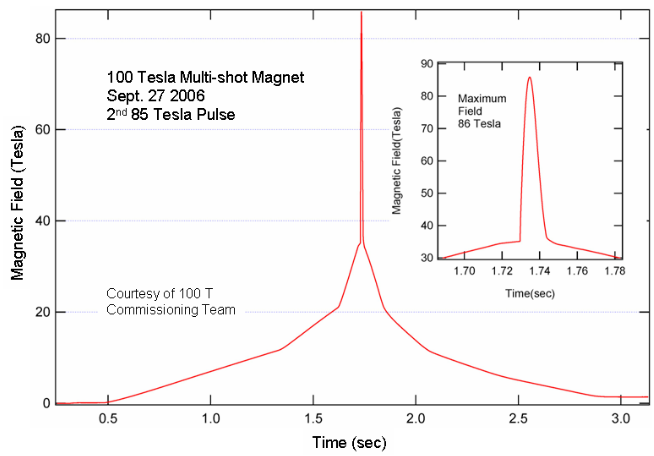

Figure 2. Field vs. time for typical pulse of 100 T Multi-shot magnet.

60 T LONG-PULSE

The assembly and commissioning of the 60 Tesla Long-Pulse Mark II magnet was completed in 2006. Operation to 55 T was reached on August 30, 2006. This controlled power, variable waveform magnet is currently in use for science experimentation. The 60 T Long-Pulse Mark II incorporated minor changes from the original design to improve electrical insulation and reduce stress concentrations in the reinforcing shells. It also benefited from extensive quality control and proof testing of its constituent materials. Analyses coupled with results of additional fatigue testing of the magnet's conductor were used to develop more optimum operating current and field distributions to extend the life of the magnet.

CAPACITOR-DRIVEN MAGNETS

Capacitor-driven magnet development in 2006 focused on inserts for the 100 T system. The first major milestone was the completion of a stand-alone 80-T prototype magnet. This prototype was intended to simulate the physical conditions an insert magnet would encounter during peak field operations at 105 T. It was successfully tested to a peak field of ~80 T and cycled 10 times in June, establishing a new world record for pulsed magnet performance. The prototype work has allowed us to validate the limits of insert operation and develop new design criteria for future stand alone high-field pulsed magnets for the Magnet Lab.

The insert for the 100 T Multi-Pulse Magnet will eventually provide 60 T in the 40 T background provided by the outsert. The insert was shipped from Tallahassee to LANL in June of 2006. Non-destructive operation to 88.9 T was achieved in October 2006, setting another new world mark for non-destructive pulsed magnet operation. The insert field performance for first-phase 90 T commissioning was 53.6 T; which is 15% above specification. Repeated non-destructive operation of the system with original components is continuing in the 85 T to 90 T range.

Presently design activities are underway to develop two magnet systems for the Pulsed Field User Facility. The projects are: (1) the development of a reliable fast cycling pulsed user magnet that will operate in the 70 T – 75 T range, (2) the implementation of quick cool technology that will reduce magnet recovery times to 5 min. Additional R&D entails high strength composite development, and the successful implementation larger high-strength high-conductivity wires suitable for generator-driven magnet systems.

RESISTIVE MAGNETS

HIGH-HOMOGENEITY UPGRADE

In July 2006 the high-homogeneity magnet in Cell 7 (the 32 mm bore, 50 ppm magnet) was upgraded. Previously it provided 23 T for extended periods and 24.5 T for up to one hour. The new magnet was tested in August 2006 and can operate at 28 T indefinitely. This is now the highest-field, 50 ppm magnet in the world. The new magnet is based heavily upon the 35 T, 32 mm bore magnet completed in 2005 with current-density grading to improve the spatial homogeneity. NMR maps have been performed confirming that the homogeneity is slightly better than the previous version of the magnet. This magnet is not only expected to provide a unique facility worldwide for low-resolution NMR, it is also 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.

SPLIT MAGNET MODEL COIL

To date, all high field resistive magnets at the NHMFL have been solenoids with cylindrical bores. A project is presently underway at the laboratory to design and build a split magnet providing field perpendicular to the access tube and using two of the Magnet Lab'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. The magnet will include two interchangeable inserts, one for scattering experiments and one for rotation experiments. 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 horizontal plane, there will be 4 ports, each of which subtends 45° as shown in **Figure 3**. In this manner, by properly positioning the source, one can obtain scattering data at any desired angle. 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.

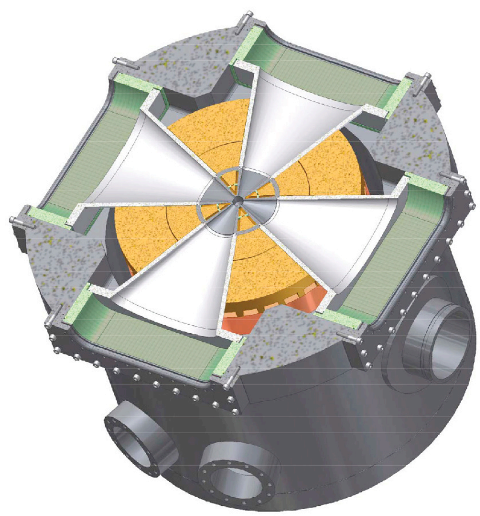

Figure 3.
Mid-plane of split magnet showing 4 scattering ports of 45 each.

MAGNETS & MATERIALS

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 2nd 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 design of the first insert coil is complete and fabrication is starting. Phase III (User Magnet) will start after the model coils are tested and performance projections are made. We will then have a specifications review with the user community and start detailed design followed by fabrication of the user magnet system including housing, coils, platform, optics, rotation equipment, power cables, etc. It is important to note that this split magnet requires significantly more technology development than previous new resistive magnets have required.

CABLE-IN-CONDUIT MAGNETS

NHMFL SERIES-CONNECTED HYBRID

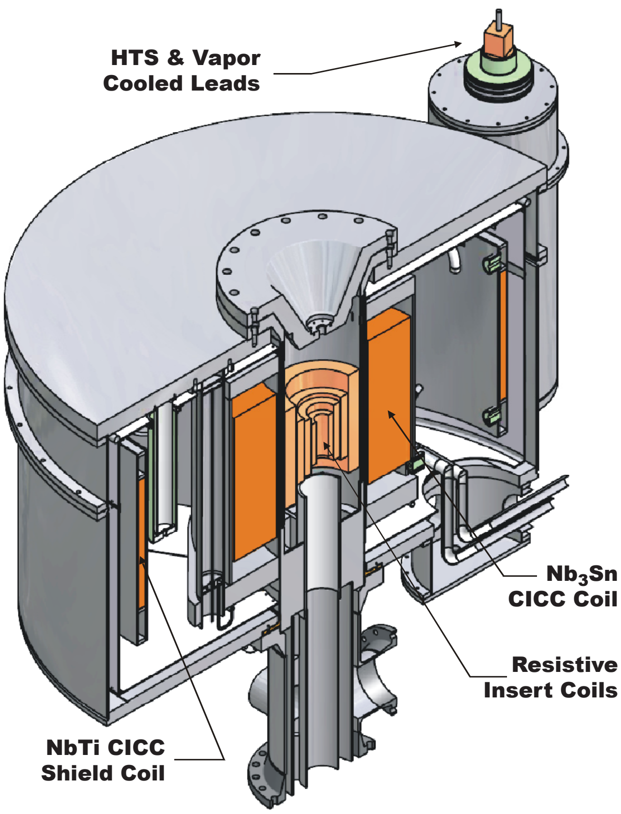

Figure 4.
Vertical section of the Series-Connected Hybrid magnet for the NHMFL.

In 2004, the NHMFL kicked off a two-year Conceptual and Engineering Design (CED) phase of the Series-Connected Hybrid (SCH) magnet project. The program objectives were to provide the design and specifications for the magnet and related subsystems, perform associated development tasks, and establish cost estimates for construction of the system.

In many ways, the magnet system (shown in **Figure 4**) is an evolution of the 45 T Hybrid magnet. New developments in magnet technology are being pursued, however, to improve the homogeneity, field stability, and operating cost. 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 improved resistive magnet current grading and water-cooled resistive shims. By connecting the resistive insert in series with the superconducting outsert, the outsert is never energized without the return flux of the insert reducing its peak field. This results in a smaller, lower cost outsert than is required for a traditional hybrid using separate power supplies for the insert and outsert. In addition, the series connection results in a higher inductance to resistance ratio and reduced field ripple compared with an all-resistive magnet. Techniques to further enhance the field stability are under development through collaboration with researchers at Penn State University. Advances in this development have been demonstrated in the resistive Keck magnet resulting in a 13 dB improvement in ripple compared with the older ripple-suppression system. This phase was extended to continue with the field stabilization techniques through July of 2007. With the primary objectives of the CED phase being met, however, a proposal was submitted to NSF for the construction of the magnet system.

A site visit on the construction proposal was held in April of 2006. With the projected system capability of producing a high field and high homogeneity, NMR is projected to be the principal science application. A second, interchangeable insert will be designed and built to attain maximum field and for use in condensed matter physics, materials chemistry, biophysics, and biology experiments. Reviewers pointed out that this magnet "uniquely bridges the performance gap between resistive and superconducting magnets" because many user experiments require a field that is as stable and uniform as that which the SCH will provide and a field strength that is higher than the 21.1 T of the 900 MHz ultra-wide bore (UWB). Funding was approved in the fourth quarter of 2006 with a budget of $11.7M. The award covers the construction costs of the resistive and superconducting coils, cryostat, and helium refrigeration system, as well as installation, probe development, and commissioning. The second insert will be funded from the core NSF grant for the NHMFL.

HYBRIDS FOR NEUTRON SCATTERING FACILITIES

The SCH is well suited for neutron scattering experiments. It can provide fields greater than what can be achieved by all-superconducting magnets and for lower infrastructure and operating costs than all resistive magnets. In October 2005 a proposal was submitted by Johns Hopkins University, the Massachusetts Institute of Technology, the Spallation Neutron Source (SNS), and the NHMFL for funding a CED of an SCH suitable for neutron scattering experiments at the Spallation Neutron Source (SNS). Funding was approved in September of 2006. During this two-year study, the four partnering institutions will develop technical specifications for the magnet, beam-line, and sample environment. Over a two-year period, the engineering design of the magnet system will be performed at the Magnet Lab and development of the user facility plan, science program, and beam-line activities at JHU, MIT, and SNS respectively.

The costs schedules of hybrid magnets are dominated by the costs and schedules of development, design and fabrication of the superconducting coils. To minimize costs and lead times, the magnet for SNS will employ the same superconducting coils as the magnet for the NHMFL. However, the SNS cryostat will need to be horizontal rather than vertical and the resistive insert will

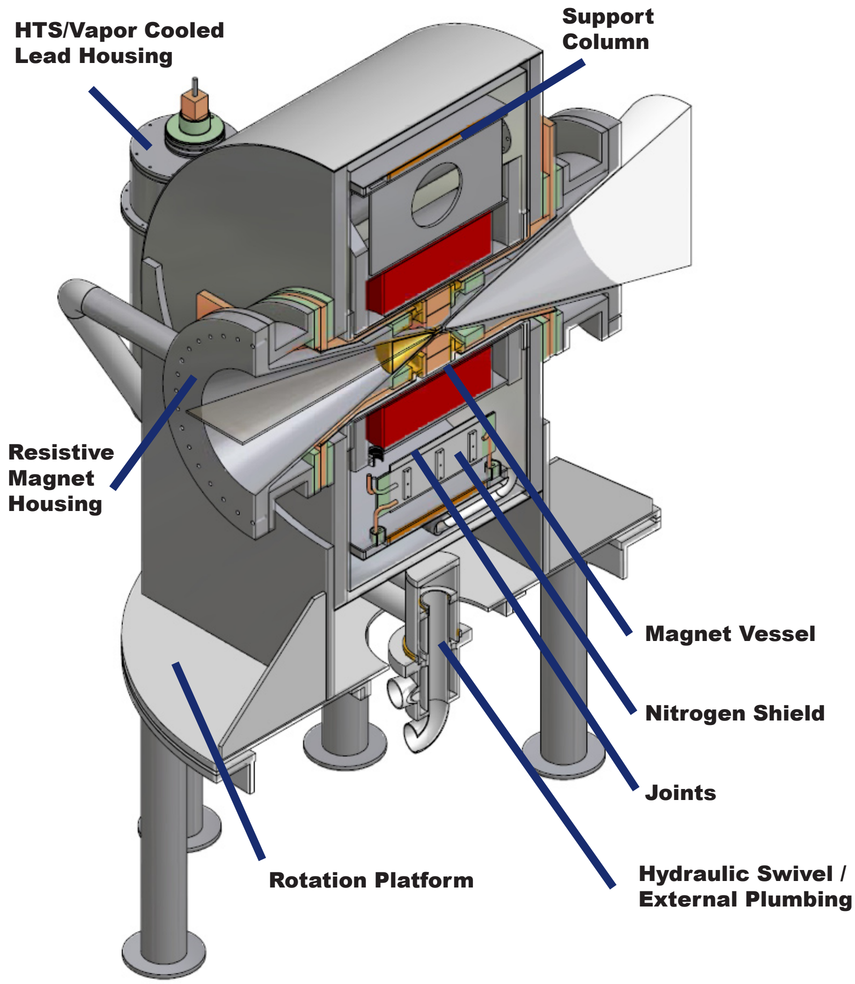

Figure 5.
Vertical section of the Series-Connected Hybrid Magnet and Cryostat for the SNS and HMI.

need to provide conical access as shown in **Figure 5**. The external helium refrigeration, superconducting outsert coil, quench protection, power system, and cooling water system are all comparable or scaleable to the power demands of the insert. The magnet systems would be installed into an available neutron guide hall at the SNS.

In addition, the collaboration with the Hahn Meitner Institute in Berlin continued to the point that we expect to sign a construction agreement in early 2007 for an SCH very similar to the SNS version.

The technology developed for the NHMFL's 45 T Hybrid magnet has set the framework for the series-connected hybrids. Now an evolution of that design and the development of new features are allowing the creation of new instruments for high field NMR, chemical, and biological research and neutron scattering experiments.

HIGHER-FIELD SUPERCONDUCTING MAGNETS

It is now clear that Nb_3Sn conductor technology will not permit operation much beyond 22 or 23 T and that higher field superconducting magnets demand new materials that are neither Nb-Ti nor Nb_3Sn. The way forward was shown in 2003 with the NHMFL 5 T insert coil that provided a total field of 25 T when tested in the background field of the 20 cm bore, 20 T Bitter magnet. This success was based on fairly primitive thin tape conductors of Bi-2212. Bi-2212 technology has now matured such that several-hundred filament, round wires carry the highest overall wire current density of any superconducting material above 20 T. Thus, this conductor technology is the basis for the development of a pre-prototype 7 T insert coil planned for 2008. With the relocation of the ASC to the NHMFL in 2006, the primary 2006 activity involved formulating a joint ASC/MS&T program that would address the key issues for making high field Bi-2212 solenoids. Despite the high critical current density in short samples of the conductor, significant challenges remain to incorporate Bi-2212 into user magnets. A partial melt of the Bi-2212 is vital to achieving high J_c but this occurs at almost 900°C and Jc is extremely sensitive to the exact melt temperature and time. Bi-2212 leakage through the silver matrix in this step sometimes occurs and needs to be understood and controlled. It is being addressed through fundamental understanding of the materials processing issues and through alternative heat treatment protocols.

In 2006, the "react-wind-sinter" approach was proposed whereby the heat treatment is separated into two stages. In the first stage, the conductor is partial-melt processed but not yet wound into final shape. After completing the partial-melt stage, which is the most temperature, time and bending-stress sensitive portion of the heat treatment, the conductor is wound into a coil and returned to the furnace for solid-stated sintering. Thus, leakage may be avoided by partial-melting before winding (the trouble with wind-and-react), while the bending strain in the conductor is reduced by sintering at high temperature after winding (the primary problem with react-and-wind). Preliminary tests on short conductors indicate promise for this approach, which will be scaled-up to test coils. An electromechanical study of Bi-2212 tape, completed in 2006, has shown that the strain dependence of the conductor is directly linked with conductor inhomogeneity. Quench studies performed in 2006 on Bi-2212 conductors and a Bi-2212 coil constructed by Oxford Instruments have shown that Bi-2212 can be protected but that quench propagation is extremely slow. Quench failure limits are being studied in conductors and coils, and alternative detection systems considered. The program is now ready for test coil production with significant conductor ordered from industrial vendors. We anticipate that 2007 will lead to considerable progress in selecting a design for the 18 + 7 T coil project. As noted later, parallel work with YBCO coated conductors and MgB_2 is providing potential alternatives to Bi-2212 technology should unanticipated problems with the present round-wire technology appear.

We held a special one-day workshop at the NHMFL on Bi-2212 conductor technology and on the magnets that could be made from it in conjunction with the Low Temperature Superconductor Workshop in November 2006.

OTHER MAGNET SYSTEMS & COMPONENTS

HTS CURRENT LEAD DEVELOPMENT

Construction of a pair of binary current leads was essentially completed in 2006. These leads are intended as replacements for the existing leads in the 45 T Hybrid and serve as half-current prototypes for those needed for the Series Connected Hybrids (SCH) under development at the NHMFL. The resistive section consists of a nitrogen-cooled pierced copper sheet that is jelly-rolled and sheathed in stainless steel. The HTS section consists of 481 parallel superconducting $(Bi,Pb)_2Sr_2Ca_2Cu_3O_x$ tapes in a thermally resistive Ag-Au matrix soldered to a stainless steel sheet that serves as an electrical shunt and a structural support.

An extensive test plan has been developed to fully test the leads with the dual purpose of qualification for use in the 45 T Hybrid and to evaluate the suitability of the design for the SCH. Installation of these leads to the 45 T Hybrid is scheduled for the summer of 2007. It should result in a reduction of the heat load to the 4 K helium bath from about 9 W/lead at 8 kA to 3.5 W/lead. This should allow the Hybrid cryogenic system to be operated on one of the available two liquefiers, instead of on two, thereby introducing redundancy and greatly reducing the workload on the operators.

Nb_3Sn UNDULATOR DEMONSTRATION

The planned beamline upgrade of the Advanced Photon Source (APS) at Argonne National Laboratory requires higher-performance undulators. In 2004 the NHMFL was funded by the APS to study the feasibility of replacing the existing permanent-magnet-based undulators with Nb_3Sn-based superconducting ones. In 2005 a follow-on project was started to demonstrate the required technology including 2 yokes of 10 racetrack minicoils and a quarter-length model. In 2006 we completed fabrication and testing of the mini-coils. Two different design approaches were used for the two yokes to examine candidate conductors, ease of manufacture, manufacturing tolerance stack up, and the resultant impact on field quality. One yoke consisted of a single piece of iron and conductor while the other employed a modular approach using ten individual coils and iron pole pieces.

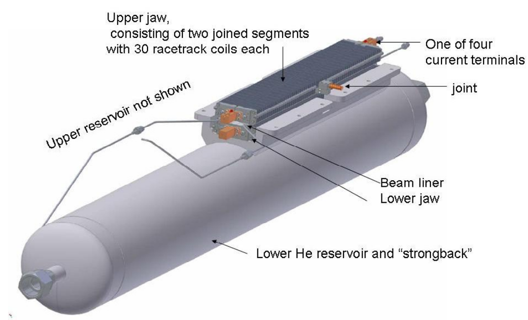

Figure 6.
Schematic view of the quarter-length model undulator.

Upon testing these in a helium bath we found that the relatively large filament-size of internal-tin conductor and multiple high-current joints resulted in insufficient stability for this application. The quarter-length model has now been designed and is being fabricated using powder-in-tube conductor (with much smaller filament size) and two segments (a single joint) in each of the two jaws (see **Figure 6**). The cryogenic structure has been simplified from previous versions and the windings brought closer to the beam. The beam-liner will be clamped between the jaws, leaving a small gap between the windings and the central part of the beam liner. A helium-filled tube in the beam-liner intercepts heat that would otherwise be conducted between the windings and the central part of the beam-liner that is most susceptible to heating by beam losses. The quarter-length model will be tested in 2007.

21 T FT-ICR SUPERCONDUCTING MAGNET

Presently the world's highest field Fourier Transform Ion Cyclotron Resonance (FT-ICR) superconducting magnet system is 14.5 T located at the Magnet Lab in Tallahassee. Based on potential scientific opportunities afforded by higher-field FT-ICR[1] and the success of the NHMFL's 105 mm bore 900 MHz (21 T) NMR magnet system, the NHMFL has identified a 21 T FT-ICR system as one of its next persistent magnet targets.

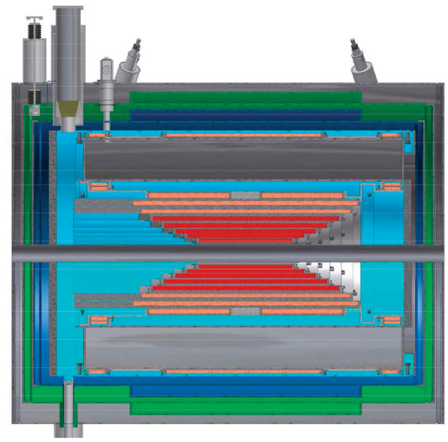

Figure 7.
Conceptual design of 21 T FT-ICR magnet.

In 2005 commercial magnet suppliers were consulted regarding the feasibility of a 21 T system. They were focused on making the step to 18 T. Consequently, the NHMFL, with support from the National Science Foundation, the Pacific Northwest National Laboratory and the Korean Basic Science Institute, undertook a conceptual design effort of a 21 T system that was completed in early 2006. Later in 2006 a commercial solicitation was conducted in which three of the top suppliers of high-field persistent magnet systems participated. The NHMFL's baseline magnetic design was offered as an option in the solicitation while alternate designs based on commercial experience were encouraged. The commercial solicitation catalyzed an outstanding response which resulted in proposals from three of the top suppliers of high-field, persistent superconducting magnet systems for a 21 T FT-ICR system. These proposals provided the pricing, schedule and level of guarantees that could be expected from the commercial sector and will be used to solicit funding for construction of multiple 21 T systems.

HIGH-STRENGTH MATERIALS DEVELOPMENT

High field magnets generate large forces or stresses. The stresses frequently exceed the strength of most of the normal conductors, superconductors, and structural materials. Therefore high strength materials are required and most of efforts in 2006 were made in characterization and development of high strength conductors and structural materials.

High strength conductor development is focused on both pure Cu and composite conductors. Obtaining large size billets of high strength conductors for the Florida-Helix magnet is of particular importance. One approach for achieving high strength in a large billet is by Equal-Channel Angular Extrusion, which introduces severe plastic deformation (SPD) in pure Cu. Bulk ultra fine-grained (UFG) materials produced by SPD usually have high strength, but relatively low ductility at ambient temperatures. The low ductility of this UFG material has been attributed to an insufficient strain hardening rate due to an inability to accumulate dislocations. In fact, for single-phased UFG materials, where dislocation slip is the primary deformation mechanism, a long-standing fundamental question concerns the feasibility of developing microstructures offering both high ductility and strength. One solution appears to be fine twinned materials in addition to fine grains. Researchers at the NHMFL and Los Alamos National Laboratory in USA, and at Ufa State Aviation Technical University in Russia have collaborated in an effort to plastically deform UFG copper in liquid nitrogen. The ductility of the UFG has been doubled while further increasing its strength. The enhanced ductility was caused by a high density of pre-existing deformation twins and a large fraction of high-angle grain boundaries formed during cryogenic deformation. This procedure provides a possible strategy for increasing the ductility of UFG materials without any concurrent loss in strength for bulk high strength conductors.[2]

We have also been pursuing the development of high strength Nb_3Sn type composite superconductors. Nb_3Sn type superconductors suffer from high strain sensitivity. Under magnet operation, the high magnetic fields and current densities achieved in the latest generation of strands also exert high electro-magnetic forces on the individual strands, potentially leading to severe irreversible degradation in the current carrying capacity. Deformation of the strands under load can

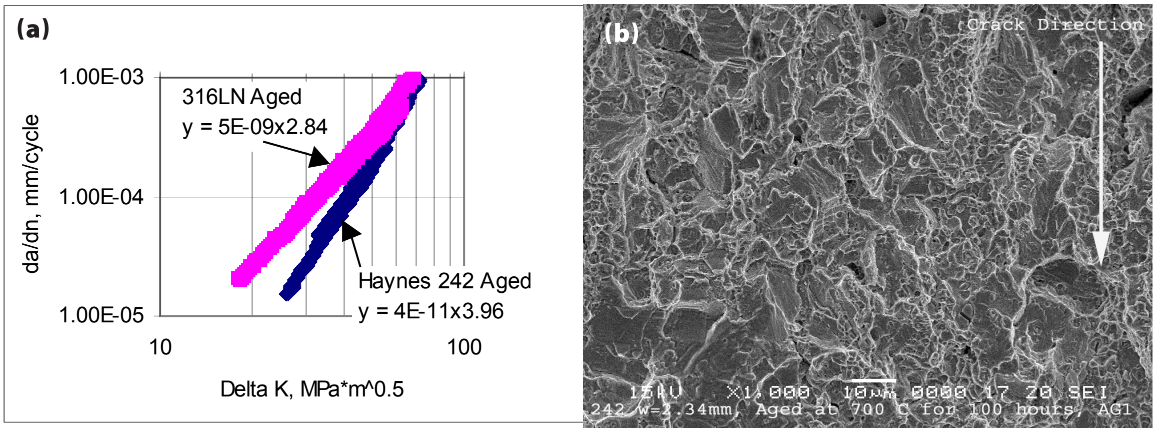

Figure 8.
Fatigue crack growth rate (FCGR, da/dn) data (a) and fracture surface image for both modified 316 LN and Haynes 242 in the aged condition. The materials were tested at 4 K. Fig. a indicates that Haynes 242 has lower FCGR or long fatigue life at relatively low stress intensity factor ranges. The fracture surface in (b) indicates the materials have ductility at 4 K.

be reduced by incorporating strengthening techniques into the composite design. By co-deformation of Al_2O_3 dispersion strengthened (DS) Cu +Nb and Cu +Nb, we have fabricated DS CuSn-Nb_3Sn wire and Cu-Nb_3Sn wire. The DS CuSn-Nb_3Sn reinforced wires show higher mechanical strength and higher J_c at 18 T than regular wires. The improvement in properties was attributed to dislocation pining by the nano-scale Al_2O_3 particles. The unique characteristic of this technology is that the Nb_3Sn content in the strengthened wire remains the same as the normal superconductor wire. Therefore, both mechanical strength and J_c are enhanced.

We made significant progress in our characterization of two candidate structural materials for jacket material for the hybrid magnets using cable-in-conduit conductor (CICC) as described earlier in this chapter, in the CIC Magnets section. The jacket provides the primary containment of the liquid helium coolant and is typically also the primary structural component for the magnet coils. These combined functions impose requirements for strength, toughness, fatigue crack resistance, and fabricability. When the CICC uses Nb_3Sn as the superconductor, the conduit alloy must also retain good mechanical properties after exposure to the superconductor's reaction heat treatment (~675°C). In addition to tensile strength, we have generated data for cryogenic fracture toughness and fatigue crack growth rate of a modified 316LN and a Cr-Mo-Ni based super-alloy (Haynes 242) at 4 K before and after exposure to the reaction heat treatment for Nb_3Sn (**Figure 8**). These alloys are presently being considered as candidates for use in the next-generation series connected hybrid magnet for the NHMFL. Both alloys have adequate fatigue and fracture properties for CICC application, while the Cr-Mo-Ni alloy has higher elastic properties of modulus and lower thermal expansion. The high modulus is desired for magnet design and is attributed to the large amount of high modulus elements, i.e. Mo and Ni, in the alloy. The age-hardening conditions for Cr-Mo-Ni alloy are compatible with the reaction conditions for Nb_3Sn conductors, because the reaction temperature and time for Nb_3Sn provide a beneficial heat treatment procedure that enhances the strength of the Cr-Mo-Ni alloy by formation of the ordered N_2Mo phase.

We have also developed new characterization capabilities: We have added (1) a 4 K crack growth rate measurement capability for MT (Middle section of centrally cracked Tensile tests) type samples that are specially useful for estimating the fracture toughness and fatigue life of the conduit materials for cable-in-conduit magnets; and (2) physical property measurement capabilities for characterization of thermal conductivities, specific heat, and electrical resistivities. We also improved our ability to make critical current measurements under strain in high field for low temperature superconductors.

SUPERCONDUCTING MATERIALS DEVELOPMENT

An extensive program of superconducting materials development moved to Tallahassee with the ASC. The Nb_3Sn work at ASC has been consistently supported for many years by the Department of Energy through the Office of High Energy Physics and the Office of Fusion Energy Science. A key issue studied in 2006 was the propensity of high Nb_3Sn matrix fraction conductors, which have the highest J_c values, to be more susceptible to filament fracture. This issue has risen to prominence due to cyclic degradation damage in the ITER model coils and some of the test magnets now being made for the ITER testing and procurements. An indentation test has been developed that addresses the fundamental fracture mechanics of the filament bundle. ITER has expressed strong interest in this work. In **Figure 9** we contrast the behavior of a high J_c Nb_3Sn composite cross-section under tensile and compressive bend strain when a diamond hardness indent is made on the surface.

MgB_2 work is supported by DOE Office of Fusion Energy Sciences and by the NSF through a multi-university (ASC at University of Wisconsin and FSU, Pennsylvania State University, Arizona State University, and the University of Puerto Rico Mayaguez) Focused Research Group. Our broad goals are to understand the upper critical field (H_{c2}) and the critical current density and the influence of the two weakly interacting gaps in MgB_2 on these parameters. The situation is fundamentally different in films and bulks at the present time. Carbon appears to be the most effective raiser of H_{c2} and in bulk MgB_2 it appears to substitute for boron, raising H_{c2} by about a factor of 2 to ~35 T in the low temperature limit. Using SiC nanoparticle additions we were able to raise H_{c2} to ~44 T, the present world record in bulk samples, though this was recently matched by a LANL group working with C nanotube doping of MgB_2. But the real paradox is that C-doped thin films made by our Penn State colleagues using the HPCVD process can achieve over 70 T. The two-gap theory of H_{c2} developed by Gurevich explains this by very strong π-band scattering. Extensive characterizations by XRD or HRTEM show that there is strong nanoscale disorder in such films that may also be associated with interstitial insertion of C into the MgB_2. Another issue that is very important for MgB_2 is control of connectivity. Unlike the HTS cuprates where grain boundaries are inherent obstacle to current flow once their misorientation exceeds about 5°, there is no such intrinsic barrier to current in MgB_2. Yet the connectivity of polycrystalline MgB_2 forms is often very compromised, as evidenced by anomalously high normal state resistivities and critical current densities that are only 1% of the depairing current density, rather than the 10% or more seen in most superconductors and clean MgB_2 films. Careful study of polycrystalline forms by high resolution SEM and TEM has shown that oxygen incorporation makes many obstacles, especially by forming insulating grain boundary "necklaces" of MgO or other more complex Mg-B-O-(Si) phases. By careful attention to processing, it has been possible to considerably advance J_c in bulk forms in 2006.

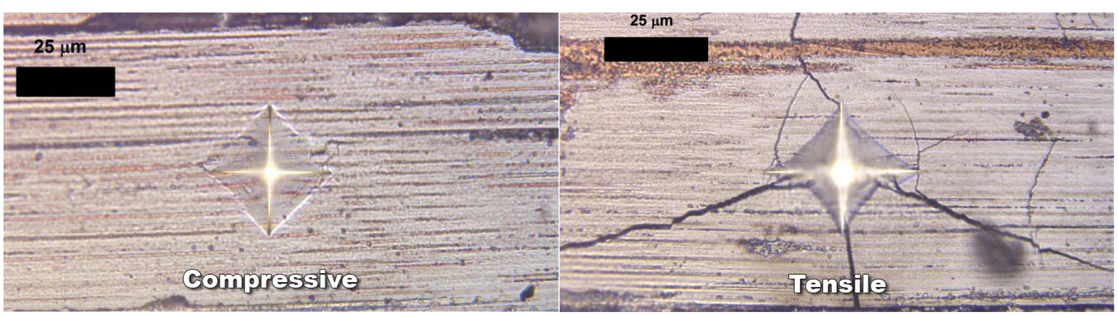

Figure 9.
Contrasting fracture behavior of a high J_c Nb_3Sn composite under compressive (left) and tensile (right) bending. The diamond hardness indent on the compressive side does not induce brittle fracture whereas catastrophic cracking across the filament is observed on the tensile side.

A major effort is also underway with the understanding and application of YBCO coated conductors under support from the Department of Energy, Office of Electricity, and the Air Force Office of Scientific Research (AFOSR). Much of this work is concerned with understanding the local J_c, which remains highly variable in most HTS forms, even in YBCO coated conductors where the grain texture has been made very good to avoid large degradations of the current density at misoriented grains. Direct imaging of the obstructive effects of grain boundaries using a low temperature laser scanning microscope (built at ASC) was demonstrated in 2006 using a system working in a 5 T field that allowed visualization of the gradual disappearance of the electric field at grain boundaries with increasing field. Deconstruction of the local current density in very high current (~500 A/cm width) coated conductors was performed by sequential ion milling experiments that revealed the development of material degradation effects that limit J_c. Since sequential milling can only be done from the free YBCO surface side, we also developed "atomic beam surgery" techniques using a focused ion beam (FIB) to cut away submicron bridges so as to enable deconstruction form both interfaces. These unique techniques have enabled progressive deconstruction of the differing roles played by vortex pinning (which sets the ultimate limit of critical current density in any superconductor) and connectivity variation from point to point that gates this vortex pinning critical current density. Another thrust of our milling experiments has been to deduce the nature of vortex pinning in today's best YBCO films. We find striking differences between films containing insulating nanoparticles and those that are well made "science" films, even though both types of film have very comparable self field current densities. When films without nanoprecipitates are thinned, thermal fluctuations greatly degrade the high field J_c and the irreversibility field, but films containing dense nanoprecipitate arrays show little or no degradation. These two types of film represent two extreme types of vortex pinning – in many science films, vortices are deformed by the weak background pinning landscape and remain continuous from top to bottom of the film. By contrast, films with dense arrays of strong pins can only depin (and thus define Jc) by bowing out of individual segments of the vortex line from each pin, much as plasticity is provoked when dislocation lines bow out in a Frank-Read source formed between strengthening nanoparticles. Collectively these characterizations, many carried out in collaboration with the Wire Development Group (a team involving American Superconductor Corporation, Argonne National Lab, Los Alamos National Lab, Oak Ridge National Lab and the ASC), the Air Force Research Lab and SuperPower are showing the way toward a further doubling of the performance of coated conductors.

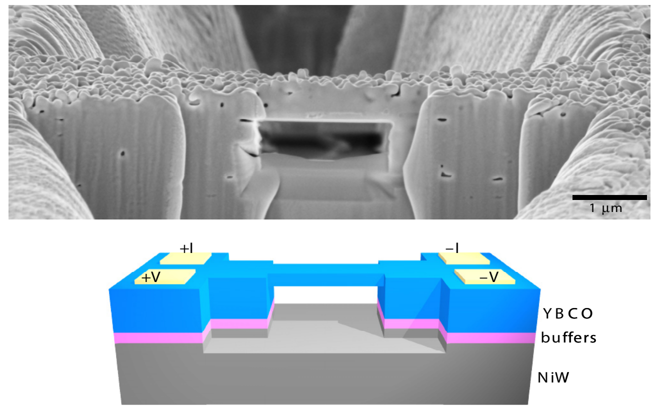

Figure 10.
A FESEM image (top) of the FIB-cut link that isolated the top layer of the YBCO film for transport measurement. Below the FESEM image is a schematic of the same link showing the geometry of the current and voltage pads.

All of these materials developments are capable of being transferred to the high field superconducting magnet programs of the Magnet Lab as the individual conductor technologies mature. Two workshops associated with the above work were held at the NHMFL in late 2006. The three-day Low Temperature Superconductor Workshop attracted 95 attendees from labs, industry, and universities to discuss Nb-base and MgB_2 superconductors. The Wire Development Group met in December and attracted about 10 members of the multilaboratory collaboration to report on their latest coated conductor results.

[1] Committee on Opportunities in High Magnetic Field Science, "Opportunities in High Field Science", National Academies Press, Washington, D.C., pg. 62-63 (2005).

[2] Zhao, Y.H.; Bingert, J.F.; Liao, X.-Z.; Cui, B.-Z.; Han, K.; Sergueeva, A.V.; Mukherjee, A.K.; Valiev, R.Z.; Langdon, T.G. and Zhu, Y.T., *Simultaneously Increasing the Ductility and Strength of Ultra-Fine-Grained Pure Copper,* Adv. Mater., **18**, 2949–2953 (2006).

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 Magnet Lab 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 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.

Eleven IHRP solicitations have now been completed with a total of 373 pre-proposals being submitted for review. Of the 373 proposals, 186 were selected to advance to the second phase of review, and 80 were funded (21.4% of the total number of submitted proposals).

2006 SOLICITATION AND AWARDS

The 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 two-stage review process (pre- and full proposals) has been handled by means of an online system designed specifically for IHRP.

Of the 32 pre-proposals received, the committee recommended that 10 be moved to the full proposal stage. Of the 10 full proposals, 7 (plus an additional proposal that was not submitted in the regular 2006 solicitation) grants were awarded. A breakdown of the review results is presented in the following tables.

Table 1.
IHRP Proposal Solicitation Results 2006

Research Area	Pre-Proposals Submitted	Pre-Proposals Proceeding to Full Proposal	Projects Funded
Condensed Matter Science	11	5	4
Biological & Chemical Sciences	17	4	3
Magnet & Magnet Materials Technology	4	1	1
Total	**32**	**10**	**8**

Table 2.
IHRP Funded Projects from 2006 Solicitation

Lead P.I.	NHMFL Institution	Project Title	Funding
Alexander Gurevich	FSU	*Establishing the Limits of High-Field Superconductivity in Two-Gap Magnesium Diboride Films and Heterostructures*	$175,929
Jurek Krzystek	FSU	*Probing Zero-Field Splitting of High-Electron Spin Systems with Frequency-Domain Magnetic Resonance Spectroscopy*	$185,303
Andrew Ozarowski	FSU	*High-Field EPR and Mössbauer Studies on the Spin Crossover and Light-Induced Excited Spin State Trapping in Iron(II) Complex Compounds*	$123,200
Denis Markiewicz	FSU	*General Invariant Strain Analysis: Experimental Verification and Analysis Development*	$180,016
Stephen McGill	FSU	*Time-Resolved Studies of Coupled Dynamics In Manganites*	$239,741
John Eyler	UF	*Infrared Spectra of Gaseous Ions: Extending Spectroscopic Capabilities of the FT-ICR-FEL Facility*	$190,682
Boris Maiorov	LANL	*Vortex Matter in $YBa_2Cu_3O_7$ Films with Strong Competing Types of Disorder*	$186,200
Vivien Zapf	LANL	*Construction of a Magnetic Force Magnetometer to Study Boson Localization in a Quantum Magnet*	$186,200

2007 SOLICITATION

The 2007 Solicitation Announcement will be released on March 16, 2007. Awards will be announced by the end of the year.

RESULTS REPORTING

To assess the success of the IHRP, reports were requested in December 2006 on grants issued from the solicitations held in the years 2000 through 2005, which had start dates respectively near the beginnings of years 2001 through 2006. 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.

Two tables summarize the results. The success of the program is evident from the wide-ranging enhancements that have resulted and from the production of peer-reviewed publications, many in high impact journals. These include 3 articles in *Nature*, 3 in *Nature Physics*, 20 in *Physical Review Letters*, and 4 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.
List of Reported Facility Enhancements

- Contribution to ^{1}H ^{19}F double resonance NMR probe development
- Cryogenic deformation process for making materials for magnets
- Development of resonant ultrasound capability
- Development of thermal conductivity and specific heat measurements for high magnetic fields
- "Digital lock-in" data acquisition instrumentation
- Emission IR and THz magneto-spectroscopy probes
- Femtosecond pump-probe beamline spectroscopy for NHMFL
- High current fast pulsed IV measurements
- High-resolution magic-angle spinning (HRMAS) NMR probe for the 25 T Keck magnet
- Low E magic angle spinning probe for biological solid state NMR at 750 MHz
- Microwave connected rotating stages for dilution fridges
- NMR instruments for 45 T hybrid
- NMR probes for 900 MHz
- Picosecond streak camera for performing time-resolved studies of photoluminescence
- Point contact spectroscopy set up
- Pressure cells, tunnel diode oscillator measurement capability
- Pulsed EPR to 336 GHz (record)
- Quasioptical high frequency spectrometer for dc resistive magnets
- rf contactless measurement set up for pulsed fields
- Two-axis rotator used in the hybrid
- Ultralow temperature ultrasound measurement setup, plus work towards Kapton thermometer

Table 4.
Publications (including accepted for publication) Resulting from IHRP Grants, as of December 2006 Reporting

Acta. Mater.	2
Adv. Mater.	1
App. Phys. Lett.	4
Biochemistry	1
Biochim. Biophys. Acta.	1
Chem. Phys. Lett.	1
IEEE Trans. Appl. Supercond.	7
Inorg. Chem.	1
Inst. of Phys. – Conf. Series	1
Int. J. of Mod. Phys. B	2
J. Am. Chem. Soc.	4
J. Biomol. NMR	2
J. Exp. and Theor. Phy.	1
J. Low Temp. Phys.	6
J. Magn. Reson.	8
J. Mod. Optics	1
J. Mod. Phys. B	3
J. Phys. – IV	1
J. Phys. – Condens. Mat.	2
J. Phys. – Conference Series	1
Macromolecules	1
Magnet. Reson. Chem.	1
Materials Science and Engineering	1
Materials Science Forum	1
Nanotechnology	1
Nature	3
Nature Physics	3
Phil. Mag.	2
Physica B	3
Physica E	5
Phys. Rev. B	21
Phys. Rev. Lett.	20
Polyhedron	2
Rev. Sci. Instrum.	3
Solid State Commun.	1
Solid State NMR	1
Synthetic Met.	1
Conference Proc.	40

IN-HOUSE RESEARCH PROGRAM

Education

The Center for Integrating Research & Learning (CIRL) provides the infrastructure through which all Magnet Lab educational programs are facilitated. Pat Dixon, director; Jose Sanchez, assistant director; Carlos Villa, outreach coordinator; Crissie Grove, graduate research assistant; and Richard McHenry, teacher in residence, form the core group that provides classroom and community outreach, designs and facilitates professional development for K12 teachers, forms partnerships with other departments at Florida State University and other universities, conducts educational research and develops curriculum. Center staff work to further the educational mission of the laboratory, as well as to further the state and national science education agendas.

K12 PROGRAMS

CIRL reaches over 9,000 K12 schoolchildren in 10 counties in Florida and Georgia through classroom visits, tours of the Magnet Lab, school and community events, and its education Web site, ***www.magnet.fsu.edu/education/***. Carlos Villa, outreach coordinator, conducts school programs that help students of all ages grasp complex concepts of magnets and magnetism, optics, and electricity. All materials are developed to support state standards as well as the National Science Education Standards. Scientists from the lab continue to serve as consultants, mentors, and judges for school fairs, competitions, and science clubs.

CIRL again hosted a ***Middle School Mentorship Program*** for 13 talented seventh graders who worked with 10 laboratory scientists on research projects ranging from the thermal expansion of copper, measurement and perspective in microscopy to measuring the speed of a golf ball with Doppler radar. Results from a recent survey of former middle school mentorship participants indicate the power of such a program by the number of students who went on to study science through college and graduate school as well as the number of students who count this experience as changing how they think about science. Former mentors were also surveyed and were unanimously supportive of continuing such programs. Gang Cao, associate professor in the Department of Physics and Astronomy at the University Kentucky, writes *"The program was clearly a spectacular success as many of them have pursued science as their career in college and beyond, and most impressively, some of them have gone into the very same areas in which they were mentored."*

Comet Tales, a new addition to the CIRL outreach menu, is a two- to three-week science inquiry unit created around the NASA Stardust mission. Fifteen local classrooms will be selected to participate in this unit based on teacher interest and application. Five each of fifth, sixth, and ninth grade teachers will be given supplies and assistance to complete the NASA-approved unit "Technology for Studying Comets" with their students. In this unit students work cooperatively, creating collection devices appropriate for use in a Stardust-like mission. During the unit, Mabry Gaboardi, a NASA representative, and Jose Sanchez, assistant director of CIRL, will visit each classroom to introduce comet properties, answer questions, and stimulate student interest. Upon completion of "Technology for Studying Comets," each participating teacher will choose one student to represent his/her classroom at the Magnet Lab for one day as "Stellar Students." These students will tour the laboratory, where they will observe actual research activities in the Cosmochemistry Laboratory and meet a NASA researcher. At the end of the day, parents and teachers of the students will be invited for refreshments and a short presentation.

Imagine an 8th grade girl experimenting with magnets and learning the principles of physics at the Magnet Lab. Imagine that same girl snorkeling beside a researcher from the Florida State University Marine Laboratory investigating hermit crab habitat in the Gulf of Mexico. The next day she will analyze the nutritional content of the Florida panther's diet at the Tallahassee Museum of History and Natural Science.

The Magnet Lab—through the ***Dragonfly TV SciGirl*** project—imagines many possibilities for that 8th grade girl. With a grant from Dragonfly TV, the NHMFL will be hosting two 2-week summer camps for rising 6th-10th grade girls. SciGirls I engages a new group of 15 middle school aged girls to explore a variety of science careers and experiences; SciGirls II focuses on older girls who will shadow undergraduates at the Magnet Lab.

In 2006, over 1,000 students and members of the general public toured the facility and over 3,600 people attended the February 2006 13th Annual Open House. Designed to translate the science conducted at the laboratory and to give people a "behind-the-scenes" look at a national laboratory, tours and the Open House challenge all of us to engage the public in real-world science.

UNDERGRADUATE PROGRAMS

Research Experiences for Undergraduates (REU) is a staple CIRL program. In summer 2006 there was unprecedented support for mentoring talented undergraduates from six states, Puerto Rico, the U.S. Virgin Islands, and the Bahamas. Sixteen students conducted research with 13 scientist-mentors at the Tallahassee and Los Alamos sites.

The final posters of the 2006 Tallahassee REUs are available online: ***www.magnet.fsu.edu/education/reu/program/2006/index.html***

In September 2006, REU participants Xiomaris Cotto, Danish Haque, Cindy Figueroa presented their research at the University of Florida Research Experiences for Undergraduates poster session in Gainesville. In addition, Ms. Cotto, University of Puerto Rico-Cayey, won first place in the senior category at the 17th RISE Program Annual Research Symposium and won best poster presentation out of almost 100 poster presentations at the XVII Undergraduate Research Symposium 2006. She also presented her research at the Annual Biomedical Research Conference for Minority Students in California. This is just one example of the high achieving students attracted to the NHMFL REU program.

Table 1.
Research Experiences for Undergraduates, Class of 2006

Tallahassee Research Location

Participant	School	Research Area	Mentor
Nicholas Brown	Colorado School of Mines	Performance Characterization of Integrated Reinforcement for High-Field Superconductors	Tom Painter
Xiomaris Cotto	University of Puerto Rico-Cayey	Fluorescent Protein Fusions an Advanced Imaging Tool for Cell Biology	Mike Davidson
Shalton Evans	The College of the Bahamas	The Linear Expansion/Contraction of Spectra and Kevlar at Low Temperatures	Eric Palm Ju Hyun
Cindy Figueroa	University of Puerto Rico	Age Dating for Esquel Meteorite Using Trace Elements Analysis and Mass Spectrometry Techniques	Roy Odom
Lyna Fredericks	University of the Virgin Islands	DNA Cloning and Live Cell Imaging of Fluorescent Protein Fusions	Mike Davidson
Danish Haque	University of Houston	Electrodeposition of Fe-Cu Multilayer for Development of High Strength Conductors	Ke Han
Tomi Herceg	Princeton University	Cu Powder Low Pass Filters for Cryogenic Applications: Manufacturing and Study with Wide Range Spectrum Analyzer	Irinel Chiorescu

EDUCATION

Tallahassee Research Location (cont.)

Participant	School	Research Area	Mentor
Shiela Jones	Pacific Lutheran University	Electromagnetic Simulation and Comparison of NMR Coil/Capacitor Designs to Lessen RF Heating through Minimization of E/B Ratios	Bill Brey
Jose Medina	Universidad Del Turabo	Penetration Depth Measurements Using Time Domain Reflectometry	Stan Tozer
Nelton Roldan	University of Puerto Rico	Resonant Ultrasonic Spectroscopy of $KTa_{1-x}Nb_xO_3$ (x = 0.12)	Alexei Suslov
Eden Steven	University of Wisconsin	Electric Field Effects on Quasi 1D Organic Conductor $(TMTSF)_2PF_6$	Jim Brooks
Mark Wartenbe	Florida State University	Third Generation Electron Gun	Jim Cao
Dereje Worku	NC A&T State University	Frequency Drift with Temperature in a Tunnel Diode Oscillator (TDO)	Stan Tozer

Los Alamos Research Location

Participant	School	Research Area	Mentor
Paul Egan	Oklahoma State University	Detailed Magnet Calibrations for Magnetization Measurements of Ferrimagnetic Nanoparticles Resonant Ultrasound Experiment at Low Temperatures and High Magnetic Fields of a Quantum Magnet Exhibiting Bose-Einstein Condensation	Alex Lacerda
Ryan Murphy	Brown University	Visible Optics for the Single Turn Magnet System	Chuck Mielke
Mack Warren	Colorado State University	Commissioning of the 60 Tesla Long Pulse Magnet (60TLP)	Chuck Mielke

PROFESSIONAL DEVELOPMENT

Once again, the Research Experiences for Teachers (RET) program attracted quality educators from around the country. Fifteen K12 teachers worked with eight mentors on research projects designed to immerse teachers in real-world science. The Center provided seminars, colloquia, and workshops to help teachers translate the new content, vocabulary, and culture of a science laboratory to the classroom. Magen Ballard from Kentucky and Jeri Martin from Florida participated in the poster session at the University of Florida. Martin's collaboration with Jim Brooks has resulted in a consulting position with a Florida engineering firm, just one example of how participation in an RET program contributes to teachers' professional development.

The final presentations of the 2006 RETs are available online: ***www.magnet.fsu.edu/education/ret/program/2006/index.html***

Table 2.
Research Experiences for Teachers, Class of 2006

Participant	Home Town	Research Area	Mentor
Jennifer Abrams	Greenville, NC	Resonant Ultrasound Spectroscopy	Alexei Suslov
Magen Ballard	Williamsburg, KY	Structural Behavior of Spectra at Low Temperatures	Eric Palm
Stephen Clark	Mayo, FL	Resonant Ultrasound Spectroscopy	Alexei Suslov
Kelly Dennis	Monticello, FL	Meteorite Comparisons Using the Environmental Scanning Electron Microscope	Mabry Gaboardi
Tracy Doyle	Pittsburgh, PA	MR Microimaging at 7 T: Pulse Sequence Development & Implementation	Bill Brey
Michelle Ellis	Gastonia, NC	Meteorite Comparisons Using the Environmental Scanning Electron Microscope	Mabry Gaboardi
Melvin Figueroa	Fort Lauderdale, FL	Comparative Analysis of Impurities in Beach Sand Using EPR	Johan van Tol
Kerry Kittredge	Greenacres, FL	Clay: The Super Absorber	Bob Goddard
Tynica Lewis	Greensboro, NC	Meteorite Comparisons Using the Environmental Scanning Electron Microscope	Mabry Gaboardi
Ramchand Maharaj	Margate, FL	MR Microimaging at 7 T: Pulse Sequence Development & Implementation	Bill Brey
Jeri Martin	Bagdad, FL	Fluxgate Magnetometer with Respect to Detection of Ferrite Distortions in the Earth's Magnetic Field	Jim Brooks
Marcia Martin	Pembroke Pines, FL	Third Generation Electron Gun	Jim Cao
Bobby Williams	N. Palm Beach, FL	Clay: The Super Absorber	Bob Goddard
Amanda Witters	Tallahassee, FL	Meteorite Comparisons Using the Environmental Scanning Electron Microscope	Mabry Gaboardi
Marcia Young	Arlington, TX	Comparative Analysis of Impurities in Beach Sand Using EPR	Johan van Tol

The Center conducted ***Myths and Misconceptions***, a summer institute for 25 area K-9 teachers. Based on the popular Discovery Channel program, teachers investigated topics such as floating and sinking, buoyancy and density, force and motion, kinetic and potential energy, animal myths and misconceptions, and magnets and magnetism. Teachers who attend CIRL's workshops are overwhelmingly positive about their experience and continue their association with the Magnet Lab through the Ambassador Program.

CIRL's research agenda is expanding with the addition of a 5-year research project that is being directed by Sherry Southerland, FSU associate professor in science education. Two RET programs, one at the Magnet Lab and one directed by Ellen Granger in the FSU Office of Science Teaching Activities, will serve as laboratories for research on how features of RET programs influence teacher behavior. Funded by NSF, ***this study will provide a model of best practices and programs*** that result in teachers conducting inquiry-based science activities in their classrooms. Two graduate students will be assigned to the Magnet Lab program, and Director Pat Dixon (co-PI on the grant) will oversee the research component for CIRL. In addition, the study begun in spring 2006 by Crissie Grove, graduate research assistant, and Pat Dixon, was presented at the Association for Science Teacher Education in January 2007 and at the National Association for Research in Science Teaching in April 2007.

The newly designed ***SuperNet*** program brings together scientists and teachers from the Magnet Lab and the affiliated Applied Superconductivity Center. For the inaugural SuperNet workshop, FSU Professors of Physics Nick Bonesteel and Vlad Dobrosavljevic and Director of the Applied Superconductivity Center David Larbalestier provided lectures and hands-on training to middle and high school science teachers. These day-long workshops, offered periodically throughout the year, give teachers new knowledge and the skills to adapt what they learn for use in their classrooms. Ultimately, SuperNet's goal is to establish new learning communities—nationwide—of scientists, teachers, and students who explore the "emergent universe" together through inquiry-based, hands-on activities.

TEACHER IN RESIDENCE

The new Teacher in Residence program joins the CIRL and the Magnet Lab with the local school district and aims to improve the teaching of science in Leon County. Richard McHenry, a 31-year veteran of Leon County schools with National Board Certification currently fills the post. McHenry has taught biology, earth science, and chemistry at the high school level and is working with CIRL to develop physical science workshops for elementary, middle, and high school teachers. These workshops will focus on improving the teaching on science through the increase of content knowledge, the amount of hands-on activities, and the use of the inquiry approach.

McHenry working with high school students.

McHenry also plans to design a "science coach" model to provide support for elementary educators teaching science. As a science coach, McHenry will be available to visit and observe teachers working with their students. He will then discuss different strategies with the teacher that will facilitate better understanding by the students of the different science concepts covered in the particular grade level curriculum and covered by the high stakes test.

Ongoing concern by scientists, educators, and the general public points to the importance of the educational mission of the Magnet Lab. The Center for Integrating Research & Learning seeks to fulfill that mission with a broad range of programs and a talented and committed group of educators.

Collaborations

Magnet Lab researchers and staff work hard to develop partnerships and collaborations with the private sector, federal agencies and institutions, and international organizations to develop a wide variety of magnet-related technologies and advance other projects that bring technologies closer to the marketplace. Indeed, engaging in these kinds of research and development activities is part of the National Science Foundation's charge to the Magnet Lab.

PRIVATE SECTOR ACTIVITIES IN THE UNITED STATES

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.

(NHMFL contact: Ke Han, MS&T)

B&B Microscopes, Pittsburg, PA.

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

(NHMFL contact: Mike Davidson, Optical Microscopy)

BakerPetrolite, Sugarland, TX.

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

(NHMFL contact: Ryan Rodgers, ICR)

Bioptechs, Butler, PA.

The lab is involved with Bioptechs 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 Corp., Billerica, MA.

The Magnet Lab's NMR instrumentation program and Bruker Biospin collaborate on the development of low-E probes for solid-state NMR in heat sensitive biological samples, such as proteins.

(NHMFL contacts: William Brey and Peter Gor'kov, NMR)

Chroma, Rockingham, VT.

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

(NHMFL contact: Mike Davidson, Optical Microscopy)

Cooke Corp., Romulus, MI.

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

(NHMFL contact: Mike Davidson, Optical Microscopy)

Covance Research Products, Berkeley, CA.

Covance is a biopharmaceutical company involved with research and diagnostic antibody production. Lab scientists are working with Covance researchers to examine immunofluorescence staining patterns in rat and mouse brain thin and thick sections using a wide spectrum of antibodies.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Diagnostic Instruments, Sterling Heights, MI.

Scientists at the lab 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 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 Magnet Lab that explain its cutting-edge technology in image sensor design. Scientists at the lab 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 Magnet Lab are working with applications specialists at Hamamatsu to field test the company's cooled and electron multiplied scientific CCD camera systems. Demanding applications in quantitative image analysis and high resolution images are being explored as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Haynes International, Inc., Kokomo, IN.

This manufacturer of specialty alloys is collaborating with the lab's 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 Magnet Lab. 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, LANL)

MBL International, Woburn, MA.

Scientists at the lab are collaborating with MBL to develop new fluorescent proteins for live-cell imaging applications. These include both optical highlighters and FRET biosensors.

(NHMFL contact: Mike Davidson, Optical Microscopy)

M.D. Anderson Cancer Center, Houston, TX.

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

(NHMFL contacts: Mark Emmett, ICR, Carol Nilsson, ICR, and Mike Davidson, Optical Microscopy)

Media Cybernetics, Silver Spring, MD.

Programmers at the lab are collaborating with Media Cybernetics to develop imaging software for time-lapse optical microscopy. In addition, the lab 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 Magnet Lab to develop educational tutorials on the use of fluorescent probes in optical microscopy.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Nikon USA, Melville, NY.

The lab maintains close ties with Nikon on the development of an educational and technical support microscopy Web site, including the latest innovations in digital imaging technology. As part of the collaboration, the lab is field testing new Nikon equipment and developing new methods of fluorescence microscopy.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Olympus America, Melville, NY.

The lab is developing an education/technical Web site centered on Olympus products and will be collaborating with the firm on the development of a new tissue culture facility at the Tallahassee facility. This activity will involve biologists at the Magnet Lab and will feature Total Internal Reflection Fluorescence microscopy.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Omega Optical, Brattleboro, VT.

The lab is involved in collaboration with Omega to develop interactive tutorials targeted at education in fluorescence filter combinations for optical microscopy. Engineers at Omega work with Magnet Lab 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 Magnet Lab 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 the lab's 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)

Pfizer Global Research & Development, San Diego, CA.

Dr. Michael Greig at Pfizer is collaborating with the ICR program in a novel application of supercritical fluid chromatography (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 Greig is a contributor.

(NHMFL contact: Mark Emmett, ICR)

Photometrics (Roper Scientific, Inc.), Tucson, AZ.

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

(NHMFL contact: Mike Davidson, Optical Microscopy)

Photonics Instruments, Pittsfield, MA.

The lab's microscopy research team is collaborating with engineers at Photonics Instruments to develop photoactivation techniques for widefield and spinning disk confocal microscopy. This collaboration involves live-cell imaging techniques.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Prior Scientific, Inc., Rockland, MA.

Prior is a major manufacturer of illumination sources and filter wheels for fluorescence microscopy. The Magnet Lab is collaborating with Prior to develop new illumination sources and mechanical stages for all forms of microscopy.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Schlumberger-Doll Research, Ridgefield, CT.

This research focuses on the correlation between downhole fluid behavior and composition determined by FT-ICR mass spectrometry. Additional research projects aim at compositional variations in reservoir fluids that reveal compartmentalization (i.e. multiple isolated compartments present in a single reservoir). Both projects address the biggest current problems in reservoir risk management.

(NHMFL contact: Ryan Rodgers, ICR)

Semrock, Rochester, NY.

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

(NHMFL contact: Mike Davidson, Optical Microscopy)

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, LANL)

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 lab 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, University of Rhode Island.

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

(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. In 2006, Leon County Schools funded a full-time Teacher in Residence at the Magnet Lab in an effort to further solidify the partnership and to assist teachers with science instruction.

(NHMFL contact: Pat Dixon, Educational Programs)

Los Alamos National Laboratory, Los Alamos, NM.

The Magnet Science & Technology group at Los Alamos National Laboratory developed a new technique in casting eutectic Cu-Ag materials with refined structures. The Tallahassee MS&T group is collaborating in fabrication of high strength conductors by further refining the microstructure. LANL is casting and extruding the materials to various strains, and we are drawing them to the final sizes. Both parties are testing the materials. Preliminary results were presented in a conference.

(NHMFL contact: Ke Han, MS&T)

Miami University, Oxford, OH.

The Magnet Lab completed a contract to provide a 500 MHz low-E RF probe for solid-state ^{15}N NMR of aligned proteins. The instrument is used by the research group of Professor Gary Lorrigan.

(NHMFL contact: Peter Gor'kov, NMR)

Princeton Plasma Physics Laboratory (PPPL), Princeton, NJ.

Researchers in the Magnet Lab's Materials Development and Characterization group 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 lab collaborates with Sandia on the development of electromagnetic launch technology.

(NHMFL contact: Chuck Swenson, LANL)

Scripps Florida, Boca Raton, FL.

The lab's ICR group 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 lab's ICR program.

(NHMFL contact: Alan Marshall, ICR)

University of Minnesota, Minneapolis, MN.

The lab has a contract with University of Minnesota for construction of the low-E RF probe for solid-state ^{15}N NMR of aligned proteins. The probe is being built for the new 700 MHz narrow-bore spectrometer in the research group of Professor Gianluigi Veglia.

(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, Educational Programs)

University of New Mexico, Albuquerque, NM.

An invention disclosure for a miniature pulsed coil transcranial magnetic stimulation was submitted to Los Alamos National Laboratory. This coil design may be used in arrays of coils surrounding the head for pulsed magnetic field stimulation of the brain. This invention was prompted by discussions with Professor Claudia D. Tesche of the Department of Psychology of the University of New Mexico in Albuquerque.

(NHMFL contact: Jim Sims, LANL)

INTERNATIONAL ACTIVITIES

A.A. Bochvar Institute of Inorganic Materials, Moscow, Russia.

The lab 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, LANL)

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 lab is collaborating with Andor-Tech to produce interactive tutorials describing electron multiplying CCD (EMCCD) technology and will work with the company to test new camera products in live-cell imaging.

(NHMFL contact: Mike Davidson, Optical Microscopy)

Forschungszentrum Karlsruhe, Karlsruhe, Germany.

The lab completed a contract to provide a 600 MHz low-E RF probe for solid-state ^{15}N NMR of aligned proteins. The instrument is used by the research group of Professor Anna Ulrich.

(NHMFL contact: Peter Gor'kov, NMR)

Göteborg University, Sweden.

The Swedish and Magnet Lab groups use electrospray FT-ICR mass spectrometry 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 (STINT) grant funds the exchange of students and researchers between the facilities.

(NHMFL contact: Carol Nilsson, ICR)

Hahn-Meitner Institute, Berlin, Germany.

HMI and the Magnet Lab have collaborated for several years on a proposal for a major resistive magnet facility installation in Berlin. In 2005 the lab 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-degree half-angle would be feasible. As of December 2006 a contract was near final.

(NHMFL contact: Mark D. Bird, 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. In early 2006, the government of The Netherlands committed to the funding of a new 45 T-class hybrid magnet at Radboud University. Possible new collaborations are being discussed.

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

Korea Basic Science Institute, Daejeon, South Korea.

The lab's Magnet Science and Technology group 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, Deajon, South Korea.

Dr. Hyun Sik Kim heads a group of several KBSI scientists who are spending two years at the Magnet Lab with the ICR group to modify a commercial 7 T FT-ICR mass spectrometer for ultimate installation in 2007 with a 15 T superconducting magnet at KBSI. In the first stage, we replaced the commercial data system with a Magnet Lab home-built system that controls data acquisition and data reduction and display. In the recently completed second stage, we modified 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 the project mentioned above.

(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, lab 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 Magnet Lab's 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 Magnet Lab 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 lab 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 this 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)

Syncrude Research, Edmonton, Alberta, Canada.

The largest petroleum reserve in North America rests in Alberta, Canada. With proven recoverable reserves approaching those of Saudi Arabia, Alberta will be an important supplier of petroleum crude oil to the United States in the near future. Although abundant, the Alberta reserves are heavily biodegraded and take the form of oil-soaked sand. The sand is mined with conventional mining equipment, and the oil is extracted by water to yield a petroleum product called bitumen. Bitumen is further refined and upgraded to produce synthetic crude oil ("syncrude"). Water extraction can form stable emulsions that significantly reduce the amount of recoverable oil. Furthermore, the large volumes of emulsion (oil) laden water must be recycled to limit the water consumed in production. Recycling the water discharges large amounts of oil (in the form of emulsions) and other water soluble oil components into the environment. In collaboration with Syncrude Research, we have analyzed the interfacial material responsible for the stable emulsion formation. The analysis identified chemical compound classes that preferentially accumulate in the interfacial material and stabilize the emulsion. Work is underway to design chemicals that interfere with those specific classes of compounds to prevent stable emulsion formation.

(NHMFL contact: Ryan Rodgers, ICR)

Université de Reims, France.

The collaboration between the lab 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)

University of Calgary, Calgary, Alberta, Canada.

In-reservoir biodegradation can alter the composition of a parent petroleum fluid and cause problems in production and refining. In collaboration with Steve Larter and Barry Bennett in the Petroleum Geochemistry group at the University of Calgary, we have analyzed a series of samples collected at different vertical and horizontal sampling locations within a single reservoir. The mass spectral results serve as a compositional map of the reservoir and indicate areas of increased microbial activity. The compositional information from the acidic species has been shown to provide a useful indicator for the degree of biodegradation in the reservoir.

(NHMFL contact: Ryan Rodgers, ICR)

COLLABORATIONS

Conferences & Workshops

With so many large-scale projects underway and completed in 2006, in particular the NSF renewal proposal, the Magnet Lab's conference participation from an organizational point of view was relatively low compared to the previous year. In addition, many conferences the lab traditionally sponsors or runs happen in odd-number years. As such, 2007 promises to be particularly active with conferences planned for the Ion Cyclotron Resonance community, a workshop on the Free Electron Laser, and much more.

35th Southeastern Magnetic Resonance Conference
November 3-5, 2006
Gainesville, Florida
Meeting Site and Hotel Headquarters: Paramount Plaza Hotel Suites
Conference Chair: Joanna Long, Gail Fanucci

The SEMRC is held every year and rotates among various locations in the Southeastern United States. The focus of the conference is the exchange of ideas and recent magnetic resonance research highlights, including new applications and technique development. Particular emphasis is placed on activities in the region.

The University of Florida, along with Florida State University and the National High Magnetic Field Laboratory, were pleased to bring the SEMRC back to Florida and to support the conference again, as it did in 1997 and 2001 (at University of Florida in Gainesville) and in 1995, 1999, and 2003 (in Tallahassee).

Over a dozen scientists from the Magnet Lab, UF, and FSU spoke during the conference.

The 2006 Low Temperature Superconductor Workshop
November 7-9, 2006
Tallahassee, Florida
Meeting Site: National High Magnetic Field Laboratory
Workshop Chair: David Larbalestier

The 30th LTSW brought about 100 representatives of the superconducting magnet and materials community together to discuss the technology of advanced superconducting magnet construction and performance, superconducting wire fabrication and properties, and the underlying science of these topics.

A special one-day workshop on the properties of the Bi-2212 superconductor was held Monday, November 6 just before the meeting at which the various plans for very high field superconducting magnet development were discussed.

Complex Magnetism in High Magnetic Field Workshop
October 21, 2006
Los Alamos, New Mexico
Meeting Site: Los Alamos Pulsed Field Facility
Workshop Chair: Neil Harrison

Held in conjunction with the Users Committee Annual Meeting, also held in Los Alamos in 2006, this daylong workshop on complex magnetism in high magnetic fields featured morning presentations from Neil Harrison, Nigel Hussey, Nai-Chang Yeh, and Boris Maiorov.

The afternoon schedule included presentations from Jun Kono, Andrei Lebed, Per Soderlind, Zachary Fisk, Q. Niu, and Arzhang Ardavan. The day closed with a tour of the Pulsed Field Facility.

Through all its efforts, the lab continued to support students' ability to attend conferences, such a providing travel support for a student and postdocs to attend the 29th International Rocky Mountain Conference's EPR symposium in July. The lab's Center for Integrating Research & Learning also provided travel support for three of its summer Research Experiences for Undergraduates students to attend a poster session at the University of Florida.

CONFERENCES & WORKSHOPS

Management & Administration

The Magnet Lab is operated for the National Science Foundation by Florida State University, the University of Florida and Los Alamos National Laboratory. FSU is responsible for administrative and financial oversight of the lab, and for ensuring that the operations are in line with the objectives outlined in the cooperative agreement. More information about the organizational structure can be found online at ***www.magnet.fsu.edu***.

MANAGEMENT & STAFFING

Recognizing that lab's rich scientific diversity, two new principal investigators were added to the lab's core grant in 2006: Tim Cross, director of the lab's Nuclear Magnetic Resonance (NMR) user program and professor of chemistry at Florida State University, and Arthur Edison, director of the Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) user program and associate professor of biochemistry and molecular biology at the University of Florida.

The Applied Superconductivity Center became an official part of the Magnet Lab and Florida State University in 2006, putting down roots in the renovated Shaw Building across the street from the Tallahassee facility. By year's end, all but one of the Center's staff had relocated to Tallahassee and the facility was close to completion.

The leadership and management of the Magnet Science & Technology program changed in 2006 with the departure of Director John Miller, who left the lab to head up the magnet system team for the U.S. ITER Project Office in Oak Ridge, Tenn. Mark Bird, long-time member of the MS&T group and leader of the lab's resistive magnet program, was named interim director.

Pulsed magnet engineering operations moved to Los Alamos in 2006, with the team reporting directly to Associate Lab Director Alex Lacerda. In other organizational changes, the Magnet Science & Technology group shifted in reporting structure to fall directly under Lab Director Greg Boebinger, and it was determined that the ASC also would report directly to the director.

The lab's Nuclear Magnetic Resonance program received a boost in 2006 with the hiring of new associate scholar/scientist Victor Schepkin. Schepkin will be key in the growth of *in vivo* work on the lab's one-of-a-kind, wide-bore 900 MHz magnet.

And finally, during 2006 the lab played a significant role in the hiring of theorist Oskar Vafek, a new faculty member at the FSU physics department. Vafek is an active member of the lab's Condensed Matter Science group.

DIVERSITY

The Magnet Lab takes seriously its responsibility to help in diversifying the country's scientific work force and to promote new opportunities for underrepresented groups in science, engineering and mathematics.

A key part of making that happen is to encourage underrepresented students to pursue advanced degrees at the universities affiliated with the lab, where students can pair their education with career development opportunities available at the Magnet Lab. That effort started in 2005 with a diversity lecture program, "College Outreach – Workforce Initiative Program" (CO-WIN) that sends Magnet Lab scientists and engineers to women's colleges, historically black and minority serving institutions to present directly to undergraduates.

In 2006 the lab focused on realizing concrete research opportunities for talented students and young scientists by building on established partnerships with several historically black and minority-serving colleges and universities. The results of those efforts include:

- The 2006 REU program included students from Prairie View A&M, North Carolina A&T, University of Puerto Rico, and the University of Virgin Islands.
- The Magnet Lab provided research support for the four REU students from Prairie View A&M.
- Frank Hunte, Rochester Institute of Technology, was awarded matching funds for postdoctoral research with the Applied Superconductivity Center at the Mag Lab.
- Postdoc Saritha Nellutla was awarded support for EMR research at the Magnet Lab.
- Kevin Storr, Prairie View A&M University, and Joseph Rugutt, Claflin College, received Magnet Lab letters of support for three successful NSF grant proposals.

BUDGET

INTRODUCTION

The National High Magnetic Field Laboratory (NHMFL) 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 NHMFL remains the National Science Foundation (NSF) 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 1.
NHMFL NSF Budget Comparison (with Indirect Distributed to Programs)

Division/Program	1996 – 2000 5-Yr NSF Summary	% of Budget	2001 – 2007 7-Yr NSF Summary	% of Budget
Director	$2,912,811	3.33%	$6,912,865	4.01%
Unassigned Budget	0	0.00%	(2,120,850)	-1.23%
Facilities & Admin	5,698,737	6.51%	13,116,080	7.63%
Instruments & Operations	18,366,654	20.99%	30,185,461	17.56%
Instruments & Operations - Electrical Power for DC Facility	7,918,471	9.05%	21,443,298	12.48%
Magnet Science & Technology	22,122,487	25.28%	32,017,172	18.63%
FSU - IHRP	7,343,739	8.39%	8,496,524	4.94%
LANL	20,838,959	23.82%	37,772,857	21.98%
LANL – IHRP[2]			1,134,407	0.66%
CIMAR – NMR -FSU	361,550	0.41%	6,737,108	3.92%
CIMAR - EMR	248,902	0.28%	1,734,327	1.01%
CIMAR – ICR[3]	175,650	0.20%	6,806,378	3.96%
CIMAR –NMR -UF - AMRIS	812,414	0.94%	3,127,359	1.82%
UF - High B/T	699,626	0.80%	1,591,393	0.93%
UF – IHRP[2]			2,389,279	1.39%
Applied Superconductivity			539,588	0.31%
Total NSF Cooperative Agreement[1]	**$87,500,000**	**100.00%**	**$171,883,246**	**100.00%**

1 Baseline budget 2001 - 2005 $117,500,000

Amendments:

Eglin AFB	49,917
Electricity	1,470,000
RET Program	623,329
Additional 2 years funding 2006 - 2007	52,500,000
Less 2006 NSF budget reduction	(260,000)
Amended Budget	**$171,883,246**

2 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

3 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.

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

Table 2.

NHMFL - NSF Budget by Program (with Indirect 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	$796,882	$589,563	$3,387,084
CIRL[1]	225,379	198,611	142,872	329,769	161,213	300,914	185,307	1,544,065
Unassigned Budget[2]	(2,780,994)	(596,653)	2,071,302	1,441,535	714,162	(819,691)	(873,285)	(843,624)
Facilities & Administration	1,374,631	1,253,506	960,122	1,314,968	1,392,666	1,384,990	1,458,470	9,139,353
Instruments & Operations	2,771,403	3,888,227	2,326,974	2,913,482	2,962,497	3,098,024	3,194,504	21,155,111
Instruments & Operations - Electricity for DC Facility	1,900,000	1,600,000	3,020,000	3,074,000	3,606,809	3,901,225	4,339,786	21,441,820
Magnet Science & Technology[3]	4,130,929	4,906,176	3,650,610	3,312,840	1,469,308	2,962,568	2,656,553	23,088,984
Science	880,889	1,037,627	813,047	874,041	968,710	1,232,868	832,049	6,639,231
LANL [4]	4,575,655	6,436,905	5,083,545	5,164,502	5,382,012	5,129,415	6,001,598	37,773,632
LANL IHRP [4]	397,107		209,802	92,000	90,000	14,490	331,008	1,134,407
CIMAR – NMR - FSU	338,597	595,990	501,271	832,097	902,429	924,683	900,225	4,995,292
CIMAR - EMR	81,473	95,650	135,388	221,880	244,347	234,768	225,976	1,239,482
CIMAR - ICR [5]	1,533,358	49,248	46,311	370,541	1,084,812	1,077,706	1,058,946	5,220,922
CIMAR – NMR-UF-AMRIS	303,110	312,202	320,288	291,161	628,890	586,115	685,592	3,127,358
UF – High B/T [4]	182,527	188,003	597,352	(147,833)	218,879	267,151	285,315	1,591,394
UF IHRP[4]	148,199	219,090	434,810	572,470	547,963	297,291	169,453	2,389,276
Applied Superconductivity	0	0	0	0	0	36,654	344,894	381,548
Indirect	3,686,446	4,578,098	3,677,083	3,547,147	4,439,087	4,436,004	4,114,046	28,477,911
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, $183k in 2004, and $122,057 in 2006.

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

3 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, $2.6 million in 2005, and $3,628.5K in 2006. 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, $923K in 2005, and $193.8 in 2006; and the AMRIS contributions were $895 K in 2003, $321K in 2004, and $166K in 2005, and $1.555 million in 2006 (2001 and 2002 AMRIS contributions are not available).

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

5 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.

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 3 presents the State of Florida matching requirements and contribution provided through Florida State University.

Table 3.

Fiscal Year 2006/2007 State of Florida Matching and Contribution

	State Matching	State Contribution	Total State Funding
State of Florida recurring funds cost sharing	$4,492,318	3,262,160	$7,754,478
Indirect Cost (51%)	2,291,082	1,663,702	3,954,784
Total	**$6,783,400**	**4,925,862**	**$11,709,262**

PROGRAM BUDGET DISCUSSION

Calendar year 2006 is the sixth year of the current grant award from the National Science Foundation, in the amount of $26,500,000. This includes the National Science Board approved allocation of $25,000,000 plus $1,500,000 for ICR that was formerly granted through the Chemistry Division of NSF. The NHMFL also receives an annual operating budget from the State of Florida through Florida State University. In fiscal year 2005/2006, the State budget was $7,212,030, and was $7,754,478 for fiscal year 2006/2007 (excluding indirect).

Table 4.

NHMFL Program Budget by Source (budget allocation by program)

Program	NSF Budget Calendar Year 2006	State Matching Fiscal Year 2006/2007	State Contributed Fiscal Year 2006/2007	Total Budget
Director	$796,882	$1,499,354	$1,019,865	$3,316,101
CIRL	300,914	121,033	62,595	484,542
Unassigned Budget	(819,691)			(819,691)
Facilities & Admin	1,384,990	332,257	171,832	1,889,079
Instruments & Operations	3,098,024	379,334	196,179	3,673,537
Instruments & Operations - Electrical Power for DC Facility	3,901,225			3,901,225
M S & T	2,962,568	253,136	308,364	3,524,068
Science	1, 232,868	945,561	489,013	2,667,442
LANL (Subcontract) [1]	5,129,415			5,129,415
LANL IHRP	14,490			14,490
CIMAR – Administration		36,623	18,940	55,563
CIMAR – NMR	924,683	298,436	247,330	1,470,449
CIMAR – EMR	234,768	253,449	131,076	619,293
CIMAR – ICR Facilities	1,077,707	255,793	132,288	1,465,788
CIMAR – Geochemistry		64,654	33,437	98,091
CIMAR – NMR @ UF – AMRIS [2]	586,115			586,115
UF- High B/T [3]	267,151			267,151
UF IHRP	297,291			297,291
ASC	36,654	52,687	451,241	540,582
Indirect [4]	4,436,004	2,291,083	1,663,702	8,390,789
Total	**$25,862,057**	**$6,783,400**	**$4,925,862**	**$37,571,319**

1 LANL's contribution to the Pulsed Magnet Program was $3.629 million in 2006
2 UF's contribution to AMRIS was $1.555 million in 2006
3 UF's contribution to the High B/T program was $0.194 million in 2006.
4 The NSF Budget includes indirect (Indirect), and the equivalent indirect is included in the state budget to reflect the total State of Florida support. FSU's federally negotiated Indirect rate is 51%

The following table summarizes the NHMFL's budget position as of 12/31/2006. 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 2006 awards and actual incurred expenses, and equipment for the 900 MHz.

Table 5.
Cumulative NSF Budget and Expenses (1/1/2001 – 12/31/2006)

Expense Classification	Budget	Spent and Encumbered	Balance 12/31/2006
Salaries, Wages & Benefits	$34,577,487	$33,987,527	$589,960
Subcontracts	39,610,990	38,988,093	622,897
Capital Equipment	13,909,110	12,499,909	1,409,201
Other Direct Cost	32,883,752	31,646,329	1,237,423
Subtotal	**120,981,339**	**117,121,858**	**3,859,481**
Indirect	24,401,907	23,885,228	516,679
Total before indirect on encumbrances	**$145,383,246**	**$141,007,086**	**$4,376,160**
Estimated Indirect on encumbrances		1,735,896	(1,735,896)
Adjusted Total	**$145,383,246**	**$142,742,982**	**$2,640,264**
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, Human Resources, Web site Development, and the Visiting Scientist Program. The Budget Administration Office is responsible for 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 NHMFL'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 6.
Director's Office Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
Director - Admin	434,969	1,081,502
Budget Administration	83,949	147,839
Visitors Program	0	142,315
Director's Research	9,176	58,560
Computer Services	268,787	0
Unassigned NHMFL Budget	(819,691)	0
Total	**(22,809)**	**1,430,216**
State Contribution		984,109

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 2006 the Center received a supplemental grant of $122,057. 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, 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 Web sites in middle, high, undergraduate, and graduate curricula around the world. The OMRC is responsible for Web application development and upgrades, and media graphics.

Table 7.
Center for Integrating Research and Learning (CIRL) and Optical Microscopy Resource Center (OMRC) Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
Education	114,017	121,033
REU Program	186,897	
Optical Microscopy	0	69,138
Total	**300,914**	**190,171**
State Contribution		98,352

FACILITIES AND FISCAL ADMINISTRATION

Facilities and Fiscal Administration provide general administrative functions for the lab including the UBA (University Business Administrators) Program. The UBA is responsible for accounts payable, accounts receivable, travel, payroll, procurement, receiving, and other accounting activities. The Facilities staff has responsibility for maintenance of the NHMFL facilities including magnet power supplies and cooling systems, helium systems, and the remainder of the facilities except buildings, grounds, janitorial, and some HVAC and plumbing preventative maintenance. 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 8.
Facilities and Administration Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
UBA	636,379	112,053
Facilities	621,600	177,053
Safety	127,010	43,151
Total	**1,384,990**	**332,257**
State Contribution		171,832

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 9.
Instrumentation and Operations Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
Administration	235,809	19,774
Cryogenics	579,772	
Electronics	147,300	
Magnet Operations	340,930	
Electrical Power for DC Magnets	3,901,225	
Mechanical Operations	285,911	
User Services	1,508,302	359,560
Total	**6,999,249**	**379,334**
State Contribution		196,179

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 10.
Magnet Science & Technology Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
Admin/Operations	1,425,219	253,136
Pulsed Magnets	434,306	
Powered Magnets	1,053,298	
Persistent Magnets	49,745	
Total	**2,962,568**	**253,136**
State Contribution		308,364

CONDENSED MATTER SCIENCE PROGRAM

The NSF funding for the science and facilities development program is primarily distributed through the In-House Research Program (IHRP). Funding also 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. The Director of the IHRP typically serves for two-year terms and rotates among the three institutions. During the current period, the program is headed by Dr. Lloyd Engel with the FSU-NHMFL. IHRP proposals must include a principal investigator from one of the three participating institutions and participation from external users as Co-Principal Investigators are 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 11.
Condensed Matter Science Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
Administration	254,987	162,318
In-House Research Program	977,881	
Condensed Matter Theory		240,195
Condensed Matter Experimental		543,048
Total	**1,232,868**	**945,561**
State Contribution		489,013

PULSED FIELD FACILITY - LOS ALAMOS NATIONAL LABORATORY

The NHMFL Pulsed Field Facility is located at Los Alamos National Laboratory (LANL) and operated under a subcontract agreement between Florida State University and the Department of Energy. Funding for the NHMFL Pulsed Field Facilities and Administration includes the facility indirect charges. The Pulsed Field Facility provides technical and instrumentation support for the user community. The staff of the NHMFL 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 develops pulsed magnets and materials for these unique systems. 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 12.
Pulsed Field Facility Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
Facilities & Admin	3,127,423	
User Operations	855,751	
Pulsed Magnets	1,146,242	
IHRP	14,490	
Total	**5,143,905**	
LANL Contribution		3,628,500

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 spectroscopy, 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 13.
Center for Interdisciplinary Magnetic Resonance Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
Administration		36,623
NMR Program	924,682	298,436
ICR Program	1,077,707	255,793
EMR Program	234,768	253,449
Geochemistry		64,654
AMRIS (UF)	586,115	
Total	**2,823,272**	**908,955**
State Contribution		563,071
UF-AMRIS Contribution		1,555,000

HIGH B/T FACILITY – UNIVERSITY OF FLORIDA

The High B/T Facility is located at the University of Florida (UF) and is housed in the existing Microkelvin facility. A special bay has been retrofitted in the Microkelvin laboratory, using a specially designed $PrNi_5$ nuclear refrigerator and a separate 14/15.5T magnet to conduct experiments at both high magnetic fields and low temperatures simultaneously, namely at a few 100 microkelvin. 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 nW 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. A state allocation in 2005-2006 provided funds to upgrade the magnetic field system of the facility to provide fields up to 20 T. This upgrade is expected to be completed in 2008-2009.

Table 14.
High B/T Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
High B/T User Support	267,151	
IHRP	297,291	
Total	**564,442**	**0**
UF-High B/T Contribution		193,773

APPLIED SUPERCONDUCTIVITY CENTER (ASC)

The NSF funding for work in ASC is for the development of a new generation of high field superconducting magnets using Bi-2212 and YBCO conductors. This research and development effort is presently in the conductor understanding, evaluation and small coil development phase. It is collaborative with Magnet Science and Technology and with outside U.S. industry.

Table 15.
Applied Superconductivity Center Program Budget

Program	NSF Budget 2006	State Matching Budget 2006/2007
ASC State Contribution	36,654	52,689 451,240

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, NM, 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 were used in the cost calculation. In some instances, the average salary rate may have been used for vacant and OPS positions.

Indirect Rates: The Florida State University's federally negotiated indirect rate is 51% for 2006. The institutional indirect rate used at the University of Florida is 46.5%, and for Los Alamos it is 100% (which includes infrastructure tax, division tax, general and administrative tax, New Mexico gross receipts tax, and cost of electricity).

Indirect Base: At FSU and UF, indirect 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 indirect 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 indirect base.

At LANL, full indirect is applied to all costs other than capital project costs. Capital projects designated as capital construction have a reduced indirect rate of 5%, and all other capital projects have a reduced indirect 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 (1.55% for non-students and .3% for students). 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 indirect. Since the actual indirect costs vary depending on the nature of the program and the institution involved, actual indirect is determined at the time of award within the total IHRP budget.

Science & Research Productivity

The laboratory continued its strong record of publishing, giving conference presentations, and educating the next generation of scientists and engineers. Table 1 summarizes these activities, and the citations follow in this chapter. For additional information, refer to the Magnet Lab's Web site: ***www.magnet.fsu.edu*** (/search/publications/), where you can search the laboratory's publication database and read many articles online. Grant information, received from Florida State University and the University of Florida's respective offices of sponsored research, is also presented in this chapter beginning on page 164.

Table 1.
2006 Magnet Lab Activities Summary

	Number Reported	Page Number for Citations
Publications in Peer-Reviewed Journals	404	128
Presentations, Posters & other Publications	426	143
Books & Book Chapters	8	160
Internet Disseminations	14	161
Patents	3	161
Awards	17	161
Dissertations, Ph.D.	41	162
Theses, Master	8	163

Of the over 400 publications reported by Magnet Lab faculty and users, 227—or 56%—appeared in some of the most prominent science and major disciplinary journals. This compares nicely to 2005 productivity, when the lab reported 386 publications, with 178 (or 46%) appearing in prominent journals.

Table 2.
2006 Prominent Journal Articles

Journal	
Advanced Materials	2
Analytical Chemistry	6
Angewandte Chemie International Edition	1
Applied Physics Letters	13
Biochemical Biophysical Research Communications	1
Biochemistry	9
Biochimica et Biophysica Acta	2
Biophysical Journal	2
Cryogenics	5
Energy & Fuels	8
Europhysics Letters	1
IEEE Transactions on Applied Superconductivity	11
Inorganic Chemistry	3
International Journal of Mass Spectrometry	2
Journal of Applied Physics	5
Journal of Biological Chemistry	1
Journal of Biomolecular NMR	1
Journal of Magnetic Resonance	9
Journal of Materials Research	1
Journal of Physical Chemistry A	4
Journal of Physical Chemistry B	1
Journal of Physics-Condensed Matter	3
Journal of Proteome Research	1
Journal of the American Chemical Society	14
Journal of the American Society for Mass Spectrometry	1
Macromolecules	1
Magnetic Resonance in Chemistry	2
Magnetic Resonance Imaging	1
Magnetic Resonance in Medicine	1
Nature	1
Nature Physics	3
Neuroimage	3
Physical Review B	46
Physical Review B Rapid Communications	6
Physical Review Letters	43
Proceedings of the National Academy of Sciences of the United States of America	2
Rapid Communications in Mass Spectrometry	1
Science	2
Solid State Nuclear Magnetic Resonance	2
Superconductor Science and Technology	6
Total:	**227**

SCIENCE & RESEARCH PRODUCTIVITY

2006 PEER-REVIEWED PUBLICATIONS

This section lists over 400 articles that appeared in print in referred journals and conference proceedings in 2006. Journal titles appearing in **red boldface** are regarded by the laboratory as prominent or major disciplinary publications.

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2006 PRESENTATIONS, POSTERS & ABSTRACTS

This section lists invited and contributed talks and papers at conferences; papers in conference proceedings that were not peer-reviewed; posters; abstracts; and presentations at universities and public forums in 2006. Over 425 activities were reported for the year.

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Balicas, L., *Field-Induced Suppression of the Charge Ordered State and Shubnikov-de Haas Effect in* Na_xCoO_2 *(invited talk)*, American Physical Society March Meeting, Baltimore, MD, March 13-17 (2006)
Balicas, L., *Field-Induced Suppression of the Charge Ordered State and Shubnikov-de Haas Effect in* Na_xCoO_2, Physics Department, Louisiana State University, Baton Rouge, LA, April 20 (2006)
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Beu, S.C.; Hendrickson, C.L. and Marshall, A.G., *SIMION Modeling of Image Charge Detection in FT-ICR MS*, 54th Amer. Soc. Mass Spectrom. Ann. Conf. on Mass Spectrometry & Allied Topics, Seattle, WA, May 27-June 2 (2006)
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Bonesteel, N.E., *Braid Topologies for Quantum Computation*, KITP, University of California Santa Barbara, Santa Barbara, CA, March 22 (2006)
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Bonesteel, N.E., *Topological Quantum Compiling*, Topological Phases and Quantum Computation (Invited Talk), Santa Barbara, CA, May 15-19 (2006)
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Crooker, S.A., *Imaging electrical spin injection and spin transport in semiconductor-ferromagnet devices*, UC San Diego Department of Physics Condensed Matter Physics Seminar, San Diego, CA, December (2006)

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Crooker, S.A., *Imaging spin transport in lateral ferromagnet-semiconductor devices*, Nanoscience Seminar, UC-Riverside, Riverside, CA, USA, January (2006)

Crooker, S.A., *Imaging the flow of spin-polarized electrons in semiconductors*, Department of Physics Colloquium, UC Santa Cruz, Santa Cruz, CA, USA, January (2006)

Crooker, S.A., *Spectroscopy of spontaneous spin noise in atomic and solid state systems*, Gordon Research Conf. on Ultrafast Phenomena in Correlated Systems, Buellton, CA, USA, February (2006)

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Dixon, I.R.; Gavrilin, A.V. and Miller, J.R., *Cooling Systems Design of the Superconducting Outsert in the Series Connected Magnet Syatems*, Applied Superconductivity Conf. 2006, Seattle, WA, August 27-September 1 (2006)

Dixon, I.R.; Gavrilin, A.V., Miller, J.R.; Powell, J.A. and Brandt, B.L., *Quench Protection System and Analysis of the Series Connected Hybrid Magnet at the National High Magnetic Field Laboratory*, Applied Superconductivity Conf. 2006, Seattle, WA, August 27-September 1 (2006)

Dobrosavljevic, V., *2D-MIT as Self–Doping the Wigner-Mott Insulator*, invited talk at the 96th Statistical Mechanics Conference, Rutgers University, Piscataway, NJ, December 19 (2006)

Dobrosavljevic, V., *Disorder-Driven Non-Fermi Liquid Behavior of Correlated Electrons*, Lawrence Livermore National Laboratory, May 16 (2006)

Dobrosavljevic, V., *invited presentation at the "Round Table on the Metal-Insulator Transitions"*, 96th Statistical Mechanics Conf., Rutgers University, Piscataway, NJ, December 19 (2006)

Dobrosavljevic, V., *Non-Ohmic Dissipation in Metallic Griffiths Phases*, invited talk at the 2006 Aspen Working Group on Quantum Phase Transitions, Aspen Center for Physics, Aspen, CO, August 10 (2006)

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Dorsey, A.T., *Phenomenology of Supersolids*, Supersolid State of Matter, Kavli Institute for Theoretical Physics, Santa Barbara, CA, February (2006)

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Barcza, A., *"Magnetostriction in Rare-Earth Elements Measured with Capacitive Dilatometry",* University of Vienna, Chemistry, advisor: Mathias Rotter (2006)

Chiesa, Luisa, *"Development of an Experiment to Study the Effects of Transverse Stress on the Critical Current of a Niobium-tin Superconducting Cable",* MIT, Physics, advisor: Joseph Minervini (2006)

Elhalel, Gal, *"Temperature Dependence of the Low Bias Region in the Tunneling Conductance of $YBa_2Cu_3O_{7-x}$ Thin Films",* Tel-Aviv University, Condensed Matter Physics, advisor: Guy Deutscher (2006)

Kitchen, Jaquiline, *"Cloning and Bacterial Expression of Notch EGF Domains 11-13 and the DSL Fragment of Delta",* Florida State University, Chemistry & Biochemistry, advisor: Timothy Logan (2006)

Merritt, Gary Adam, *"Proof of Principle for $Bi_2Sr_2CaCu_2O_{8+x}$ React Wind Sinter Magnet Manufacturing",* Florida State University, Mechanical Engineering, advisor: Justin Schwartz (2006)

Ramos, Manuel, *"Texturing of Low Aspect Ratio $Bi_2Sr_2CaCu_2O_{8+x}$ /AgMg Wires Processed in High Magnetic Field as Measured by Electrical Transport",* Florida A&M University, Mechanical Engineering, advisor: Justin Schwartz (2006)

Serrano, G., *"Optimizacion de las propiedades superconductoras en alambres y cintas de MgB_2 para la obtencion de altos campos magneticos",* Instituto Balseiro - Universidad de Cuyo, advisor: Adriana Serquis (2006)

GRANTS AWARDED TO NHMFL-AFFILIATED FACULTY AT FLORIDA STATE UNIVERSITY

As reported by the FSU Office of Sponsored Research for calendar year 2006

PI: Alamo, Rufina
Grant Title: Structure and Rheology of Complex Nanoparticle Fluids
Agency: Florida State University Research Foundation
Project Dates: 2/14/06 - 6/14/06
Award: $30,000.00

PI: Alamo, Rufina
Grant Title: Characterization of the Branching Microstructure of a New Ethylene 1-Hexene Copolymer and Impact on Film Properties
Agency: Exxon Chemical Company
Project Dates: 10/1/06 - 9/30/08
Award: $35,332.00

PI: Bird, Mark
Grant Title: IMR-MIP Conceptual And Engineering Design Of A Conical Series-Connected Hybrid For Neutron Scattering At The Spallation Neutron Source
Agency: Johns Hopkins University
Project Dates: 9/15/06 - 8/31/07
Award: $639,011.00

PI: Bird, Mark
Grant Title: Series Connected Hybrid Construction Phase
Agency: National Science Foundation
Project Dates: 8/25/06 - 8/31/11
Award: $3,477,348.00

PI: Bird, Mark
Grant Title: KBSI-NHMFL Collaboration on FT-ICR Conceptual Design
Agency: Korea Basic Science Institute
Project Dates: 3/1/05 - 12/31/06
Award: $150,116.00

PI: Bizimis, Michael
Grant Title: Kaua'I Xenoliths
Agency: National Science Foundation
Project Dates: 10/1/06 - 9/30/07
Award: $73,575.00

PI: Bizimis, Michael
Grant Title: Nb/Ta Fractionations as Tracer of Subduction
Agency: National Science Foundation
Project Dates: 12/1/06 - 11/30/07
Award: $102,813.00

PI: Boebinger, Gregory
Grant Title: NHMFL Research Experiences for Teachers Summer Internship Program
Agency: National Science Foundation
Project Dates: 5/1/02 - 12/31/07
Award: $122,057.00

PI: Boebinger, Gregory
Grant Title: National High Magnetic Field Laboratory
Agency: National Science Foundation
Project Dates: 1/1/01 - 12/31/07
Award: $25,740,000.00

PI: Boebinger, Gregory
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/02 - 3/31/12
Award: $5,893.05

PI: Bonesteel, Nicholas
Grant Title: Correlated Electrons in Reduced Dimensions
Agency: U. S. Department of Energy
Project Dates: 6/1/97 - 7/31/07
Award: $55,000.00

PI: Brandt, Bruce
Grant Title: Series Connected Hybrid Construction Phase
Agency: National Science Foundation
Project Dates: 8/25/06 - 8/31/11
Award: $3,477,348.00

PI: Brooks, James
Grant Title: Properties of Molecular Solics
Agency: National Science Foundation
Project Dates: 7/15/06 - 6/30/07
Award: $117,860.00

PI: Bruschweiler, Rafael
Grant Title: Correlated Protein Motions
Agency: National Science Foundation
Project Dates: 7/1/06 - 6/30/07
Award: $133,292.00

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 - 4/30/07
Award: $166,449.00

PI: Bruschweiler, Rafael
Grant Title: NMR/MD Studies f Human MDM2 Interaction with P53
Agency: National Cancer Institute
Project Dates: 7/1/05 - 6/30/07
Award: $45,976.00

PI: Cao, Jianming
Grant Title: Ultrafast Structural Dynamics in Solics and Nanoparticles
Agency: National Science Foundation
Project Dates: 6/1/06 - 5/31/07
Award: $110,000.00

PI: Chanton, Jeff
Grant Title: Technician Support for the Stable Isotope Laboratory at Florida State University
Agency: National Science Foundation
Project Dates: 12/15/05 - 11/30/06
Award: $69,128.00

PI: Chanton, Jeff
Grant Title: NCCR Year 3 Workplan: Carbon Isotopic Studies of Assimilated and Ecosytem Respired CO2 in a SE Pine Forest
Agency: Duke University
Project Dates: 9/1/06 - 8/31/07
Award: $50,986.00

PI: Chanton, Jeff
Grant Title: Controls of the Isotopic Composition of Fixed CO2 and Ecosystem-Respired CO2 in Southeastern Pine Forests
Agency: National Science Foundation
Project Dates: 4/1/04 - 3/31/07
Award: $113,550.00

PI: Chanton, Jeff
Grant Title: REU Supplement, Year 3, Inexpensive Biocover and Biofilter Approaches For Effective Reduction of Methane Emissions From Landfills
Agency: National Science Foundation
Project Dates: 9/1/03 - 9/30/07
Award: $8,100.00

PI: Chanton, Jeff
Grant Title: Ichetucknee Springs State Park Dye Test
Agency: Florida Department of Environmental Protection
Project Dates: 2/27/06 - 6/30/06
Award: $5,760.00

PI: Chanton, Jeff
Grant Title: Impact of Landfill Leachate on Iron Release from Northwest Florida Iron Rich Soil
Agency: University of Florida
Project Dates: 8/1/06 - 7/31/07
Award: $35,000.00

PI: Chanton, Jeff
Grant Title: Methane Emissions at Springhill and Outer Loop Landfill
Agency: Waste Management, Inc.
Project Dates: 3/15/06 - 9/30/06
Award: $87,000.00

PI: Chanton, Jeff
Grant Title: Technician Support for the Stable Isotope Laboratory at Florida State University
Agency: National Science Foundation
Project Dates: 12/15/05 - 11/30/07
Award: $71,893.00

PI: Chanton, Jeff
Grant Title: Modeling of Gas Transport and Oxidation at Different Landfills and Climates
Agency: Waste Management, Inc.
Project Dates: 10/1/06 - 1/31/07
Award: $28,934.00

PI: Chiorescu, Irinel
Grant Title: Alfred P. Sloan Foundation Research Fellowship
Agency: Sloan Foundation
Project Dates: 9/16/06 - 9/15/08
Award: $45,000.00

PI: Cross, Timothy
Grant Title: Membrane Protein Backbone Structure Determination
Agency: National Institutes of Health
Project Dates: 12/22/05 - 12/21/06
Award: $29,149.00

PI: Cross, Timothy
Grant Title: Series Connected Hybrid Construction Phase
Agency: National Science Foundation
Project Dates: 8/25/06 - 8/31/11
Award: $3,477,348.00

PI: Cross, Timothy
Grant Title: Correlations: Structure-Dynamics-Functions in Channels
Agency: National Institute of Allergy & Infectious Diseases
Project Dates: 3/1/05 - 2/28/07
Award: $338,434.00

PI: Cross, Timothy
Grant Title: Structure Determination of kdpcC: the C Subunit of the Potassium Transporting ATPase, kdp
Agency: American Heart Association
Project Dates: 7/1/06 - 6/30/08
Award: $43,540.00

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 - 3/31/07
Award: $216,051.00

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 - 4/30/07
Award: $166,449.00

PI: Dalal, Naresh
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/02 - 3/31/12
Award: $2,078.76

PI: Dalal, Naresh
Grant Title: Undergraduate Education in Chemistry
Agency: Various Sources (Business/Industry)
Project Dates: 6/13/95 - 6/30/07
Award: $46.50

PI: Dalal, Naresh
Grant Title: NMR/MD Studies f Human MDM2 Interaction with P53
Agency: National Cancer Institute
Project Dates: 7/1/05 - 6/30/07
Award: $45,976.00

PI: Dalal, Naresh
Grant Title: Undergraduate Education in Chemistry
Agency: Various Sources (Business/Industry)
Project Dates: 6/13/95 - 6/30/07
Award: $3,098.00

PI: Davidson, Michael
Grant Title: Construction of Interactive Tutorials
Agency: Olympus America
Project Dates: 4/1/00 - 3/31/07
Award: $150,000.00

PI: Davidson, Michael
Grant Title: Construction of Interactive Media
Agency: Nikon, Inc.
Project Dates: 4/1/00 - 3/31/07
Award: $150,000.00

PI: Davidson, Michael
Grant Title: Construction of Educational Digital Imaging Website
Agency: Various Sources (Business/Industry)
Project Dates: 4/1/00 - 8/31/11
Award: $50,000.00

PI: Dixon, Patricia
Grant Title: Exploring the Effects Of Teacher Research Experiences on Classroom Inquiry
Agency: National Science Foundation
Project Dates: 8/11/06 - 9/30/07
Award: $367,868.00

PI: Dixon, Patricia
Grant Title: NHMFL Research Experiences for Teachers Summer Internship Program
Agency: National Science Foundation
Project Dates: 5/1/02 - 12/31/07
Award: $122,057.00

PI: Dixon, Patricia
Grant Title: Exploring the Effects Of Teacher Research Experiences on Classroom Inquiry
Agency: National Science Foundation
Project Dates: 10/1/06 - 9/30/07
Award: $110,400.00

PI: Dobrosavljevic, Vladimir
Grant Title: Complex Behavior Near the Metal-Insulator Transition
Agency: National Science Foundation
Project Dates: 3/1/06 - 2/29/08
Award: $220,000.00

PI: Emmett, Mark
Grant Title: Structural Mapping of Protein Complexes by Hydrogen/Deuterium Exchange
Agency: National Imager and Mapping Agency
Project Dates: 8/1/06 - 7/31/07
Award: $314,755.00

PI: Emmett, Mark
Grant Title: Analysis of Canadian Crude Oils
Agency: Canadian Association of Petroleum Producers
Project Dates: 9/20/02 - 12/31/07
Award: $15,000.00

PI: Emmett, Mark
Grant Title: Analysis of Petroleum Samples
Agency: Natural Resources Canada
Project Dates: 12/23/03 - 7/20/07
Award: $25,000.00

PI: Engel, Lloyd
Grant Title: Microwave Spectroscopy
Agency: Princeton University
Project Dates: 6/1/05 - 1/15/07
Award: $40,739.00

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: Fu, Riqiang
Grant Title: Correlations: Structure-Dynamics-Functions in Channels
Agency: National Institute of Allergy & Infectious Diseases
Project Dates: 3/1/05 - 2/28/07
Award: $338,434.00

PI: Gaffney, Betty
Grant Title: Reactive Intermediates in Lipoxygenase Pathways
Agency: National Institute of General Medical Sciences
Project Dates: 4/10/03 - 3/31/07
Award: $175,596.00

PI: Gaffney, Betty
Grant Title: Reactive Intermediates in Lipoxygenase Pathways
Agency: National Institute of General Medical Sciences
Project Dates: 4/10/03 - 3/31/07
Award: $175,596.00

PI: Gao, Fei
Grant Title: Correlations: Structure-Dynamics-Functions in Channels
Agency: National Institute of Allergy & Infectious Diseases
Project Dates: 3/1/05 - 2/28/07
Award: $338,434.00

PI: Gor'kov, Lev
Grant Title: Fabrication of 600 MHz WB Low-E PISEMA NMR Probe
Agency: Forschungszentrum Karlsruhe
Project Dates: 3/2/06 - 9/4/06
Award: $10,901.33

PI: Gor'kov, Petr
Grant Title: Wb Solid State Nmr Probe
Agency: Miami University
Project Dates: 4/6/06 - 1/5/07
Award: $26,874.13

PI: Gor'kov, Petr
Grant Title: 700 Nb Low-E Nmr Probe
Agency: University of Minnesota
Project Dates: 4/25/06 - 1/24/07
Award: $25,268.00

PI: Gor'kov, Petr
Grant Title: 600 MHz WB NMR Probe
Agency: Forschungszentrum Karlsruhe
Project Dates: 10/11/06 - 4/12/07
Award: $11,366.44

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 - 7/31/07
Award: $128,695.00

PI: Greenbaum, Nancy
Grant Title: Bess Ward Fellowship & Honors Thesis Award 2006-2008
Agency: University Honors Program
Project Dates: 5/1/06 - 4/30/08
Award: $11,000.00

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 - 7/31/07
Award: $203,387.00

PI: Hendrickson, Christopher
Grant Title: Structural Mapping of Protein Complexes by Hydrogen/Deuterium Exchange
Agency: National Imager and Mapping Agency
Project Dates: 8/1/06 - 7/31/07
Award: $314,755.00

PI: Hendrickson, Christopher
Grant Title: Analysis of Canadian Crude Oils
Agency: Canadian Association of Petroleum Producers
Project Dates: 9/20/02 - 12/31/07
Award: $15,000.00

PI: Hendrickson, Christopher
Grant Title: Analysis of Petroleum Samples
Agency: Natural Resources Canada
Project Dates: 12/23/03 - 7/20/07
Award: $25,000.00

PI: Humayun, Munir
Grant Title: Siderophile Element Analysis by ICP-MS
Agency: National Aeronautics & Space Administration
Project Dates: 8/15/06 - 8/14/09
Award: $94,000.00

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: $125,000.00

PI: Humayun, Munir
Grant Title: Development of an ICP Dual Mass Spectrometer for the
Agency: National Aeronautics & Space Administration
Project Dates: 8/15/05 - 4/14/07
Award: $14,992.00

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: $127,000.00

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: $150,195.00

PI: Landing, William
Grant Title: Trace Metals Analysis on CLIVAR Samples
Agency: National Science Foundation
Project Dates: 12/1/05 - 12/31/08
Award: $320,229.00

PI: Landing, William
Grant Title: REU Supplement to Trace Element Analysis of Aerosol and Seawater Samples Collected on the A16N, P02, and P16S CLIVAR Cruises
Agency: National Science Foundation
Project Dates: 12/1/05 - 12/31/08
Award: $5,000.00

PI: Landing, William
Grant Title: Apalachicola Nerrs Nutrient Analysis Project 2006-2007
Agency: Florida Department of Environmental Protection
Project Dates: 3/1/06 - 6/30/06
Award: $6,225.00

PI: Landing, William
Grant Title: Apalachicola Nerrs Nutrient Project
Agency: Florida Department of Environmental Protection
Project Dates: 7/1/06 - 6/30/07
Award: $18,675.00

PI: Larbalestier, David
Grant Title: Understanding & Development of High Field Scs for Fusion
Agency: U. S. Department of Energy
Project Dates: 7/1/06 - 6/30/07
Award: $100,000.00

PI: Larbalestier, David
Grant Title: Francis Eppes Professorship
Agency: Florida State University Research Foundation
Project Dates: 7/1/06 - 6/30/13
Award: $40,000.00

PI: Larbalestier, David
Grant Title: Investigation of Superconductivity in High Purity Niobum
Agency: Fermi National Accelerator Laboratory
Project Dates: 7/20/06 - 12/31/07
Award: $50,000.00

PI: Larbalestier, David
Grant Title: Electromagnetic and Nanostructural Studies of Rare Earth Copper Oxide Grain Boundaries in High Temperature Superconductors
Agency: Air Force Office of Scientific Research
Project Dates: 7/1/06 - 11/30/06
Award: $100,000.00

PI: Larbalestier, David
Grant Title: Electromagnetic and Nanostructural Studies of Rare Earth Copper Oxide Grain Boundaries in High Temperature Superconductors
Agency: Air Force Office of Scientific Research
Project Dates: 7/1/06 - 11/30/07
Award: $240,000.00

PI: Larbalestier, David
Grant Title: Magnetic Investigation of High Purity Nobium
Agency: U. S. Department of Energy
Project Dates: 9/1/06 - 8/31/07
Award: $64,000.00

PI: Lee, Peter
Grant Title: Understanding & Development of High Field Scs for Fusion
Agency: U. S. Department of Energy
Project Dates: 7/1/06 - 6/30/07
Award: $100,000.00

PI: Lee, Peter
Grant Title: Investigation of Superconductivity in High Purity Niobum
Agency: Fermi National Accelerator Laboratory
Project Dates: 7/20/06 - 12/31/07
Award: $50,000.00

PI: Lee, Peter
Grant Title: Magnetic Investigation of High Purity Nobium
Agency: U. S. Department of Energy
Project Dates: 9/1/06 - 8/31/07
Award: $64,000.00

PI: Liang, Zhiyong
Grant Title: Investigation and Optimization of High Performance Nanocomposites Produced with Nanotube Buckypaper Materials
Agency: Air Force Office of Scientific Research
Project Dates: 4/15/05 - 11/30/06
Award: $50,000.00

PI: Liang, Zhiyong
Grant Title: Cooperative Agreement: Nanocomposites Optimized for Lightweight Exceptional Strength for the Army Future Combat Systems
Agency: U. S. Army Research Laboratory
Project Dates: 4/27/04 - 5/29/07
Award: $1,500,000.00

PI: Liang, Zhiyong
Grant Title: Investigation and Optimization of High Performance Nanocomposites Produced with Nanotube Buckypaper Materials
Agency: Air Force Office of Scientific Research
Project Dates: 4/15/05 - 11/30/06
Award: $50,000.00

PI: Liang, Zhiyong
Grant Title: Investigation and Optimization of High Performance Nanocomposites Produced with Nanotube Buckypaper Materials
Agency: Air Force Office of Scientific Research
Project Dates: 4/15/05 - 5/31/07
Award: $180,000.00

PI: Liang, Zhiyong
Grant Title: Exploration and Demonstration of SWNT Buckypaper/Shape Memory Polymer Nanocomposites for Morphing Structure Applications
Agency: Lockheed-Martin Corp
Project Dates: 9/1/06 - 12/8/06
Award: $49,245.00

PI: Liang, Zhiyong
Grant Title: Design and Fabrication of a Thermal Management Demonstration Panel Using SWNT BuckyPaper
Agency: Northrop Grumman Corporation
Project Dates: 10/26/06 - 1/29/07
Award: $11,760.00

PI: Logan, Timothy
Grant Title: Peptide Activators of Diphtheria Toxin Repressor Dtxr
Agency: Boston Medical Center
Project Dates: 2/1/06 - 1/31/07
Award: $169,819.00

PI: Logan, Timothy
Grant Title: Peptide Activators of Diphtheria Toxin Repressor Dtxr
Agency: Boston Medical Center
Project Dates: 2/1/06 - 1/31/07
Award: $236,237.85

PI: Logan, Timothy
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/02 - 3/31/12
Award: $1,377.85

PI: Logan, Timothy
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/02 - 3/31/12
Award: $1,804.00

PI: Marshall, Alan
Grant Title: Structural Mapping of Protein Complexes by Hydrogen/ Deuterium Exchange
Agency: National Imager and Mapping Agency
Project Dates: 8/1/06 - 7/31/07
Award: $314,755.00

PI: Marshall, Alan
Grant Title: Program Income for Project 007232
Agency: Various Sources (Royalties/ Other)
Project Dates: 11/26/03 - 12/31/05
Award: $93,300.00

PI: Marshall, Alan
Grant Title: Analysis of Canadian Crude Oils
Agency: Canadian Association of Petroleum Producers
Project Dates: 9/20/02 - 12/31/07
Award: $15,000.00

PI: Marshall, Alan
Grant Title: Analysis of Petroleum Samples
Agency: Natural Resources Canada
Project Dates: 12/23/03 - 7/20/07
Award: $25,000.00

PI: Marshall, Alan
Grant Title: Analysis of Petroleum Samples
Agency: Various Sources (Business/ Industry)
Project Dates: 12/23/03 - 7/20/07
Award: $3,000.00

PI: Moerland, Timothy
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/02 - 3/31/12
Award: $1,181.13

PI: Moerland, Timothy
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/02 - 3/31/12
Award: $1,735.00

PI: Painter, Thomas
Grant Title: 21 T FTICR W/ PNNL
Agency: Battelle Memorial Institute
Project Dates: 1/26/06 - 4/30/07
Award: $100,000.00

PI: Painter, Thomas
Grant Title: KBSI-NHMFL Collaboration on FT-ICR Conceptual Design
Agency: Korea Basic Science Institute
Project Dates: 3/1/05 - 12/31/06
Award: $150,116.00

PI: Popovic, Dragana
Grant Title: Study of Correlated Insulators and Metals in Two Dimensions
Agency: National Science Foundation
Project Dates: 5/1/04 - 4/30/08
Award: $100,000.00

PI: Rikvold, Per
Grant Title: Computational Studies of Dynamical Phenomena in Nanoscale Ferromagnets
Agency: Mississippi State University
Project Dates: 4/1/05 - 3/31/07
Award: $48,461.00

PI: Rodgers, Ryan
Grant Title: Analysis of Canadian Crude Oils
Agency: Canadian Association of Petroleum Producers
Project Dates: 9/20/02 - 12/31/07
Award: $15,000.00

PI: Rodgers, Ryan
Grant Title: Analysis of Petroleum Samples
Agency: Natural Resources Canada
Project Dates: 12/23/03 - 7/20/07
Award: $25,000.00

PI: Salters, Vincent
Grant Title: Nb/Ta Fractionations as Tracer of Subduction
Agency: National Science Foundation
Project Dates: 12/1/06 - 11/30/07
Award: $102,813.00

PI: Schepkin, Victor
Grant Title: Dual Sodium MRI and Proton ADC Assessment of Rodent Glioma Therapy
Agency: National Cancer Institute
Project Dates: 8/21/06 - 3/31/07
Award: $154,034.00

PI: Schlottmann, Pedro
Grant Title: Correlated Electrons
Agency: U. S. Department of Energy
Project Dates: 8/15/06 - 8/14/07
Award: $50,000.00

PI: Schwartz, Justin
Grant Title: Quench Behavior of YBCO Coated Conductors
Agency: University of Wisconsin
Project Dates: 7/1/04 - 6/30/06
Award: $20,837.00

PI: Schwartz, Justin
Grant Title: MRI Applications
Agency: Supercon, Inc.
Project Dates: 9/30/05 - 8/31/07
Award: $146,837.00

PI: Schwartz, Justin
Grant Title: Evaluation/ Characterization of MgB2/Ga Rods in Liquid Ne
Agency: NOVE Technologies, Inc.
Project Dates: 5/10/06 - 8/15/06
Award: $2,000.00

PI: Schwartz, Justin
Grant Title: High Field Magnets for MRI Applications
Agency: Supercon, Inc.
Project Dates: 9/1/06 - 8/31/07
Award: $173,796.00

PI: Tozer, Stanley
Grant Title: Electron Interactions in Actinides and Related Systems under Extreme Conditions
Agency: U. S. Department of Energy
Project Dates: 5/1/06 - 4/30/07
Award: $600,000.00

PI: Tozer, Stanley
Grant Title: Research on the Actinides and Related Materials At Extreme Conditions
Agency: Prairie View A&M University
Project Dates: 10/1/05 - 8/31/07
Award: $534,100.00

PI: Van Sciver, Steven
Grant Title: Liquid Helium Fluid Dynamics Studies
Agency: U. S. Department of Energy
Project Dates: 1/1/96 - 12/31/06
Award: $205,000.00

PI: Van Sciver, Steven
Grant Title: UCF - Densified LH2 and LO2
Agency: University of Central Florida
Project Dates: 6/1/02 - 2/1/07
Award: $250,000.00

PI: Van Sciver, Steven
Grant Title: Thermal Conductivity of Powder Insulations
Agency: University of Central Florida
Project Dates: 2/1/05 - 5/30/07
Award: $50,000.00

PI: Wang, Xiaoming
Grant Title: Uncertainty Analysis of Certain Fluid Systems
Agency: National Science Foundation
Project Dates: 7/1/06 - 6/30/09
Award: $167,781.00

PI: Wang, Xiaoming
Grant Title: A Geometric Method for Image Registration
Agency: National Science Foundation
Project Dates: 9/1/06 - 8/31/09
Award: $633,298.00

PI: Wang, Yang
Grant Title: Technician Support for the Stable Isotope Laboratory at Florida State University
Agency: National Science Foundation
Project Dates: 12/15/05 - 11/30/06
Award: $69,128.00

PI: Wang, Yang
Grant Title: Technician Support for the Stable Isotope Laboratory at Florida State University
Agency: National Science Foundation
Project Dates: 12/15/05 - 11/30/07
Award: $71,893.00

PI: Wiebe, Christopher
Grant Title: A New Interdisciplinary Crystal Growth Facility at the NHMFL
Agency: Florida State University Research Foundation
Project Dates: 2/14/06 - 6/14/06
Award: $15,000.00

PI: Woodruff, Stephen
Grant Title: Full Scale, High Power Density, Lightweight, Advanced Electric Propulsion System Technology Demonstrator
Agency: American Superconductor
Project Dates: 3/3/03 - 3/31/06
Award: $12,500.00

PI: Woodruff, Stephen
Grant Title: HTS Generator Simulation
Agency: Northrop Grumman Corporation
Project Dates: 3/10/06 - 4/28/06
Award: $25,000.00

GRANTS AWARDED TO NHMFL-AFFILIATED FACULTY AT THE UNIVERSITY OF FLORIDA

As reported by the UF Office of Sponsored Research for calendar year 2006

PI: Abernathy, C.
Grant Title: Magneto-Optical Behavior of II-TM-N Materials & Devices
Agency: U.S. Army
Project Dates: 10/1/04 - 2/28/07
Award: $106,000.00

PI: Abernathy, C.
Grant Title: Dielectrics for Improved Compound Semiconductor Device Performance
Agency: U.S. Navy
Project Dates: 12/1/04 - 11/30/07
Award: $108,835.00

PI: Bartlett, R. J.
Grant Title: High-Performance Computer Cluster for DoD Research Projects in Quantum Chemistry
Agency: U.S. Air Force
Project Dates: 6/1/06 - 5/31/07
Award: $238,404.00

PI: Bartlett, R. J.
Grant Title: Metastable Molecules in the Ground an in Excited States: Theory Development, Implementation and Application
Agency: U.S. Air Force
Project Dates: 2/15/04 - 12/31/06
Award: $155,000.00

PI: Bartlett, R. J.
Grant Title: Determination of Potential Energy Surfaces for Energetic Molecules
Agency: University of Missouri
Project Dates: 6/1/04 - 1/31/07
Award: $135,000.00

PI: Bartlett, R. J.
Grant Title: ITR: Science and Software for Predictive Simulation of Chemo-Mechanical Phenomena in Real Materials
Agency: National Science Foundation
Project Dates: 9/15/03 - 8/31/07
Award: $313,000.00

PI: Blackband, S. J.
Grant Title: Noninvasive Monitoring Glutathione Metabolism in Tumors
Agency: Duke University
Project Dates: 3/17/06 - 2/28/07
Award: $64,685.00

PI: Blackband, S. J.
Grant Title: High Field Magnetic Resonance Research and Technology (Continuation)
Agency: National Institutes of Health
Project Dates: 5/1/01 - 4/30/07
Award: $344,228.00

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: $10,910.00

PI: Blackband, S. J.
Grant Title: High-Field MRI: Limitations and Solutions
Agency: Pennsylvania State University
Project Dates: 9/3/02 - 8/31/07
Award: $138,142.00

PI: Brennan, A. B.
Grant Title: Development of a Creep Mitigation Process for Ultra High Molecular Weight Polyethylene Fiber for the ISIS Program
Agency: Lockheed Martin
Project Dates: 6/1/06 - 4/30/08
Award: $670,052.00

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 - 8/31/11
Award: $279,290.00

PI: Constantinidis, I.
Grant Title: Enhancement of Islet Viability
Agency: Juvenile Diabetes Foundation
Project Dates: 2/1/06 - 1/31/07
Award: $43,624.00

PI: Constantinidis, I.
Grant Title: Cryopreservation of Tissue Engineered Substitutes
Agency: Georgia Institute of Technology
Project Dates: 7/1/06 - 6/30/07
Award: $62,000.00

PI: Douglas, E.P.
Grant Title: Guided Inquiry Activities for Introduction to Materials
Agency: National Science Foundation
Project Dates: 1/1/07 - 12/31/09
Award: $148,955.00

PI: Edison, A. S.
Grant Title: National High Magnetic Field Laboratory
Agency: Florida State University
Project Dates: 1/1/06 - 12/31/07
Award: $586,115.00

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: $16,207.00

PI: Edison, A. S.
Grant Title: Discovery of *Caenorhabditis Elegans* Chemical Ecology
Agency: Human Frontier Science Program Org.
Project Dates: 7/1/05 - 6/30/07
Award: $189,942.00

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 - 4/30/07
Award: $150,000.00

PI: Fanucci, G. E.
Grant Title: Membrane Binding Properties of the GM2 Activator Protein
Agency: National Institutes of Health
Project Dates: 5/5/06 - 4/30/11
Award: $272,264.00

PI: Fanucci, G. E.
Grant Title: Double Electron-Electron Resonance (Deer) Spectroscopy of Biological Macromolecules – NHMFL In-House Research Program
Agency: Florida State University
Project Dates: 1/1/06 - 12/31/07
Award: $95,970.00

PI: Fanucci, G. E.
Grant Title: Site-Directed Spin Labeling EPR Studies of Conformational Dynamics in the Flap Region in HIV Protease
Agency: American Heart Association
Project Dates: 7/1/06 - 6/30/08
Award: $21,770.00

PI: Fanucci, G. E.
Grant Title: Double Electron-Electron Resonance (Deer) Spectroscopy of Biological Macromolecules - NHMFL In-House Research Program
Agency: Florida State University
Project Dates: 1/1/06 - 12/31/07
Award: $74,807.00

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: $111,505.00

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: $120,549.00

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 - 6/30/07
Award: $24,999.00

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: 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: $99,902.00

PI: Ihas, G. G.
Grant Title: Materials World Network: Collaborative Experimental Investigation of Pure Quantum Turbulence in Superfluid 4He
Agency: National Science Foundation
Project Dates: 5/1/06 - 5/31/07
Award: $135,000.00

PI: Ingersent, J. K.
Grant Title: REU Site: Materials Physics at the University of Florida
Agency: National Science Foundation
Project Dates: 4/1/06 - 3/31/07
Award: $104,000.00

PI: Lee, Y.
Grant Title: Nature of Pure & Dirty Liquid 3He-Fundamental Investigations and Educational Activities
Agency: National Science Foundation
Project Dates: 2/15/03 - 1/31/07
Award: $92,075.00

PI: Liu, Y.
Grant Title: Mathematical and Computational Algorithms for Visualization of Human Brain Neural Pathways
Agency: University of Kentucky
Project Dates: 10/1/05 - 9/30/07
Award: $23,257.00

PI: Liu, Y.
Grant Title: Functional MRI Investigation of Impaired Leptin Regulation Due to Secondhand Smoking
Agency: Flight Attendant Med. Res. Institute
Project Dates: 7/1/04 - 6/30/07
Award: $108,500.00

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: $69,863.00

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: $50,759.00

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: $224,485.00

PI: Mareci, T. H.
Grant Title: Convective Drug Transport in the Spinal Cord
Agency: National Institutes of Health
Project Dates: 4/15/06 - 1/31/08
Award: $50,164.00

PI: Mareci, T. H.
Grant Title: CRCNS: Evolution Into Epilepsy
Agency: National Institutes of Health
Project Dates: 9/1/04 - 6/30/08
Award: $83,475.00

PI: Mareci, T. H.
Grant Title: CRCNS: Automatic Prediction of the Onset of Epilepsy via Analysis of High Angular Resolution Diffusion Weighted MRI
Agency: National Institutes of Health
Project Dates: 8/1/06 - 5/31/10
Award: $85,305.00

PI: Mareci, T. H.
Grant Title: A Study of Model B-Cells in Diabetes Treatment
Agency: National Institutes of Health
Project Dates: 5/15/02 - 8/31/11
Award: $9,483.00

PI: Mareci, T. H.
Grant Title: CRCNS: Automatic Prediction of the Onset of Epilepsy via Analysis of High Angular Resolution Diffusion Weighted MRI
Agency: National Institutes of Health
Project Dates: 8/1/06 - 5/31/10
Award: $3,290.00

PI: Meisel, M.W.
Grant Title: Magnetism of Quantum Spins Systems in Low Dimensions
Agency: National Science Foundation
Project Dates: 06/14/2005-06/30/2007
Award: $95,000.00

PI: Norton, D. P.
Grant Title: Transition Metal Doped ZnO for Spintronics
Agency: U.S. Air Force
Project Dates: 8/1/03 - 1/31/07
Award: $87,500.00

PI: Norton, D. P.
Grant Title: Alternative Chemistries for Barrier Materials in Cu Metalization
Agency: National Science Foundation
Project Dates: 6/1/03 - 8/31/08
Award: $131,835.00

PI: Norton, D. P.
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: $60,139.00

PI: Obukhov, S.
Grant Title: Transitional Properties of a Polymer Chain
Agency: American Chemical Society
Project Dates: 1/1/06 - 8/31/08
Award: $42,500.00

PI: Pearton, S. J.
Grant Title: Materials Processing For ZnO
Agency: National Science Foundation
Project Dates: 4/1/04 - 3/31/07
Award: $83,630.00

PI: Pearton, S. J.
Grant Title: High Density Three-Dimensional Packaging Technology for Rf Devices
Agency: International Technology Corp.
Project Dates: 5/18/04 - 6/30/07
Award: $121,000.00

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: 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: $115,000.00

PI: Richards, N. G.
Grant Title: Biochemical Studies of Oxalate Decarboxylase
Agency: National Institutes of Health
Project Dates: 4/1/03 - 7/31/07
Award: $159,335.00

PI: Rinzler, A. G.
Grant Title: Vertical Architecture TFT
Agency: Arrowhead Research Corp.
Project Dates: 7/20/06 - 7/20/08
Award: $647,533.00

PI: Rinzler, A. G.
Grant Title: Carbon Nanotube-Based Transparent Electrodes for Polymer Emittin, Electro
Agency: Nanoholdings Llc.
Project Dates: 7/15/05 - 6/14/07
Award: $51,275.00

PI: Rinzler, A. G.
Grant Title: Carbon Nanotube-Based Transparent Electrodes for Polymer Emittin, Electro
Agency: Nanoholdings Llc.
Project Dates: 7/15/05 - 6/14/07
Award: $181,649.00

PI: Stanton, C. J.
Grant Title: U.S.-Japan Cooperative Research and Education: Ultrafast & Nonlinear Optics In 6.1-Angstrom Semiconductors
Agency: Rice University
Project Dates: 1/1/06 - 12/31/10
Award: $50,914.00

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: $190,895.00

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: $24,375.00

PI: Stewart, G. R.
Grant Title: Novel Strongly Correlated (Primarily F-) Electron Behavior
Agency: U.S. Department of Energy
Project Dates: 12/1/03 - 11/30/06
Award: $107,411.00

PI: Sullivan, N. S.
Grant Title: The National High Magnetic Field Laboratory
Agency: Florida State University
Project Dates: 1/1/06 - 12/31/07
Award: $267,151.00

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: $110,000.00

PI: Tanner, D. B.
Grant Title: IMR-MIP: Concept and Engineering Design of a Free Electron Laser Light Source for High Magnetic Field Research
Agency: Florida State University
Project Dates: 1/1/06 - 8/31/07
Award: $65,041.00

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 - 2/28/07
Award: $58,000.00

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 - 5/14/09
Award: $125,000.00

PI: Vandenborne, K. H.
Grant Title: Validation of MR Imaging for Clinical Trials in Muscular Dystrophy
Agency: Muscular Dystrophy Association
Project Dates: 7/1/06 - 6/30/09
Award: $340,889.00

PI: Vandenborne, K. H.
Grant Title: Molecular Signatures of Muscle Rehabilitation after Limb Disuse
Agency: National Institutes of Health
Project Dates: 9/28/04 - 7/31/09
Award: $315,116.00

PI: Vandenborne, K. H.
Grant Title: Noninvasive Monitoring and Tracking of Muscle Stem Cells
Agency: National Institutes of Health
Project Dates: 9/22/04 - 8/31/08
Award: $19,598.00

PI: Walter, G. A.
Grant Title: Multimodal Qdot Based Nanoprobe for Real Time Noninvasive Bioimaging
Agency: National Science Foundation
Project Dates: 9/1/05 - 8/31/09
Award: $210,164.00

PI: Walter, G. A.
Grant Title: Noninvasive Monitoring and Tracking of Muscle Stem Cells
Agency: National Institutes of Health
Project Dates: 9/22/04 - 8/31/08
Award: $236,796.00

PI: Walter, G. A.
Grant Title: Validation of MR Imaging for Clinical Trials in Muscular Dystrophy
Agency: Muscular Dystrophy Association
Project Dates: 7/1/06 - 6/30/09
Award: $50,987.00

Research Reports by Category

BIOCHEMISTRY - 57 REPORTS

Facility	PI Name	Title
DC Field Facility	Krzystek, J.	Tunable-frequency, High-field EPR of a High-spin Ferric Heme Protein: Met-myoglobin
DC Field Facility	Angerhofer, A.	Ultra-high Field EPR of the Mn-dependent Enzyme Oxalate Decarboxylase from Bacillus Subtilis
EMR Facility	Fajer, P.G.	Activation by Metal Binding of the Anthracis Repressor from Bacillus Anthracis
EMR Facility	Smirnova, T.I.	Binding of DPPC Lipid to Sec14 Protein
EMR Facility	Fajer, P.G.	Conformational Changes of TnI C-terminus upon Ca2+ Binding in Thin Filament
EMR Facility	Fajer, P.G.	Conformational Switching in Troponin
EMR Facility	Thomas, D.D.	DEER Measurements on the Actomyosin Complex
EMR Facility	Thomas, D.D.	DEER Measurements on the Phospholamban Pentamer
EMR Facility	Dalal, N.S.	Dielectric, Electron Paramagnetic Resonance and Magnetization Studies of Spanish Moss
EMR Facility	Redding, K.E.	HF-EPR Studies of Cyanobacterial Photosystem I Mutants with Altered P700 Hydrogen-bonding Patterns
EMR Facility	Fanucci, G. E.	Pulsed Electron Paramagnetic Resonance Studies of the Flap Region in HIV-1 Protease
EMR Facility	Redding, K.E.	Use of High-field EPR to Investigate the Effect of the Loss of Hydrogen-bonds Upon the g-Tensor of A0–, the Reduced Primary Electron Acceptor of Photosystem I
ICR Facility	Marshall, A. G.	Bryostatin-1 Structural Modifications Induced by UV Radiation Exposure and Revealed by Mass Spectrometry
ICR Facility	Marshall, A. G.	Characterization of the Capsid Protein Glycosylation of Adeno-Associated Virus (AAV-2) by High Resolution Mass Spectrometry
ICR Facility	Marshall, A. G.	De Novo Sequencing and Disulfide Mapping of a Bromotryptophn-Containing Conotoxin by Electrospray Ionization FT-ICR Mass Spectrometry
ICR Facility	Marshall, A. G.	Structural Basis of Molecular Motor Regulation in a Viral Capsid
ICR Facility	Marshall, A. G.	Structural Characterization of an Unusually Stable Cyclic Peptide Kalata B 2 from Oldenlandia affinis
MBI-UF AMRIS	Walter, G.A.	Characterization of Paramagnetic Lanthanide Ion Complexes as MRI Contrast Agents as a Function of Magnetic Field Strength
MBI-UF AMRIS	Flotte, T.R.	Cross-correction of a Fatty Acid Oxidation Defect by Intramuscular Injection of a Recombinant Adeno-associated Virus Vector
MBI-UF AMRIS	Walter, G.A.	Gadolinium Functionalized Quantum Dot MRI Contrast as a Function of Magnetic Fields Strength
MBI-UF AMRIS	Vasenkov, S.	Introduction of Pulsed Field Gradient (PFG) NMR with Ultra-high Gradient Strength for Studies of Diffusion in Domains of Lipid Membranes
MBI-UF AMRIS	Molinski, T.F.	Metabolites From Marine Organisms
MBI-UF AMRIS	Moudgil, B.M.	Multimodal Qdot Based Nanoprobe for Noninvasive Bioimaging
MBI-UF AMRIS	Hagen, S.J.	Residue Level Folding of the Intrinsically Unstructured IA3
MBI-UF AMRIS	Long, J.R.	Structural Studies of the Lung Surfactant Peptide KL4 using MAS ssNMR
MBI-UF AMRIS	Edison, A. S.	Structure-Activity Relations of C. elegans Neuropeptides
MBI-UF AMRIS	Simpson, N.E.	Studying Metabolic Pathways in Native Islets by 13C NMR Spectroscopic Techniques Using a Microcoil Apparatus

RESEARCH REPORTS BY CATEGORY

Facility	PI Name	Title
MBI-UF AMRIS	Simpson, N.E.	Studying the Link between Metabolic Pathways and Insulin Secretion in Insulinomas by 13C NMR Spectroscopic Techniques
NMR Facility	Logan, T.M.	Activation of Iron-sensitive Bacterial Repressors
NMR Facility	Barbar, E.	Binding of Dynein Light Chains LC8 and Tctex-1 to Intrinsically Disordered Intermediate Chain
NMR Facility	Cross, T.A.	Characterization of the Transmembrane Peptides of CorA from Mycobacterium Tuberculosis by NMR
NMR Facility	Bruschweiler, R.	Conformational Dynamics of the Na+/Ca2+ Exchanger
NMR Facility	Cross, T.A.,	Conformational Plasticity of M2-TMD Characterized by Static Solid-state NMR
NMR Facility	Bruschweiler, R.	Covariance NMR with Minimal Datasets
NMR Facility	Bruschweiler, R.	Covariance Processing of 3D and 4D NOESY Data
NMR Facility	Zhou, H.-X.	Drug–Membrane Interactions: Molecular Dynamics Simulations of Amantadine Bound to DMPC Membrane Bilayer
NMR Facility	Kern, D.	Dynamics of Pin1-PPlase Mutants in the Free and Substrate-Saturated States
NMR Facility	Bruschweiler, R.	Dynamics of the N-terminal Domain of Human MDM2 Protein Bound to a p53 Peptide
NMR Facility	Bruschweiler, R.	Efficient Deconvolution of Complex Mixtures by Covaniance NMR
NMR Facility	Greenbaum, N.	Examining Structural Features of the Larger Construct Representing the Spliceosomal Branch Site
NMR Facility	Chapman, M.S.,	Functional Dynamics of Arginine Kinase
NMR Facility	Cross, T.A.	Global Rotation of KcsA in Hydrated Liposome Observed by 17O Solid State NMR
NMR Facility	Cotten, M.,	High Field Solid-State NMR Structural Studies of Membrane-bound Antimicrobial Piscidins
NMR Facility	Duran, R.S	High Magnetic Gradient Studies of Multi-Component Core-Shell Particle Dynamics
NMR Facility	Cross, T.A.	Initial Characterization of Rv0008c, an Integral Membrane Protein from Mycobacterium tuberculosis by Solution NMR
NMR Facility	Greenbaum, N.	Investigation of an RNA Triplex in the Spliceosome
NMR Facility	Greenbaum, N.	Investigation of RNA Duplexes at Supercooled Temperatures
NMR Facility	Logan, T.M.	Isotope Enrichment in Eukaryotic Cells as a Prelude to Glycoprotein Structural Biology
NMR Facility	Greenbaum, N.	Mg2+ Induced Changes In Chemical Shifts of Imino Protons of the Branch Site Region of Domain 6 of A Group II Self-Splicing Intron
NMR Facility	Greenbaum, N.	Probing Features of Spliceosomal Protein p14 with RNA Ligands
NMR Facility	Cross, T.A.	Probing the Interactions of Micellar Environments with the Extramembranous Domains of Integral Membrane Proteins
NMR Facility	Cross, T.A.	Reconstitution of Intact Membrane Proteins into Nano-porous Substrate for Structural Characterization by Solid-state NMR
NMR Facility	Cross, T.A.	Solution NMR of a Membrane Protein from M. Tuberculosis Weakly Aligned in Polyacrylamide Gel
NMR Facility	Cross, T.A.	Solution NMR Study of M2 Proton Channel from Influenza A Virus
NMR Facility	Veglia, G.	Structure of Monomeric Phospholamban in Oriented Lipid Bilayers
NMR Facility	Veglia, G.	Two-dimensional NMR Spectroscopy of Sarcolipin in Oriented Lipid Bilayers
NMR Facility	Cross, T.A.	Uniformly Aligned Full-length Membrane Proteins in Liquid Crystalling Lipid Bilayers for Structural Characterization

BIOLOGY - 27 REPORTS

Facility	PI Name	Title
MBI-UF AMRIS	Gamscik, M.P.	13C Spectroscopy of Glycine Incorporation in the Rat Brain at 11T
MBI-UF AMRIS	Vandenborne, K.	A Quantitative Study of Bioenergetics in Skeletal Muscle Lacking Carbonic Anhydrase III Using 31P Magnetic Resonance Spectroscopy
MBI-UF AMRIS	Carter, S.	ACE Inhibition and Angiotensin Receptor Blocker Treatment on Skeletal Muscle Fat Content in Aged Rats
MBI-UF AMRIS	Harfe, B.	Analysis of Dicer Null Muscle
MBI-UF AMRIS	Forder, J.R	Contribution of Vascular Volume to Diffusion in the Myocardium
MBI-UF AMRIS	Behnke, M.	Diffusion Tensor Imaging of Cocaine Exposed Children
MBI-UF AMRIS	Blackband, S.J.	Diffusion Tensor Studies of the Isolated Rat Hippocampus
MBI-UF AMRIS	Edison, A. S.	Discovery of C. elegans Chemical Ecology
MBI-UF AMRIS	Zolotukhin, S.	Ectopic Expression of Wnt10b Decreases Adiposity and Improves Glucose Homeostasis in Obese Rats
MBI-UF AMRIS	Bradley, M.M.	Fear Relevance Modulates Frontal Cortex Activity During Anticipation of Pain
MBI-UF AMRIS	Kluger, B.M.	FMRI Investigation of the Crossed Response Inhibition Task in the Elderly and Parkinson's Disease
MBI-UF AMRIS	Edison, A. S.	Imaging C. elegans in Soil
MBI-UF AMRIS	Walter, G.A.	Magnetization Transfer Contrast in MRI as a Diagnostic and Monitoring Tool for Muscular Dystrophy
MBI-UF AMRIS	Constantinidis, I.	MR Imaging of the Pancreas
MBI-UF AMRIS	Blackband, S.J.	MR Microscopy Studies of Rat Hippocampal Slice Cultures
MBI-UF AMRIS	Raizada , M.K.	MR Monitoring of the Effect of ACE2 Expression on the Protection of the Heart from Ischemic Injury
MBI-UF AMRIS	Vandenborne, K.	Muscle T2 Relaxation Properties Following Spinal Cord Injury and Locomotor Training
MBI-UF AMRIS	Sambanis, A.	Non-Invasive Monitoring of Oxygen Availability within Pancreatic Substitutes
MBI-UF AMRIS	Blackband, S.J.	Postmortem Interval Effects on MRI of Human Autopsy Samples
MBI-UF AMRIS	Sabatinelli, D.	Selective Nucleus Accumbens and Medial Frontal Cortex Activation in Appetitive Picture Processing
MBI-UF AMRIS	Edison, A.S.	Single Insect NMR: Technology Leading to New Science
MBI-UF AMRIS	Malloy, C.	Small Volume Metabolomics of Rodents
MBI-UF AMRIS	Blackband, S.J.	Temperature and Fixation Effects On Water Diffusion In Cell Ghosts
MBI-UF AMRIS	Price, C.	White Matter In Parkinson's Disease: Preliminary Data
NMR Facility	Houpt, T.A.	Adaptation to the Behavioral Effects of High Magnetic Fields after Repeated Exposures
NMR Facility	Locke, B.R.	Micro-Magnetic Resonace Imaging of Rat Skin at 21 Tesla
NMR Facility	Schepkin, V.D.	Sodium MRI Can Grade Pre-Necrotic Development in Animal Tumor Models

RESEARCH REPORTS BY CATEGORY

CHEMISTRY - 40 REPORTS

Facility	PI Name	Title
DC Field Facility	Telser, J.	Tunable-Frequency High-Field EPR of a Series of Cobalt(II) "Scorpionate" Complexes as Models for Zinc Enzymes
DC Field Facility	Telser, J.	Tunable-Frequency High-Field EPR of Ferric Phthalocyanine Chloride
EMR Facility	Kokozay, V. N.	An Unprecedented Heterotrimetallic Fe/Cu/Co Core For Mild And Highly Efficient Catalytic Oxidation Of Cycloalkanes By Hydrogen Peroxide
EMR Facility	Stiegman, A.E.	Characterization of the Active Site in the Phillips Ethylene Polymerization Catalyst
EMR Facility	Kokozay, V. N.	Crystal Structures And Magnetic Properties Of Polynuclear Heterometallic Cu/Mn Carboxylate Complexes
EMR Facility	Desrochers, P. J.	Electronic Structure of Four-Coordinate C3v Nickel(II) Scorpionate Complexes: Investigation by High-Frequency and -Field Electron Paramagnetic Resonance and Electronic Absorption Spectroscopies
EMR Facility	Misra, S. K.	EPR Measurements on Samples Containing Transition Metal Ions at High Frequencies and at Variable Temperatures
EMR Facility	Krzystek, J.	HFEPR Investigation of Regular and N-Confused Porphyrin Complexes with Molybdenum
EMR Facility	Telser, J.	HFEPR Studies on Vanadium(III) Complexes as Models for the Active Site of Vanadium Nitrogenase Enzymes
EMR Facility	Ozarowski, A.	High-Field EPR Studies on an Isomeric Pair of Binuclear Iron(III) Complexes: The Red And Green [Fe(1,10-Phenanthroline)]2O(SO4)2×6H2O
EMR Facility	Krzystek, J.	High-Frequency and -Field EPR of Open Chain Mn(III) Porphyrinoid Complexes
EMR Facility	Dalal, N.S.	Magnetic and Variable Frequency EPR Studies of Penta-Nuclear Cu(2+) Polyoxometalate
EMR Facility	Dalal, N.S.	Magnetization and EPR Studies of a Mixed-Valence Vanadogermanate
EMR Facility	Krzystek, J.	Novel Linear Manganese Clusters of a Heptadentate bis-β-diketone Ligand
EMR Facility	Kokozay, V. N.	Self-Assembly of the Unique Heterotrimetallic Cu/Co/M Complexes Possessing Triangular Antiferromagnetic {Cu2CoPb}2 and Linear Ferromagnetic {Cu2CoCd2} Cores
EMR Facility	Dobrzynska, D.	Structural, Spectroscopic, and Magnetic Study of bis(9,10-dihydro-9-oxo-10-acridineacetate)bis(imidazole)bis(methanol) nickel(II)
Geochemistry	Canfield, G.M.	Sodalite Ion Exchange in Ethylene Oxide Oligomer Solutions
ICR Facility	Marshall, A. G.	Cage Fragmentation of Hydrogenated C60
ICR Facility	Marshall, A. G.	Characterization of Compositional Changes in Vacuum Gas Oil Distillation Cuts by Electrospray Ionization FT-ICR Mass Spectrometry
ICR Facility	Marshall, A. G.	Charge Location Directs Electron Capture Dissociation of Peptide Dications
ICR Facility	Marshall, A. G.	Compositional Differences between Pressure-Drop and Solvent-Drop Asphaltenes Determined by Electrospray Ionization FT-ICR Mass Spectrometry
ICR Facility	Marshall, A. G.	Comprehensive Compositional Analysis of Hydrotreated and Untreated Nitrogen-Concentrated Fractions from Syncrude Oil by Electron Ionization, Field Desorption/Ionization, and Electrospray Ionization Ultrahigh-Resolution FT-ICR Mass Spectrometry
ICR Facility	Marshall, A. G.	Detailed Compositional Comparison of an Asphaltene Deposit to Its Crude Oil Counterpart for Two Geographically Different Crude Oils by Electrospray Ionization FT-ICR Mass Spectrometry
ICR Facility	Marshall, A. G.	Hydrogenation of C60 at 2 GPA Pressure and High Temperature
ICR Facility	Marshall, A. G.	Identification of Hydrotreatment Resistant Heteroatomic Species in a Crude Oil Distillation Cut by Electrospray Ionization FT-ICR Mass Spectrometry

Facility	PI Name	Title
ICR Facility	Marshall, A. G.	Isolation and Characterization of Naphthenic Acids from a Metal Naphthenate Deposit. Molecular Properties at Oil-Water and Air -Water Interfaces
ICR Facility	Marshall, A. G.	Non-Polar Compositional Analysis of Vacuum Gas Oil Distillation Fractions by Electron Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
ICR Facility	Marshall, A. G.	Oil Reservoir Characterization via Crude Oil Analysis by Downhole Fluid Analysis in Oil Wells with Visible-Near IR Spectroscopy and by Laboratory Analysis with Electrospray Ionization FT-ICR Mass Spectrometry
ICR Facility	Marshall, A. G.	Petroleomics: Advanced Characterization of Petroleum-Derived Materials by FT-ICR MS
ICR Facility	Marshall, A. G.	Structural Characterization and Interfacial Behavior of Acidic Compounds Extracted from a North Sea Oil
ICR Facility	Marshall, A. G.	Truly "Exact" Mass: Elemental Composition Can Be Determined Uniquely From Molecular Mass Measurement at ~0.1 mDa Accuracy for Molecules Up To ~500 Da
ICR Facility	Marshall, A. G.	Use of Saturates/Aromatics/Resins/Asphaltenes (Sara) Fractionation to Determine Matrix Effects in Crude Oil Analysis by Electrospray Ionization FT-ICR Mass Spectrometry
MBI-UF AMRIS	Deinzer, M. L.	Structure Characterization of Proanthocyanidins by High Sensitivity NMR Spectroscopy with 1-mm HTS Probe
NMR Facility	Grey, C.	17O MQMAS NMR Studies of Zeolite HY
NMR Facility	Separovic, F.	39K NMR of Free Potassium in Geopolymers
NMR Facility	Alamo, R.G.	Crystallization in Precision Polyolefins
NMR Facility	Fu, R.	High Resolution Solid-State NMR of Lithium Rechargeable Battery Materials
NMR Facility	Cross, T.A.	Mathematical Analysis of Structural Information Contained in PISEMA Data
NMR Facility	Chmelka, B.F.	Monitoring the Synthesis of Hierarchically Porous Rutile Titania by Solid-State 67Zn and 47,49 Ti NMR
NMR Facility	Fu, R.	Unexpected Line-Narrowing and Sensitivity Enhancement at High Fields in Magic Angle Spinning NMR of Spin-1/2 Nuclei In Solids

ENGINEERING MATERIALS - 12 REPORTS

Facility	PI Name	Title
DC Field Facility	Walsh, R. P.	77 K Fatigue Crack Growth Rate of Modified CF8M Stainless Steel Castings
DC Field Facility	Xin, Y.	A New High Modulus High Strength Ni-Mo-Cr-Re Superalloy
DC Field Facility	Walsh, R. P.	Effect of Heat Treatments on the 4 K Fracture and Fatigue Properties of 316LN and Haynes 242
DC Field Facility	Molodov, D.A.	Impact of a Magnetic Field on Recrystallization in Commercial Aluminum Alloy
DC Field Facility	Molodov, D.A.	In-situ Measurements of Grain Boundary Motion in Zinc
DC Field Facility	Bult, J.B.	Load Transfer in Aligned Nanotube Composites
DC Field Facility	Parker, M. R.	Mechanical, Thermal and Electrical Enhancement of Epoxy-Based Composites Using Nanoparticle Infusion and High Magnetic Fields
DC Field Facility	Ludtka, G.M.	Non-Contact Ultrasonic Treatment of Conductive Materials in a High Magnetic Field Environment
DC Field Facility	Putatunda, S. K.	Thermo-Magnetic Processing Of Ductile Cast Iron
MBI-UF AMRIS	Vasenkov, S.	Transport in Nanomaterials with a Hierarchy of Pore Sizes
MS & T	Han, K	Structure and Transport Property of Nanolaminate Cu/Nb Composite Foils by a Simple One-Step Fabricate Route
Pulsed Field/LANL	Frings, P.	High-Magnetic-Field Limit Test of the Toulouse 80 Tesla Magnet

RESEARCH REPORTS BY CATEGORY

GEOCHEMISTRY - 14 REPORTS

Facility	PI Name	Title
Geochemistry	Wang, Y.	A Study of the Reliability of Bioapatite delta18O and delta13C as Proxies for Change in Paleovegetation and Paleoenvironment
Geochemistry	Wang, Y.	Abiogenic Hydrocargon Accumulations in the Songliao Basin, China
Geochemistry	Holmes, C. W.	Archive in the Deep: A 2000 Year History of Oceanography and Climate Change Recorded in the Western North Atlantic Deep-Sea Corals
Geochemistry	Salters, V.J.M.	Assessing the Crustal and Mantle Sources for Mt. Rainier Volcanics
Geochemistry	Bizimis, M.	Constraints on the Oxygen Fugacity of the Sub-Oceanic Lithosphere Beneath Hawaii
Geochemistry	Cable, J.E.	Evaluating the Role of a Subterranean Estuary on the Redox Cycling of Uranium
Geochemistry	Salters, V.J.M.	Heterogeneity in the Upper Mantle From Nd Isotopic Composition of the Abyssal Peridotites
Geochemistry	Humayun, M.	Iron/Manganese Ratio and Manganese Content in Shield Lavas from Ko'olau Volcano, Hawai'i
Geochemistry	Kish, S.	Isotope Analyses of Galena from Prehistoric Archaeological Sites in Eastern United States
Geochemistry	Bizimis, M.	Nd-Sr-Pb Isotope Compositions of Garnet Pyroxenites from Ka`ula, Hawaii: Implications for Plume-Lithosphere Interaction
Geochemistry	Wang, Y.	Paleoenvironment of a Late Pliocene Fauna of Northern Tibetan Plateau
Geochemistry	Humayun, M.	The Distribution of Hf and W in Inclusions from Meteorites and the Chronology of the Early Solar System
Geochemistry	Das, R.	Trace Element & Pb Isotope Studies of the Kutch Volcanics of NW-India
Geochemistry	Salters, V.J.M.	Trace Metal-Humic Complexes in Natural Waters: Insights From Speciation Experiments

INSTRUMENTATION - 14 REPORTS

Facility	PI Name	Title
DC Field Facility	Choi, E. S.	Piezoelectric Actuator Driven VSM - Feasibility Test with the 45T Hybrid Magnet
ICR Facility	Marshall, A. G.	Atmospheric Pressure Photoionization FT-ICR Mass Spectrometry for Complex Mixture Analysis
ICR Facility	Marshall, A. G.	External Electron Ionization 7 T Fourier Transform Ion Cyclotron Resonance Mass Spectrometer for Resolution and Identification of Volatile Complex Mixtures
ICR Facility	Marshall, A. G.	Impact of Ion Magnetron Motion on Electron Capture Dissociation FT-ICR Mass Spectrometry
iCR Facility	Marshall, A. G.	Probing Protein-Ligand Interactions by Automated Hydrogen/Deuterium Exchang Mass Spectrometry
ICR Facility	Marshall, A. G.	Supercritical Fluid Chromatography Reduces Back-Exchange in Solution-Phase Hydrogen/Deuterium Exchange with Mass Spectrometric Analysis
MBI-UF AMRIS	Crozier, S.	A Novel PIN Diode Switch Design for Large Arrays at 11.1T
MBI-UF AMRIS	Grant, S.C.	Focused Parallel Imaging Array For Mouse Brain Imaging at 11.1T
MBI-UF AMRIS	Blackband, S.J.	MR Microscopy of Brain Tissue Using a 200 Micron Diameter Surface Coil
MBI-UF AMRIS	Blackband, S.J.	Volume Birdcage Coils Optimised for Large Samples at 900 MHz
NMR Facility	Ulrich, A.	Small Sample Low-E Probe for Solid State NMR of Peptides Available in Limited Quantities
Pulsed Field/LANL	Rickel, D.G.	Measurement of Pulsed Magnetic Field Reproducibility
Pulsed Field/LANL	Balakirev, F. F.	Multi-Channel Digital Lockin for DC and Pulsed Magnets

Facility	PI Name	Title
Pulsed Field/LANL	Sharma, P. A.	Pulsed Magnetic Field Calibration of CERNOX Thermometers at 3He Temperatures

KONDO/HEAVY FERMION SYSTEMS - 23 REPORTS

Facility	PI Name	Title
CMT/E	Wiebe, C. R.	Gapped Itinerant Spin Excitations Account for Missing Entropy in the Hidden Order State of URu2Si2
DC Field Facility	Andraka, B.	Crystalline Electric Field Effects in Specific Heat and Magnetoresistance of pure and La-doped PrOs4Sb12
DC Field Facility	Harrison, N.	Doped Mott Insulator Physics in the f-Electron Superconductors CeIn3 – An Investigation
DC Field Facility	Balicas, L.	Field-Induced Fermi Surface Reconstruction and Adiabatic Continuity Between Antiferromagnetism and Hidden-Order State in URu2Si2
DC Field Facility	Petrovic, C.	High Magnetoresistance in a Doped Nearly Magnetic Semiconductor
DC Field Facility	Tozer, S.W.	High Pressure Tunnel Diode Oscillator Experiments on CeCoIn5
DC Field Facility	Schmiedeshoff, G.M.	Low Temperature Magnetostriction of Heavy Fermion YbAgGe
DC Field Facility	Basov, D.N.	Magneto-Optical Measurements of Heavy Fermion YbFe4Sb12 Thin Films
DC Field Facility	Capan, C.	Magnetoresistance and dHvA Study of the Metamagnetic Transition in CeIrIn5 Up to 45T
DC Field Facility	Andraka, B.	Observation of Kondo-Holes in La-Doped CeOs4Sb12
DC Field Facility	Stewart, G.R.	Two Quantum Critical Points in Ce(Ru1-xRhx)2Si2; nFl Behavior in the Magnetically Ordered State of U(Pt0.94Pd0.06)3
High B/T at UF	Julian, S.R.	Ultra-Low Temperature de Haas-van Alphen Oscillations in CeCoIn5
Pulsed Field/LANL	Harrison, N.	de Haas-van Alphen Experiments on Sn-Doped CeIn3 – An Investigation
Pulsed Field/LANL	Fisk, Z.	de Haas-van Alphen Study of the Fermi Surface of CexLa1-xB6 as a Function of Composition: The Evolution of Field-Dependent Quasiparticle Effective Masses
Pulsed Field/LANL	Singleton, J.	Dirty Peierls Transitions in Alpha-Uranium
Pulsed Field/LANL	Hayden, S.M.	High-field de Haas-van Alphen Effect Studies of ZrZn2
Pulsed Field/LANL	Maple, B.	Magnetization Measurements on URu2-xRexSI2: X = 0.02, 0.04 and 0.10
Pulsed Field/LANL	Harrison, N.	Magnetization of CeRhIn5 – An Investigation
Pulsed Field/LANL	Maple, B.	Magnetoresistance Measurements on URu2-xRexSi2 : X = 0.01 and 0.08
Pulsed Field/LANL	Maple/Ardavan	On the de Haas-van Alphen Effect of PrOs4As12 and LaOs4As12
Pulsed Field/LANL	Maple, M.B.	Preliminary Study of the Hidden Order Transition in URu2-xRexSi2
Pulsed Field/LANL	Bud'ko, S.	Pulse-Echo Measurements of the Field Dependent Elastic Moduli of the Heavy Fermion YbAgGe
Pulsed Field/LANL	Zapf, V.S.	Specific Heat of CeRh1-xCoxIn5 in High Magnetic Fields

MAGNET TECHNOLOGY - 6 REPORTS

Facility	PI Name	Title
DC Field Facility	Han, K.	Alumina Particle-Reinforced Nb3Sn Wire
DC Field Facility	Han, K.	Magnetic-Field-Induced Crystallographic Texture Enhancements in Cold-Deformed FePt and FePt/Fe3Pt Nanostructured Magnets
DC Field Facility	Han, K.	Physical Properties of Super Alloy Haynes 242 at Low Temperatures
MS & T	Bird, M.D.	Cooling System Analysis and Design of the Superconducting Outsert in the Series-Connected Hybrid Magnet System
MS & T	Han, K.	High Strength Pure Cu
Pulsed Field/LANL	Swenson, C.A.	Performance of 1st 90 T Insert Magnet for DOE-NSF 100 Tesla Multi-shot Magnet System

MAGNETIC RESONANCE TECHNIQUES - 48 REPORTS

Facility	PI Name	Title
DC Field Facility	Brey, W.W.	Reduction of Temporal Magnetic Field Variations in Resistive Magnets using Digital Feedback Control
EMR Facility	van Tol, J.	Design Study of a FIR/THz FEL for High Magnetic Field Research
EMR Facility	van Tol, J.	Frequency Dependent Relaxation and 39K Pulsed ENDOR of Cr5+ Impurities in K3NbO8
EMR Facility	van Tol, J.	High-Frequency Microwave Response of 2D Electron Gas
EMR Facility	Brunel, L.C.	Pioneering 0.24 THz Nanosecond Resolution Pulsed EPR with U.C. Santa Barbara Free Electron Laser
EMR Facility	van Tol, J.	Pulsed Electron Paramagnetic Resonance Spectrometer Operating at 110-336 GHz
MBI-UF AMRIS	Vandenborne, K.	31P Magnetic Resonance Spectroscopy of Calpain 3 Knockout Mouse Skeletal Muscle
MBI-UF AMRIS	Forder, J.R.	A Novel DTI Method for Analyzing the Diffusion of Water in Retina
MBI-UF AMRIS	Byrne, B.	AAV SDF-1 Augmented Myoblast Therapy for Cardiac Failure
MBI-UF AMRIS	Blackband, S.J.	Anololous Diffusion In Nervous Tissue as a Novel MRI Contrast
MBI-UF AMRIS	White, K.D.	Comparisons of Signal Change from InVivo SmartPhantom and Human BOLD fMRI of Language and Motor Systems
MBI-UF AMRIS	Forder, J.R.	Diffusion Imaging Quantifies Changes in Permeability in Murine Retina
MBI-UF AMRIS	Mareci, T. H.	Diffusion Tensor Magnetic Resonance Imaging at 11 and 17.6 Tesla in a Rat Model of Mesial Temporal Lobe Epilepsy
MBI-UF AMRIS	Mareci, T. H.	Evolution of Temporal Lobe Epilepsy Observed with 11.1 Tesla Magnetic Resonance Imaging In Vivo
MBI-UF AMRIS	Crozier, S.	Experimental Verification of a Combined MoM/FEM Model at 2 and 11T
MBI-UF AMRIS	Constantinidis, I.	Inductively Coupled RF Coils for Tissue Engineering Applications
MBI-UF AMRIS	Long, J.R.	Low-E Magic Angle Spinning Probe for Biological Solid State NMR At 750 MHz
MBI-UF AMRIS	Sadleir, R.J.	Magnetic Resonance Electrical Impedance Tomography at 11 and 17 T
MBI-UF AMRIS	Mareci, T. H.	Magnetic Resonance Imaging at 17.6 Tesla in an Animal Model of Mesial Temporal Lobe Epilepsy and Correlation with Histological Analysis
MBI-UF AMRIS	Byrne, B.	MRI for Cardiac Evaluation of Pulmonary Hypertension in Rats

Facility	PI Name	Title
MBI-UF AMRIS	Byrne, B.	rAAV2/9 Mediated Gene Therapy for the Cardiac Phenotype in a Mouse Model of Pompe Disease
MBI-UF AMRIS	Mareci, T. H.	Resolution of Complex Tissue Microarchitecture using Diffusion Orientation Transform
NMR Facility	Gan, Z.	13C/14N Distance Measurement in Natural Abundant Solids Using R-RESPDOR NMR
NMR Facility	Gan, Z.	13C/14N HMQC with Rotary Resonance and REDOR Dipolar Recoupling
NMR Facility	Witter, R.	15N-Solid State NMR Investigations on TTAA
NMR Facility	Reyes, A.P.	51V NMR and Competing Ordered States in MnV2O4
NMR Facility	Brey, W.W.	Comparison of Sample Heating in Solenoidal and Low-E NMR Probes
NMR Facility	Cross, T.A.	Direct Measurement of Proton Transport Through Influenza Virus A M2 Protein Reconstituted Vesicles
NMR Facility	Brey, W.W.	Electromagnetic Simulation and Comparison of NMR Coil/Capacitor Designs to Lessen RF Heating Through Minimization of E/B Ratios
NMR Facility	Fu, R.	High Resolution 15N NMR of Antiferroelectric Phase Transition in a Single Crystal of Ammonium Dihydrogen Arsenate, NH4H2AsO4
NMR Facility	Fu, R.	High Resolution Heteronuclear Correlation Spectroscopy in Solid-State NRM of Aligned Samples
NMR Facility	Grant, S.C.	High Resolution Sodium Imaging of Isolated Single Neurons
NMR Facility	Gan, Z.	High-Resolution NMR Above 1 GHz in a Resistive Magnet
NMR Facility	Cappendijk, S.L.T.	In Vivo Imaging of the Zebra Finch Brain
NMR Facility	Cross, T.A.	Induction of Membrane Protein Tubular Structures in Escherichia Coli
NMR Facility	Cross, T.A.	Mathematical and Algorithmic Developments in Solid-State NMR
NMR Facility	Grant, S.C.	MR Microscopy at 21.1 T: An Evaluation of Sensitivity & Contrast
NMR Facility	Brey, W.W.	Nuclear Magnetic Resonance Thermometry for Aligned Proteins in Lipid Bilayers
NMR Facility	Bruschweiler, R.	Protein Dynamics from NMR Spin Relaxation at High Magnetic Fields
NMR Facility	Gan, Z.	Proton-Detected 14N MAS NMR Using Homonuclear Decoupled Rotary Resonance
NMR Facility	Ulrich, A.	Single Coil Triple Resonance HFX-Probes for Solid-State NMR Spectroscopy
NMR Facility	Cotten, M.,	Solid-State NMR Structural and Dynamic Studies of Membrane-Bound Antimicrobial Piscidins Using Low E-Field Probes
NMR Facility	Cross, T.A.	Towards Structure Determination of Mycobacterium tuberculosis Cell Wall Hydrolase Rv2719c via Solution Nuclear Magnetic Resonance Spectroscopy
NMR Facility	Witter, R.,	Using 15N Molecular Thermosensor to Account for RF-induced Heating in Solid-State NMR Probes
Pulsed Field/LANL	McDonald, R.D.	Characterization of Non-Metallic Pressure Cells at GHz-Frequencies
Pulsed Field/LANL	Sebastian, S.E.	Role of Anisotropy in the Spin-Dimer Compound BaCuSi2O6
UF Physics	Hill, S.	High-Frequency EPR Studies of NiCl2-4SC(NH2)2
UF Physics	Bowers, C.R.	Single File Diffusion and Laser Polarized Tracer Exchange NMR in Peptide Nanotubes

RESEARCH REPORTS BY CATEGORY

MAGNETISM & MAGNETIC MATERIALS - 46 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	Chiorescu, I.	Development of a Pulsed Network Analyzer for Studies on Molecular Magnets and Organic Conductors
CMT/E	Hoch, M.J.R.	Disorder and Double Exchange Spin Dynamics in La0.7Sr0.3MnO3 and La0.7Sr0.3CoO3 via NMR Hyperfine Couplings
CMT/E	Reyes, A.P.	Magnetic Phase Separation in La1-xSrxCoO3 Single Crystals Using 139La NMR
CMT/E	Bonesteel, N.E.	Monte Carlo Study of Entanglement Scaling in Random Spin Chains
CMT/E	Dobrosavljevic, V.	Quantum Critical Behavior of the Cluster Glass Phase
CMT/E	Cao, J.	Structural Phase Transitions in Colossal Magnetoresistive Materials
DC Field Facility	Takano, Y.	Anisotropic Magnetic Phase Diagram of Cs2CuBr4
DC Field Facility	Strouse, G.F.	Change in Spin-Orbit Coupling Upon Addition of Manganese in CdSe Nanocrystals
DC Field Facility	Musfeldt, J.L.	Discovery of High-Energy Magneto-Dielectric Effect in a Frustrated Kagome Lattice Material
DC Field Facility	Mitrovic, V.F.	Field Induced Staggered Magnetization in Cs2CuCl4
DC Field Facility	Fisher, I. R.	Heat Capacity at 3He Temperatures in BEC Magnet BaCuSi2O6
DC Field Facility	Ghosh, K.	High Field Magnetoresistance and Hall Effect in Dilute Magnetic Semiconductors
DC Field Facility	Hill, S.	High Frequency EPR Study of High Spin Co(II) Complex
DC Field Facility	Dunbar, K. R.	Investigation of Magnetic Properties of a Family of Molecular Squares by HFEPR
DC Field Facility	Kosaka, M.	Magnetic Phase Diagram of Quadrupolar Ordering Compound YbAl3C3
DC Field Facility	Kim, K. H.	Magnetic-Field-Induced Quantum Phase Transition in BiMn2O5
DC Field Facility	Dalal, N.S.	Magneto Heat Capacity and Torquemagnetometric Studies of a Cr(IV) Based 2-D Antiferromagnet
DC Field Facility	Fisher, I. R.	Magnetostriction and Anisotropic Magnetic Phase Diagram of the Spin Dimer Compound BaCuSi2O6
DC Field Facility	Doerr, M.	Magnetostriction of Antiferromagnetic Materials
DC Field Facility	Imai, T.	NMR Investigation of Anomalous Antiferromagnet NA0.5CoO2
DC Field Facility	Harrison, N.	Phase Diagram of the Frustrated 2D Dimer Spin System SrCu2(BO3)2
DC Field Facility	Tozer, S.W.	Possible Bose-Einstein Condensation of Spin Degrees of Freedom in NiCl2-4SC(NH2)2
DC Field Facility	Brooks, J.S.	Probing Multiferroicity and Spin-Spin Interactions via Angular Dependent Dielectric Measurements on Y-Doped HoMnO3 in High Magnetic Fields
DC Field Facility	Hill, S.	Role of Anisotropy in the Spin Dimer Compound BaCuSi2O6
DC Field Facility	Lee, Y.S.	Specific Heat Measurements on a S=1/2 Kagome Lattice System
DC Field Facility	Garlea, V.O.	Spin-Level Crossings in the Cubane-Type Magnetic Molecule {Cr8}
DC Field Facility	Takano, Y.	Stability of the New Antiferromagnetically Ordered Phase of the S=1 Linear-Chain Compound Ni(C5H14N2)2N3(PF6)
EMR Facility	Zorko, A.	High-Field ESR Study of the 2D Spin System Ni5(TeO3)4X2 (X = Cl, Br)

Facility	PI Name	Title
EMR Facility	Dalal, N.S.	Zero-Field 55Mn NMR Measurements on Single Crystals of the Single-Molecule Magnet Mn12-Brac Down to 400 Mk
Pulsed Field/LANL	Bhansali, S.	Characterization of Ni-Fe Nanowires: Effect of Template Material and Deposition Conditions
Pulsed Field/LANL	Burch, K.S.	Determination of the Carrier Density in Ga1-xMnxAs via High Field Hall Measurements
Pulsed Field/LANL	Lawrence, J.M.	High Field Magnetization in the Induced Magnetic Moment System Pr3In
Pulsed Field/LANL	Cheong, S-W.	High Magnetic Field Anisotropic Magnetization Measurements of LuFe2O4
Pulsed Field/LANL	Cheong, S-W.	High Magnetic Field Studies of Geometrically Frustrated Multiferroic HoMnO3
Pulsed Field/LANL	Blundell, S.J.	High-Field Characterization of Magnetic Oxides
Pulsed Field/LANL	Burch, K.S.	Imaging Magnetization in Ga1-xMnxAs
Pulsed Field/LANL	Burch, K.S.	Magnetic Gradient-Induced Voltage in Mn-doped GaAs Films
Pulsed Field/LANL	Junior, A.	Magnetic Properties Of Nanoparticles Of CoxFe(3-X)O4 (0.05 ≤ X ≤ 1.6) Prepared By Combustion Reaction
Pulsed Field/LANL	Kim, K. H.	Magnetization of LiCu2O2 Under High Magnetic Fields
Pulsed Field/LANL	Kimura, T.K.	Magnetoelastic and Magnetoelectric Effects in a Triangular Lattice Antiferromagnet CuFeO2
Pulsed Field/LANL	Ruegg, Ch.	Quantum Phases of an Organic Spin-Ladder Compound
Pulsed Field/LANL	Paduan-Filho, A.	Search for 2nd Sound at 50 mK in BEC compound NiCl2-4SC(NH2)2
Pulsed Field/LANL	Crooker, S.A.	Spatial Imaging and Manipulating Domain Structure in Permalloy Thin Film Micro-Structures
Pulsed Field/LANL	Lawrence, J.M.	Specific Heat and Magneto Caloric Effect in Pr3In
Pulsed Field/LANL	Fabris, F.W.	Specific Heat Measurements on NiCl2-4SC(NH2)2 (DTN sample)

METAL-INSULATOR TRANSITIONS - 8 REPORTS

Facility	PI Name	Title
CMT/E	Popovic, D.	Nonequilibrium Relaxations and Aging Effects in a 2D Coulomb Glass
DC Field Facility	Rosenbaum, R. L.	Electronic Transport in a Quasicrystalline Icosahedral Al-Cu-Re Sample
DC Field Facility	Drichko, I. L.	Frequency Dispersion of the Complex High-Frequncy Conductance in the p-type Si/SiGe Heterostructures in the Ultra-Quantum Limit. Acoustic Study
DC Field Facility	Drichko, I. L.	High Field DC Magnetotransport in p-type Si/SiGe Heterostructures
DC Field Facility	Souslov, A.	Metal-Insulator Transition in Si/SiGe Heterostructures
DC Field Facility	Tanner, D.B.	Temperature- and Field-Dependent Far-Infrared Studies of LPCMO Films
High B/T at UF	Tsui, D.C.	Disappearance of the Metal-Like Behavior in GaAs Two-Dimensional Holes Below T=30 mK
Pulsed Field/LANL	Littlewood, P.B.	Charge Density Wave Type Behaviour of the Low Temperature Superstructure in Manganites

RESEARCH REPORTS BY CATEGORY

MOLECULAR CONDUCTORS - 13 REPORTS

Facility	PI Name	Title
CMT/E	Brooks, J.S.	Angular and Temperature Dependent 77Se NMR in the Metallic and Field-Induced Spin Density Wave State in (TMTSF)2ClO4
CMT/E	Brooks, J.S.	Angular Dependent Magnetoresistance Measurements Under Pressure
CMT/E	Brooks, J.S.	Anisotropic Current-Voltage Characteristics of (PER)2AU(MNT)2 in High Magnetic Fields
CMT/E	Brooks, J.S.	Enhanced Detection of the Quantum Oscillation of Resistance Using the Field Modulation Technique
DC Field Facility	Tanaka, H.	Magnetic Torque Measurement of Antiferromagnetic Transition in Molecular Conductors Using a Microcantilever
DC Field Facility	Brooks, J.S.	Magnetic Torque Study of beta-(BDA-TTP)2FeCl4
DC Field Facility	Park, Y.W.	Magnetotransport of Conducting Polymer Nanofibers: Helical Polyacetylene and Polyaniline Nanofiber
DC Field Facility	Ardavan, A.	Mapping the Quasiparticle Scattering Rate over the Fermi Surface of an Organic Superconductor
DC Field Facility	Ohta, H.	Observation of the Superconducting Gap in the Field-Induced Superconducting State of Lambda-(BETS)2FeCl4 by Multi-Frequency ESR Spectroscopy
DC Field Facility	Ardavan, A.	On the Origin of the Coherence Peak in the Interplane Resistance of Quasi-Two Dimensional Organic Metal: beta”-(BEDT-TTF)2SF5 CHF SO3
DC Field Facility	Kang, W.	Shubnikov-de Haas Oscillations of the Quasi-Two-Dimensional Organic Conductor β–(BEDT-TTF)2I3
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CMT/E	Pankov, S.	Mean Field Theory for the 3D Coulomb Glass
CMT/E	Engel, L. W.	Microwave Response of 2D Electron System in Spatially Varying Magnetic Field
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DC Field Facility	Baranov, A.	Effect of High Magnetic Field Up to 45T on Emission Intensity of InAs/AlSb Quantum Cascade Lasers
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Pulsed Field/LANL	McDonald, R.D.	Using the Angular Dependence of a Quantizing Magnetic Field to Probe the Bloch States in Room Temperature Superlattice Devices
UF Physics	Ulloa, S.E.	Title: Zero-Field Kondo Splitting and Quantum-Critical Transition in Double Quantum Dots

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ASC	Schwartz, J.	Iniitial Studies Towards React-Wind-Sinter Processing of Bi2Sr2CaCu2O8+x Conductors for High Field Magnets
ASC	Schwartz, J.	Quench Experiments on YBa2Cu3O7-δ Coated Conductors in Self Field
ASC	Schwartz, J.	Quench Studies on Bi2Sr2CaCu2Ox Conductors and Coils
ASC	Schwartz, J.	Relationships Between Conductor Damage, Quenching and Electromechanical Behavior in YBCO Coated Conductors
ASC	Schwartz, J.	Statistical Analysis of the Electromechanical Behavior of AgMg Sheathed Bi2Sr2CaCu2O8+x Tapes Using Weibull Distributions
DC Field Facility	Minervini, J.V.	Characterization of Nb3Sn Superconducting Wires Under Strain: Transverse Stress and Bending Effects
DC Field Facility	Hong, S.	Development of Wires for High Magnetic Field Applications

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CMT/E	Gor'kov, L.P.	Superconducting Order on Different Fermi Surfaces in Multi-Band Superconductors
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Pulsed Field/LANL	Sidorov, V.A.	Ongoing Characterization of the Effect of B Doping on the Superconducting Properties of Diamond
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