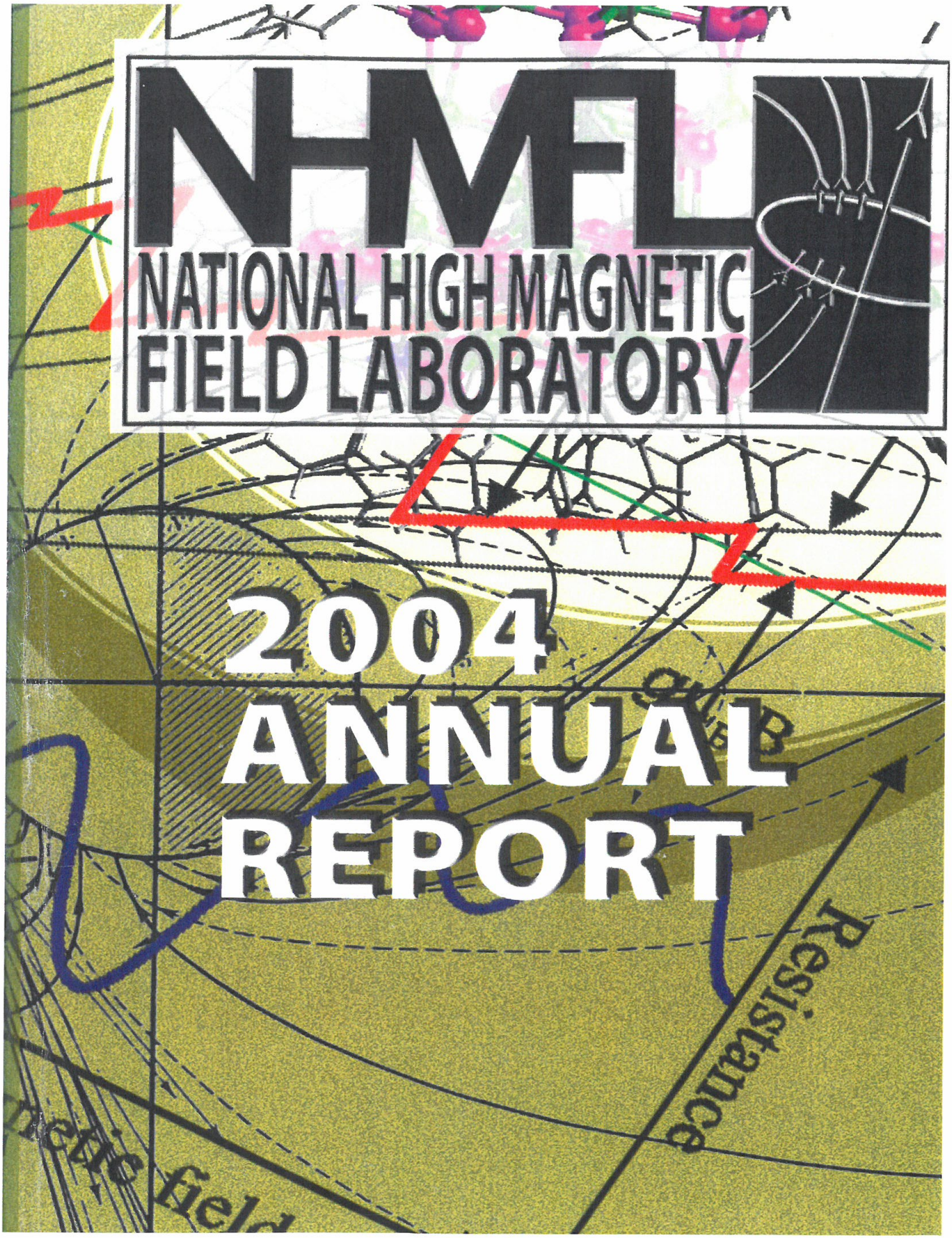
NHMFL

NATIONAL HIGH MAGNETIC FIELD LABORATORY

2004 ANNUAL REPORT



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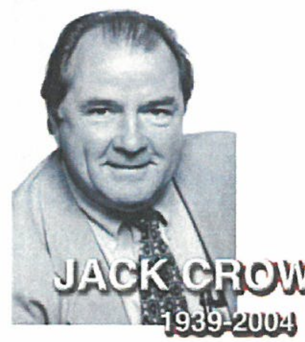
Chapter 1
YEAR IN REVIEW

2004: The Magnet Lab Transitions into Its Second Decade

Dr. Greg Boebinger

The first transition in the short history of the National High Magnetic Field Laboratory occurred during the years following the laboratory's dedication in October 1994 when the Magnet Lab moved from its construction phase to the start-up of its user programs. The emphasis shifted from bricks, mortar, and recruitment of inaugural faculty to expanding user facilities and services. Ten years later, the laboratory marks a second major transition, as founding director Jack E. Crow stepped down and Gregory S. Boebinger became the second director of the NHMFL (on April Fool's Day, no less !). Dr. Boebinger is highly regarded by the National Science Foundation, which hailed his selection as "a superb appointment." He is also well-known to the Magnet Lab community, having served on the first NHMFL Users' Committee in the early 1990s when he was at Bell Laboratories. Since 1998, Greg has been a principal investigator on the Magnet Lab's core NSF grant and from 1998 to 2003 was the director of the NHMFL Pulsed Field Facility at Los Alamos.

Less than six months after stepping down as Director, Dr. Crow lost his battle with cancer, and the laboratory and its extended family said goodbye to its patriarch. During the September 20 memorial service at the laboratory, Dr. Boebinger remarked, "Jack was a legacy, both as a man and as a scientist. His leadership and vision will live on for the benefit of society and scientific research for years to come."



As we move through this second transition, the Magnet Lab is building broad new partnerships with other research institutions around the Nation and the world, opening new avenues for magnet-related scientific research and technology development. One particularly exciting prospect is the proposal to introduce magnetic fields in excess of 30 teslas into new beamlines at the Spallation Neutron Source at Oak Ridge and the Advanced Photon Source in Argonne. A January 2005 draft report from the National Academy of Sciences' Committee on Opportunities in High Magnetic Field Science (available at: *http://www7.nationalacademies.org/bpa/COHMAG_committee.html)* endorses this broader application of the NHMFL's unique magnet technologies, and further makes the scientific case for continued investment in high magnetic field research. The report calls for development of a 30 T superconducting NMR magnet, a

In its May 2004 review report, the NHMFL External Advisory Committee remarked on this important time in the NHMFL's history:

We are confident that the transition in leadership will continue and further advance the established pre-eminence of the NHMFL in magnetic field-based scientific and engineering research, in pioneering magnet technology, as a national and international user facility, and as an important resource for the State of Florida and the cities of Tallahassee and Gainesville for promoting scientific education and outreach.

60 T DC hybrid magnet, and a 100 T one-second-duration pulsed magnet. The report acknowledges that these magnets will require substantial materials research to develop new superconducting conductor technologies, as well as higher-strength resistive conductors and reinforcing materials, calling for increased collaboration among institutions with magnet-related technical expertise. The NHMFL's Magnet Science and Technology Division is leading that collaborative evolution and now includes significant numbers of "work for others" projects in its portfolio.

Multidisciplinary science is flourishing throughout the Magnet Lab's user programs. At year end, NHMFL users and faculty submitted brief research reports that were made available on the laboratory's Web site (*www.magnet.fsu.edu*) by late January 2005. From those reports, a panel co-chaired by Dr. Boebinger and Chief Scientist J. Robert Schrieffer selected 25 highlights for 2004. Chapter 2 of this volume features these highlights of the outstanding research underway at the laboratory.

The vitality of NHMFL research is further evidenced by the nearly 400 peer-reviewed publications in 2004. A complete database is available on the Magnet Lab's Web site, including information on 430 scholarly presentations and 16 new doctorates awarded during the year. Over 25 percent of the NHMFL publications appeared in particularly prominent journals (listed in box above). Complete details appear on the Magnet Lab's Web site and in Chapter 10.

NHMFL Significant Publications In 2004

- 5 articles in *Analytical Chemistry*
- 3 *Europhysics Letters*
- 3 *Journal of Biological Chemistry*
- 10 *Journal of Magnetic Resonance*
- 1 *Journal of Neuroscience*
- 6 *Journal of the American Chemical Society*
- 2 *Journal of the American Society for Mass Spectrometry*
- 2 *Magnetic Resonance in Medicine*
- 3 *Nature*
- 1 *Nature Structural & Molecular Biology*
- 46 *Physical Review B*
- 29 *Physical Review Letters*
- 1 *Proceedings of the National Academy of Sciences of the United States*
- 5 *Science*

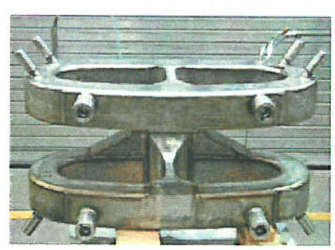
The technological highlights of 2004 include:

- The completion of the 900 MHz ultra-wide bore (105 mm diameter) NMR magnet for chemical and biomedical research. The magnet meets all technical specifications and features 1 ppb homogeneity (over 1 cm DSV) and full drift compensation, making it a true high-resolution magnet that features double the bore diameter of other magnets in its class. The NHMFL's MRI program has already achieved its first images of the mouse brain at 900 MHz, representing one of several envisioned research programs that take full advantage of the magnet's unique ultra-wide bore.

- The completion and delivery of the Sweeper Magnet, a large-gap, super-ferric dipole magnet, for use in radioactive beam experiments at the National Superconducting Cyclotron Laboratory at Michigan State University. This complex magnet is a great example of the emergence of the NHMFL's Magnet Science and Technology Division as a national asset in magnet design, construction, and delivery to specs.

- A new 14.5 T, 104 mm bore Ion Cyclotron Resonance magnet system was installed and tested in August 2004. As the highest field superconducting ICR magnet in the world, it will further advance the

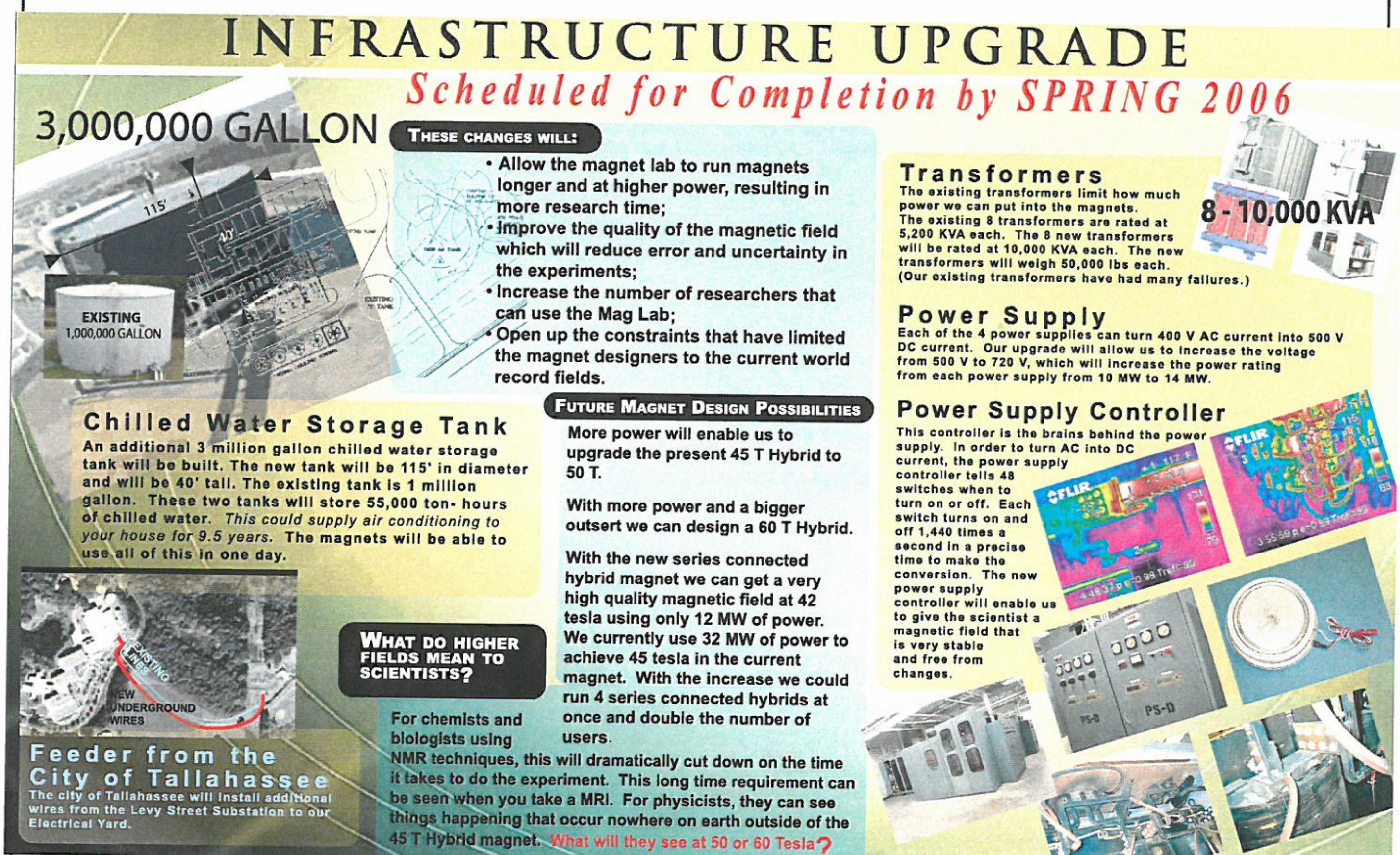
900 MHz NMR Magnet



Sweeper Magnet

unique capabilities offered by the Magnet Lab's ICR program in analyzing complex mixtures, an NHMFL world-leader that draws the interest of big pharmaceutical and petroleum companies.

- The launching of a newly engineered series of pulsed magnets driven by the stringent requirements of the 100 T Multi-shot Magnet project. These magnets have already delivered reliable 65 T, 10 msec pulses to the NHMFL user program and, upon completion of the capacitor bank upgrade, have the promise of 70 T and beyond.
- Finally, in 2004 the State of Florida appropriated $10 million to address urgent upgrade and infrastructure needs at the laboratory. The largest portion, $7.5 million, goes to the DC magnet user program, for replacement of aging power supplies (for which replacement parts are no longer available) and upgrading over-loaded transformers (for which only one spare remains). The remaining $2.5 million will be spent roughly equally at the two NHMFL facilities at the University of Florida to purchase an upgraded superconducting magnet at the High B/T laboratory and a 600 MHz NMR magnet and upgraded instrumentation at the Advanced Magnetic Resonance Imaging and Spectroscopy facility. In an era of tight budgets, this show of significant state support for the NHMFL strengthens our position as we approach the 2006-2007 renewal of the NSF grant. For further information, including scheduling for these state-funded upgrades, see Chapter 3.



Major International Conferences Hosted by the NHMFL in 2004

16th International Conference on High Magnetic Fields in Semiconductor Physics
in Tallahassee, August 2-6

Applied Superconductivity Conference
in Jacksonville, October 3-8

15th Conference of the International Society of Magnetic Resonance
in Ponte Vedra Beach, Florida, October 24-29

The laboratory also hosted a number of workshops to explore new science opportunities. An excellent example was the May 2004 *"Big Light" Workshop: Exploring the Combination of High Magnetic Fields and Bright Light Sources*.

The NHMFL continues its strong educational outreach, hosting over 4,000 visitors during the five hours of our Annual NHMFL Open House, a record 22 students and 14 teachers in the Research Experiences for Undergraduates and Teachers programs, and 50 local teachers for two summer institutes.

The new Magnet Lab management team further emphasizes the three-site nature of the NHMFL. Brian Fairhurst is now the NHMFL Associate Director for Management and Administration. Alex Lacerda keeps his appointment in Los Alamos as Director of the Pulsed Field Facility and has assumed labwide responsibilities as NHMFL Associate Director for User Programs. We also welcome new leadership at the University of Florida facilities, where the High B/T Program is directed by Yasu Takano, and the MRI program (formally referred to as AMRIS, Advanced Magnetic Resonance Imaging and Spectroscopy) is directed by Art Edison.

The new leadership of the Magnet Lab, its research faculty and its administrative staff, are all dedicated to the continued legacy of Jack Crow. The future is extremely bright for the National High Magnetic Field Laboratory so long as we keep a passion for science and innovation, a focus on high scientific and technical standards, and a collaborative interaction with each of our many user communities.

In April 2004, in accepting the NHMFL directorship, Dr. Boebinger acknowledged the extraordinary contributions of its founding director, Dr. Jack E. Crow.

I continue to be amazed by how far we have come in ten short years—from essentially a field of green grass to a world-class magnet laboratory, recognized as the world leader in magnet science, engineering, and experimental infrastructure. The exceptional faculty and staff at FSU, UF, and LANL, the involvement and counsel of the NHMFL's advisory committees, and the vision and leadership of Jack Crow have all collaborated to make this happen. As I assume the duties and responsibilities of this "House That Jack Built," I would like to publicly thank Jack for his extraordinary accomplishments and dedication. His outstanding contributions to science and education in our Nation and the world have made a lasting impact.

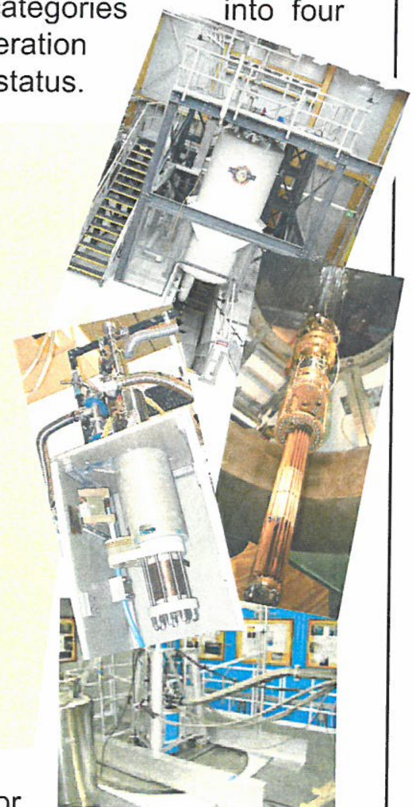
The NHMFL Diversity Initiative is contributing additional opportunities to enhance diversity among future U.S. scientists and engineers through its outreach and mentorship programs.

This document, along with all 335 NHMFL research reports and additional information, appears on the Internet at http://www.magnet.fsu.edu/publications/2004annualreport/. Several formats are available, including "Make Your Own CD" and "Order a CD" options. The comprehensive online presentation replaces the two-volume format that had been used by the laboratory for seven years (Annual Research Review and Annual Programs Report).

Chapter 2
SCIENCE & RESEARCH HIGHLIGHTS

In November and December of each year, NHMFL users and affiliated faculty submit brief reports that describe their scientific and R&D activities for the year. The reports are then reviewed and approved by facility and department directors. To communicate the science and engineering efforts of the laboratory quickly and effectively, the laboratory made all reports available on the NHMFL Web site *(http://www.magnet.fsu.edu/publications/2004annualreport/)* by the end of January 2005.

All approved reports were then considered for selection as NHMFL Annual Highlights. This year's review panel was co-chaired by Chief Scientist J. Robert Schrieffer and NHMFL Director Greg Boebinger, and their first decision was to change the selection strategy. Rather than identifying one highlight for each of 17 or 18 categories, it was decided to collapse the categories into four broader groups, thereby allowing greater flexibility in the selections. Consideration was also given to balancing internal and external activities, and publication status.



Category	Reports Received	Highlights Selected
Life Sciences, *including Biochemistry and Biology*	56	4
Chemistry, *including Chemistry, Magnetic Resonance Techniques, and Geochemistry*	74	4
Magnet Science & Technology, *including Engineering Materials, Instrumentation, and Magnet Technology*	42	7
Condensed Matter, *including Kondo/Heavy Fermions, Magnetism & Magnetic Materials, Metal-Insulator Transitions, Molecular Conductors, Other Condensed Matter, Quantum Fluids and Solids, Semiconductors, Superconductivity (Basic & Applied)*	163	10

Following a comprehensive review, the panel selected 25 Annual Highlights for 2004 that are representative of the broad scientific and technology activities underway at NHMFL facilities at Florida State University, at the University of Florida, and at Los Alamos National Laboratory. These reports are presented in this chapter, along with brief general statements about their significance.

The vast majority of research conducted at the NHMFL is enabled by the laboratory's world-class facilities, which are described in the next chapter of this annual report. For additional evidence of the strength and breadth of laboratory activities, refer to Chapter 10, Science & Research Productivity, which provides information and data on publications, theses, and other activities of NHMFL faculty and users.

Muscle has a tremendous capacity to adapt to changes in its functional demands, as shown by the desired increases in strength and endurance that accompany exercise and training. Muscle also adapts to forced inactivity, such as occurs when a limb is immobilized in a cast. Here, the response is in many ways the opposite of the response to exercise: it undergoes disuse atrophy, which is marked by weakness and early fatigue. Relative to exercise, however, less is known about the biochemical and metabolic changes in muscle that are associated with disuse atrophy. Using ^{31}P NMR spectroscopy, Vandenborne and coworkers have investigated the *in vivo* aerobic capacity of muscle in an animal model of disuse atrophy. The time-course of change in phosphocreatine (PCr) of muscle after a bout of stimulation or ischemia is a sensitive measure of *in vivo* aerobic capacity. In this report, Parthare *et al.* find that the time-course of recovery in PCr is significantly slower in the atrophy model, which indicates that immobilization and disuse of muscle are accompanied by a loss of aerobic capacity and mitochondrial function. This has practical implications when considering that disuse atrophy and detraining are common factors following prolonged inactivity associated with many surgeries, heart failures, and aging.

^{31}P MAGNETIC RESONANCE SPECTROSCOPY OF MOUSE SKELETAL MUSCLE FOLLOWING HIND LIMB CAST IMMOBILIZATION

Pathare, N. (UF, Physical Therapy), Liu, M. (UF, Physical Therapy), Stevens, J.E. (UF, Physical Therapy), Walter, G.A. (UF, Physiology and Functional Genomics), Vandenborne, K. (UF, Physical Therapy)

Introduction

Apart from structural and morphological adaptations, disuse atrophy has been shown to induce important metabolic adaptations in the skeletal muscle. A large number of *in vitro* studies have shown that there is a significant reduction in the maximal activity of essential oxidative enzymes following immobilization. The purpose of this study was to determine the impact of disuse atrophy on the *in vivo* oxidative capacity of mouse hindlimb muscles using ^{31}P MRS.

Methods

The lower hindlimbs of young adult mice (C57BL6 female, n = 8) were studied prior to and after 2 weeks of immobilization. ^{31}P NMR data were acquired in a Bruker 11 T spectrometer using a 6-mm x 12-mm oblong ^{31}P surface coil, placed over the belly of the gastrocnemius muscles. A 3-cm ^{1}H surface coil was placed underneath the hindlimb to adjust magnetic field homogeneity. An inflatable blood pressure cuff was positioned around the animal's thigh. Spectra were collected with a 50 μs square pulse, a TR of 2 s, sweep width of 10,000 Hz and 8,000 complex data points in 30 s bins starting at rest (10 min), during ischemia (30 min), and throughout recovery (30 min). Areas of the resting γ-ATP, inorganic phosphate (P_i), and phosphocreatine (PCr) peaks were determined using area integration following saturation correction. Dynamic changes in PCr levels were determined using complex principal component analysis. The pseudo-first-order rate constant for PCr recovery (k_{PCr}) was determined and used to calculate the *in vivo* oxidative capacity.

Results and Discussion

Following immobilization, resting ^{31}P MRS spectra were characterized by a significant increase in the basal P_i content (~70%; p<0.001) and the resting P_i/PCr ratio (~80%; p< 0.001). The resting PCr content and the intracellular pH values were not different. During 30 minutes of ischemia, the PCr levels decreased by 45 to 55% while the ATP and pH values remained unchanged in both pre immobilized and immobilized muscles. No significant difference was noted in the rate of PCr depletion between pre immobilized vs. immobilized muscles (0.45± 0.03 mM/min^{-1} vs. 0.52 ± 0.01 mM/min^{-1}; p=0.78). In contrast, immobilization induced a 30% decrease in the PCr recovery rate constant (0.45± 0.01 min^{-1} vs. 0.31± 0.01 min^{-1}; p<0.001; Fig. 2). This decrease in k_{PCr} reflects a decrease in the *in vivo* oxidative capacity of 5.4 mM ATP/min (~35%).

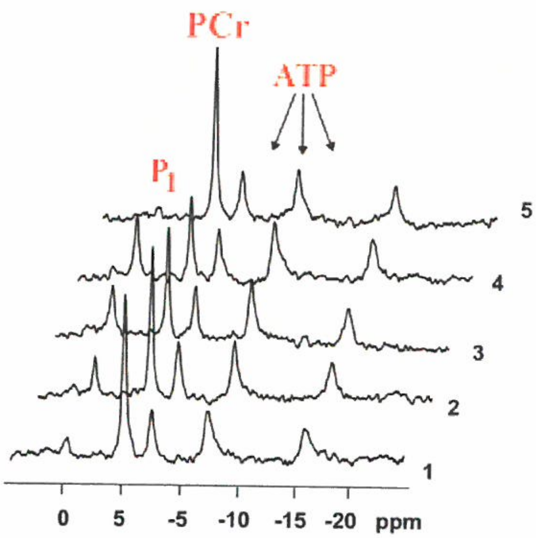


Figure 1. ^{31}P spectra obtained from a pre-immobilized C57 mouse at rest (1), after 10, 20, 30 min of ischemia (2-4) and after 10 min of recovery (5).

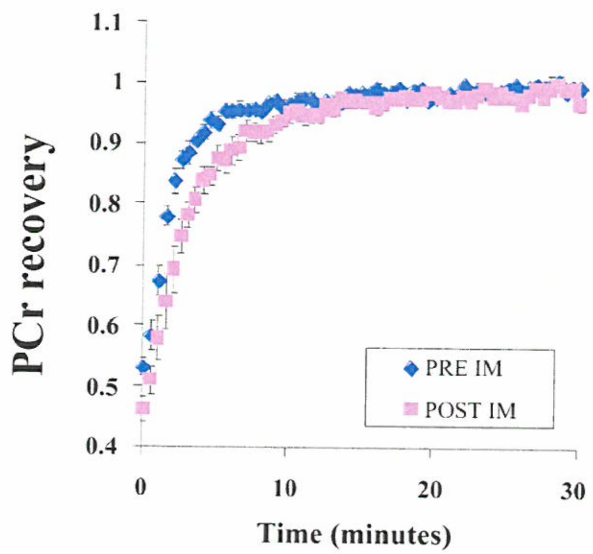


Figure 2. PCr recovery kinetics in C57 mice (n=8) prior to immobilization (PRE IM) and following 2 weeks of immobilization (POST IM).

Conclusions

Based on the PCr recovery kinetics following ischemia we conclude that disuse atrophy induces a significant decrease in the *in vivo* oxidative capacity of skeletal muscle. Therefore therapeutic interventions following prolonged inactivity should include strategies to enhance mitochondrial function.

Acknowledgements

This research was supported by NIH-RO1HD37645, NIH-RO1HD40850. NMR data were obtained at the Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) facility in the McKnight Brain Institute of the University of Florida.

Genetic disorders of mitochondria, the "power plant of the cell," have been linked to more than forty diseases such as Alzheimer's, diabetes, Parkinson's, and cancer. One of the most significant obstacles in treating mitochondrial disorders is that the diagnosis often must rely on indirect and relatively nonspecific markers of metabolism. Simpson and coworkers describe a significant advance in the diagnostic toolkit: using fibroblast cultures, derived from a relatively simple skin biopsy, they performed extracts of their intracellular milieu and examined them with high-field NMR spectroscopy. Mitochondria carry out a complex network of metabolic reactions that can be investigated with the aid of ^{13}C labeled glucose. Use of ^{13}C and ^{31}P NMR spectroscopy permits the quantitative assessment of reaction products and reactants as well as flux through metabolic pathways. In turn, this information permits the locus of metabolic dysfunction to be identified and may lead to making diagnosis of mitochondrial disorders more rapid, specific, and direct.

PROBING MITOCHONDRIAL DISORDERS BY NMR SPECTROSCOPY

N.E. Simpson (UF, Medicine), J. Oca-Cossio (UF, Medicine), Z. Han (UF, Medicine), P.W. Stacpoole (UF, Medicine), I. Constantinidis (UF, Medicine)

Introduction

The traditional approach to diagnosing inborn errors of metabolism has relied on: (1) clinical suspicion of a disease phenotype, (2) quantitation of readily measurable, but relatively nonspecific, surrogate disease markers such as the blood lactate concentration, and (3) enzymological and/or molecular genetic techniques to identify the primary defect. Very little is known, however, of the quantitative or qualitative consequences of such defects on vital processes, such as the flux through the tricarboxylic acid cycle or the overall intracellular energy charge. Our long-term objective is to investigate the biochemical consequences of primary genetic defects of mitochondrial function. Experiments performed in this study are designed to establish the utility of alginate encapsulation to maintain mitochondrial defective human fibroblasts viable for prolonged periods of time.

Experimental

Human fibroblasts obtained from skin biopsy samples of patients with mitochondrial defects were cultured and examined by ^{13}C and ^{31}P NMR spectroscopy following exposure to uniformly labeled ^{13}C-glucose for 20 hours prior to a dual phase extraction. Cells were examined in the presence and absence of dichloroacetate (DCA) treatment. All NMR spectra were acquired at 11.75 T vertical bore Bruker Avance-500 spectrometer located at the AMRIS facility of UF. Isotopomer analysis of the glutamate resonances was used to assess relative fluxes through the TCA cycle.

Results and Discussion

To date we have examined 5 patients with an E1α defect and one patient with an E1β defect. In addition to these patient samples we have also examined fibroblasts obtained from 5 healthy volunteers. ^{31}P NMR spectra acquired from the aqueous phase of the extract show that the ATP/ADP ratio was statistically reduced in the E1α patient population. Analysis of the ^{1}H decoupled ^{13}C NMR spectra (Figure 1) with a Wilcox signed rank test determined that the labeled pyruvate pool increased while the flux through pyruvate carboxylase compared to pyruvate dehydrogenase decreased with DCA treatment.

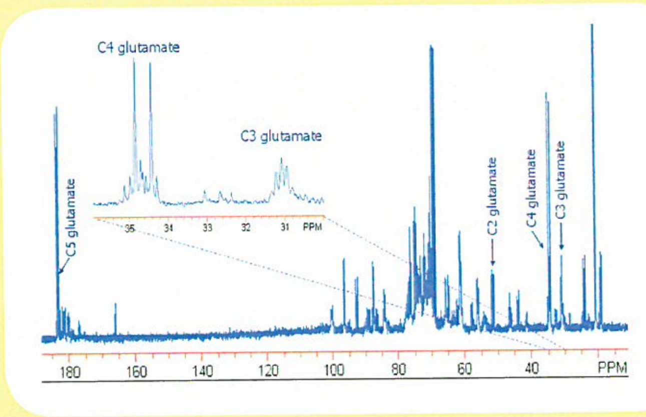


Figure 1. ^{1}H decoupled ^{13}C NMR spectrum of human fibroblasts obtained from a patient with an E1α defective pyruvate dehydrogenase complex.

Conclusions

Our data show that treatment with DCA increased the energy charge of the E1α defective cells and altered TCA cycle flux. Specifically, ^{13}C NMR spectra showed that the activity of pyruvate carboxylase was markedly reduced and that the cells favored the pyruvate dehydrogenase pathway. Thus, NMR spectroscopic techniques applied to cellular extracts of fibroblast cultures is a useful technique to study the biochemical consequences of inborn errors of metabolism.

Acknowledgements

This work was supported by NIH grants DK556890 and DK47858. This financial support is greatly appreciated.

The effects of influenza can range from an annoyance to a life-challenging illness. One of the primary challenges in combating the pathogenicity of the influenza virus, and to developing effective preventative programs and treatments for it, is to understand the mechanisms by which the virus takes over its host cells. An important step in the process of infection involves creation of specific protein channels that permit ions to flow across the membrane systems of the host cell. This work addresses M2, which is a key viral channel protein. Structural resolution by NMR is improved at higher field strengths because the spectra that form the foundation for structural analysis have greater resolution and signal-to-noise. In this study, use of the 900 MHz Ultra Wide Bore NMR Spectrometer at the NHMFL has led to a significant advance in understanding the structure of this viral protein.

STRUCTURAL CHARACTERIZATION OF THE M2 PROTON CHANNEL FROM INFLUENZA A VIRUS IN DETERGENT MICELLES BY SOLUTION NMR SPECTROSCOPY AT 900 MHz

M. Sharma (NHMFL/FSU, Chemistry and Biochemistry); F.P. Gao (NHMFL/FSU, Chemistry and Biochemistry); K.K. Shetty (NHMFL/FSU); W.W. Brey (NHMFL/FSU); R. Fu (NHMFL/FSU), T.A. Cross (NHMFL/FSU, Chemistry and Biochemistry)

Influenza A virus, like other enveloped viruses, enters the host by attaching to the host cell's membrane. Membrane fusion which is triggered by conformational changes of the membrane protein hemagglutinin and the release of the virus' RNA into the host cell are consequences of lowering of the pH. M2 protein of influenza A virus forms a homo-tetrameric proton channel that is involved in modifying virion and trans Golgi pH for virus infection. The protein is 97 residues long with a 19 residue long transmembrane helix. This homo-tetrameric assembly is activated at low pH and inhibited by influenza drugs amantidine and rimantidine. M2 protein is a potential paradigm system for the functional and structural studies of viral ion channels. Three dimensional structure of 25 residue long peptide including transmembrane helix was solved by our group using solid state NMR[1]. But the structure and functional analysis of the full-length M2 protein still remains elusive. The efforts in this direction are underway using solid and solution state NMR spectroscopy and combination thereof. We here report initial solution NMR results for full length M2 protein.

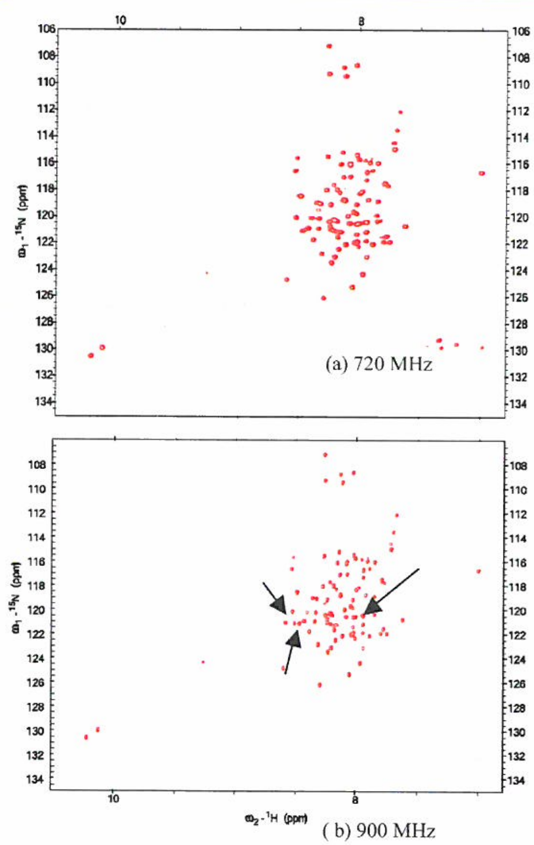


Figure 1. (^{15}N-^{1}H)-TROSY Spectra of 1 mM M2 protein obtained using (a) 720 MHz Varian Spectrometer and (b) 900 MHz Ultra Wide Bore Spectrometer at NHMFL. The arrows represent additional and better resolved peaks at 900 MHz.

M2 protein was cloned, expressed, and purified with uniform ^{15}N, $^{15}N/^{13}C$ and amino acid specific ^{15}N-Leu, ^{15}N-Phe and ^{15}N-Trp labeling. The yield for purified protein varied from 30 mg/Liter for $^{15}N/^{13}C$ to 150 mg/Liter ^{15}N-Phe labeled M2 protein. The preliminary requirement of structural and functional studies of proteins is to complete resonance assignments which (more specifically for membrane proteins than for soluble proteins) are in turn dependent upon successful determination of optimum condition for NMR sample preparation. A considerable time and effort were spent to obtain the optimum combination of pH, detergent type and detergent concentration to keep the characteristic line-broadening tractable while keeping the protein in best possible native-like environment. Fig. 1 shows the (^{15}N-^{1}H)-TROSY spectra obtained for 1 mM M2-protein in detergent micelles at 720 MHz Varian Spectrometer and 900 MHz Ultra Wide Bore Spectrometer. Both spectra were acquired with 32 scans and 256 increments in the indirect dimension. Due to significantly higher resolution and signal-to-noise ratio achieved on 900 MHz spectrometer, 90% of the total number of expected peaks could be identified.

Acknowledgements

The work was supported by NIH and the NHMFL.

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1 Wang, J., *et al.*, *Prot. Sci.*, **10**, 2241-2250 (2001).

The active agent in the AIDS-causing human immunodeficiency virus (HIV) is RNA. Outside a cell, the RNA is packaged in a protein "capsid." After the virus enters a human cell, the main protein of the capsid is cut into several pieces, one of which (CA, ~24,000 Dalton in mass) spontaneously assembles into hexamers that interlock to form a sort of mesh that envelops and protects the virus. Thus, an obvious drug target is the contact surface between adjacent CA molecules—once those contact sites are known, one can imagine designing a drug to bind there, thereby destroying the mesh and leaving the RNA unprotected. Last year, the NHMFL ICR group was able to locate the contacts between CA hexamers by dissolving them in heavy water (D_2O). As each surface-exposed CA protein backbone -NH hydrogen is replaced by deuterium, the mass goes up by 1 Dalton. Thus, by letting the H/D exchange

proceed for a while, then cutting up the protein into pieces and weighing them by FT-ICR mass spectrometry, it was possible to determine which parts of the protein were exposed to the solvent. The contact sites could then be identified as those segments that are solvent-inaccessible in the hexamer but not in the monomer. This year, the group was able to repeat the experiment with intact capsids. The results were the same, except that only half of the CA molecules self-assemble to form the hexameric mesh network under these more biologically realistic conditions. In support of that finding, independent experiments have recently shown that mutations at this hexamer interface result in non-infective virus particles. Finally, these results were obtained for a system for which neither X-ray diffraction nor NMR was possible—a good example of how mass spectrometry can contribute to the arsenal of powerful bioanalytical tools.

KEY INTERACTIONS IN HIV-1 MATURATION IDENTIFIED BY HYDROGEN-DEUTERIUM EXCHANGE

Jason Lanman (U. of Alabama-Birmingham, Microbiology), TuKiet T. Lam (NHMFL/FSU, Chemistry and Biochemistry), Mark R. Emmett (NHMFL/FSU, Chemistry and Biochemistry), Alan G. Marshall (NHMFL/FSU, Chemistry and Biochemistry), Michael Sakalian (U. of Oklahoma Health Science Center) and Peter E. Prevelige, Jr. (U. of Alabama-Birmingham, Microbiology)

Introduction

To characterize the intersubunit interactions underlying assembly and maturation in HIV-1, we determined the amide hydrogen exchange protection pattern of capsid protein (CA) in the immature virion and the mature virion by FT-ICR mass spectrometry. Alterations in protection upon maturation provide evidence for the maturation-induced formation of an interaction between the N- and C-terminal domains in half of the capsid molecules, indicating that only half of the capsid protein is assembled into the conical core.[1]

Results and Discussion

H/D-exchanged immature and mature virus-like particles (iVLP and mVLP) were digested with pepsin and the extent of deuterium incorporation into each peptide was analyzed by high resolution mass spectrometry. The peptide spanning CA residues 55 to 68 (m/z 744.84) corresponding to the N/C interface identified *in vitro*[1] displays a bimodal distribution in the mature virion but not in the immature virion. The H/D exchange profiles of the 55-68 segment in iVLP and the faster component in the bimodal H/D-exchange profile of mVLP are very similar to that seen for unassembled CA,[1] indicating that these CA molecules are probably similar in conformation to CA from unassembled subunits. The exchange profile for the slower exchanging component in mVLP is similar to that previously observed for *in vitro* assembled CA,[1] suggesting that the core associated CA molecules form the heterotypic N-terminal domain:C-terminal domain interaction in mVLP. The relative distribution of fast and slow exchanging subpopulations agrees well with that observed in intact CA and suggests this interface is present in the bulk of the core associated molecules independent of their location.

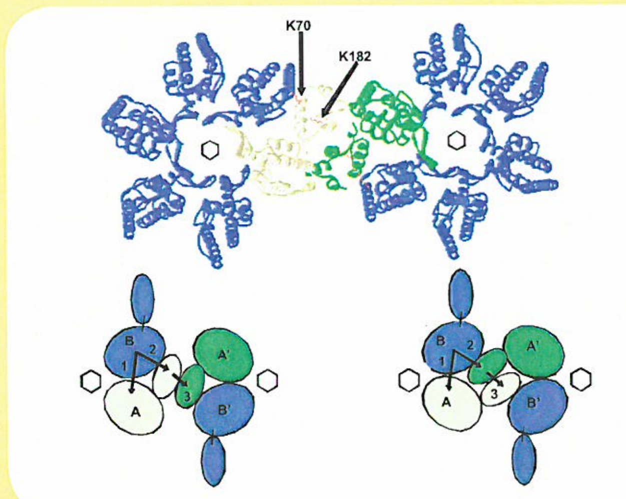

Figure 1. Top: Hexamer-hexamer CA protein interaction sites (K is lysine). Bottom: The ICR experiments narrow the possible configurations to the two shown here.

Taken together, the present results suggest that helices I and II are involved in intersubunit interactions in both the immature and mature virion, whereas a defining characteristic of core formation appears to be the formation of the heterotypic N-terminal domain: C-terminal domain interaction. In support of this model, mutations in this interface region result in non-infectious virions, and a small molecule compound that binds near the interface interferes with core formation but not assembly.

Acknowledgements

This work was supported by grants from the U.S. National Institutes of Health (AI44626) and the U.S. National Science Foundation (CHE-99-09502), Florida State University, and the U.S. National High Magnetic Field Laboratory.

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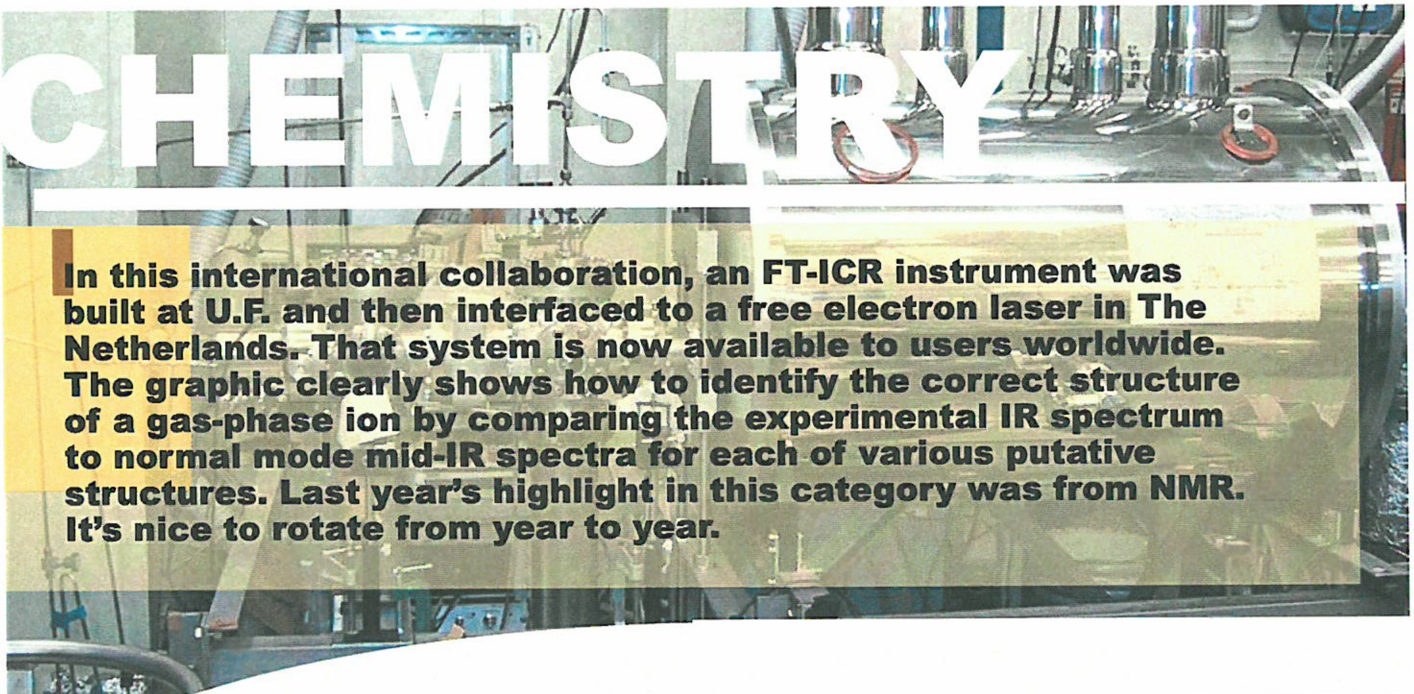


CHEMISTRY

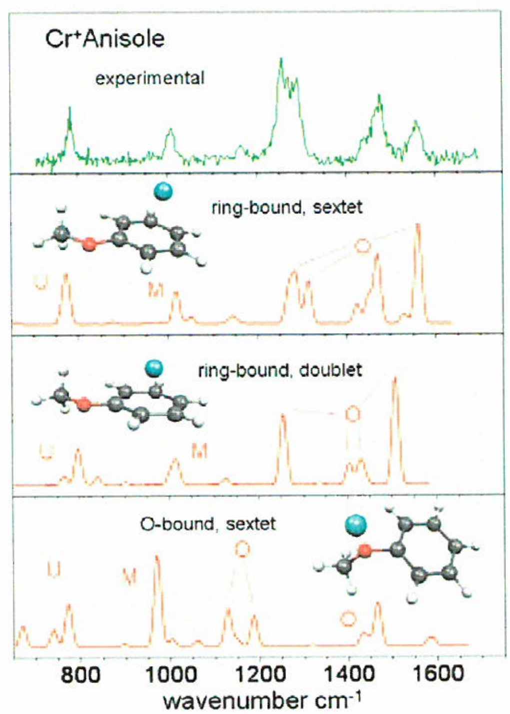
In this international collaboration, an FT-ICR instrument was built at U.F. and then interfaced to a free electron laser in The Netherlands. That system is now available to users worldwide. The graphic clearly shows how to identify the correct structure of a gas-phase ion by comparing the experimental IR spectrum to normal mode mid-IR spectra for each of various putative structures. Last year's highlight in this category was from NMR. It's nice to rotate from year to year.

GAS-PHASE CR^+ COMPLEXES OF AROMATIC LIGANDS: SITE OF BINDING AND SPIN STATE OF THE METAL ION CHARACTERIZED BY INFRARED SPECTROSCOPY USING THE FELIX FREE-ELECTRON LASER

R.C. Dunbar (Case Western Reserve U., Chemistry); J. Oomens (FOM Institute); D. T. Moore (FOM Institute); G. von Helden (Fritz-Haber-Institut der Max-Planck-Gesellschaft); G. Meijer (Fritz-Haber-Institut der Max-Planck-Gesellschaft); J. R. Eyler (UF, Chemistry)

Introduction

The combination of a Fourier-transform ion cyclotron resonance (FT-ICR) spectrometer with the Free Electron Laser for Infrared eXperiments (FELIX) at FOM Institute in Nieuwegein, Netherlands[1] has been found to give remarkable new capabilities for characterizing gas-phase organometallic complexes of transition metal ions. In initial work described in the *2003 NHMFL Research Review* (Dunbar, R.C., *et al.*, p. 76) and subsequently published[2] it was found that the site of binding of the Cr^+ ion to a bi-functional ligand (aniline) could be identified with confidence. In new work including additional ligands (anisole, acetophenone) it has been shown that not only the site of complexation, but also the spin state of the metal ion can be identified.



Experimental

The FELIX laser provides continuously tunable IR radiation over the IR fingerprint region, typically 10 macropulses of pulse energy 35 mJ. Light is directed into the cell of the FT-ICR spectrometer (4.7 T actively shielded magnet). Atomic metal ions are produced external to the magnet by laser desorption/ionization, and guided into the cell. Organometallic complexes are formed by ion chemical processes within the cell, isolated by selective ion ejection, and their signal intensity is monitored both with and without FELIX irradiation to determine dissociation rate vs. wavelength.

Results and Discussion

The figure shows the results for anisole, as an example. In the top panel is shown the infrared photodissociation spectrum from the FT-ICR/FELIX instrument. The other panels show the computed predictions for high-spin ring-bound, low-spin ring-bound, and high-spin side-chain-bound complexes. The high-spin ring-bound prediction clearly gives by far the best fit to the experiment.

Among these three ligands, ring binding has been proven for anisole and aniline, while acetophenone binds at the oxygen. The bis-complexes of aniline and anisole were shown to be low-spin, whereas the respective mono-complexes, as well as the acetophenone bis-complex, are high-spin.

Acknowledgements

Establishment of the FT-ICR facility at FELIX was made possible by funding (NSF #CHE-9909502) from the NHMFL. This work was financially supported by the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO). RCD acknowledges the support of the donors of the Petroleum Research Fund, administered by the American Chemical Society.

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In 2004, Shapira *et al.* demonstrated the successful generation of a two-dimensional NMR spectrum from a single experimental time-domain data set at 25 T. The resulting very short data acquisition period enables the experiment to be conducted with a resistive magnet for which conventional 2D NMR is precluded because of its requirement for a lengthy series of data acquisitions. Moreover, because the new experiment relies on spatial rather than temporal encoding of the signal, it can be achieved even in the spatially somewhat inhomogeneous field of NHMFL's 25 T Keck resistive magnet. Thus, the new 2D single-scan technique promises to open up a broad range of new NMR applications that take advantage of the very high field of a resistive magnet, while compensating for its temporal and spatial field inhomogeneity.

2D SINGLE SCAN NMR SPECTROSCOPY ON A 25 T KECK MAGNET

Boaz Shapira, Lucio Frydman (Weizmann Institute, Israel); Zhehong Gan (NHMFL, CIMAR/NMR)

Introduction

2D NMR involves scanning a series of time-domain signals $S(t_2)$ as a function of a t_1 time variable which undergoes parametric incrementation throughout independent experiments. This procedure requires, first and foremost, a stable NMR magnet that does not change during the course of the acquisition. Therefore, in spite of their unique strengths, the relatively unstable Bitter magnet design does not provide the sufficient stability demanded by 2D NMR acquisitions—they are qualified for the execution of only a single scan experiment. High inhomogeneities constitute a related issue from which Bitter magnets suffer, as they result in low spectral resolution which makes it difficult to resolve inequivalent sites. Very recently, the Frydman laboratory originated a general approach whereby the serial data acquisition mode of 2D NMR can be parallelized, enabling the acquisition of complete multidimensional NMR data sets within a single transient. The short timescale of such "ultrafast" 2D experiments should enable us to overcome many of the problems associated with the time instability of the Bitter system. Furthermore, the fact that ultrafast NMR relies on a spatial rather than on a time-domain encoding of the signals could allow us to implement high resolution NMR acquisitions even when using inhomogeneous fields.[2] These two features combined could enable the successful acquisition of high resolution liquids 2D NMR spectra at the intense fields provided by Bitter systems; a natural candidate for exploring this was the NHMFL Keck magnet.

Experimental

Spectra were measured on the Keck magnet at 25 T using a Tecmag console and Doty probe with a single axis z gradient. Maximum strengths of 90 G/cm and receiver coil lengths of 1 cm long were calibrated prior to the actual measurements on a model 7 T system; 60 Hz B_0 fluctuations were attenuated with a flux stabilizer designed and built by W.W. Brey and coworkers at the NHMFL.

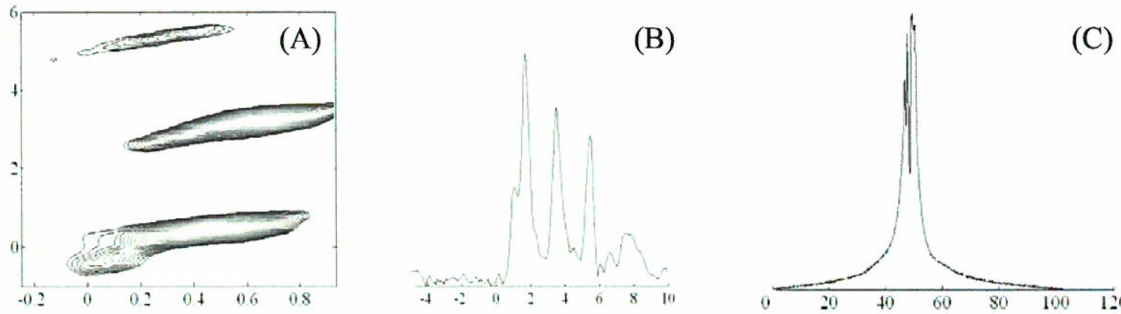

Figure 1. (A) Mixing-less ^{1}H 2D NMR spectrum recorded on 95% EtOH at 21.2 T. (B) Slice extracted from the 2D spectrum, showing the potential for resolving the various sites. (C) Comparable 1D NMR trace arising from the same sample after a single pulse excitation. Spectral axes are given in kHz (C) and in ppm referenced to H_2O (ext.) in (A) and (B).

Results and Discussion

During 2004, we began exploring ultrafast 2D NMR's potential by implementing a continuous spatial excitation sequence without any mixing period and without extensive compensation for the effects of inhomogeneities. Our principal goal at this stage was to test the overall feasibility of the concept, and the suitability of the NMR hardware available at the NHMFL. Fig 1 shows preliminary results on a 95% ethanol sample, which promises a bright future for the approach exposed above. This molecule exhibits three peaks located at 1.22, 3.6, and 5.4 ppm. As can be seen in Fig. 1C, the inhomogeneity and instability of the Keck system is such that no real resolution of the three sites can be observed in a conventional single-pulse 1D acquisition. By contrast, no complications in distinguishing the three sites are observed upon carrying out even a mixing-less single-scan 2D NMR experiment, where inhomogeneities appear correlated along orthogonal dimensions and thus allow a clear distinction of the peaks. The spectral width along ν_2 was in this case only 1.2 ppm, which resulted in peak folding. Still, cross section of the peaks taken from the 2D spectrum provide a first glimpse into the high resolution liquid-state potential of the 25 T system (Fig. 1A): the FWHM are then ca. 5 times smaller than in the single-pulse experiment.

Conclusions

The prospects for carrying out single-scan high-resolution 2D NMR experiments are excellent. Our main goals during 2005 will be to activate a sample spinning device capable of further reducing linewidths, and to extend the homonuclear 2D experiments tested so far to heteronuclear cases.

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In this work, we performed dipolar recoupling experiments at 900 MHz to be used for structural determination. Those experiments clearly demonstrate that the newly available 900 MHz magnet is of high quality in terms of stability and homogeneity and it is capable of conducting a variety of solid state NMR experiments ranging from biological solids and quadrupolar nuclei in materials science. As demonstrated in this report, in addition to sensitivity enhancement, high field greatly improves spectral resolution so as to increase frequency selectivity leading to precise distance measurements, which are the key to accurately elucidating secondary structures of molecules such as proteins and polypeptides in solids.

DIPOLAR RECOUPLING NMR SPECTROSCOPY AT 900 MHz

R. Fu (NHMFL); W.W. Brey (NHMFL); T.A. Cross (NHMFL/FSU)

Introduction

In the initial stage of the 900 commissioning period, scientists at the NHMFL are exploiting a variety of scientific projects that can take advantage of the ultra-wide bore 900 MHz magnet, from biological solids to quadrupolar nuclei in materials science. Here we used a uniformly ^{13}C, ^{15}N labeled valine sample to demonstrate some dipolar recoupling experiments on 900 MHz, the methods in general used to obtain distance constraints for structure determination.

Experimental Results

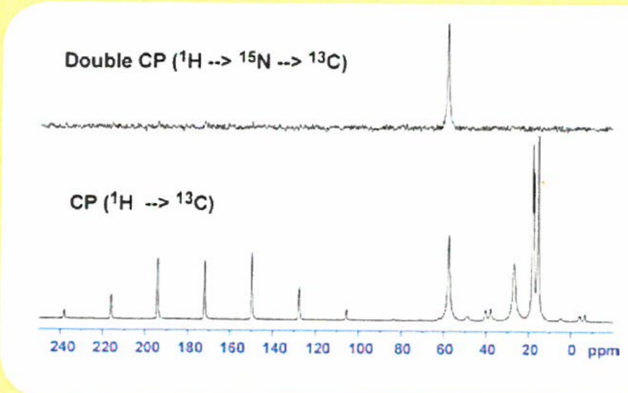

Figure 1. ^{13}C CPMAS spectra of uniformly ^{13}C, ^{15}N labeled valine sample using a 3.2 mm Bruker triple-resonance CPMAS probe. This type of technique has been widely used to acquire 2D ^{13}C-^{15}N correlation spectra of uniformly labeled samples. A large chemical shift dispersion at 900 MHz enhances spectral resolution, thus permitting us to more accurately determine structural connectivities of molecules.

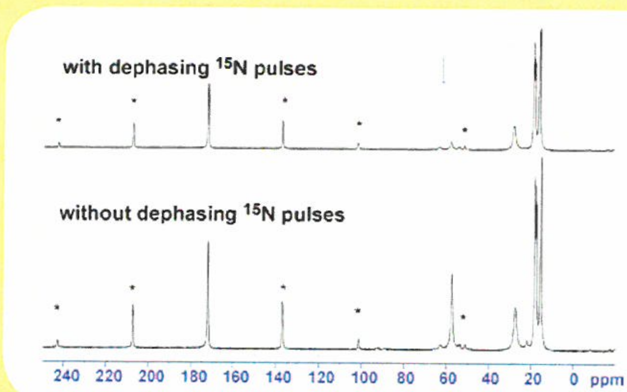

Figure 2. ^{13}C spectra of uniformly ^{13}C, ^{15}N labeled valine sample using a 3.2 mm Bruker triple-resonance CPMAS probe. The asterisks indicate spinning sidebands. From the changes in ^{13}C signal intensities vs. the dephasing time, we can precisely measure internuclear distances between the ^{13}C and ^{15}N sites. Distance constraints, along with orientational constraints and torsional constraints, lead to secondary structural determination of proteins and polypeptides.[1,2]

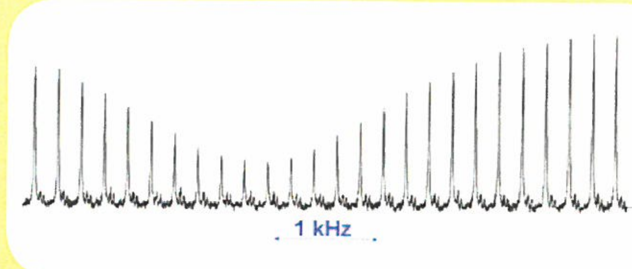

Figure 3. Plot of ^{15}N dephased ^{13}C spectra of the valine sample vs. ^{15}N offsets. Here only the signal at 57 ppm is shown. At on-resonance the ^{13}C signal is efficiently dephased by the ^{15}N pulses, while at off-resonance, the dephasing becomes insufficient. Frequency-selective heteronuclear recoupling[3] allows one to select a spin-pair in uniformly labeled samples thus to measure their internuclear distance without interference from other labeled sites. A large chemical shift dispersion at 900 MHz significantly increases the frequency selectivity.

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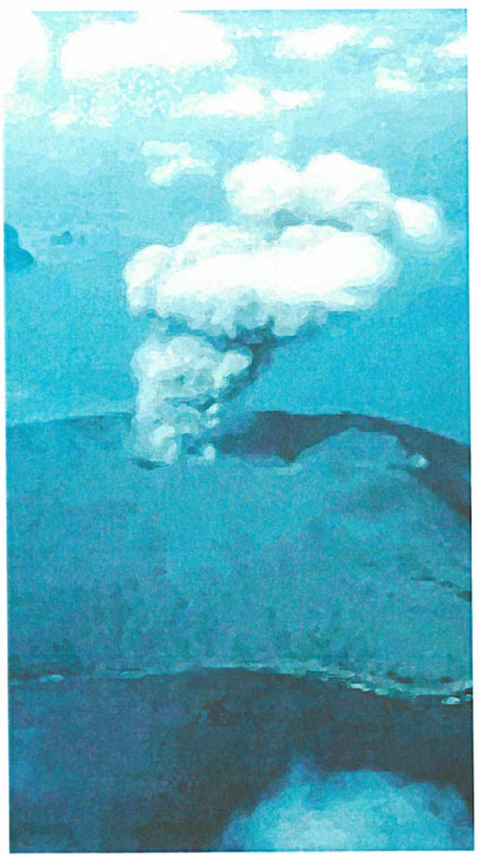
The research reported on shows that part of the Hawaiian plume contains an ancient (older than one billion years) depleted component. The "depleted component" is depleted in trace elements that prefer to reside in melts compared to silicate minerals. Ocean island volcanics in general are characterized by enrichments in trace elements that prefer the melt over solid. This is the first time that such a depleted component is recognized in Hawaii. The research is accepted for publication by *Geochimica Cosmochimica Acta.*

EVIDENCE FOR A DEPLETED COMPONENT IN HAWAIIAN VOLCANISM FROM HAFNIUM-NEODYMIUM ISOTOPE SYSTEMATICS OF GARNET PYROXENITES

M. Bizimis (FIU, Earth Sciences/NHMFL, Geochemistry), G. Sen (FIU, Earth Sciences), V.J.M. Salters (NHMFL, Geochemistry), S. Keshav, (GL, Carnegie Inst. Washington)

Introduction

Characteristic of Hawaiian and other oceanic island volcanism is the eruption of small volume, highly alkalic, and incompatible element enriched "post-erosional" lavas at the end of volcano activity. These lavas are isotopically more depleted than the voluminous tholeitic, shield-building stage volcanism requiring a trace element enriched, but long term depleted mantle source. The presence of garnet pyroxenite xenoliths in the post erosional lavas from Oahu, Hawaii, provide a unique opportunity to study the deeper (>60 km) lithosphere and the processes taking place therein. Here we present the first comprehensive major, trace element and Hf, Nd, and Sr isotope investigation of clinopyroxene and garnet mineral separates from a set of garnet clinopyroxenite xenoliths from the Salt Lake Crater, Oahu, Hawaii, in order to constrain their origin in the context of Hawaiian volcanism.



Results and Discussion

Thermobarometric calculations suggest that these SLC garnet pyroxenites last equilibrated at 20 to 30 kb (60 to 90 km) and about 1200 C. These temperatures are about 200 to 300 degrees C hotter than the temperature of the lithosphere at these depths. The calculated melts in equilibrium with these pyroxenites better resemble the Honolulu Volcanics (HV), rather than MORB or EMORB. In terms of Lu-Hf and Sm-Nd isotope systematics, all clinopyroxene-garnet mineral pairs analyzed here show, within error, zero-age. The SLC pyroxenites have relatively radiogenic Hf isotope compositions (ε_{H} = 11.8-18), for a given Nd, (ε_{Nd} = 7.2-8.5) and define a distinct steep slope (3.2) in ε_{Hf}-ε_{Nd} isotope space, similar to the Honolulu Volcanics but unlike most other ocean island basalts (OIB). The above evidence suggests that these pyroxenites are zero-age cumulates from melts isotopically similar to the Honolulu Volcanics. However the distinct steep slope in Hf/Nd isotope space of both SLC pyroxenites and HV lavas require an endmember component that falls above the OIB array. Such an endmember is identified in the SLC spinel peridotites that have extremely radiogenic Hf and unradiogenic Os isotope compositions and have been explained as ancient (> 1Ga) depleted recycled oceanic lithosphere.[1,2] However, the radiogenic Os isotope compositions in similar pyroxenites[3] require that such ancient lithosphere cannot directly contribute (directly by melting, or indirectly by reaction) to melts that give rise to the pyroxenites. Instead, melts derived from this depleted lithosphere must mix with a (presumably) plume-derived melt with radiogenic Os isotopic composition to generate these pyroxenites and, by inference based on the similarities, the Honolulu Volcanics. Irrespective of the Os isotopes however, the Hf/Nd isotopes clearly require a previously depleted component to contribute to these pyroxenites.

Conclusions

The zero-age Lu-Hf, Sm-Nd isotope systematics of the SLC garnet pyroxenites and their Hf-Nd isotope similarity to the host Honolulu volcanics points to a genetic link between the two. The relatively radiogenic Hf isotope ratios require a depleted component, unlike MORB, in the source of these pyroxenites. Whether this depleted lithosphere is an ancient (>1 Ga old) depleted lithospheric component intrinsic to the Hawaiian plume (i.e., recycled old lithosphere) or the 100 Ma old lithosphere that lies beneath Oahu, is not entirely clear. Based on the isotopic similarities between the recent Honolulu volcanics and old (70 Ma) volcanics from the Emperor seamounts, Frey *et al.*[4] suggested that a depleted component, intrinsic to the hot spot, must have been present in the source of both lavas. In this case, we consider it more likely that the depleted component recognized in these pyroxenites resides within the Hawaiian plume and its signature becomes more evident in the winding stage of volcanism where it is not diluted by the voluminous shield-stage plume melts.

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MAGNET SCIENCE & TECHNOLOGY

Recrystallization processes in cold worked metals advance during heat treatment by changes in the microstructure caused by change of average grain size and its orientation distribution. Grain boundary motion is the dominating process. It can be affected by a magnetic field because a driving force is induced due to crystal and shape anisotropy of the susceptibility. Magnetic fields are, therefore, an excellent means to study these effects in ferromagnetic materials and also for materials processing. Earlier experiments of Molodov *et al.* at the NHMFL have shown that grain boundary motion can also be observed in non-ferromagnetic materials if the magnetic field is strong enough. His report on grain growth in Ti by means of magnetic annealing demonstrates that the texture evolution can be effectively influenced. Similar experiments on single Zn crystals show a clear deviation from the random distribution after magnet annealing. In this context, reference is made to the development of a new technique by the same author to measure grain boundary migration *in situ* with a space resolving polarization microscopy probe. This research field has the highly promising potential for future industrial applications that materials can be tailored with magnetic fields to specific needs.

MAGNETICALLY DRIVEN SELECTIVE GRAIN GROWTH

P.J. Konijnenberg, D.A. Molodov, and G. Gottstein (RWTH-Aachen University, Institute of Physical Metallurgy and Metal Physics)

Introduction

At suitably high field strengths and temperatures even the microstructure evolution of non-ferromagnetic anisotropic metals is affected by magnetic annealing.[1] During this process the non-uniformity and anisotropy of the boundary mobility plays an important role. Selective grain growth during magnetic annealing yields valuable insight into these parameters.

Experimental and Results

Large single crystals (2x4x15mm^3, Zn 99.99+%) were locally deformed by a Vickers hardness indentation along either $\langle 2\bar{1}\bar{1}0\rangle$ or $\langle 10\bar{1}0\rangle$. Annealing at about 673 K in a high purity inert gas atmosphere initiated a local recrystallization which resulted in a set of new local orientations. SEM-EBSD analysis revealed that at the sample surface all grains invariantly border with the host matrix. Rodrigues-Frank parameters of boundaries between these grains and the single crystalline host matrix are plotted separately; disorientation angles in Fig. 1a and disorientation axes in Fig. 1c. Both figures show a clear deviation from a random distribution (resp. indicated by a MacKenzie distribution and contour lines).

A subsequent addition of a high magnetic field (Keck magnet) for several minutes (in similarly pretreated samples) along the extraordinary axis of the host matrix resulted frequently in selective growth of an individual grain into the single crystalline host

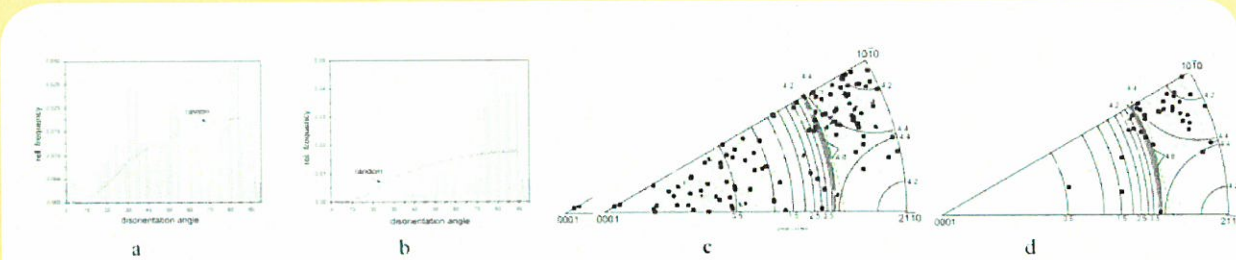

Figure 1. Disorientation angle and axis distribution before (a,c) and after (b,d) magnetic annealing.

matrix. Orientations of these grains were determined by Laue X-ray backscatter diffraction. Apparently these grains can be distinguished from their competitors by their combination of driving force and boundary mobility. Boundaries of these prevailing grains are plotted correspondingly in Fig. 1b and d.

Discussion

Clearly, after magnetic annealing a large part of the angle distribution as available before magnetic annealing is suppressed. The axis distribution behaves similarly. Before magnetic annealing two clusters can be recognized; roughly around <0001> and <10$\underline{1}$0> of which only the latter is maintained after magnetic annealing. The angle distribution becomes less random whereas the axis distribution becomes more random, seen along the symmetry line <0001>-<10$\underline{1}$0>. Due to the sample geometry boundary normals point along <0001> of the host matrix. Consequently selectively grown grain boundaries have a strong asymmetric <10$\underline{1}$0> tilt component. Previous research revealed, however, that symmetric <10$\underline{1}$0> 86±3° tilt boundaries tend to be quite immobile under similar conditions. Further research is needed.

Acknowledgements

Financial support from the Deutsche Forschungsgemeinschaft (GO 335/24) is gratefully acknowledged.

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IN SITU MEASUREMENTS OF GRAIN BOUNDARY MIGRATION WITH A HIGH MAGNETIC FIELD POLARIZATION MICROSCOPY PROBE

P.J. Konijnenberg, D.A. Molodov, and G. Gottstein (RWTH-Aachen University, Institute of Physical Metallurgy and Metal Physics)

Introduction

A space resolving high magnetic field polarization microscopy probe has been developed to track grain boundaries at the surface of magnetically anisotropic metals during magnetic annealing at high field strengths. It is known from experiments that also in non-ferromagnetic anisotropic materials a sufficient driving force for grain boundary migration can be provided by external high magnetic fields.[1,2,3] Two major advantages in this approach to measure boundary properties are a constant, adjustable, and accurately known driving force and the possibility to drive plane grain boundaries with a uniform and well-defined boundary structure.

Experimental and Results

In essence this probe comprises a conventional polar magneto-optic Kerr setup. An incident light polarizing microscope with CCD camera in field direction is arranged over a sample chamber at the field center. The gas tight sample chamber is equipped with a quartz window and an adjustable DC resistance heated sample stage perpendicular to the field direction. The heater temperature is gauged by two platinum resistance sensors to avoid drift effects on usual thermocouples. The sample temperature is derived from a calibration curve and accurate within 1 K. For lower than cubic crystal symmetries, grain boundaries become visible as a contrast between differently orientated crystallites due to a plane polarized LED-illumination in combination with an analyzing filter in front of the CCD. A spectral half width of 20 to 30 nm enables it to anticipate to a large Faraday rotation of the polarization plane in the field. Microscope images are digitally stored at regular instances. Focus and both polarizing filters are remotely controlled by three DC stepper motors on top of the magnet, 1.4 m off axis. The current configuration was successfully tested at sample temperatures up to 673 K and fields of 25 T in the 50 mm Keck magnet.

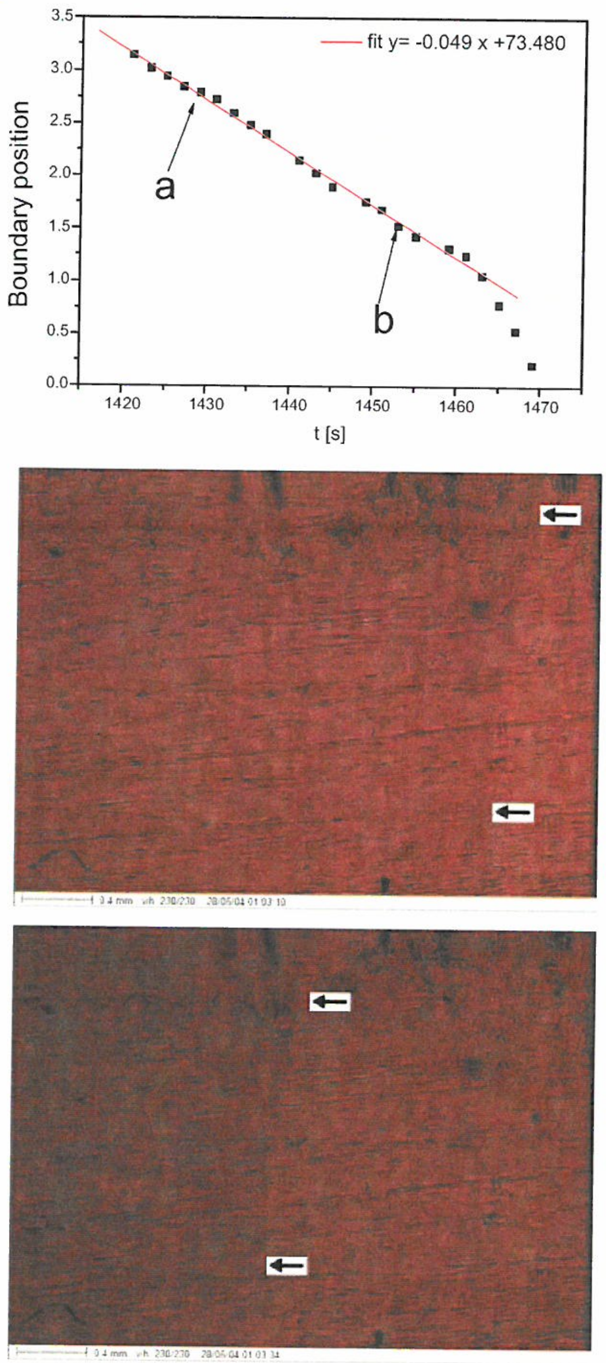

Figure 1. Boundary position vs. time. Data points: a - upper image, b - lower image.

Exemplary in Fig. 1, the boundary position is shown vs. annealing time of an individual nearly plane high angle boundary at about 603 K and 25 T in a Zn (99.99+%) bicrystalline sample (2x4x15mm^3). It shows a constant boundary velocity (0.049x10^{-3}m/s) over a macroscopic distance of about 2 mm. The difference in free energy density due to the misalignment of both grains with the field is approximately 1.2 KJ/m^3 (<5141> 81° asymmetric tilt grain boundary). From this the absolute mobility of this boundary structure at this temperature (m=v/p) becomes 4.1x10^{-8} m^4/Js.

Acknowledgements

Financial support from the Deutsche Forschungsgemeinschaft (GO 335/24, MO 848/4) as well as Dr. Scott T. Hannahs' technical support are gratefully acknowledged.

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The design and construction of superconducting magnets depends very much on the precise knowledge of the electrical and mechanical properties of the conductor to be used. Detailed characterization is needed, especially of the degradation of the current carrying capability at a temperature of 4.2 K in a magnetic field as a function of the applied stress. A unique and very versatile instrument has been developed and constructed at the NHMFL for this type of measurement. Measurements at different Nb_3Sn wires have been performed and show that these wires can support a strain level of 0.4 %.

IN-FIELD I_c of Nb_3Sn WIRES UNDER STRAIN

U.P. Trociewitz (NHMFL), R.P. Walsh (NHMFL), V.J. Toplosky (NHMFL), J. Miller (NHMFL)

Introduction

High current carrying capabilities and strain tolerance are important properties to achieve in superconductors to be used in successful high field magnet applications. To study the various effects of strain on practical Nb_3Sn conductor and ultimately to characterize conductor that will be used within high-field magnet projects at the NHMFL, a device has been built to measure the critical current of short wire samples at 4.2 K as a function of strain in a large-bore high-field magnet. The device is operated by a stepper-motor and worm gear assembly and is rated for maximum loads up to 2.5 kN. Tensile strains of 1 % can be easily accommodated. The probe is instrumented with vapor-cooled current leads and high temperature superconducting current lead extensions to allow for transport currents up to 1.5 kA. The setup was operated in the NHMFL large bore resistive magnet in fields up to 20 T.

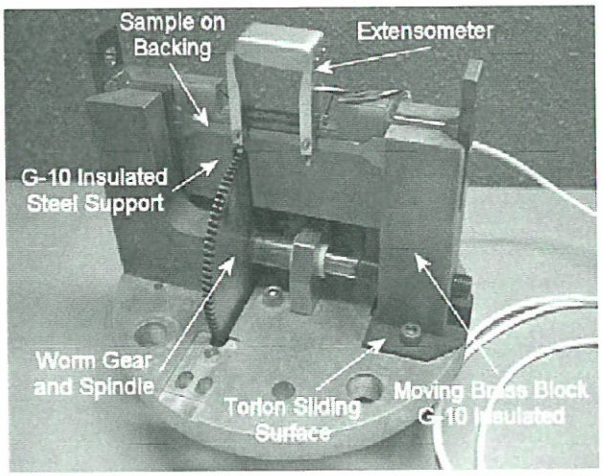

Figure 1. View of the strain device. Below the bottom flange (not visible in the picture) is a guiding rod, which is connected to the moving brass block. It moves in a slide bearing that is bolted to the bottom flange and enforces parallel displacement.

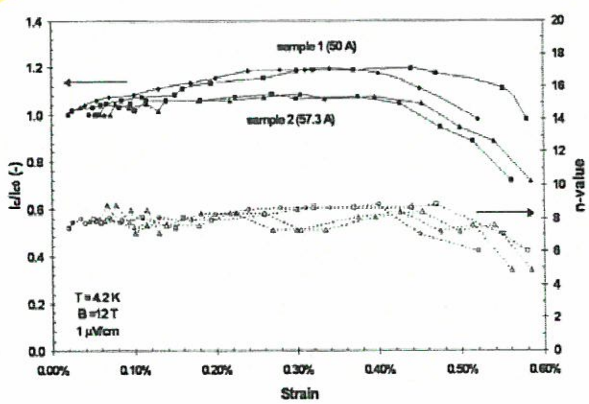

Figure 2. top: Normalized I_c ($\varepsilon = 0$) vs. strain at 4.2 K and 12 T background field for two wire samples of different sections from the same batch. The values in brackets represent the maximum currents achieved under strain. Bottom: n-values of the samples vs. applied strain.

Experimental

Fig. 1 shows the complete probe and the strain device. The strain device consists of two brass blocks, between which the sample is mounted. One of the blocks is bolted to the bottom flange and the other can move freely operated by a stainless steel spindle and worm gear assembly, which is driven by a stepper motor on the outside of the cryostat. At a thread pitch of 24 inch^{-1} one turn of the stepper motor translates to 0.011 mm linear displacement of the brass block. This ratio provides sufficient resolution for the strain data. In this configuration the whole setup is rated for tensile loads up to 2.5 kN. The setup allows for characterization of short sample lengths of 130 mm.

Results and Discussion

Preliminary experiments were conducted on research grade Nb_3Sn wire samples of 0.42 mm diameter. I_c ratios vs. strain data for two samples from different sections of a wire batch are shown in Fig. 2 (top). Both samples have peak I_c values of 50 A and 57.3 A at strain values of about 0.30 %, averaged over two strain gauges mounted on each sample. Fig. 2 (bottom) shows the n-values as a function of the applied strain. Up to about 0.4 % strain, the n-values for both samples stay almost constant at around $n = 8$. Above 0.4 % strain, the n-values drop to $n = 5$ indicating the beginning of mechanical damage to the samples. Microstructural analysis on sections of the conductor material revealed irregularities in the filament geometry, which contributed to low n-values. Further modifications and experiments, allowing the use of an extensometer for the strain characterization, are in progress.

Reference

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The report by Canfield *et al.* is an important advance, recently published in *Physical Review Letters*, in our understanding of the role of defects and doping in the MgB_2 class of materials. Previous work at the NHMFL has shown a dramatic increase in Hc_2 with carbon doping. The suppression of T_c with neutron damage and subsequent recovery by annealing show the fundamentally different behavior from the effects of carbon doping. This ability to separate the effects of different induced defects in the material will significantly enhance our understanding of the underlying coupling and isolate the effects of the different scattering channels. In related work by Larbalestier *et al.*, similar carbon-doped MgB_2 conductor performance was reported using a scalable manufacturing process. The ultimate goal of these investigations could be significantly improved superconducting wires for next-generation superconducting magnets. These reports are prime examples of the NHMFL serving competing groups in a rapidly-developing area of research, in which sample preparation and preliminary measurements are made at other facilities and the NHMFL provides key measurements at the highest obtainable magnetic fields.

IMPROVED H_{c2} IN BULK-FORM MAGNESIUM DIBORIDE BY MECHANICAL ALLOYING WITH CARBON

B.J. Senkowicz, J.E. Giencke, S. Patnaik, C.B. Eom, E.E. Hellstrom, D.C. Larbalestier (Applied Superconductivity Center, University of Wisconsin)

Introduction

Recent studies of magnesium diboride thin films by Braccini *et al.*[1] found $H_{c2}(0K)^{||} > 50$ T for C-doped MgB_2 films. Such critical field properties exceed those of any Nb-based conductor at any temperature, suggesting that MgB_2 could be a viable replacement for Nb_3Sn as a high field magnet conductor. Untextured carbon-doped filaments fabricated by a CVD method can achieve upper critical fields in excess of 30 T at 4.2 K[2].

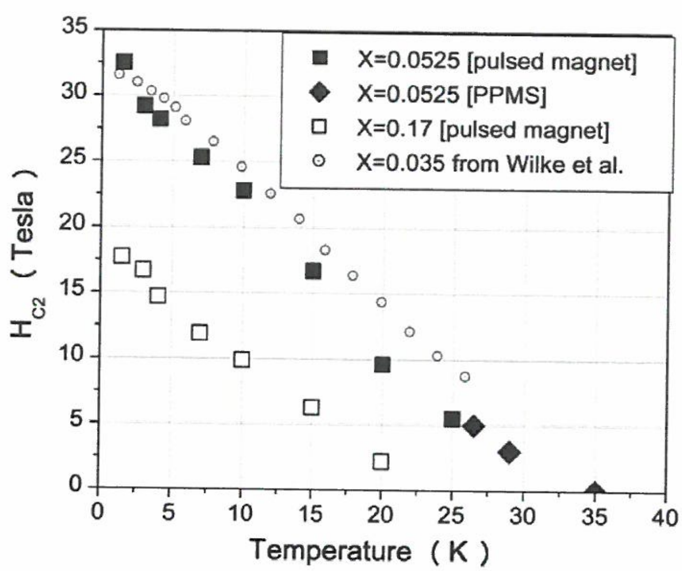

Figure 1. H_{c2} defined by the 90% normal state resistivity of our carbon-doped samples and final onsets of resistance for the sample of Wilke *et al.*[2]

The present document discusses the *ex-situ* synthesis of alloyed MgB_2 powder using high energy ball milling of MgB_2 with C. Since a major goal of MgB_2 technology is the fabrication of high critical current density, multifilament wire suitable for magnet applications, we need a scalable bulk process capable of producing carbon-doped precursor powder. One such method is provided by this work.

Experimental

MgB_2 powder was mixed with powdered graphite in several proportions and high energy ball milled for tens of hours, then made into pellets. Pellets were hot isostatic pressed (HIP) at 1000°C and >30 ksi for 200 minutes, then exposed to Mg vapor at 900°C for 5 hours. Properties were then measured by various techniques. High field electrical properties were measured at NHMFL – Los Alamos using the 65 T pulsed magnet.

Results and Discussion

Fig. 1 shows measured H_{c2} for our samples, plotted alongside data from the literature, where x is the carbon content given by $Mg(B_{1-X}C_X)_2$. Our analyses showed that while our X=0.0525 sample had near total carbon incorporation into the lattice, our nominally X=0.17 sample had a lattice composition of only about X=0.69. While the X=0.0525 sample had $J_c > 10^6$ A/cm^2 as well as excellent H_{c2}, the nominal X=0.17 sample had J_c reduced by nearly two orders of magnitude. Normal state resistivity was also much higher for the more heavily doped sample.

Conclusions

We have shown that milling C with MgB_2 can produce $H_{c2}(0K)$ equal to that obtained for single crystals and CVD filaments. Lattice disorder introduced in the milling process is indicated by weakened XRD patterns and high normal state resistivity. Excess carbon not incorporated into the crystal lattice can result in detrimental effects such as grain boundary obstruction (causing reduced J_c), reduced T_c, and reduced H_{c2}.

Acknowledgements

BJS was supported by the Fusion Energy Sciences Fellowship Program, administered by Oak Ridge Institute for Science and Education under a contract between the U.S. Department of Energy and the Oak Ridge Associated Universities. This research was also supported by the NSF under the University of Wisconsin- Madison MRSEC program. The authors thank the excellent staff of the NHMFL-Los Alamos as well as W. Starch, A. Squitieri, J. Mantei, and R. Mungall in Wisconsin.

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EFFECTS OF CARBON DOPING AND NEUTRON IRRADIATION ON THE UPPER CRITICAL FIELD OF MgB_2

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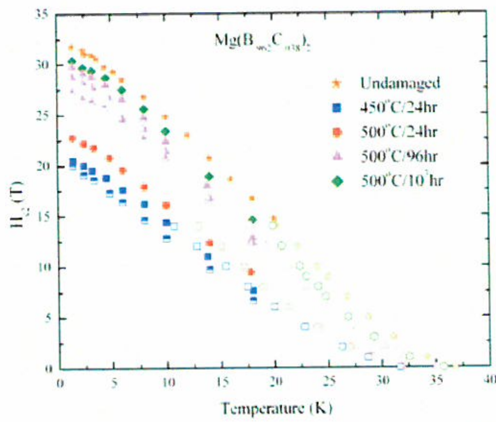
Introduction

MgB_2[1] is a conventional phonon mediated BCS superconductor with the unconventional property of having two superconducting gaps.[2] Three scattering rates associated with the two (σ and π) bands influence the temperature dependence of the upper critical field. Theoretical calculations predict different developments of H_{c2} if the scattering rates can be selectively tuned.[3] The enhancement of H_{c2} through carbon doping[4] has been attributed to an increase in scattering in the π band.[5] Neutron damage studies on pure MgB_2 wire segments show a suppression of H_{c2} that approximately scales with T_c.[6] We have irradiated $Mg(B_{.962}C_{.038})_2$ to study the interplay between two different types of defects.

Experimental

Carbon doped boron filaments were prepared using a chemical vapor deposition system at Specialty Materials. Filaments were converted to MgB_2 by exposure to magnesium vapor at elevated temperatures. These samples were exposed to fluences of 7×10^{18} thermal neutrons at the Missouri University Research Reactor. Upper critical field values were determined using the onset criteria in transport measurements. Resistance vs. temperature was measured in fields up to 14 T in a Quantum Design PPMS at Ames Laboratory and resistance vs. field was measured using a lock in technique in a 32.5 T resistive magnet at the NHMFL in Tallahassee, FL.

Results and Discussion



The 7×10^{18} fluence fully suppressed superconductivity in the $Mg(B_{.962}C_{.038})_2$ samples. Superconductivity was restored by post exposure annealing for various times and temperatures. For example, a 24 hour anneal at 300ºC gave T_c near 20 K. Figure 1 presents H_{c2} data for samples which had $T_c > 30$ K. $H_{c2}(T=0)$ scales with T_c for each of the irradiated samples. This behavior is analogous to the case of neutron damaging in pure MgB_2 and in contrast to the effects of carbon doping alone. The effects of scattering, resulting from defects introduced by exposure and subsequent annealing, appear to act independently of the effects produced by the presence of carbon.

Conclusions

The transition temperature for neutron damaged carbon doped MgB_2 filaments was tuned by the post exposure annealing. For the full range of T_cs accessed by this method, $H_{c2}(T=0)$ approximately scaled with T_c, suggesting neutron damage acts to globally suppress superconductivity and doesn't selectively enhance any specific scattering channel.

Acknowledgements

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The generation of pulsed high magnetic fields is a major engineering challenge due to the enormous Lorentz forces, which have to be handled reliably. The step from the successful 65 T user magnet to the new 75 T user magnet corresponds to an increase in stress of over 30 %. A series of research reports describes the recent developments at the NHMFL. The efforts not only include a precise failure analysis of one magnet after 470 full field shots, but also material evaluation, in this case a new insulation technique, which must withstand the high compressive forces between the turns and maintain its electrical integrity (see online Swenson, *et al.*, "Evaluation of High Voltage Breakdown Properties of Zylon Served Kapton Insulation System Under Cyclic Compression"). The new poly-layer technique represents a breakthrough in magnet design, which was necessary to pave the road toward 100 T inserts (see online Marshall, *et al.*, "Design Enhancements to the New NHMFL Pulsed Magnets for Improved Performance and Manufacturability"). In "Coil Fabrication Technology Development for Copper Niobium Pulsed Magnet Conductors," Marshall *et al.* describe design improvements to manufacture repeatable and predictable coil geometries. The efforts have been crowned by the very satisfying performance of the 75 T prototype insert, which not only generated this field reliably, but also offers a longer pulse time and shorter cooling time.

INSPECTION OF 65 T PROTOTYPE AFTER LONG TERM OPERATION

C.A. Swenson, W.S. Marshall, E.L. Miller, K.W. Pickard, (NHMFL-FSU)

Introduction

A prototype 65 T magnet assembly failed after 470 full field science shots. The fault was traced to the inner "A" coil inside the nested two coil assembly. The construction of the inner "A" coil assembly is based upon the poly-layer assembly technique developed for the 100 T insert program. The fault was unique in that the entire magnet assembly was intact save for the winding layer that failed (see Fig. 1). Inspection and analysis of the assembly presented an opportunity to examine all internal interfaces to evaluate structural performance of components after long term service. Such inspection and design review is critical to the practical improvement of pulsed magnets. The inspection of the assembly allows direct evaluation of the structures used in the poly-layer assembly planned for the 100 T insert magnets.

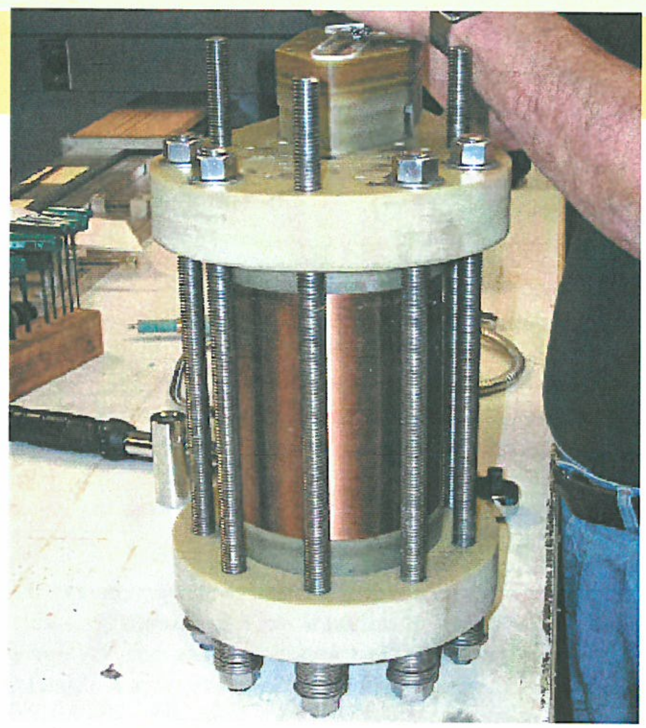

Figure 1. 65 T assembly at start of inspection.

Observations

The first operational fault was located in the mid-plane of layer one in the "A" coil insert winding. (See Fig. 2) There is evidence of extreme heat as ~ ½ of two turns were vaporized. The metal vapor burned through the layer-one zylon reinforcement and MP35N metal reinforcement. Atomized metal particles were observed to be condensed upon the internal radius of the layer two windings. There was no evidence of an electrical fault to layer two.

Electrical insulation structures and lead structures were intact and functioning as designed with no evidence of degradation after long term operation. Geometrical measurements were made on each layer at the winding diameter and the inside diameter of the metal reinforcement. No deformation was observed. Measured dimensions were essentially as constructed.

Figure 2. Layer 1 mid-plane fault illustrating short between turns.

Summary

The hypothesis after gross morphological examination is that the kapton™ wire insulation failed via mechanical compression. The two mid-plane turns short circuited initiating an electrical arc. The arc burned insulation and conductor between the turns progressively ablating metal from both wires. The temperature of the shorted turns increased rapidly due to heating from the plasma and the magnet current. It is interesting to note that the axial magnetic field in the mid-plane region will focus a plasma discharge concentrating the heating in one location. The pulsed conductor insulation has since been upgraded to a zylon-kapton system that can take cyclic compression associated with high field operation.

TRAINING PERFORMANCE OF 75 T PROTOTYPE PULSED MAGNET

C.A. Swenson, W.S. Marshall, E.L. Miller, K.W. Pickard, A. Gavrilin, (NHMFL-FSU);
D.G. Rickel, J.S Schilig, (NHMFL: Pulsed Field Facility)

Introduction

A new 75 T pulsed magnet design is now undergoing operational evaluation at the NHMFL Pulsed Field Science Facility (See Fig. 1). The magnet design incorporates improvements to the engineering template developed for the 65 T pulsed user magnets. The development of the 75 T magnet is part of the NSF effort to develop insert magnets for the DOE 100 T multi-shot (MS) magnet program. An important objective of the 75 T project is to gain experience operating insert-like coils in the same temperature, stress, and strain range encountered at 100 T. The 75 T magnet assembly is comprised of two solenoid coils nested together. The inner "A" coil is constructed with materials and techniques identical to those planned for the 100 T inserts.

The 75 T testing protocol entails three phases of operation: (1) Training and operation at 75 T. (2) Magnet operation at 70 T to baseline reliability performance at 90 T operational stress. (3) Demonstration of cryogen-free operation at 70 T. We report the results of phase 1 in this article. This experimental activity is critical for insert design validation.

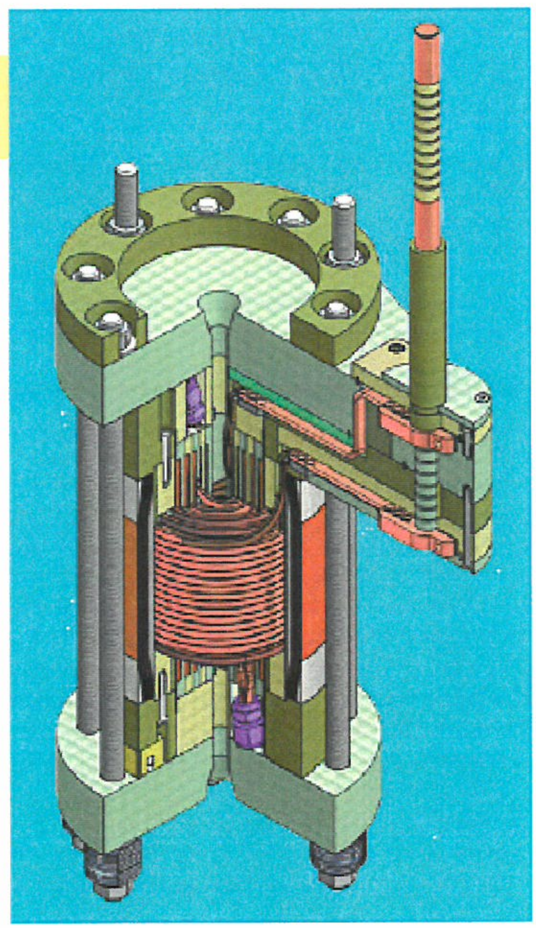

Figure 1. Section view of 75 T with windings.

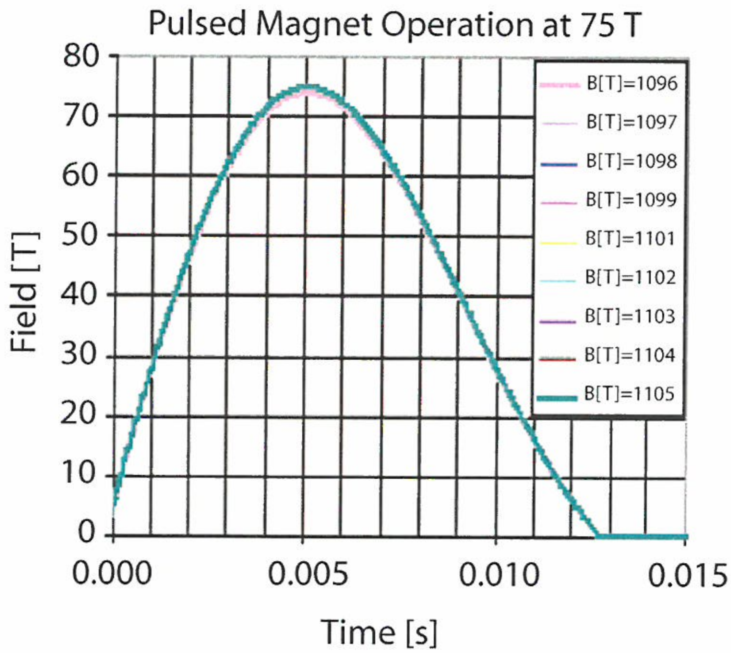

Figure 2. Pulsed field waveforms integrated from B-Dot signal.

Experimental Results

The 100 T capacitor bank is configured to 15.2 mF for high-energy pulsed operations with the 75 T magnet. We successfully trained the 75 T prototype to full field over 21 pulses of increasing intensity. The capacitor bank energy for a 75 T pulse is 1.44 MJ. We energized the magnet ten times to 75 T in accordance with the test protocol (See Fig. 2). The "100 T Intensity" phase of the testing protocol was completed on November 18. The 75 T testing protocol entails pulses at 70 T to validate reliability at stress levels comparable to the MS Insert at 90 T and cryogen-free operation.

Summary

Magnet performance closely followed design predictions. The drive voltage calculation was within 50 volts of the measured experimental value. The 75 T prototype and the insert capacitor bank both operated together according to specification. The 100 T insert capacitor bank functioned flawlessly throughout training. We are optimistic and encouraged by the technical results obtained thus far.

CONDENSED MATTER PHYSICS

Single-walled carbon nanotubes (SWNTs), tubular crystals of *sp*^{2}-bonded carbon atoms that are just one atom thick, come in different varieties, each with a subtle difference in structure and properties – some of them are metals and others are semiconductors. However, their basic electronic properties can change when they are placed inside a magnetic field. Specifically, the band gap is predicted to oscillate with period $\phi_0 = h/e$, (i.e., the magnetic flux quantum), and thus, metallic tubes become semiconducting even in an infinitesimally small magnetic field and semiconducting tubes can become metallic in ultrahigh magnetic fields.[1] Furthermore, the Kramers degeneracy between the K and K' points can be lifted by a magnetic field. See Fig. 1. Consequences of these band structure changes are expected to appear in interband optical spectra as peak shifts and splittings. Here, we performed the first magneto-optical study on SWNTs in DC magnetic fields up to 45 T, verifying some of the predictions.[2] We clearly observed that the band gaps of semiconducting SWNTs shrink steadily with magnetic field. We also observed significant field-induced optical anisotropy as well as splittings of absorption and photoluminescence peaks, quantitatively consistent with the predictions. This behavior is unique among known materials, and it is a direct consequence of the change in the circumferential boundary condition through the Aharonov-Bohm phase. The Aharonov-Bohm effect has been observed in other physical systems, but this is the first case where the effect interferes with another fundamental solid-state theorem, that is, the Bloch theorem. We are already extending this exciting work to higher magnetic fields, using the pulsed field facilities in Toulouse, Los Alamos, and Berlin. In even higher magnetic fields (~2000 T), we expect the gap to disappear altogether, causing the semiconducting nanotubes to transform into metals.

INTERBAND MAGNETO-OPTICAL STUDIES OF SINGLE-WALLED CARBON NANOTUBES IN HIGH DC MAGNETIC FIELDS UP TO 45 T

S. Zaric, G.N. Ostojic, J. Kono (Rice U., ECE); J. Shaver, V.C. Moore, R.H. Hauge, R.E. Smalley (Rice U., Chemistry); X. Wei (NHMFL, Tallahassee)

Introduction

The band structure of a single-walled carbon nanotube (SWNT) is predicted to depend on the Aharonov-Bohm (AB) phase $2\pi\phi/\phi_0$ (ϕ_0: magnetic flux quantum). Consequences are expected to appear in interband optical spectra as peak shifts and splittings. Here we report the first magneto-

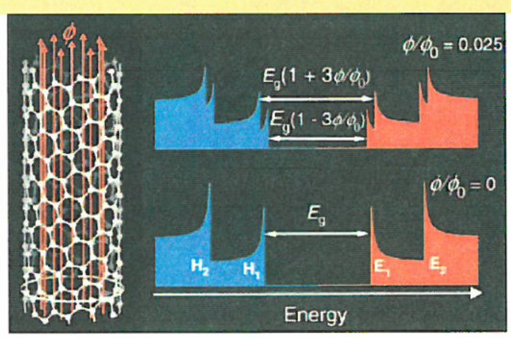

Figure 1. Schematic diagram showing band structure modifications induced by a magnetic flux threading a single-walled carbon nanotube.

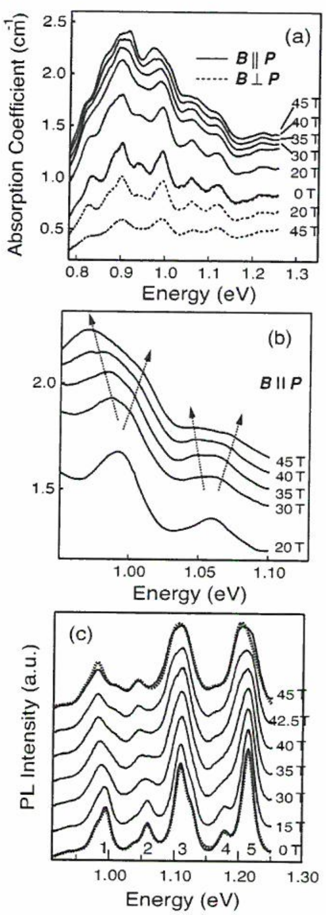

Figure 2. (a) Polarization-dependent absorption spectra. Solid (dashed) lines are for parallel (perpendicular) polarization. No traces are offset. (b) Expanded plot for the *B//P* case from 20 T to 45 T. (c) PL spectra. Solid (dashed) lines correspond to measured (fitted) data. The chiralities of the dominant peaks are 1: (10,3), 2: (8,6), 3: (7,6), 4: (10,2), 5: (7,5).

-optical study on SWNTs, revealing the predicted peaks shifts and splittings.[2]

Experimental

The nanotube solution was contained in a quartz cell, mounted with a polarizer on a specially designed sample stick with integrated optic fibers, lenses, and mirrors. All measurements were done at room temperature.

Results and Discussion

Fig. 2(a) shows polarization-dependent absorption in the Voigt geometry. The solid (dashed) lines are for parallel (perpendicular) polarization. The field induces optical anisotropy. Also, each peak broadens with *B* [Fig. 2(b)]. Fig. 2(c) shows PL spectra up to 45 T. All peaks shift to lower energy, and the shift is more obvious for lower energy peaks.

These data can be explained in terms of the AB-effect-induced splitting and magnetic alignment of tubes. The obtained values for 45 T splitting are comparable to the predicted values, and an order of magnitude larger than the Zeeman splitting.

Conclusions

We have performed magneto-optical experiments on SWNTs up to 45 T, confirming theoretical predictions that the band structure of a SWNT is dependent on the magnetic flux, ϕ, threading the tube.

Acknowledgements

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Congratulations to Jan Jaroszyński, Dragana Popović and all who contributed to the recent publication in *Physical Review Letters* [92, 226403 (June 4, 2004)] in which noise measurements are used to study the electron dynamics in the still-unexplained metallic phase that exists at low temperatures in the two-dimensional electron system. This paper, the latest in a series of PRL's coming from this NHMFL group, provides clear evidence that charge, not spin, degrees of freedom freeze randomly in the "glassy" regime as the metal-insulator transition is approched from the 2D metallic phase.

TIME-DEPENDENT CONDUCTANCE FLUCTUATIONS IN THE METALLIC PHASE OF A TWO-DIMENSIONAL ELECTRON SYSTEM IN SILICON

J. Jaroszyński, D. Popović (NHMFL); T.M. Klapwijk (Delft Univ. of Technology, Applied Physics)

Introduction

The interplay between strong Coulomb interactions and disorder is believed to be responsible for many surprising and intriguing experimental observations that suggest the existence of a metallic phase in two dimensions (2D).[1] One of the central unresolved issues involves the role of the electrons' spins. Our studies of low-frequency resistance noise[2,3] in a 2D electron system (2DES) in Si have revealed a dramatic change in the electron dynamics that occurs near the metal-insulator transition (MIT) as it is approached from the metallic side. This change in the dynamics, attributed to glassy freezing, persists even when the electrons are fully spin polarized indicating that charge, not spin, degrees of freedom are responsible for glassy ordering. On the other hand, the origin of the $1/f$ resistance noise observed in the metallic phase has not been understood. In disordered metals at low temperatures, slow atomic motion gives rise to $1/f$ noise via the mechanism of universal conductance fluctuations (UCF).[4] Such noise is suppressed by a magnetic field B in a very specific way.[5] In order to shed light on the origin of noise in the metallic phase, we have studied the effect of a parallel B on noise, and compared our results to theoretical predictions.[5]

Experimental

Measurements of resistance as a function of time for a fixed carrier density n_s and in fixed parallel B of up to 9 T were carried out on a high-mobility ($\mu \approx 2.5$ m^2/Vs at 4.2 K) 2DES in Si using a standard four-probe lock-in technique at 2.7 Hz. The samples and the measurement technique have been described in more detail elsewhere.[3]

Results and Discussion

The noise power for n_s in the metallic phase is suppressed by a parallel B, and the spectrum changes from $1/f$ to $1/f^{0.5}$. This suppression of noise suggests that its origin is probably related to the electrons' spins. In case of UCFs, the theory predicts[5] that the variance of conductance, $(\delta G)^2$, will be reduced exactly by a factor of 2 in a parallel B because of the Zeeman splitting, but it does not predict any change in the power spectrum. Fig. 1 shows that, in our samples, $(\delta G)^2$ is reduced by almost two orders of magnitude before it becomes more or less independent of B for B>4 T, where the 2DES is spin polarized.

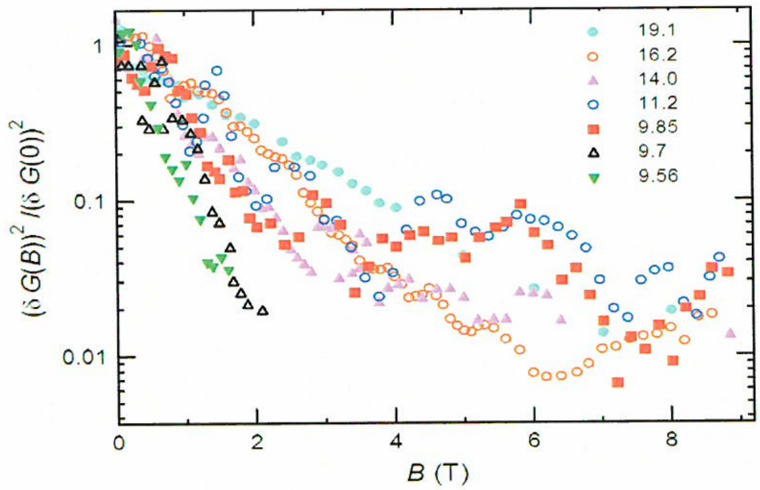

Figure 1. The B-field dependence of the conductance fluctuations for several densities n_s(10^{10}cm^{-2}) from 9.56 to 19.1 at T=0.24 K.

Conclusions

We have established that the $1/f$ resistance noise observed in the metallic regime of a 2DES in Si does not result from the motion of impurities and UCFs, but rather it appears to originate from some type of spin scattering. One possibility includes disorder-induced local magnetic moments, but a detailed mechanism presents yet another puzzle in the understanding of this novel metallic phase.

Acknowledgements

This work was supported by NSF Grant No. DMR-0071668 and the NHMFL. We are grateful to V. Dobrosavljević for useful discussions.

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Congratulations to Scott Crooker, Dwight Rickel, and colleagues for their article "Spectroscopy of spontaneous spin noise as a probe of spin dynamics and magnetic resonance" that appears in the September 2 issue of *Nature* magazine and establishes the usefulness of noise spectroscopy as a perturbation-free probe of spin dynamics and magnetic resonance. As devices shrink in size to the nanoscale regime, fewer atoms and spins dominate the device behavior and noise fluctuations become more prominent. By drawing on the fluctuation-dissipation theorem, this work, to appear in the next issue of *NHMFL Reports*, firmly establishes that one scientist's noise is another scientist's signal. Conventional magnetic resonance techniques, such as those used in magnetic resonance imaging (MRI) machines, require the excitation and absorption of specific radio-frequency waves by atoms in a magnetic field. These absorption patterns can be used to reveal molecular and magnetic properties . . . and even make a medically useful image. Instead of "shining" radio-frequency waves on the sample, the NHMFL researchers simply "listen" very carefully to the tiny, intrinsic thermal and quantum-mechanical fluctuations of a group of magnetic spins—called spin noise. They demonstrate that those fluctuations are able to reveal a number of the same properties without having to disturb it from its natural resting state. Using a laser technique known as Faraday rotation, the scientists measured the spectrum of spin noise in vapors of magnetic rubidium and potassium atoms. The noise spectrum alone revealed the complete magnetic structure of the atoms. This research might pave the way for magnetic resonance imaging techniques that are useful in fields like nanotechnology and quantum information science where systems containing only a few atoms are becoming commonplace and their associated magnetic fluctuations play an increasingly dominant role.

MEASURING RANDOM SPIN FLUCTUATIONS FOR PERTURBATION-FREE PROBES OF SPIN DYNAMICS AND MAGNETIC RESONANCE

S.A. Crooker, D.G. Rickel (NHMFL-LANL); A.V. Balatsky, D.L. Smith (Theory Division, LANL)

Introduction

In magnetic systems, fundamental noise can exist in the form of random spin fluctuations. In his seminal 1946 paper on nuclear induction, Felix Bloch noted that random, statistical fluctuations of N paramagnetic spins should generate measurable noise of order $N^{1/2}$ spins, even in zero magnetic field. By the fluctuation-dissipation theorem, this "spin noise" alone contains detailed information about the spin system itself. (The fluctuation-dissipation theorem states that the response of a system to an external perturbation— *i.e.*, the susceptibility—can be described by its spectrum of fluctuations while in thermal equilibrium). We are using optical techniques to passively and sensitively "listen" to the magnetization noise in a classical, equilibrium ensemble of paramagnetic alkali atoms.[1] Correlation spectra of the measured spin noise reveals the complete magnetic structure of the atomic $^2S_{1/2}$ ground state (g-factors, nuclear spin, isotope abundance ratios, hyperfine splittings, nuclear moments, and spin coherence lifetimes)—without having to excite, optically pump, or otherwise drive the system away from thermal equilibrium.

Results and Discussion

A linearly polarized laser, detuned from any atomic absorption, is focused through a cell containing rubidium or potassium vapor (Fig. 1a). Random magnetization fluctuations along **z** impart small polarization (Faraday) rotation fluctuations $\delta\theta_F(t)$ on the laser, which are sensitively measured with a balanced photodiode bridge. Helmholtz coils provide a small transverse magnetic field B along **x**, about which all magnetization fluctuations δM_z must precess. The detuned laser ensures that atoms are not optically pumped or excited in any way. The spin correlation function, $S(t)=\langle M_z(0)M_z(t)\rangle$, has a Fourier transform $S(\omega)$ that is related simply to the power spectrum of $\delta\theta_F(t)$. A typical noise spectrum is shown in Fig. 1b. The sharp peaks at Ω=869 and 1303 kHz are due to random spin fluctuations which are precessing in the small 1.85 G transverse magnetic field, effectively

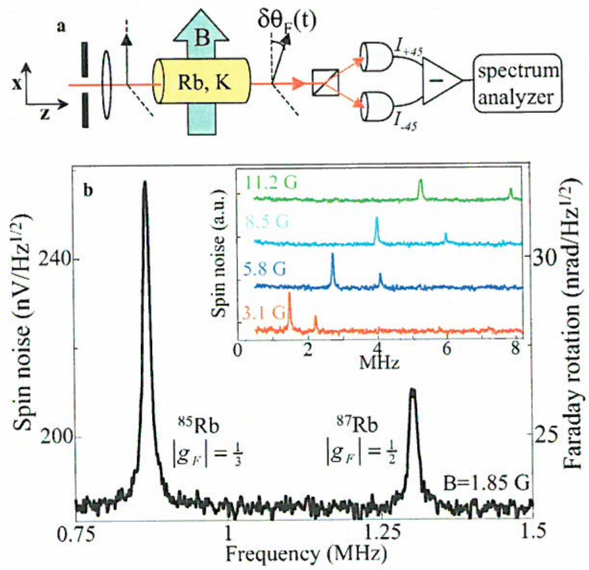

Figure 1. (a) Experimental schematic. (b) Spin noise spectrum in Rb vapor at 369 K and 1.85 G, showing spontaneous spin coherence peaks from ^{85}Rb and ^{87}Rb. Inset: Noise peaks vs. magnetic field (offset vertically for clarity).

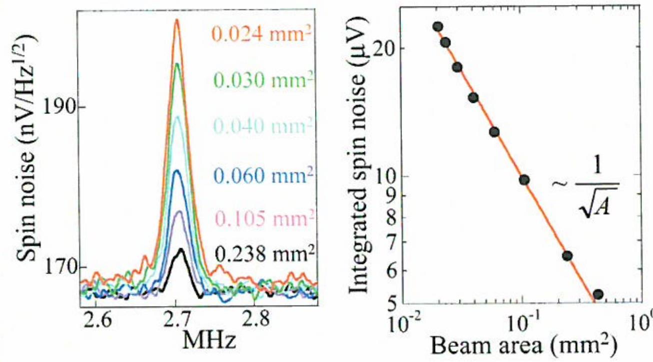

Figure 2. *Increasing* absolute spin noise with *decreasing* cross-sectional beam area. B=5.8 G, fixed spin density, and constant laser power.

generating spontaneous spin coherences between ground-state Zeeman sublevels. These coherences precess with g-factors ~ 1/3 and 1/2, which are the ground-state g-factors of the stable isotopes ^{85}Rb and ^{87}Rb. Coupling of the nuclear spin *I* to the $J=½$ valence electron splits the $^2S_{1/2}$ atomic ground state into two hyperfine levels with total spin $F = I \pm J$ and g-factor $|g_F| \cong g_J / (2I+1)$, where $g_J \cong 2$ is the free electron g-factor. Thus, the nuclear spin of ^{85}Rb $(I=5/2)$ and ^{87}Rb $(I=3/2)$ may be directly measured from spin fluctuations in thermal equilibrium. Strikingly, the measured spin noise actually *increases* when the diameter of the probe laser *shrinks* (Fig. 2). This result may be understood by considering that the Faraday rotation imposed on light passing through an intentionally-magnetized system is independent of beam area, so that the effective measurement sensitivity (rotation angle per unit polarized spin, θ_F/N) is larger for narrower beams. Therefore, fluctuations of order $N^{1/2}$ spins induce correspondingly more signal. These data suggest the utility of noise spectroscopy for passive probes of small systems, where the absolute amplitude of measured fluctuations actually increases when probe size is reduced, as long as measurement sensitivity increases correspondingly.

With a Neel temperature of 10 K, $CeIn_3$ is an antiferromagnetic heavy fermion compound situated at the very heart of the debate as to the role of spin fluctuations in unconventional superconductivity. It is of particular interest to quantum criticality theorists owing to its unique simple cubic crystal structure. Superconductivity occurs under pressure at close proximity to a putative pressure-induced quantum critical point at 25 kbar, whereupon the Neel order vanishes. It was recently shown in Los Alamos that the Neel temperature can also be suppressed to zero by applying very big magnetic fields of order 60 T. The present report concerns measurements of the specific heat and magnetocaloric effect that provides unambiguous evidence for the effect of a magnetic field on the Neel ordering temperature.

References

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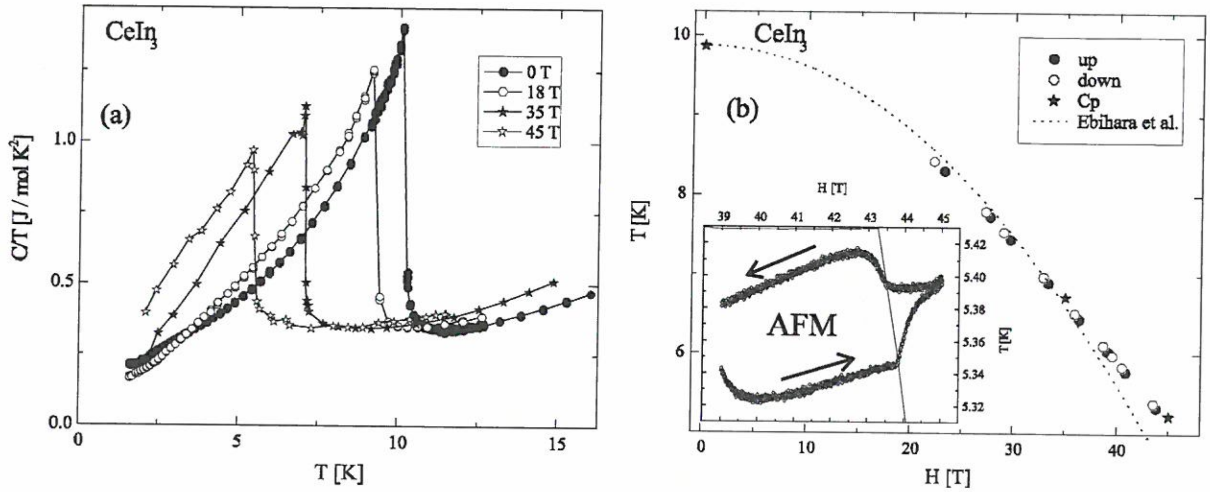

Figure 1. (a) Specific heat C/T as a function of temperature for $H = 0$, 18, 35, and 45 T. (b) Main Panel: phase boundary determined by specific heat measurements (star symbols) and magnetocaloric effect measurements increasing (solid symbols) and decreasing (open symbols) field. Insert: quasi-adiabatic change of temperature $T(H)$ during a fast change of magnetic field (MCE).

HIGH FIELD PHASE DIAGRAM OF CUBIC $CeIn_3$

A.V. Silhanek; M. Jaime; N. Harrison (MST-NHMFL, LANL); and T. Ebihara (Dep. of Phys., Shizuoka University, Shizuoka 422-8529, Japan)

The $CeIn_3$ compound is an intermetallic heavy fermion with a ground state resulting from the competition of a long ranged magnetically ordered state produced by RKKY interactions and the Kondo effect. The former dominates at low temperatures leading to an antiferromagnetic phase (AFM) for temperatures $T < 10$ K. Under relative small pressure (~25 kbar), however, the screening of the 4f moments by the conduction electrons compensates the RKKY interaction and a particular situation where neither one of the ground state dominates leads to the formation of a quantum critical point (QCP). In a similar fashion the magnetic ordering temperature T_N may also be suppressed by applying high magnetic fields H~60 T with a possible emerging quantum critical point.

In this work we have determined the H-T phase boundary of the AFM phase using specific heat (see Fig.1(a)) and magnetocaloric effect (see inset of Fig.1(b)) measurements. The main panel of Fig. 1(b) summarizes the obtained diagram with star symbols indicating the specific heat measurements and circles symbols corresponding to magnetocaloric effect (MCE) measurements. In the MCE experiments the temperature of the sample is recorded during a rapid sweep of the magnetic field as shown in the inset of Fig. 1(a). Here the phase transition manifests itself as a kink in the quasi-adiabatic $T(H)$ evolution without any evidence of field irreversibility in agreement with a second order transition.

The phase diagram depicted in Fig. 1(b) exhibits a quadratic field dependence at low fields that turns into a linear dependence at high fields and extrapolates to $T_N = 0$ at H~80 T. This value is significantly higher than the previous estimations using a quadratic fitting. In any case, these data confirm that as $T_N \rightarrow 0$, the slope of the phase diagram remains finite implying that the transition at $T_N = 0$ is still second order making it a good candidate for quantum criticality.[1]

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The contributions to the research category *"Kondo/Heavy Fermion Systems"* were generally of outstanding quality this year, both by the volume and detail of the reported research efforts, as well as by their first-rate scientific content. Most activities concentrated on the central open question in this field—that of the physics of quantum phase transitions. Because of the high quality of the contributions it proved very difficult to select one or two that deserve special attention. This work, however, caught special attention; it reports striking evidence of quantum critical behavior, induced by suppressing antiferromagnetic ordering through the application of high magnetic fields. Both the resistivity and the specific heat data clearly show how the conventional Fermi liquid behavior is suppressed precisely where magnetic ordering is destroyed. Even more interestingly, this work reports the emergence of a novel high-field metallic phase characterized by an unusual T3 form for the resistivity, in striking contrast to the conventional T2 behavior found below the critical point. These data thus seem to identify a novel type of quantum critical point, one separating a conventional Fermi liquid from an exotic high-field phase. This work is a perfect example of how the cutting edge experimental tools available at the Magnet Lab continue to uncover tremendously exciting and unexpected phenomena, which will guarantee that our efforts will continue to bloom for many years to come.

MAGNETIC FIELD-TUNED QUANTUM CRITICAL POINT IN $CeAuSb_2$

L. Balicas (NHMFL); S. Nakatsuji (U. Kyoto, Physics); H. Lee (UC Davis, Physics); P. Schlottmann (FSU, Physics); T.P. Murphy (NHMFL); Z. Fisk (UC Davis, Physics)

Introduction

When the long-range order in a system is suppressed to zero temperature by tuning an external variable, such as pressure, chemical composition or magnetic field *H*, the system is said to exhibit a quantum critical point (QCP).[1] The magnetic field is an ideal control parameter, since it can be reversibly and continuously tuned towards the QCP. Two compounds with field-tuned QCP, $YbRh_2Si_2$ and $Sr_3Ru_2O_7$, reached prominence due to the non-Fermi liquid (NFL) behavior triggered by the quantum fluctuations associated with the QCP. In this report we present a Ce-compound, $CeAuSb_2$, exhibiting a field-tuned QCP and unusual transport and thermodynamic properties. All three systems have a field-tuned QCP as a common thread, yet their behavior in high fields and low *T* are considerably different.

Experimental

Here we report on the anomalous metallic properties of $CeAuSb_2$ having used a combination of cryogenic and high field facilities provided by the NHMFL.

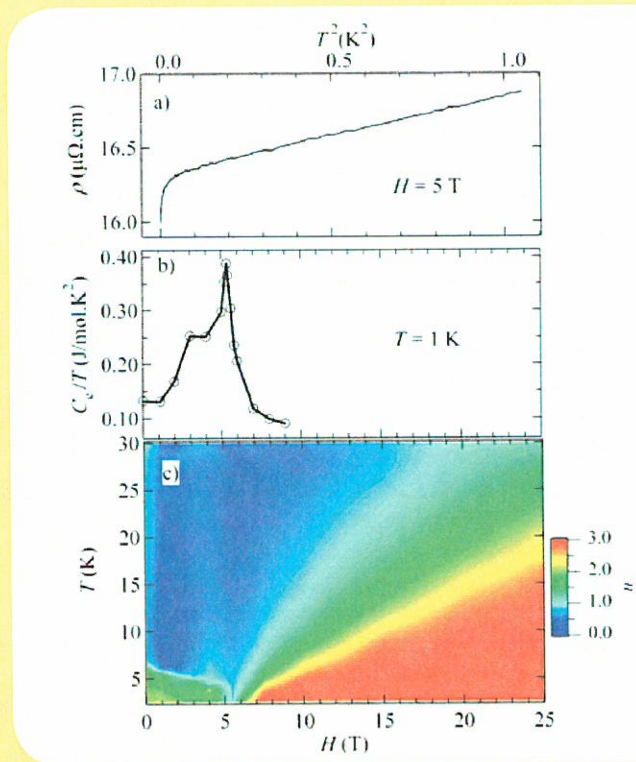

Figure 1. (a) The T^2-dependence of ρ down to T ≅ 25 mK for $H = 5$ T $\leq H_C$. Notice the pronounced deviation from the T^2 dependence at the lowest *T*, which is observed only in the vicinity of the critical field H_C. (b) The electronic heat capacity as a function of field *H* and at $T = 1$ K. (c) The exponent *n* of the resistivitity ρ in the *T* - *H* plane.

Results and Discussion

H = 0, $CeAuSb_2$ displays AF ordering at T_N = 6.0 K. Above T_N, the resistivity ρ displays a T^{α} dependence with $\alpha < 1$ and C_e/T has the $-lnT$ dependence characteristic of NFL behavior. For $T < T_N$, ρ has the AT^2 FL-like dependence and the extrapolation of C_e/T to $T = 0$ yields a Sommerfeld coefficient of $\gamma \sim 0.1$ J/mol.K^2, so that $CeAuSb_2$ is to be considered a heavy-Fermion system. A magnetic field along the inter-plane direction leads to two subsequent metamagnetic transitions and the concomitant *continuous* suppression of T_N to $T = 0$ at $H_C = 5.3 \pm 0.2$ T. As the AF phase boundary is approached from the paramagnetic (PM) phase, γ is enhanced and the A coefficient of the resistivity diverges as $H - H_C^{-1}$. As T is lowered for $H \sim H_C$, the T-dependence of ρ and C_e/T is sub-linear and $-ln\,T$, respectively. These observations suggest the existence of a field-induced QCP at H_C. At higher fields an unconventional T^3-dependence emerges and becomes more prominent as H increases, suggesting that the FL state is *not* recovered for $H >> H_C$.

Conclusions

The field-tuned QCP systems represent a challenge from the theoretical perspective, since the different compounds have some common aspects, but do *not* seem to belong to the same universality class.

Acknowledgements

This work is sponsored by the National Nuclear Security Administration under the Stewardship Science Academic Alliances program through DOE grant DE-FG03-03NA00066.

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1 See, for instance, S. Sachdev, *Quantum Phase Transitions* (Cambridge Univ. Press, Cambridge, 1999); For a review in materials and properties see, G.R Stewart, *Rev. Mod. Phys.*, **73**, 797 (2001).

The conventional view is that the pseudo gap in cuprate superconductors arises from phase fluctuations of the energy gap. Gor'kov and Teitel'baum have investigated an alternative point of view, namely the tendency of HTS materials to phase separate. They have shown that the NMR pseudogap behavior can arise from fluctuating aggregates of holes. While at high T the holes form a continuous phase, at a critical temperature T* and a first-order transition takes place, with strong fluctuations in the size and location of domains occurring. An analysis of the data shows that the 1/63T1 curves collapse onto a single curve. The domains may be pinned by structural defects. The theory agrees well with data from LSCO.

PSEUDOGAP REGIME IN HIGH T_c-CUPRATES AS A MANIFESTATION OF A DYNAMICAL PHASE SEPARATION

L.P. Gor'kov (NHMFL); G.B.Teitel'baum (Zavoiskii Inst., Kazan, Russia)

Introduction

The popular view is that the pseudogap state in cuprates arises as a crossover in the density of states. We investigated an alternative view taking into account an inherent tendency of high-T_c materials to the phase separation[1] now confirmed by numerous experimental data. Analyzing existing NMR data we have shown[2] that the pseudogap behavior of the nuclear spin relaxation for cuprates may be considered as a manifestation of the frustrated phase separation to the "metallic" (holes enriched) and "AF" (holes depleted) regions. The temperature variation of the relative volumes of the coexisting phases having different fluctuation rates would result in the transfer of the fluctuation spectral weight away from the NMR resonance frequency to be seen as a pseudogap suppression of the relaxation rate.

While at high enough temperatures, itinerant holes and Cu d^9 spins form a homogeneous phase, at a certain temperature $T^*(x)$ the first order transition takes place and the frustrated phase separation to the x=0 and to the finite x phases starts. (For interacting holes rigidly localized on Cu's in the CuO_2 plane the lattice "liquid-gas" transition at some T^* is known from the exact solution of the 2D Ising-problem). Taking hole-doped $La_{1-x}Sr_xCuO_4$, for the sake of argument, missing (with respect to the Sr ionicity) hole's density in the AF area must be recompensed by local metallic inclusions or droplets with higher hole's content. The tiny structure of sub-phases caused by charge neutrality condition leads to strong fluctuations in island's sizes and positions.[1] Phase boundaries move rapidly, inducing the strong hyperfine field fluctuations (note that a Cu-site merely loses spin when a "metallic" region crosses over the position of that ^{63}Cu nuclear spin). Experimentally one sees only one nuclear resonance frequency, this provides an evidence in favor of the dynamical picture. We discuss only $1/^{63}T_1$ behavior because for cuprates spin fluctuations on Cu-site prevail over the Korringa mechanisms.

Results and discussion

After the careful analysis of the existing experimental data for the nuclear spin relaxation in different materials, we have found that after an appropriate vertical offset all $1/^{63}T_1$ curves collapse onto the same T dependence above their T_c and below 300 K.[2,3] In this temperature region the nuclear spin relaxation is a sum from two parallel processes: $1/^{63}T_1 = 1/^{63}\overline{T}_1(x) + 1/^{63}\tilde{T}_1(T)$. Here

$1/^{63}\overline{T}_1(x)>0$ depends only on temperature and degree of disorder, while $1/^{63}\widetilde{T}_1(T)$ depends only on temperature and is very near to the $1/^{63}T_1$ dependence for the two chain's material YBCO 124 above its T_c=62 K. Since for all materials with non-zero $1/^{63}\overline{T}_1(x)$ incommensurate (IC) magnetic peaks at $[\pi(1\pm\delta),\pi]$ and $[\pi,\pi(1\pm\delta)]$ were observed at neutron scattering, we conjectured $1/^{63}\overline{T}_1(x)$ be related with these IC peaks (δ is the IC splitting parameter). For $La_{1.86}Sr_{0.14}CuO_4$ the detailed experimental data available[4] provide the correct estimate for the offset $1/^{63}\overline{T}_1(x)$.

As for $1/^{63}\widetilde{T}_1(T)$, we ascribe its temperature dependence to the crossover from the *local* regime to the *dynamical* one, when the hyperfine field fluctuates due to the fast variations in the configuration of the d^9 holes surrounding the copper nuclei. In the first case the relaxation is determined by the spin susceptibility, and in the second one by the probability to have the AF hyperfine field at the given nuclei.

To summarize, the nuclear spin relaxation for a broad class of cuprates is due to two independent mechanisms: relaxation on the "stripe"-like excitations and a "universal" temperature dependent term. IC "stripes" always come about with external doping and may be pinned by structural defects. The whole pattern fits well the notion of the dynamical phase separation into coexisting metallic and IC magnetic phases. Among the most recent of our results is the reconstruction of the 1st order phase transition line, $T^*(x)$, that agrees well with the phase diagram for LSCO in the (x,T)-plane measured by other means.

Acknowledgements

The work was supported by the NHMFL through the NSF cooperative agreement No.DMR-0084173 and the State of Florida.

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Another very interesting report concerns the T-P phase diagram and magnetoresistance of *β-(BDA-TTP)$_2$MBr$_4$ (M=Fe, Ga)*. In some such materials, the existence of local magnetic moments on ions leads to dramatic changes of the ground state. In other cases, magneto-transport experiments show behavior between magnetic and non magnetic-like. The π-*d* interaction is attributed as the source of this behavior. To understand this π-*d* interaction, the *T-P* phase diagram and the magnetoresistance were thoroughly studied. As *T* is decreased, this material undergoes a metal-insulator transition with superconductivity appearing at *12.8 kbar* and *T$_c$=0.5 K.*

INVESTIGATION OF TEMPERATURE-PRESSURE PHASE DIAGRAM AND MAGNETORESISTANCE OF β-(BDA-TTP)$_2$MBr$_4$ (M=Fe, Ga)

E.S. Choi, J.S. Brooks, S.W. Tozer (Florida State University/NHMFL); J. Yamada (Himeji Institute of Technology, Japan)

The existence of local magnetic moments as magnetic anions in charge transfer salts induces dramatic changes in the ground state of some organic conductors. In other cases, the magnetotransport properties show distinct behaviors between magnetic and non-magnetic compounds even when they show similar ground states. The π-d interaction was attributed to account for those behaviors, and the magnitude of the interaction (expressed as *J*) can be varied depending upon the distance between conducting planes and neighboring magnetic anions. As a continuous effort to understand the π-d interaction in charge transfer salts, we have investigated a temperature-pressure (*TP*) phase diagram and magnetoresistance of β-(BDA-TTP)$_2$MBr$_4$ (M=Fe, Ga). The clamped pressure cells made of either BeCu or MP35N alloy developed in NHMFL were used in this study. SCM II and Cell 12 magnet were used to measure high field magnetoresistance.

The *TP*-phase diagram of β-(BDA-TTP)$_2$MBr$_4$ is insensitive to the existence of magnetic anions and more or less similar to that of β-(BDA-TTP)$_2$MCl$_4$ (M=Fe, Ga)[1] as shown in Fig. 1 (a). As the temperature is decreased, β-(BDA-TTP)$_2$MBr$_4$ undergoes

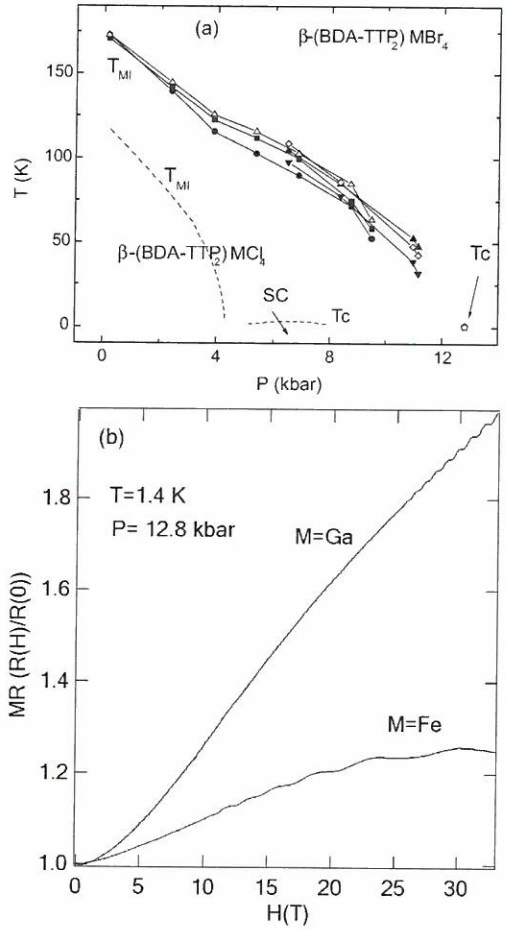

Figure 1. (a) The *TP*-phase diagram of β-(BDA-TTP)$_2$MBr$_4$ (M=Fe, Ga). Each symbol represents different samples with filled symbols for M=Fe and unfilled symbols for M=Ga. The dashed lines are phase boundaries for β-(BDA-TTP)$_2$MCl$_4$ compounds. (b) MR (R(H)/R(0)) of β-(BDA-TTP)$_2$MBr$_4$ at 1.4 K at 12.8 kbar. The SdH oscillation is also observed from for both samples with similar FFT frequency of 900 T. A slow oscillation with frequency of 100 T is observed only for M=Fe sample.

metal to insulator transition at T_{MI}. The insulating phase is suppressed with pressure and the superconductivity eventually appears at 12.8 kbar with T_c^{onset} ~ 0.5 K for both M=Fe and Ga samples. Compared to β-(BDA-TTP)$_2$MCl$_4$, the pressure for T_{MI} and T_c shifts to higher values for β-(BDA-TTP)$_2$MBr$_4$, which may be due to the higher negative chemical pressure effect for the larger MBr$_4$ anion.

It is of note that both M=Fe and Ga samples show positive magnetoresistance (MR) with small differences between them as shown in Fig. 1 (b). This behavior is rather unusual compared to other organic conductors with local magnetic moments which show negative MR. It is speculated that the π-d interaction in this compound can be much smaller than others. In a simple picture that the interaction is proportional to the extent of overlap between the energy levels of donors and anions, one may need higher pressure to observe the effect of the π-d interaction in this compound.

Acknowledgements

This work is supported by NSF-DMR 0203532.

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The works by Yong *et al.* and Gervais *et al.* concern novel, crystalline states of electrons confined in two-dimensional systems in semiconductors. These two dimensional electron systems are also known for exhibiting the quantum Hall effects. The reports present examples of advanced, nonstandard rf techniques applied to high magnetic field research. Yong *et al.* employed transmission line-based spectroscopy to a newly discovered electron crystal that exists at high magnetic field. They found this phase, even though strongly affected by disorder, has a correlation length of 80 µm or more. Gervais *et al.* used NMR, detected by changes in resistance on application of rf, to find evidence for a crystal of Skyrmions, exotic particles that bundle multiple electron spins, which occur under certain conditions in 2D electron systems in high magnetic field.

Pinning Mode Dispersion of 2D Wigner Solid Phases in High Magnetic Field

Yong P. Chen, R.M. Lewis (NHMFL and Princeton); L.W. Engel (NHMFL); D.C. Tsui (Princeton); L.N. Pfeiffer and K.W. West (Lucent Bell Labs)

The ground state of a sufficiently clean two-dimensional electron system (2DES) in high magnetic field (above the termination of the fractional quantum Hall state series) is generally believed to be a Wigner solid (WS). Pinned by disorder, such a solid is an insulator and possesses a characteristic pinning mode resonance, due to the solid oscillating within the pinning potential. Recent measurements[1] on very low disorder 2DES realized in GaAs/AlGaAs quantum

EVIDENCE FOR SKYRMION CRYSTALLIZATION FROM NMR RELAXATION EXPERIMENTS

G. Gervais (Columbia U. and NHMFL), H.L. Stormer (Columbia U.), D.C. Tsui (Princeton), P.L. Kuhns (NHMFL), W.G. Moulton (NHMFL), A.P. Reyes (NHMFL), L.N. Pfeiffer (Lucent), K.W. Baldwin (Lucent) and K.W. West (Lucent).

Introduction

In the presence of a strong perpendicular magnetic field, the orbital motion of electrons confined to a two-dimensional plane is quantized into discrete Landau levels. When only the lowest of such level is almost completely occupied, the elementary excitations of the system become large topologically stable spin texture known as Skyrmions.[1] Here, we present an extensive study of nuclear magnetic resonance (NMR) spin-lattice relaxation rate in the first Landau level of an extremely high-quality GaAs/AlGaAs sample. We find strong and enhanced relaxation in the limit of T→0 and Rxx →0 where localization of electronic states occurs. This is consistent with the predictions of, and finds a natural interpretation in terms of a magnetic ground state containing a Skyrme crystal.[2]

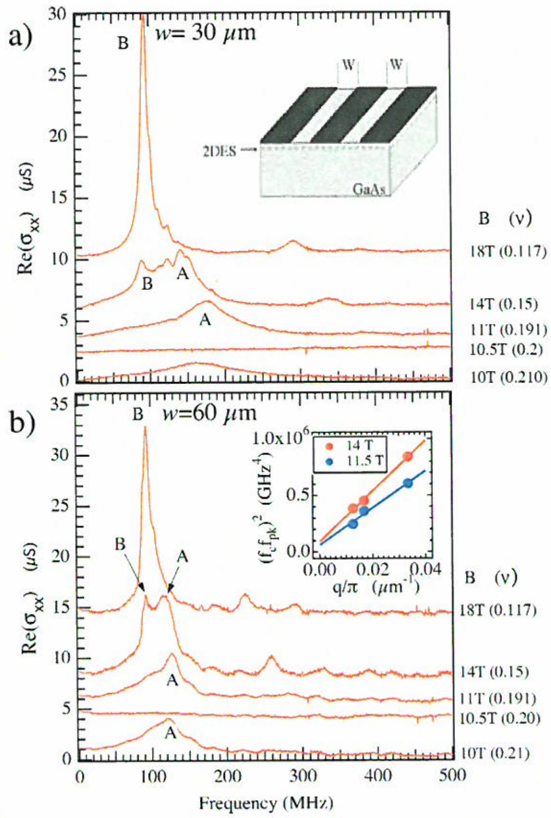

Figure 1 (a) and (b). Conductivity spectra for samples with different transmission line widths, w=60 and 30 µm, for various Landau level filling factors ν. Resonances interpreted as due to solids A and B are marked. There is a crossover from the A to the B resonance as ν decreases. The density of both samples was 5.1 ×10^{10} cm^{-2}, and the measuring temperature was 50 mK. The higher frequency peaks may be due to spatial harmonics.

Inset in (a): magnified cross section of transmission line pattern fabricated on top of sample. The transmission line has three conductors, two grounded side planes and a driven center conductor, separated by slots of width w.

Inset in (b): Experimentally measured dispersion of solid-A pinning mode at two representative magnetic fields. Solid lines show fits to the theory in.[2] Fit parameter was density: 5.1 ×10^{10} cm^{-2} (14.5 T data, red), 4.9 ×10^{10} cm^{-2} (11.5 T data, blue). f_c is the cyclotron frequency; f_{pk} is the measured resonance frequency.

wells found two different resonances, with one crossing over to the other as Landau filling factor (ν) is reduced, suggesting that there are two different solid phases ("A", dominant at high ν and "B", dominant at low ν).

We have probed the dispersion of the pinning mode of solid A by varying the wave vector $q=\pi/w$ imposed by a planar transmission line that couples to the 2DES in these measurements, as shown in the inset in Fig. 1a. Samples were made from the same wafer (with 2DES in a 65 nm wide quantum well), but with various w's ranging from 20 to 80 µm. Fig. 1 shows that the peak frequency of the pinning mode (f_{pk}) of solid A is lower for larger w. This trend continues at least to w=80 µm, the largest w we measured. This means solid A has some type of *correlation length exceeding ~80 µm*. The q dependence of the peak frequency, shown in the inset in Fig. 1b, is in reasonable agreement with the predicted dispersion[2] for the magnetophonon mode of a disorder-pinned Wigner crystal. In contrast, the resonance in solid B is independent of w.

Acknowledgements

We acknowledge support from the AFOSR and from the NHMFL in-house research program.

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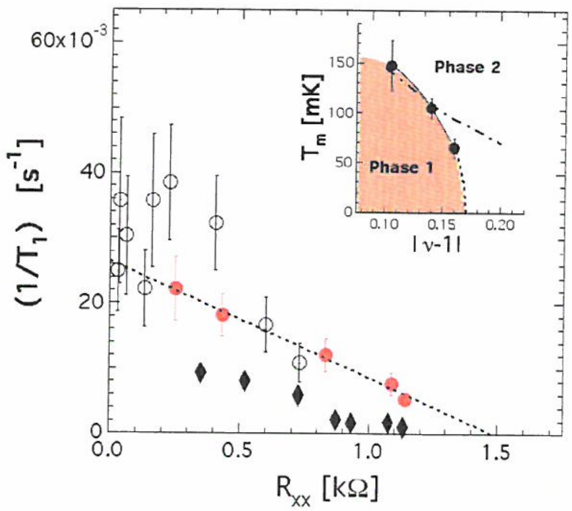
Results and Discussion

Fig. 1 shows the spin-lattice relaxation rate (1/T1) extracted using resistively detected NMR in the vicinity of the υ =1 Quantum Hall state, at filling factors υ =0.84 (diamonds), 0.86 (filled circles), and 0.895 (open circles). The nuclear spin of 75As is found to relax much more efficiently with T→0 and when a well developed quantum Hall state with Rxx~0 occurs. The data show a remarkable correlation between the nuclear spin relaxation and localization. Extrapolating the rate in Fig.1 to the x-axis defines a resistance Rm at which T1→∞. While there will remain other, weaker relaxation mechanisms, this extrapolated Rm should provide a measure where nuclear relaxation by the strong low-temperature mechanism ceases. When translated to Tm via our Rxx vs. T calibration, the Tm's define a temperature boundary for the low-temperature magnetic phase as shown in the inset of Fig.1 vs. the partial filling factor, |υ -1|. Efficient relaxation of the nuclear spins requires magnetic fluctuations in their environment and the data in Fig.1 requires an increase of such fluctuations as Rxx (and hence σxx) decreases. A spin-polarized two-dimensional Fermi gas is extremely inefficient in providing such fluctuations. On the other hand, a spin-wave Goldstone mode of a Skyrme crystal[2] provides a very efficient mechanism for relaxing the nuclear spins. Within this scenario, phase 1 would correspond to a square lattice phase of Skyrmions with long-range positional and orientation order, while phase 2 would correspond possibly to a melted skyrmion phase with quasi long-range magnetic order only.



Conclusions

In the vicinity of the υ =1 quantum Hall state, in GaAs/AlGaAs the nuclear spin relaxation increases strongly as the temperature is lowered and when Rxx→0. This strongly suggests that the localized states are responsible for the fast nuclear relaxation. We find a natural interpretation of our data in terms of a magnetic phase of localized Skyrmions relaxing the nuclear spin via a Goldstone mode of the crystal and deduce a partial phase diagram in the T- υ plane.

Acknowledgements

Research funded by the NSF under grant # DMR-0084173 and # DMR-03-52738, and by the DOE under grant # DE-AIO2-04ER46133.

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Congratulations to Yoon Lee, Jian-Sheng Xia and Carlos Vicente, all from the NHMFL High B/T facility, for their article titled "A1 and A2 Transitions in Superfluid ^{3}He in 98% Porosity Aerogel" in *Physical Review Letters* [Choi, *et al.*, 14, 145302 (1 Oct 2004)]. This work, performed at the NHMFL's High B/T Facility and partially funded by the In-House Research Program, reports the discovery of the third superfluid phase in helium-three in the presence of high porosity aerogel. The discovery of superfluidity in helium-three was awarded the 1996 Nobel Prize in Physics. This work studies the effects of disorder in this unconventional (p-wave) superfluid by placing the helium-three in 98% porosity aerogel. The newly discovered phase is only observable in magnetic fields above 3 T and at extremely low temperatures below 2 mK. This work maps the high field phase diagram of helium-three in aerogel up to 15 T.

OBSERVATION OF A HIGH FIELD PHASE IN SUPERFLUID ^{3}He IN 98% POROSITY SILICA AEROGEL

H.C. Choi, A.J. Gray (UF, Physics), C.L. Vicente, J.S. Xia (NHMFL, UF), G. Gervais, W.P. Halperin (Northwestern, Physics & Astronomy), N. Mulders (U. of Delaware, Physics), and Y. Lee[1,2] (UF, Physics)

Introduction

Superfluid ^{3}He in high porosity aerogel is the system in which the effects of static disorder on a p-wave superfluid can be investigated in a systemic manner. The nano-meter scale structure of high porosity aerogel provides a self-sustaining matrix of dilute static impurity which interferes with the formation of Cooper pairs in superfluid ^{3}He. The fragile nature of the p-wave Cooper pairs against impurities was clearly demonstrated by the significant depression of the superfluid transition. To date, two distinct superfluid phases have been observed in this system in moderate magnetic fields (< 8 kG). We report our finding of the third superfluid phase in 98% porosity aerogel which appears only in the presence of strong magnetic fields.[1]

Experimental

We performed continuous wave shear acoustic impedance measurements on both bulk liquid (pure) and liquid in aerogel (dirty) in the presence of magnetic fields up to 15 T at 28.4 and 33.5 bar using the High B/T Facility. In brief, we detect the change in electrical impedance of an ac-cut quartz transducer in contact with both pure and dirty liquid. The acoustic measurement is performed at 8.7 MHz. Temperature is determined by the ^{3}He melting pressure thermometer attached right below to the main sample cell made out of pure silver and titanium. In high magnetic fields (3 T < H < 14.5 T), the recent calibration by a University of Tsukuba group was employed.[3]

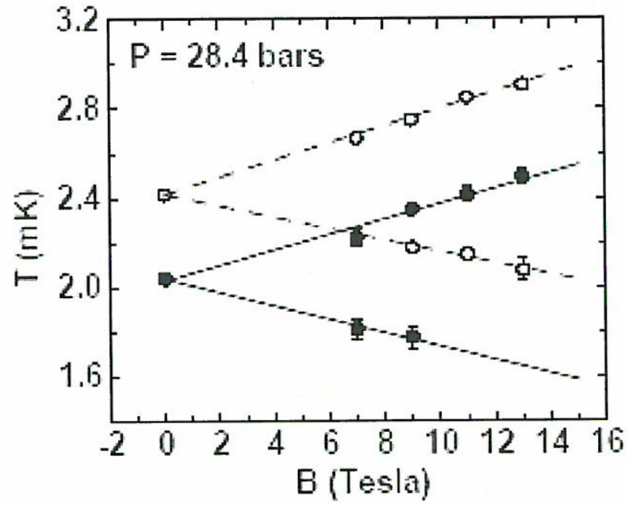

Figure. 1. Transition temperature vs. field.

Results and Discussion

Fig. 1 shows the field dependent transition temperatures at 28.4 bar. Open (closed) circles are for bulk (aerogel) transitions. The transition features are identified as distinct steps (bulk) and slope changes (aerogel) in the acoustic trace. The single transition feature at zero field splits into two transitions in magnetic fields inducing a new phase appearing inside the wedge. The size of the splitting is linear in field as demonstrated in the figure. The high field phase in bulk has been identified as the A_1-phase in which only the spin up component participates in forming Cooper pairs. Similar behavior is observed for 33.5 bar. We could not resolve or identify the splitting in aerogel below 3 T. This might suggest antiferromagnetic exchange between the localized ^{3}He adsorbed on the aerogel surface and mobile ^{3}He spins in liquid.

Conclusions

We observed the superfluid transition in 98% aerogel split into two transitions in the presence of magnetic fields above 3 T at 28.4 and 33.5 bar. The field dependence of each transition is consistent with that of the A1-phase observed in pure liquid.

Acknowledgements

This work is partially supported by a NHMFL IHRP grant and the NSF through DMR-0239483. YL is an Alfred P. Sloan Research Fellow.

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Chapter 3
USERS PROGRAMS

The strength and success of NHMFL users programs and facilities are carefully built around the synergies of the highest field magnets, unique instrumentation, and strong supportive services of faculty and staff. The narratives in this chapter describe the measurement capabilities of each facility with special emphasis on magnet systems, instruments, and techniques that were new in 2004. 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.

For a comprehensive review of all research activities supported by the NHMFL facilities described herein, see the NHMFL Web site: *http://www.magnet.fsu.edu/publications/2004annualreport/*. Hundreds of research reports in seventeen categories are conveniently available to readers. In addition, detailed lists of users and projects are presented that show the breadth of research activity by users of the NHMFL.

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.

Several major systems provide a broad magnetic field - temperature - pressure - angle - frequency "parameter space" to researchers. Two dilution refrigerators offer 20 mK to 40 mK base temperatures in fields up to 20 T in a superconducting magnet and up to 45 T in the Hybrid magnet. Furnaces offer temperatures to 1500 K in the resistive magnets. Diamond anvil high-pressure cells permit optical and transport measurements to 12 GPa at temperatures from 20 mK to 350 K. Larger volume metallic piston cylinder cells can be used for similar experiments in pressures to 2 GPa and temperatures down to 40 mK. Magneto-optical measurements can cover wavelengths from the near ultraviolet to far-infrared. Non-optical measurements of transport properties can be done at DC through audio frequency AC to millimeter and microwave frequencies. Magnetic properties of materials can be measured optically, by AC susceptibility, cantilever force and torque, and vibrating sample magnetometry. Nuclear magnetic resonance, electron magnetic resonance (both spin and cyclotron resonance), and the sub/millimeter wave spectroscopy facility provide unique insights into materials, including many of interest to biologists and chemists. Sample rotators allow researchers to vary not only the amplitude of the applied magnetic field but also its angle with respect to the sample. NHMFL staff members often help visitors develop new instruments for unique experiments not possible with the general purpose instrumentation that is kept on hand for everyone.

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

Computer hardware and software at the NHMFL allow any member of a research group to connect directly to the experimental areas at all three NHMFL sites. Collaborators far from the NHMFL facilities can view data and modify experimental strategies "live" during the magnet runs. General computer support is provided to facility users at all levels from the Internet to data acquisition software programming.

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

Highlights of Research and New Instrumentation for Users of the Continuous Field General Purpose Magnets

While there were no major new instruments or magnets installed in 2004, several were brought into productive use or improved.

- **The new sample environments for the 18/20 T superconducting magnet** have been welcomed enthusiastically by users and support staff. The Janis Research top-loading ^{3}He refrigerator has a usable base temperature of 270 mK and can provide sample temperatures to 70 K. Two probes are available, one of which has a sample rotator permanently installed. They are designed so that the sample mounting is compatible with that used in the top-loading dilution refrigerator. Tim Murphy redesigned the Janis Research variable temperature insert cryostat so that it would use the probes built for the ^{3}He system. Being able to use one set of probes for a wide range of temperatures simplifies the work of the researchers and NHMFL staff, as well as saving money for probes and storage space.
- **A new power supply for the 18/20 T superconducting magnets** was developed by NHMFL Instrumentation and Operations staff using standard parts from Alpha Scientific and American Magnetics. The new supply can be ramped smoothly through zero, is computer controlled, and will be duplicated for other magnets after it has been used longer.
- **Ultrasound Spectroscopy was enhanced by adding the ability to tilt the sample relative to the magnetic field.** Two ultrasonic techniques, the pulse-echo transmission technique and resonant ultrasound spectroscopy, allow users to study elastic properties of matter in magnetic fields. These techniques provide information about the electron and magnetic systems of studied solids by revealing information about electron-phonon and magnon-phonon interactions. Development of transducers small and sensitive enough to fit on samples that are small enough to fit into a sample rotator permits the measurement of sound velocity and phase changes that occur when the angle between the magnetic field and principal crystal axes of the sample is varied.

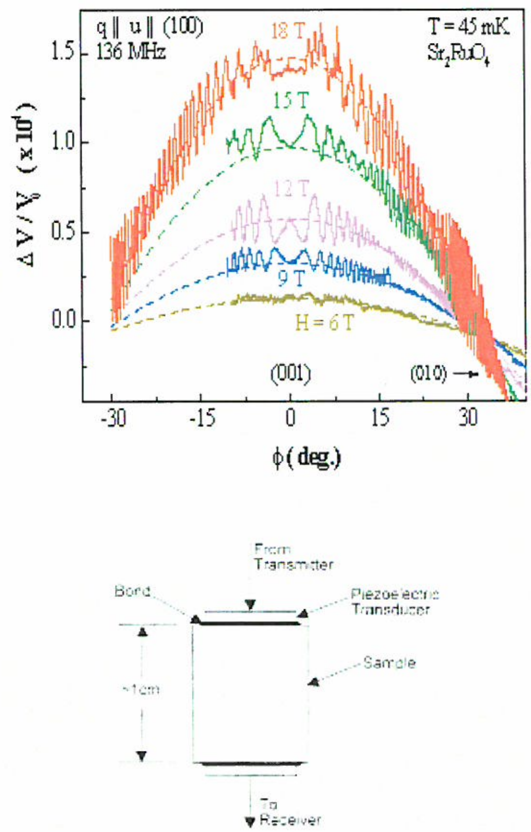


Figure 1. Angle-dependent pulse-echo ultrasound measurements allow quantum oscillations in sound velocity to be related to similar oscillations in magnetization.

Table 1. Magnet Systems for Users of the Continuous Field Facility, Tallahassee, as of January 2005

FLORIDA-BITTER and HYBRID MAGNETS

Field (T), Bore (mm)	Power (MW)	Supported Research
45, 32	32	Magneto-optics – ultra-violet through far infrared, Magnetization, Specific heat, Transport – DC to microwaves, High Pressure, Temperatures from 40 mK to 1500 K, Dependence of optical and transport properties on field, orientation, etc.
33, 32	20	
32, 32	20	
30, 32[1]	18	
25, 32 to 50[2]	15.7	
25, 52[3]	19	
24.5, 32[4]	13.1	Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.
20, 195	20	

SUPERCONDUCTING MAGNETS

Field (T), Bore (mm)	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[5]	4 K – 300 K	
15, 45	10 mK – 1 K	

1 Upgrade to ~35 T planned. First coil set ready by the third quarter of 2005.
2 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. This magnet was upgraded to 31.3 T in March, 2005.
3 Higher homogeneity magnet.
4 Upgrade to ~29 T with inhomogeneity of ~50 ppm for broad line NMR to be complete in the fourth quarter of 2005.
5 Special system for optical measurements.

- **Cells 3 and 5 have been modified to serve as "optics cell".**
  - A 17.5 T superconducting magnet with optical windows in the bottom of the new Janis Research cryostat has been installed on a stand in cell 3. It allows direct access optics experiments from below and either far infrared or sub/millimeter wave spectroscopic measurements from the top.
  - A mezzanine floor, special wall surfaces, and a filtered air conditioning system have been installed in cell 3 to provide a clean, climate-controlled environment for the fast pulse optics mentioned above, as well as access to the top of the superconducting magnet.
  - Holes in the wall between cells 3 and 5 allow direct optical access to a cryostat in the cell 5 magnet.
  - The 50 mm bore resistive magnet in cell 5 remains accessible for non-optics experiments. It provided 25 T in 2004 and was upgraded to ~32 T in March of 2005.
  - A platform in cell 3/5 will provide a stable base for the Bruker Far Infrared Spectrometer from which it will be able to access the 17.5 T superconducting magnet in cell 3 and the 25 T, 50 mm bore resistive magnet in cell 5.

Figure 2. View of cells 3 and 5 with the new platform covering the clean room in cell 3.

- Ultra-Fast Pulse Optics instrumentation developed through an In-House Research Program (IHRP) grant to Chris Stanton and David Reitze of the University of Florida has been installed in cell 3. The main instrumentation consists of a chirped pulse amplifier (CPA), an optical parametric amplifier (OPA), and a Ti: Sapphire laser. It is capable of probing over an energy range of 0.06 to 4.0 eV with 150 fs time resolution. Sample temperatures can be controlled between 4.2 K and 300 K. The facilities are being and will be used for magneto-exciton spectroscopy, "quantum optics" of excitons, spin relaxation characterization, quantum information science, and novel coherent control methods in high magnetic fields.

Other DC Facilities improvements in 2004

- A Bruker model 66v FT-IR spectrometer has been put into use. It updates the existing Bruker model 112v spectrometer, is much more portable, is capable of "step-scan" as well as Fourier transform spectroscopy, and will be used for experiments in cells other than 3 and 5.

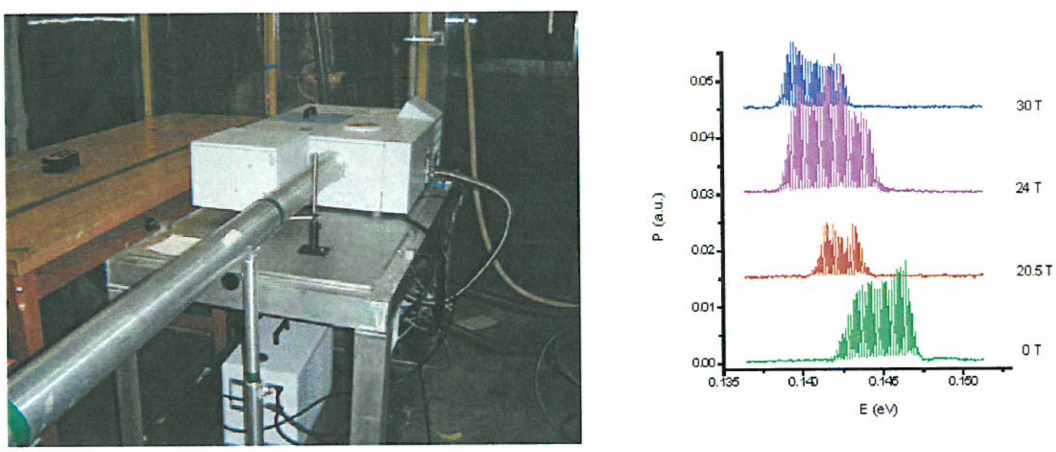


Figure 3. The first spectra measured with the new Bruker Model 66 Step-Scan Fourier Transform, Infrared Spectrometer. The spectra are of light emitted by a Quantum Cascade Laser at several magnetic fields.

- Mid-infrared light emission from quantum nanostructures can now be measured as a function of sample current and magnetic field. Current-voltage characteristics of the samples can also be determined. The wavelength range covered is 5 μm to 30 μm, and the temperature range is 4.2 K to 300 K. The measurement range is being extended so that far-infrared (THz) frequencies should be accessible by the middle of 2005. This line of research and instrumentation development will allow and include the study of inter-subband transitions in nanostructures and should lead to the development of new materials and designs for infrared and THz sources.
- General-purpose instrumentation was updated by the addition of a new multi-frequency Andeen-Hagerling capacitance bridge, new Keithley current sources, new Apple data acquisition computers, new Lake Shore and CryoCon temperature controllers, and new LabVIEW software. Efforts to push the measurement noise floor lower included purchases of additional power line conditioning equipment, transformer pre-amplifiers for AC measurements of low impedance samples, and low triboelectric effect, low noise, coaxial cables.

Improvements scheduled for 2005

- The State of Florida appropriated 7.5 million dollars to renew and upgrade the resistive magnet power supplies and cooling water systems. NHMFL staff members have been working with consultants to plan the upgrades based on experience with the existing equipment and input from users of the DC High Field Facility. Details of the planned improvements are as follows:
- Power Supply Upgrade

  Maximum available power from the existing City of Tallahassee Electric Department substation is 72 MW. It will be divided into 13 MW for building and water-cooled equipment, 3 MW allowance for added water-cooled research equipment, and 56 MW for magnets. Further power increases will require expansion of the substation.

  The magnet power supplies will be upgraded in stages with the highest priority changes made first. The goal of the funded expansion is 56 MW total or 14 MW per power supply. The option of increasing some or all of the power supplies to 16 MW will be kept open by ensuring that all components purchased for interim upgrades will be rated at 16 MW. The first upgrade step, to 48 MW, will be completed by the summer of 2006. Each 12 MW supply will deliver 600 V and 20,000 A to the magnets. New power supply controllers will solve some existing problems and improve magnetic field stability. The increase to 56 MW will be done gradually, as existing magnets are replaced by magnets able to use 730 V, 20,000 A.
- Cooling Capacity Upgrade

  A 35 m diameter cooling water tank and additional pumps will support 56 MW, 14 hour/day operation. The facility can operate 24 hour/day if steady-field operation is mixed with experiments that require sweeping the magnets from zero to full field and back. There will be one 32 MW magnet cooling water loop, and one at 24 MW. Improved valves will enable better magnet temperature control. An optional (but budgeted) second cooling water return header will also improve magnet temperature and field stability.
- Operational Benefits
  - Ability to run existing magnets at full power for long periods of time
  - Improved magnetic field stability and reduced field noise
  - Allow the proposed Series Connected Hybrid to reach its design field
  - Permit new magnets to be developed to produce higher fields
- Schedule
  - Scope Development: Complete
  - Detailed Design / Engineering: December 1, 2004 – March 1, 2005
  - Purchasing / Construction: March 1, 2005 – March 15, 2006
  - Installation: March 15, 2006 – May 15, 2006

Table 2. DC Facility User Statistics for 2004 (1/1/04 – 12/31/04)

User and Project Data	Total	Minority	Female
Number of Research Projects	127	2	11
Number of Senior Investigators, U.S.	87	2	10
Number of Senior Investigators, non-U.S.	22	0	1
Number of Students, U.S.	76	0	6
Number of Students, non-U.S.	23	NA	3
Number of Postdocs, U.S.	42	0	3
Number of Postdocs, non-U.S.	15	NA	1

Table 3. DC Facility Operations Statistics for 2004 (1/1/04 – 12/31/04)

Number of Magnet Days	Florida-Bitter & Hybrid	Superconducting
NHMFL, UF, FSU, FAMU, LANL	283	263
U.S. University	209	246
U.S. Govt. Lab.	20	21
U.S. Industry	32	0
Non-U.S.	156	85
Test, Calibration, & Maintenance	11	87
Idle	11	25
Total	**722**	**727**

NHMFL Pulsed Field Facility at Los Alamos National Laboratory

The NHMFL Pulsed Field Facility (PFF) located in Los Alamos, New Mexico at the Los Alamos National Laboratory is the premier facility in the world for conducting high magnetic field experiments in transient, research-grade, magnetic fields. 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 extremely active researchers and often collaborate with multiple users per year. The apparatus used at the NHMFL-PFF is amongst the world's most powerful, and is highly customized to maximize efficiency in pulsed magnetic field experiments. A fully multiplexed, computer-controlled, 6 position, 1.6 megajoule capacitor bank power system is at the heart of the pulsed field activities at the NHMFL-PFF. Some 4000 shots per year are fired for the user program, which accommodates approximately 120 individual user groups.

Figure 4. The NHMFL-PFF and some adjacent Los Alamos National Laboratory facilities viewed from the air.

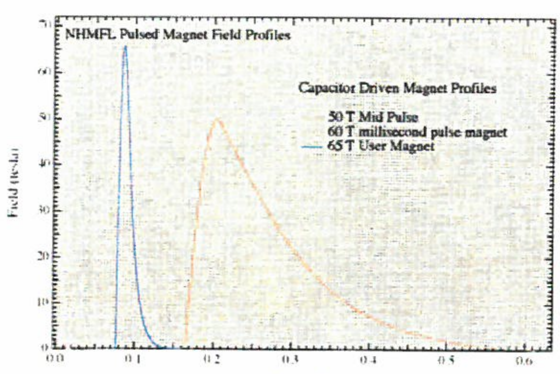


Figure 5. Capacitor-bank-driven magnet waveforms currently available for NHMFL-PFF users.

Other magnet systems at the NHMFL-PFF include the 60 T Controlled Waveform Magnet (also known as the 60 T Long Pulse Magnet). The 100 Tesla Multi-Shot (MS) magnet is also resident at the NHMFL-PFF. These two systems utilize a unique power source, the 1.4 gigawatt Pulse Mode Generator, which is capable of delivering a 700 megajoule energy pulse.

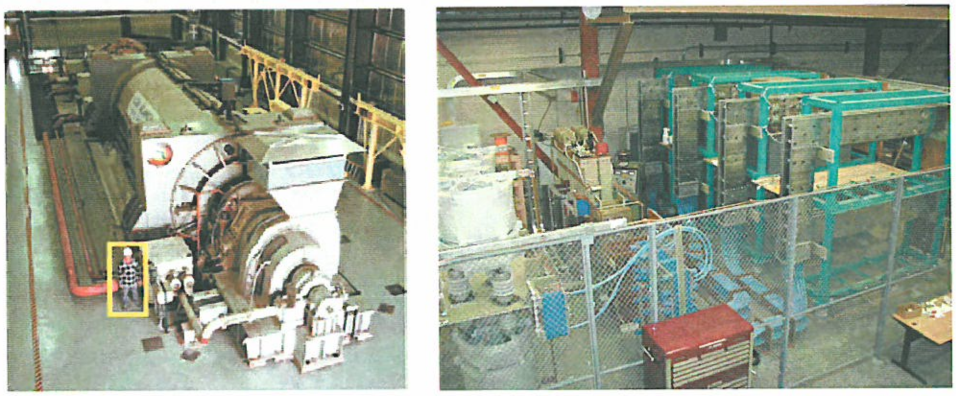


Figure 6. The 100 T Multi Shot magnet system capacitor bank (right) and the 1.4 GW pulse mode generator (left).

Recently (November-December 2004) the prototype insert for the 100 T MS magnet was tested at the NHMFL-PFF using the newly commissioned 100 T MS system capacitor bank. This system will be unique in the world as it is designed to handle the tremendous stresses of 100 T magnetic fields and survive multiple shots. One of the design principles is to reduce the local energy density so that the materials are able to withstand the stress of operation in such an extreme environment. This is accomplished in part by making the magnet physically large and spreading the mechanical load over a big volume. The price for this approach, however, is an energy usage of approximately 140 megajoules per pulse, making this one of the largest (energy wise) magnets in the world. The technology also uses a hybrid approach to achieving 100 T. A capacitor-driven "insert" coil will be nested in an approximately 100 mm bore. The insert will deliver approximately 52 T while the outsert delivers approximately 48 T. The insert coil was recently tested by itself up to fields 75 T. A local field of 75 T replicates the same forces the coil will see at 52 T in a 48 T background (approximately). Below is a recent pulse profile from the successful tests.

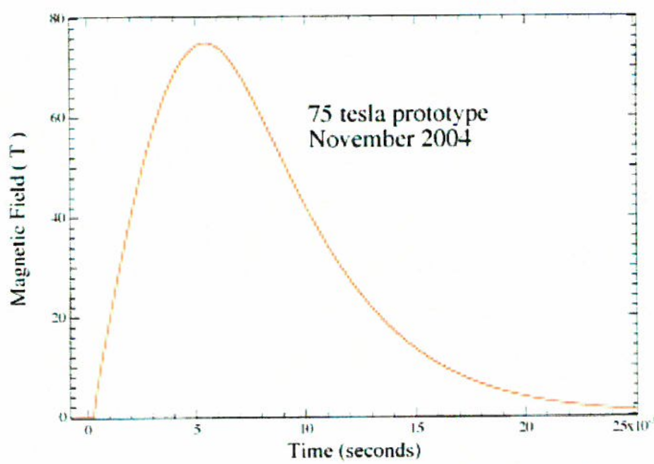


Figure 7. The insert coil prototype recently tested to 75 T as part of the 100 T Multi-Shot magnet.

The NHMFL-PFF is part of the Los Alamos National Laboratory (LANL), which is itself a world leading scientific institution. A symbiotic relationship exists amongst the nested institutions where the capabilities of the NHMFL provide LANL with some mission objective assistance, such as the study of the condensed state of actinide and actinide compounds. The NHMFL-PFF has also received significant benefits from LANL. As part of LANL, NHMFL-PFF staff members are encouraged to compete for institutional funding opportunities such as the Laboratory Directed Research and Development (LDRD) funds. A recent example of a mutually benefiting award is the 300 T Single Turn Project ("Quasi-Particles and Phase Transitions; Critical Tests of our Understanding of Plutonium" LDRD-DR20030084) This LDRD project is funded over a three-year period to build a single turn magnet system specifically designed to study plutonium. At the end of the grant cycle (October 2005) the system will be turned over to the User Program at the NHMFL-PFF. Staff scientists from the NHMFL-PFF are currently performing the first test pulses from the recently completed system.

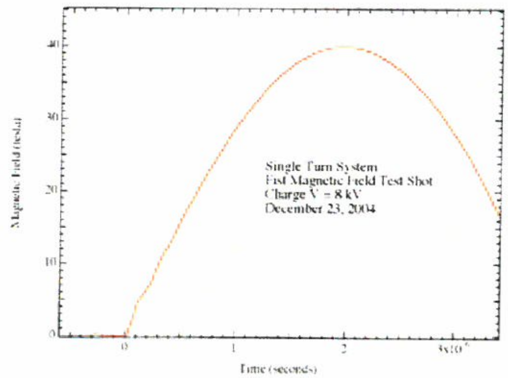


Figure 8. The first test shot waveform (left) from the single turn system and the complete system (right) showing the containment tank and capacitor bank mounted above.

Table 4. Summary of User Magnet Systems Available to NHMFL-PFF Users

Capacitor-Bank-Driven Magnets	
Field (T), Duration, Bore (mm)	**Supported Research**
Cell#1: 50 T Short Pulse, 25 msec, 24 mm Cell#1: 50 T Mid-Pulse, 400 msec, 15 mm Cell#2: 40 T Mid-Pulse, 400 msec, 24 mm Cell#2: 50 T Mid-Pulse, 400 msec, 15 mm Cell#3: 65 T Short Pulse, 25 msec, 15 mm Cell#4: 65 T Short Pulse, 25 msec, 15 mm Cell#5: 60 T Short Pulse, 40 msec, 9.8 mm Cell#6: Test Cell 100 kA peak current	Magneto-optics (IR through UV), magnetization, and magneto-transport from 350 mK to 300 K Pressure from 10 kbar typical, up to 100 kbar. GHz Conductivity, MHz Conductivity, Pulse Echo Ultra-sound Spectroscopy. 60 T Long Pulse Magnet to return to service in 4th quarter 2005.

Superconducting Magnets	
Field (T), Bore (mm)	**Supported Research**
20 T magnet, 52 mm 15 T magnet, 52 mm 14 T-PPMS magnet	Same as pulsed fields, plus thermal-expansion, specific heat, and 20 mK to 600 K temperatures Heat Capacity, THz Resistivity, Heat Capacity, Magnetometry.

Pulsed Field Facility Research and Development Highlights for 2004

Using a non-metallic photonic bandgap resonant cavity R. D. McDonald and collaborators were successful in resolving quantum oscillations in a well characterized organic superconductor. This technology further expands the NHMFL-PFF capability in the frequency domain. These measurements were carried out at 64 GHz but can easily be extended out to 200 GHz.

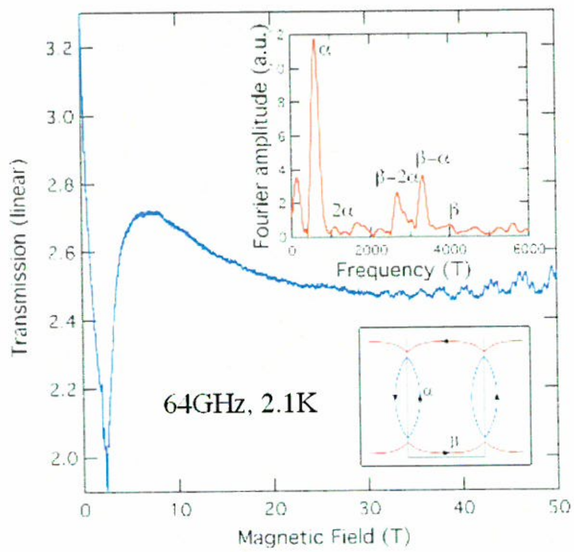


Figure 9. GHz-frequency conductivity measurements of κ-(BEDT-TTF)$_2$Cu(SCN)$_2$.

Developed by V. Correa (NHMFL Postdoctoral Fellow) and collaborators, the magnetostriction probe (Figure 10) was successfully tested in the 50 T mid-pulse magnet. To test this new probe, we have investigated a well known structural transition on $YbInCu_4$. The length constriction at 36 T and 4 K was observed in agreement with published results taken in DC fields. The experimental data is shown (Figure 11) from the confirmation experiments.

Figure 10. Magnetostriction probe for use in pulsed magnetic fields.

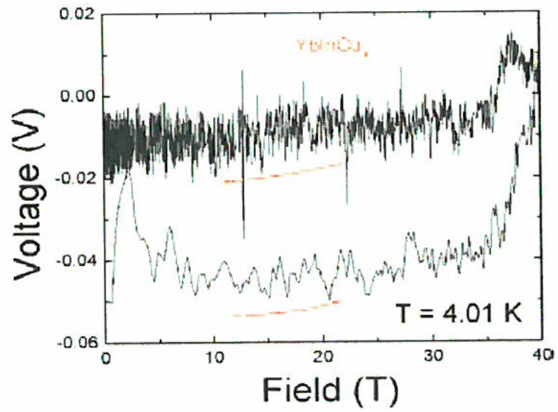
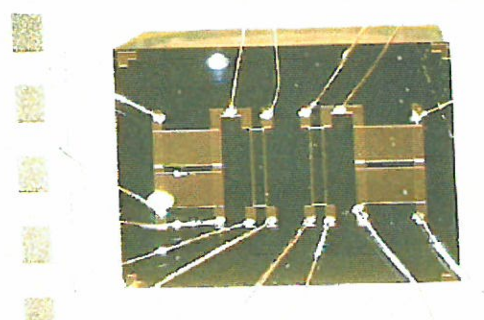


Figure 11. Pulsed field magnetostriction data taken on $YbInCu_4$ in the 50 T Mid-Pulse magnet. The structural transition is clearly resolved at approximately 36 T.

D. Kim (NHMFL Postdoctoral Fellow) and collaborators successfully tested the 3-ω technique by measuring the thermal conductivity of $Nd_{0.5}Sr_{0.5}MnO_3$ thus marking yet another measurement capability available to users of the NHMFL-PFF. This technique is orders of magnitude faster at determining the thermal conductivity of materials when compared with the conventional pulse-relaxation technique.



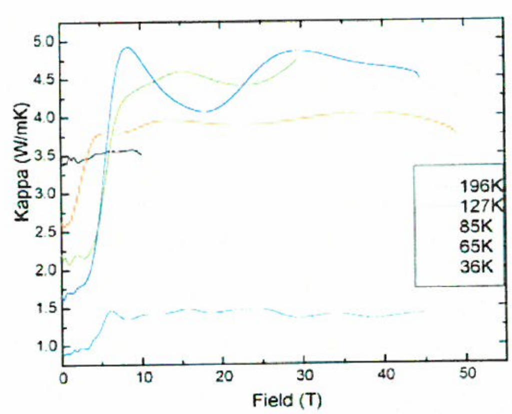


Figure 12. The 3-ω technique was successfully tested on $Nd_{0.5}Sr_{0.5}MnO_3$ in the mid-pulse magnet.

T. Coffey and V. Zapf (NHMFL Postdoctoral Fellows) have recently made significant improvements to the probe infrastructure surrounding the contactless conductivity technique. New probe boards and super-heterodyne electronics are key elements in the suite of electronic components used in this experimental method. These components will be tested early this 2005.

V. Zapf (NHMFL Postdoctoral Fellow) and collaborators have developed a new calorimeter for the 20 T DC superconducting magnet at the NHMFL. The calorimeter operates in a dilution refrigerator between 50 mK and 4 K in fields up to 20 T, and uses a heat pulse relaxation technique. This new capability is currently available to users of the 20 T SC magnet at the NHMFL-PFF.

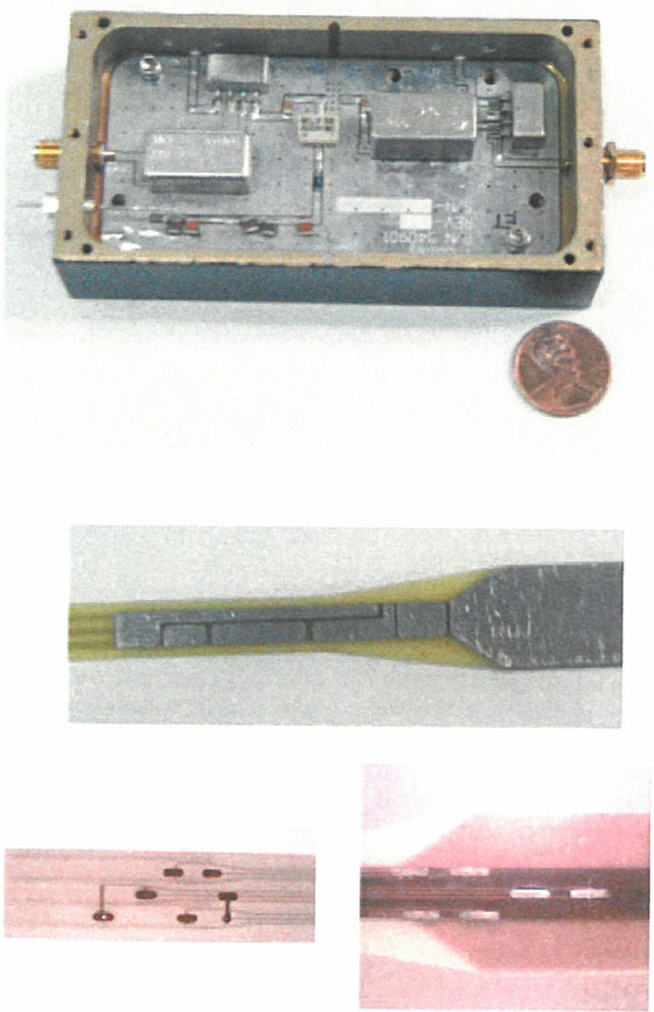


Figure 13. Contactless conductivity probe developments (AKA TDO). These new components will directly benefit users who wish to perform such experiments at the NHMFL.

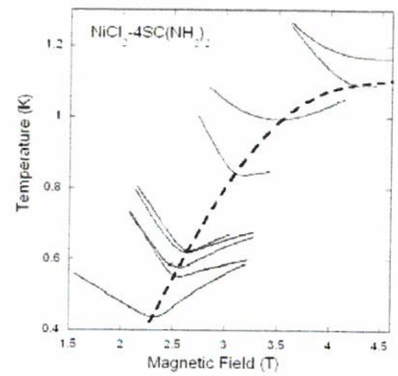


Figure 14. Adiabatic temperature sweeps as a function of magnetic field of single crystalline $NiCl_2$-$4SC(NH_2)_2$ oriented with the magnetic field parallel to the tetragonal c-axis. Dashed lines indicate the estimated onset of field-induced long-range order.

NHMFL-PFF System Statistics

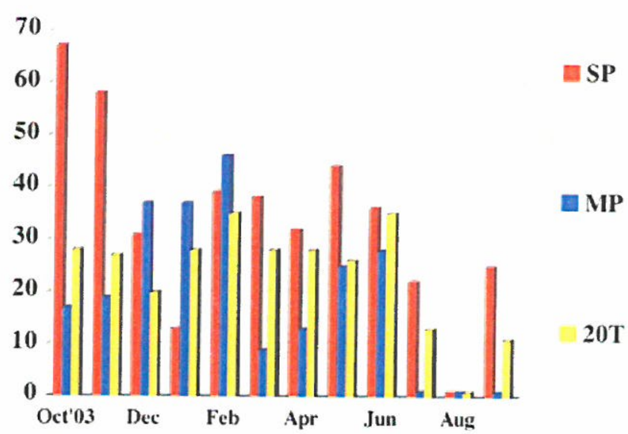


Figure 15. This chart shows the system usage during the fiscal year. The first 65 T magnet was put into use October 2003. The increase in mid-pulse magnet days is due to a second system being operated in cell 1. A second 65 T magnet was installed in cell 3 in May 2004. The LANL Shutdown occurred from July 16 to September 17, 2004, causing a loss of magnet days.

Short Pulse Usage By Experimental Technique

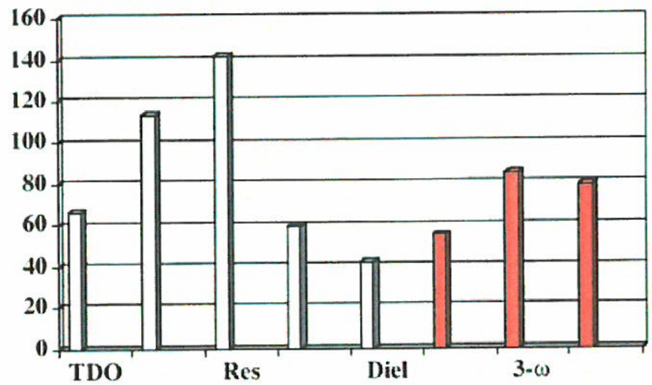


Figure 16. Magnet days by experimental technique, TDO = contactless conductivity, Mag = magnetization or magnetic susceptibility, Res = resistivity, Diel = dielectric constant measurements, GHz = GHz Spectroscopy, 3-ω = three omega thermal conductivity, US = Pulse Echo Ultra-sound. Red denotes technique development; light blue represents established techniques.

Pulsed Field Facility Usage

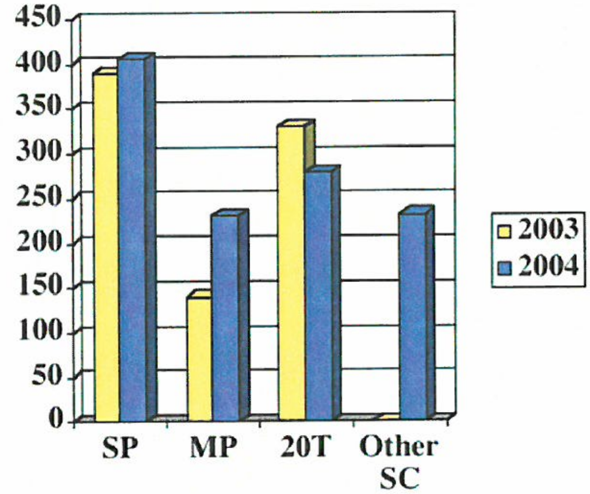


Figure 17. Pulsed Field Facility usage, 2003 vs. 2004.

Summary of 2004 PFF statistics:

- Increased SP usage
- Placed a second Mid-Pulse magnet in Cell 1
- 20 T magnet days decreased due to LANL Shutdown
- Made a 14 T PPMS, and a 17 T SC available to users via special collaborations
- 2004 Magnet Days =1147 (not counting PPMS and 17 T SC = 915)
  - 33% (not counting PPMS and 17 T SC = 7%) increase in Magnet Days
- 2003 Magnet Days = 859

Table 5. Pulsed Field Facility User Statistics for 2004

	Total	Minority	Women
Number of Projects	116		
Number of Research Groups	51		
Number of Users	110	7	22
Number of Senior Investigators, U.S.	40	0	4
Number of Senior Investigators, non-U.S.	16	2	3
Number of Students, U.S.	15	2	6
Number of Students, non-U.S.	2	0	2
Number of Postdocs, U.S.	31	3	4
Number of Postdocs, non-U.S.	6	0	3

Table 6. Pulsed Field Facility Operations Statistics for 2004

	Short Pulse	Mid-Pulse	Superconducting
User Affiliation	**Number of Magnet Days**		
NHMFL	207	138	163
U.S. Universities	153	72	265
U.S. Government Labs	11	6	51
Industry	0	0	14
Non-U.S.	34	15	18
Total	**405**	**231**	**511**

High B/T Facility at the University of Florida

The NHMFL High B/T Facility is operated as part of the Microkelvin Laboratory that is located in the Physics Department at the University of Florida. The Facility is designed to meet the needs of NHMFL users who wish to conduct experiments in high magnetic fields (up to 15.2 T) and at very low temperatures (down to 0.4 mK) simultaneously. Faculty members in the facility work with users in the design of experiments where needed. Instrumentation is available for studies of magnetization, thermodynamic quantities, transport measurements, magnetic resonance, viscosity, diffusion, ultrasound measurements, capacitance and pressure. The facility is housed in an ultra-quiet environment with "tempest" quality electromagnetic shielding and vibration isolation of the experimental station to permit high sensitivity measurements.

Access to the 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, Dr. J.S. Xia (352-392-8871, jsxia@phys.ufl.edu), and Prof. Yasu Takano (*takano@phys.ufl.edu*) or Prof. Neil S. Sullivan (*sullivan@phys.ufl.edu*) in advance.

Status of the Magnet Upgrade

This year, the State of Florida funded the long-awaited 20+ T superconducting magnet system for the High B/T Facility. It consists of an 8+ T demagnetization magnet, a 5+ T active shielding magnet, and a 20+ T experimental high-field magnet. This upgrade from the present 15.2 T system has been the highest priority for the High B/T Facility since its inception. The new magnet system is expected to be delivered by early 2006. Our long term goal is to achieve a 25 T capability that will include a 20+ T conventional superconducting magnet with a 25 mm ID experimental volume, and a high-T_c insert capable of bringing the full field above 25 T with a 12.5 mm experimental access.

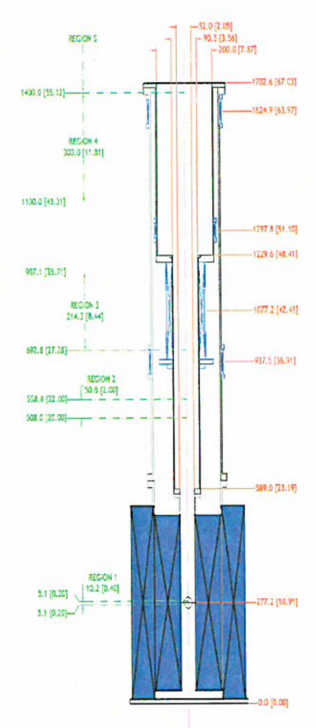


Figure 18. New 20+ T magnet system for the High B/T Facility.

Instrumentation and Services Update

We have carried out high-frequency (8.69 MHz) shear impedance measurements on superfluid ^3He confined in 98% porosity silica aerogel at ultra-low temperatures down to 1.5 mK in magnetic fields up to 15 T. The results provide the first confirmation of the A_1 and A_2 phases in superfluid ^3He in aerogel, only observable in magnetic fields above 3 T. The ultrasound signatures of the A_1 and A_2 transitions at a typical pressure are shown in Figure 19.

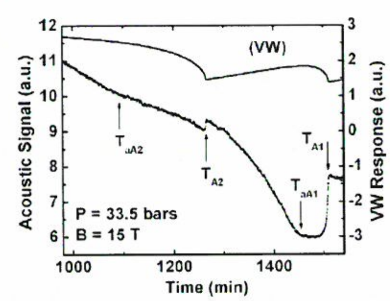


Figure 19. $A_1$and A_2 transitions in superfluid ^3He at 15 T. The lower trace is the ultrasound signal, which shows the transitions of the superfluid ^3He confined in aerogel, as well as the transitions of the bulk liquid. The upper trace (marked VW) shows the bulk transitions observed simultaneously by a vibrating-wire viscometer.

A sample rotator for the ultra-low temperature environment has been developed. This specially designed device operates with liquid ^{3}He as the hydraulic fluid and allows a rotation of sample over 100° relative to the magnetic field. By using this rotator, the behavior of various electronic phases near the even-denominator $\nu = 5/2$ fractional quantum Hall effect (FQHE) state has been studied in a single heterojunction of GaAs/AlGaAs. These phases, which involve the second Landau level, are very sensitive to the sample orientation, and the ability to rotate the sample in magnetic field is crucial for their characterization. Novel electronic transport properties have been observed in the insulating phases that exist between the 5/2 state and the adjacent FQHE states with ν = 2+2/3, 2+1/3, and 2+1/5, revealing an interesting interplay of localization and delocalization governing the electrons in the second Landau level. In addition, the quantum phase transition between the FQHE plateaus has been found to exhibit a new behavior at low temperatures.

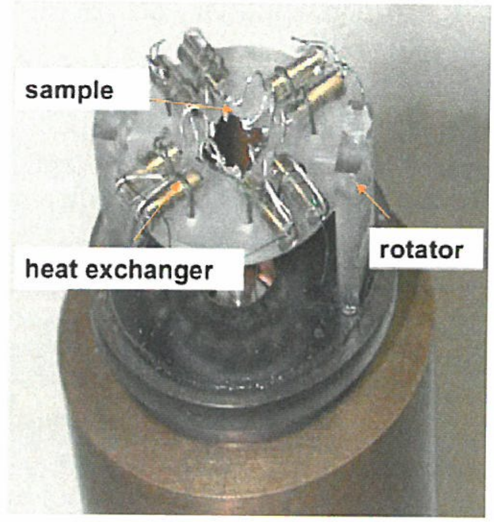


Figure 20. Ultra-low temperature sample rotator for use inside a sample chamber that is filled with liquid ^{3}He to keep the sample cold.

Table 7. High B/T Facility User Statistics (1/1/04 through 12/31/04)

	Total	Minority	Female
Number of Research Projects	3		
Number of Senior Investigators, U.S.	9		
Number of Senior Investigators, non-U.S.			
Number of Students, U.S.	6		
Number of Students, non-U.S.			
Number of Postdocs, U.S.	3	1	
Number of Postdocs, non-U.S.			

Table 8. High B/T Facility Operations Statistics (1/1/04 through 12/31/04)

Number of Magnet Days	Number Per Category	Percent of total
NHMFL, UF, FSU, FAMU, LANL	17	5%
U.S. University	312	85%
U.S. Govt. Lab.		
Industry		
Overseas		
Experiment setup, & Maintenance	36	10%
Idle		
Total	**365**	**100%**

Center for Interdisciplinary Magnetic Resonance (CIMAR)

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

Table 9. CIMAR Facilities in Tallahassee, as of January 2005

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+	35, 40	0.1 ppm	Solid State/Solution NMR
1066 MHz	25, 52	1 ppm	Solid State/Solution NMR
900 MHz	21.1, 105	1 ppb	Solid State/Solution NMR, MRI
830 MHz	19.6, 31	100 ppb	Solid State/Solution NMR
800 MHz**	18.7, 52	1 ppb	Solution NMR, Cryoprobe
720 MHz	16.9, 52	1 ppb	Solution NMR
600 MHz	14, 89	1 ppb	MRI and Solid State NMR
600 MHz**	14, 89	1 ppb	Solid State NMR
600 MHz	14, 52	1 ppb	Solution State NMR
EMR Frequency	**Field (T), Bore (mm)**	**Homogeneity**	**Measurements**
Up to 7 THz	30, 32	100 ppm	ECR*
700 GHz	25, 52	10 ppm	Multi-frequency EMR
470 GHz	17, 61	3 ppm	Multi-frequency EMR
336 GHz	12.5, 88	3 ppm	Transient EMR
95 GHz	≤ 6 T	1 ppm	W-band Pulsed EPR
9 GHz		1 ppm	X-Band EPR
ICR	**Field (T), Bore (mm)**	**Homogeneity**	**Measurements**
	14.5, 104+	1 ppm	ESI FT-ICR
	9.4, 220	1 ppm	ES, 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 ** Spring 2005 delivery

Table 10. CIMAR Facilities at the University of Florida, as of January, 2005

MAGNETIC RESONANCE SYSTEMS in Gainesville

Frequency	Field (T), Bore (mm)	Homogeneity	Measurements
750 MHz	17.6, 89	1 ppb	Solution/solid state NMR and MRI
600 MHz	14, 52	1 ppb	Solution state NMR and MRI
500 MHz	11.7, 52	1 ppb	Solution/solid state NMR
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, 600	0.1 ppm	MRI of human heads and larger animals

NMR Spectroscopy and Imaging Program

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

Tallahassee Update

Senior Personnel. It is with great pleasure that we announce that Prof. Rafael Brüschweiler has moved as of January 1, 2005, to join the faculty at Florida State University and the Department of Chemistry and Biochemistry. At the NHMFL he has the position of Associate Director of Biophysics. Prof. Rafael Brüschweiler's research focuses on the dynamics and structure of proteins in solution characterized by high field NMR spectroscopy, as well as computational development of novel relaxation analyses and simulations. His expertise will bring great benefits to our users and his stature in NMR will aid us in the continued development of this unique spectroscopy and imaging facility. He received his Ph.D. from the ETH, and subsequently served as a postdoctoral research scientist at The Scripps Research Institute and as a junior research faculty at ETH before spending the last six years at Clark University.

800/52 and 600/89 Spectrometers. These systems will be delivered to the NHMFL during the first quarter of 2005. The 800 MHz instrument will be primarily for the use of Prof. Brüschweiler, but will also serve as the NHMFL's highest field cryoprobe system. The 600/89 will be the second such magnet in a facility. We have been very fortunate to procure this used instrument from Washington State University, where it was formally in the research group of Prof. Jeremy Evans, a pioneer in solid state NMR characterizations of enzymes before his untimely death. This instrument will permit us to dedicate considerable time on the first 600/89 to staging imaging experiments for the NHMFL's 900/105 spectrometer system.

900/105 NMR spectrometer. Magnet Science and Technology at the NHMFL has delivered a unique magnet system to the NMR spectroscopy and imaging user program. The 4-channel Bruker Avance spectrometer system is equipped for solution, solid state, and imaging capabilities. The Resonance Research 89 mm inner diameter shim set provides better than +/- 0.1 ppm homogeneity in a cylinder 17 mm in diameter and 35 mm in height. The inner 26 channel Bruker Bio-Spin shim set has an excellent demonstrated non-spin lineshape of 4/12 Hz. The residual drift of the magnet is less than 10 Hz/hr following drift correction that has no significant effect on the lineshape over the time-course between helium fills. Currently, the magnet is boiling helium at a rate that is approximately four times what was predicted, and consequently the present maximum hold time is 5 days between fills.

Figure 21. The NHMFL's 21.1 T, 105 mm bore NMR magnet is the product of a 13-year effort. It stands 16 feet tall, weights over 30,000 pounds, and has a stored energy of 40 megajoules.

This instrument will remain in a commissioning phase through the first two quarters of 2005 as new and unique hardware is tested, refined, and optimized for solution-state, solid-state spectroscopy and imaging capabilities. The best spectrum ever recorded of a very challenging membrane protein system, the M2 protein from influenza virus (a drug target) is shown in Figure 22 at 900 MHz. We are still at an early stage in our development of solution capabilities on the 900. We anticipate very significant benefits for a class of experiments that include TROSY techniques. From these first spectra we observe several resonances at 900 MHz that were severely broadened at 720 MHz. In other words, there is a set of signals in this protein that are only observable through the use of the 21.1 T spectrometer.

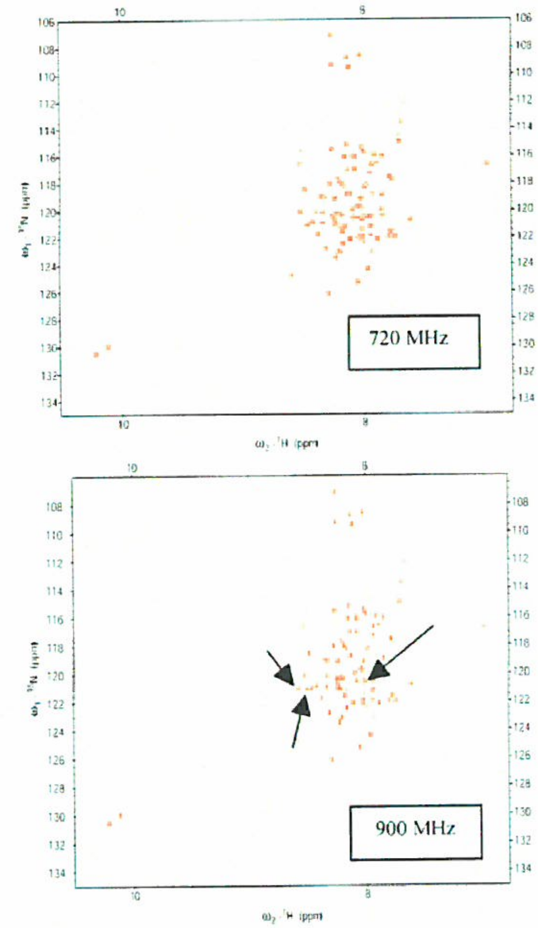


Figure 22. (^{15}N-^{1}H)-TROSY Spectra of 1 mM M2 Protein, a membrane protein in detergent micelles is obtained at 720 and 900 MHz at the NHMFL. Spectral resolution at 900 MHz is enhanced and the arrows point to additional resonances observed at 900 MHz (Sharma, Gao & Cross).

In addition, resonance linewidths appear to be significantly narrower at 900 MHz. Figure 23 shows solid state cross-polarized magic angle spinning spectra of a small peptide isotopically labeled with ^{13}C. The high field of the 21.1 T magnet reduces the broadening due to coupling with the ^{14}N quadrupolar nuclei resulting in substantially better resolution. The glycine carbonyls differ in chemical shift by 0.43 ppm. Linewidths with and without (data not shown) adjacent ^{14}N are 80 and 40 Hz at 9.4 T and 65 and 40 Hz at 21.1 T. The 40 Hz linewidths at 9.4 T is 1.0 ppm while it is only 0.44 ppm at 21.1 T.

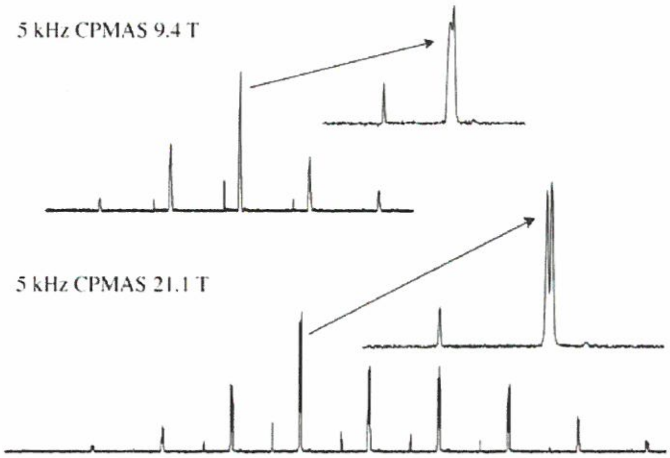


Figure 23. Cross polarized ^{13}C spectra of the tripeptide GGV with $^{13}C_1$ labeled Glycine at 9.4 and 21.1 T using magic angle sample spinning at a rate of 5 kHz. Isotropic expansions plotted with constant Hz/cm show improved resolution at 21.1 T.

A major effort during the commissioning phase is the development of new radio-frequency probe technology. As an example, while multi-tuned transmission line probes have been used for solid-state NMR for two decades, in physically long high field magnets the efficient low frequency channel comes at a price of high loss in the high frequency channel. Two enhancements have made these probes appropriate for field strengths up to 900 MHz: (1) positioning the high frequency capacitors within the probe and (2) enhanced radio frequency homogeneity by electrically balancing the sample coil at the ^1H frequency. The result is a double resonance probe with enhanced RF homogeneity and at the same time enhanced RF efficiency on both the low and high frequency sides of the circuit.

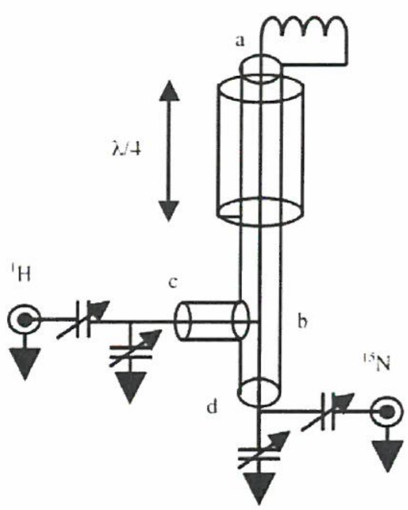


Figure 24. Schematic diagram of double tuned balanced HN transmission line probe.

Gainesville Update

Bruker Avance 500 MHz. This system has been used routinely for solution and more recently biological solid state NMR. It has been booked nearly 100% of the time during the past year and split about evenly between solids and solution studies.

Bruker Avance 600 MHz. The spectrometer is completely equipped for all solution state NMR experiments, and a Bruker 5 mm triple resonance cryoprobe is fully functional. As expected, the signal-to-noise (S/N) gain from the probe is close to 4x for non-conducting samples. Bill Brey (NHMFL) and Richard Withers (Bruker) are designing and building a 1 mm triple resonance HTS probe for this instrument as part of the UF NIH/NCRR resource grant, and this probe will be ready for testing in early 2005. The 600 also has a microimaging accessory for samples up to about 20 mm in diameter. The instrument switches about every two months between cryoprobe and imaging. We will soon order a second 600 system with state of Florida funds for the NHMFL infrastructure upgrades. One 600 will be dedicated to cyroprobes and the second to warm bore probes, including microimaging, solid state NMR, high resolution MAS, and broadband solution NMR.

Bruker Avance 750 MHz wide bore. This instrument is fully functional for solution-state, solid-state ^2H studies, and imaging. A number of microcoils have been developed for this instrument for both solution state NMR and microimaging through the NIH/NCRR resource grant. Last year Bruker replaced at their cost the original magnet which had been damaged and was drifting. The new magnet is exceptionally stable and has very high homogeneity and is providing fabulous service.

Bruker 4.7 T, 33 cm. This horizontal imaging system is fully functional for routine animal imaging. It is now equipped with four receiver channels and has phased-array detection capabilities. A large number of in-house custom built coils are available. Cardiac imaging for rodents has been implemented and is providing exceptional high-resolution movies of live, beating hearts. Novel molecular imaging protocols are being developed to monitor stem cell and gene therapy *in vivo* (Figure 25).

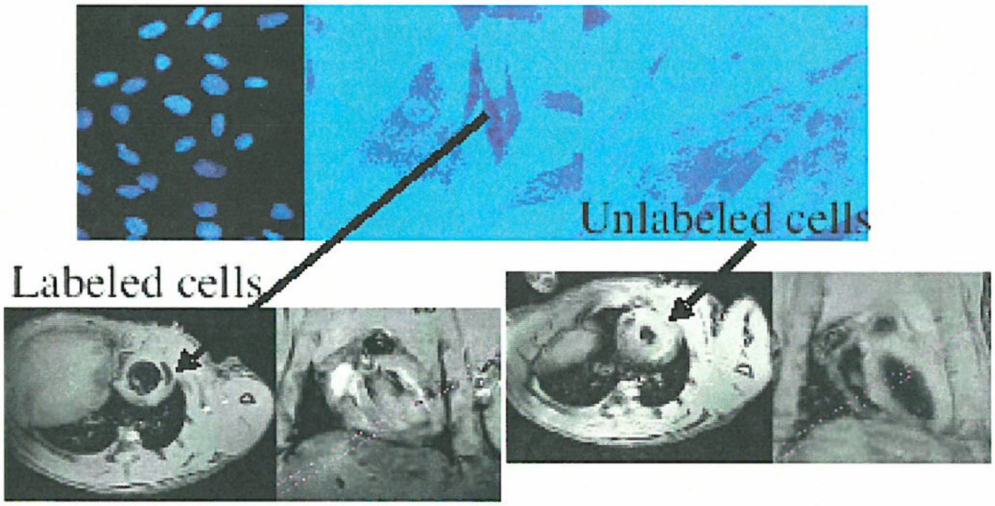


Figure 25. Magnetic particles have been added to stem cells for injection into a mouse heart. The labeled cells are shown in the upper middle panel, and the magnetic particles can be tracked in a living and beating heart by MRI (lower left). Cahill *et al., Transplantation*, **78**(11), 1626-1633 (2004).

Bruker/Magnex 11.1 T, 40 cm. This magnet system is fully functional for imaging and *in vivo* spectroscopy. Several new coils have been designed and built through the NIH resource grant. We have upgraded the operating system to Linux, and phased array detection is working for a limited number of sequences, and we are attempting to make this more general. Volume imaging of large samples at ^{1}H frequencies is problematic because of interference effects between the conductive sample and the RF, because the wavelength of the RF is approaching the same size as the sample. Several ways to deal with this problem are being investigated including phased array detection with an array of surface coils. One of the best applications at high field strength is spectroscopy and imaging with lower gamma nuclei.

Siemens 3 T, 60 cm head magnet. This system works very well and provides some of the finest human brain images available. It is being used for several different human fMRI studies and work on recovery from brain injury or repair on research subjects. No clinical work is done with this system. It is also being used for larger animal studies, and in the near future we will develop an animal cardiac imaging project on this magnet. Recently, we have upgraded the system to include 8 channels for higher sensitivity imaging.

Table 11. NMR Spectroscopy and Imaging Facility User Statistics

	Total	Minority	Women
Number of Projects	113		
Number of Research Groups	77		
Number of Users	236	19	46
Number of Senior Investigators, U.S.	127	3	17
Number of Senior Investigators, non-U.S.	19	3	4
Number of Students, U.S.	46	1	15
Number of Students, non-U.S.	18	4	6
Number of Postdocs, U.S.	18	5	4
Number of Postdocs, non-U.S.	8	3	0

Table 12. NMR Spectroscopy and Imaging Facility Operations Statistics

User Affiliation	833 NB	720 SB	600 SB	600 WB
	Number of Magnet Days			
NHMFL	128	180	174	160
U.S. Universities	55	176	186	171
U.S. Government Labs	20	0	0	0
Industry	7	0	0	0
Non-U.S.	95	0	0	22
Development & Maintenance	18	10	6	13
Idle	43	0	0	0
Total	**366**	**366**	**366**	**366**

Note 1: In addition, 318 days of spectrometer time have been used by external users and collaborators on Tallahassee low field instruments.
Note 2: In Gainesville, 154 days of spectrometer time have been used by in-house and external users on various instruments described in Table 10.

Electron Magnetic Resonance Program

The Electron Magnetic Resonance (EMR) facilities at the NHMFL provide users with EMR instruments operating at higher fields and frequencies than can be obtained through commercially available instrumentation. We employ the term EMR to encompass not only Electron Paramagnetic Resonance (EPR), and Electron Cyclotron Resonance (ECR), but also Anti-Ferromagnetic Resonance (AFMR) and Ferro Magnetic Resonance (FMR), as the latter form an important part of the high field magnetic resonance research.

The needs for high frequencies stem from several factors. First of all, the Zeeman splitting resolution (g-factor resolution) is proportional to the applied magnetic field. This is of crucial importance for the study of organic radicals, like those encountered in photosynthetic reaction centers of green plants and photosynthetic bacteria. Second, high frequencies and fields are necessary for the study of systems with large Zero-Field Splitting (ZFS), as are frequently encountered for magnetic ions of transition metals and rare-earths, and which are "EPR-silent" at low frequencies (see Figure 26). Third, for the study of systems with phase transitions at high field, a multi-frequency high-field measurement allows one to follow changes through the phase transition. Fourth, concentrated spin systems, like manganites and diluted magnetic semiconductors, often exhibit relatively large linewidths and possibly considerable shifts as a function of field and frequency. Therefore measurements at multiple high frequencies are needed for their measurement and interpretation. Fifth, higher frequencies enable faster measurement, enabling a <1ns time resolution in our 240 GHz transient spectrometer, but also enabling the measurement of the dynamics in a faster time regime. In combination with the higher g-resolution, this is especially important for nitroxide spin labeled proteins and other biomolecules. Finally, while the concentration sensitivity does not improve with frequency, the sensitivity in terms of absolute number of spins does improve with increasing frequency under similar conditions. This is important for small single crystals and samples for which only small quantities are available.

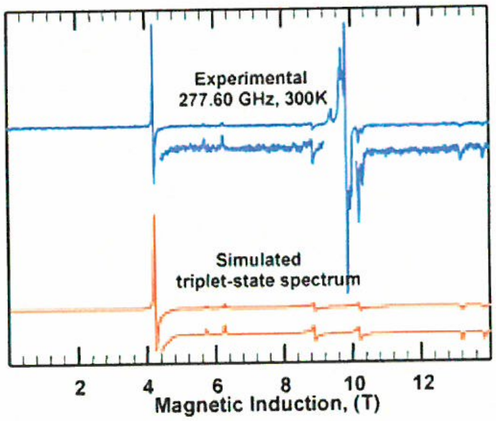


Figure 26. EPR spectrum of the S=1 excited triplet state of $[Fe(bipy)]_2O(SO_4)_2{\cdot}5H_2O$ at 300 K. The lines around 10 T are from the S=2 quintet excited state. (Ozarowski *et al.*)

The multidisciplinary character of EMR applications was clearly present in the research conducted in 2004. Ranging from an application driven study of Fe^{3+} and Cu^{2+} impurity centers that are likely involved in the aging of PZT ($PbZr_xTi_{1-x}O_4$) materials (P. Dinse *et al.*) to the study of the influence of protein backbone mutations on the primary donor of bacterial photosynthetic reaction centers (K. Redding *et al.*), research was performed from many disciplines, including solid state physics, engineering, chemistry, and biophysics.

For 2004, the 9 T superconducting magnet at the 240 GHz instrument has been upgraded to a 12.5 T magnet. This will allow extension of the 120 GHz and 240 GHz quasi-optical superheterodyne transient EPR spectrometer to operation at 336 GHz. The first promising tests at this frequency have been performed, and 336 GHz will be available in 2005. A new rotation mechanism that allows rotation with an accuracy of about 0.4 degrees has been installed in this instrument.

There are presently five high field EMR spectrometers at the NHMFL in Tallahassee. The first two are based on a 17 T Teslatron superconducting magnet made by Oxford Instruments Inc. This magnet consists of a main 17 T coil with a +/- 0.1 T sweep coil. The third is a quasi-optical CW/Transient spectrometer also with a superconducting magnet, while the fourth uses the 25 T resistive "Keck" magnet. The fifth spectrometer is a low/medium frequency Bruker spectrometer for pulsed EPR and ENDOR.

1. Very Broad Band CW Spectrometer. We use different sources in the 23 GHz to 3 THz range. The detector is either a Schottky diode or a "hot electron" InSb bolometer. This instrument is a direct transmission system, has very broadband capabilities, allows for fast frequency change, and accepts a great variety of sample configurations. The room temperature sensitivity is around 10^{12} spins/gauss. Temperature range: 1.6 to 300 K.

2. High Sensitivity CW Quasi Optical Instrument for EPR and ENDOR. The sources operate from 190 GHz up to 475 GHz for a g = 2 paramagnetic center. The system, optimized at 220 and 330 GHz, employs very low loss quasi optical (QO) techniques; these techniques allow for phase information. The detector is an InSb mixer. The sensitivity of the QO machine is approximately 10^{10} spins/gauss at room temperature; all other specifications are identical to the specifications of the very broad band CW spectrometer.

3. Transient and CW EMR/ENDOR Instrument. The design of the spectrometer, which operates at 120, 240, and now also 336 GHz, combines quasi-optical techniques and a super-heterodyne detection scheme based on Schottky diode mixers with a 1 GHz detection bandwidth. The combination of sub-ns time-resolution and high g-resolution makes it especially suited for time-resolved EPR. The room-temperature sensitivity in CW-mode is of the order of 10^{10} spins/Gauss without cavity and $3x10^8$ spins/Gauss in a Fabry-Perot cavity. The maximum time resolution is 600 ps. Nd-YAG lasers and an Optical Parametric Oscillator are available for optical excitation. In addition, this spectrometer is now equipped with an RF coil for high-field ENDOR (1 MHz to 1000 MHz), as well as a goniometer for sample rotation. Temperature range is 3 K to 400 K.

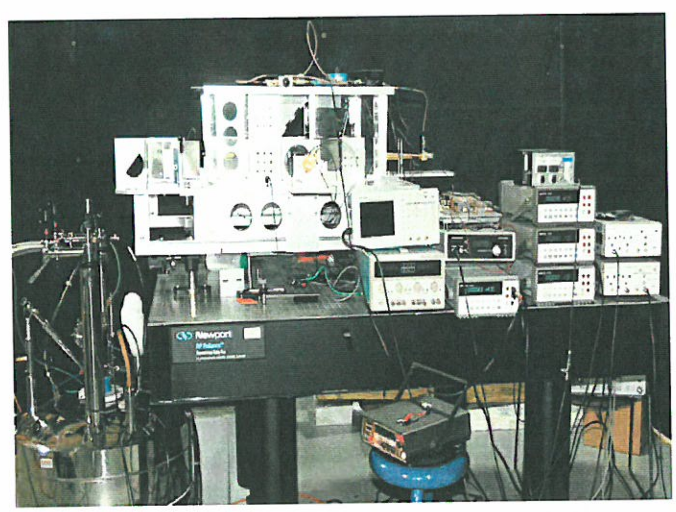


Figure 27. Transient 120, 240, and 336 GHz spectrometer.

4. 25 T "Keck" Magnet Spectrometer. This instrument is built around the 25 T, high homogeneity resistive magnet. The "Keck" magnet is perfectly poised for EMR thanks to fast ramping to the magnetic field of interest, very convenient sweepability, homogeneity better than 10 ppm over a typical sample size (a few mm^3), and good field stability. It uses backward wave oscillators as sources for the 150 to 700 GHz range, and a far-infrared molecular gas laser for higher frequencies. An InSb "fast electron" liquid helium-cooled bolometer is used as detector. The sensitivity is about 10^{12} spins/gauss at room temperature. Temperature range: 1.5 to 300 K.

5. Bruker Elexsys E680 X- and W-Band Pulsed Spectrometer. This commercial spectrometer provides advanced pulsed techniques that are not yet available at higher frequencies. 20% of the total spectrometer time is available for external users. The two pulsed microwave channels and two RF channels at both 9.4 (X-band) and 95 GHz (W-band) offer a diverse range of pulsed experiments like ESEEM, HYSCORE, DEER, pulsed ENDOR and TRIPLE, etc., and are especially valuable for measuring electron-electron and electron-nuclear spin couplings. The spectrometer is equipped with a 1.5 T electromagnet for X-band, and a 6 T split coil superconducting magnet for W-band. The temperature range at both frequencies is 3.8 to 300 K.

Table 13. EMR Facility User Statistics, 1/1/2004 to 12/31/2004

Research Projects/Groups	**Total**	**U.S.**	**Non-U.S.**
Number of Research Projects	63	46	17
Number of Research Groups	56	40	16
Users	**Total**	**Minority**	**Female**
Numbers of Users	124	19	15
Number of Senior Investigators, U.S.	50	4	6
Number of Senior Investigators, non-U.S.	42	6	3
Number of Students, U.S.	19	8	3
Number of Students, non-U.S.	6	1	2
Number of Postdocs, U.S.	4	1	1
Number of Postdocs, non-U.S.	3		

Table 14. EMR Facility Operations Statistics, 1/1/2003 to 12/31/2003

	17 T	**12.5 T**	**W-band**
User Affiliation	**Number of Magnet Days**		
NHMFL, UF, FSU, FAMU, LANL	127	89	152
U.S. University	26	32	21
U.S. Government Lab	-	-	-
Industry	-	-	-
Non-U.S.	60	45	31
Development	0	21	5
Maintenance/Repair	12	19	30
Total	**225**	**206**	**239**

Fourier Transform Ion Cyclotron Resonance Mass Spectroscopy

During 2004, the ICR program continued instrument and technique development as well as pursuing novel applications of FT-ICR mass spectrometry. These methods are made available to external users through the NSF National High-Field FT-ICR Mass Spectrometry Facility. The facility features directors for instrumentation, biological applications, environmental applications, and user services as well as a machinist, technician, and six 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) was installed and tested in August 2004. 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. Infrared multiphoton dissociation (IRMPD) and electron capture dissociation (ECD) are under development, but the spectrometer is available now.

The **9.4 T, 220 mm bore system** continues to be the highest performance electrospray FT-ICR mass spectrometer in the world. It offers unrivaled mass resolving power (m/Δm = 10,000,000 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 (MS^n 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 for unattended (and even 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 T and 7 T, actively shielded **FT-ICR instruments** are available for analysis of complex nonpolar mixtures. The 9.4 T magnet is currently used for field desorption (FD, including continuous-flow FD) and matrix-assisted laser desorption/ionization (MALDI). The 7 T magnet is optimized for volatile mixture analysis. Samples are volatilized in a heated glass inlet system (at 200 to 300 °C) and externally ionized by an electron beam (0-100 eV, 0.1-10 μA). The ions are collected in a linear multipole trap and injected into the FT-ICR cell. Mass resolving power (m/Δm) 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 (*Anal. Chem.*, ***75***, 3256-3262 (2003)). Sites and nature of post-translational modification (*e.g.*, glycosylation, phosphorylation, etc.) are readily determined (*Proteomics,* **4**, 970-981 (2004). In-house software has been developed for rapid data analysis.

Tertiary structure can also be probed. Hydrogen/deuterium exchange can be carried out (in solution or gas phase) and monitored with the mass spectrometer. Details of biomolecular conformation and surface contact between molecules in a noncovalent complex can be deduced. For example, we were able to characterize intersubunit interactions underlying assembly and maturation in the HIV-1 RNA virus (*Nat. Struct. Mol. Biol.*, **11**, 676-677 (2004)).

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

Table 15. ICR User Statistics, 1/1/04 through 12/31/04

	Total	Women
Number of Projects	88	
Number of Research Groups	82	
Number of External Users	130	29
Number of Senior Investigators, U.S.	60	10
Number of Senior Investigators, non-U.S.	22	4
Number of Students, U.S.	21	11
Number of Students, non-U.S.	4	1
Number of Postdocs, U.S.	2	1
Number of Postdocs, non-U.S.	3	1
Number of Collaborators, U.S.	6	1
Number of Collaborators, non-U.S.	2	1

Table 16. ICR Facility Operations Statistics 1/1/2004 through 12/31/2004

	9.4 T, 220 mm	9.4 T, 155 mm
User Affiliation	**Number of Magnet Days**	
NHMFL, UF, FSU, FAMU, LANL	128	20
U.S. Universities	70	0
U.S. Government Labs	5	17
U.S. Industry	42	35
Overseas	63	11
Development & Maintenance	36	242
Idle	21	20
Total	345	345

Geochemistry

In the past year the Geochemistry Program has concentrated on using existing instrumentation for geochemical and environmental research, and they have been successful in obtaining external funding for these programs, primarily from the NSF Earth Science and Ocean Sciences Division. The program has eight active research grants (six from NSF and one from EPA, NASA). The research funded through these programs concerns the study of the chemical evolution of the solid Earth and solar system through trace element and isotope analyses as well as the use of isotopes to study several aspects of environmental geochemistry and global change. In 2004, a stable isotope gas source mass spectrometer (Thermo-Finnigan Delta XP) was added to our arsenal of analytical tools. This instrument allows rapid and precise analysis of oxygen, carbon, and nitrogen isotope ratios, as well as the elemental concentrations in a large variety of geological materials, which is essential for our studies on climate change as well as studies that determine the source, fate, and transport of nutrients through an ecosystem. The system was installed in spring 2004 and has brought additional users from Florida State University to our facility.

This year the program added a new faculty member, Dr. Munir Humayun. Humayun's research in siderophile elements and extraterrestrial material (solar wind particles, cometary material returned from NASA's GENESIS and STARDUCT missions) has broadened the expertise and analytical capabilities of the Geochemistry program.

Existing efforts, as well as the arrival of Philip Froelich in 2003, led to the initiation of a new research direction in Biogeochemical Processes. This research direction is building on our previous collaborations with the FT-ICR program and on our successful research funded through a Program Enhancement grant at FSU. The program is aimed at obtaining a molecular level understanding of the interactions of the chemistry and the biology of an ecosystem. Nutrients and bioactive metals are, therefore, the focus of our studies. This program requires interactions between several disciplines. To facilitate this research, FSU has provided support for a workshop and a lecture series in Biogeochemical Dynamics.

Table 17. Types and Configuration of Mass Spectrometers

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	Thermal-Plasma	M-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 18. Geochemistry Facility User Statistics, 1/1/04 through 12/31/04

	Total	Minority	Female
Number of Research Projects	22	n/a	n/a
Number of Senior Investigators, U.S.	15	2	2
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.	2	-	1
Number of Postdocs, non-U.S.	-	-	-

Table 19. Geochemistry Operations Statistics, 1/1/04 through 12/31/04

Number of Magnet Days	Isolab	262/RPQ	ICP-MS	Total
NHMFL, UF, FSU, FAMU, LANL	150	140	190	480
U.S. Universities	80	50	30	160
U.S. Government Labs	-	-	-	-
U.S. Industry	-	-	-	-
Overseas	-	-	-	-
Maintenance	30	40	30	100
Total	**260**	**230**	**250**	**740**

Access to NHMFL Facilities

User access to the NSF-funded NHMFL Continuous and Pulsed Field Facilities is controlled by a two-step 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 NHMFL. Then, every year, a summary listing of all user programs is compiled and ranked in order of magnet use. Users who have consumed a significant portion of resources (about 1% to 2%) within the previous twelve months are required to submit a more extensive proposal based on their present and future work in high fields. Users in this category are the largest users and collectively account for at least 80% of the annual total facility use. In addition, all users of the 45 T Hybrid and 60 T Long Pulse magnets will be required to submit such a proposal. Each major proposal is reviewed by a panel of scientists chosen for their familiarity with the fields of research commonly done at the NHMFL. The panel can also seek input in the form of mail reviews. A grade from A to C is given to each proposal with an A being required for heavy use of facilities, and especially, use of "expensive" or high demand facilities. A "C" grade means the user has access only after other demands are met. (Work that would merit a failing grade is blocked or stopped before it reaches the major proposal process.) 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 described in more detail in the "High B/T section" of this chapter.

The 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 to 3 days), equipment, or salary support requires a 2- to 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 by contacting Dr. Vincent Salters. Although there is a charge for the use of the facilities, pilot projects and development of analytical techniques are regularly accommodated without a charge.

Chapter 4
MAGNET SCIENCE & TECHNOLOGY

The Magnet Science and Technology Group (MS&T) has as its primary mission providing state-of-the-art magnet systems for NHMFL users. MS&T sustains a constant effort toward that mission through a variety of major internal projects. It also maintains and replenishes its capabilities for pushing the frontiers of magnet technology through:

- Vigorous research and development activities
- Education of new scientists, engineers, and technologists
- Involvement in external activities that have synergy with the primary mission.

MS&T's core responsibilities typically fall into one of the following three categories:

- Powered dc magnets, which comprise a variety of resistive magnets and hybrids (a combination of resistive and superconducting technologies)
- Pulsed magnets, which comprise short-pulse, capacitively driven magnets and long-pulse, extended-life magnets powered by a motor-generator
- Persistent magnets, which comprise all-superconducting, research magnets (such as the 900 MHz NMR system).

Reports of progress on major projects within MS&T's core responsibilities are described in subsequent sections. Outside these major project areas, MS&T has made valuable contributions to its core mission through the definition of magnet systems that will meet the NHMFL's long-term goals (e.g., a 1.1 GHz NMR system, a 21 T FTICR system, and scattering magnets based on series-connected-hybrid technology for collaborative programs being pursued at the Advanced Photon Source and the Spallation Neutron Source) and by helping other NHMFL groups to specify and procure state-of-the-art magnet systems for current programs (e.g., the High B/T system at Gainesville and the condensed matter NMR system at Tallahassee).

MS&T has also pursued external funding for projects and programs that have provided unique service to external organizations and that were also congruent with long-term MS&T development goals. Examples of funded activities are as follows:

- Conceptual design of an ultra-high current density undulator for the Advanced Photon Source using Nb_3Sn conductor technology, funded by Argonne National Laboratory
- Analysis and design of a quench-protection system for a unique persistent magnet system used in the industrial production of large, high-quality Si crystals, funded by Duksung Co. Ltd.
- A study of stability and quench protection in magnets constructed with high-temperature superconductors, funded by U.S. Air Force/MTECH Laboratories

- Fabrication of pulsed coils for magnetic propulsion, funded by Sandia National Laboratories.

Programs for the development of large-animal MRI (University of Florida Veterinary School), for development of MRI-guided radiation therapy (NIH/ViewRay, Inc.), for testing of high-temperature-superconductor components for space-borne generators (NASA/Advanced Magnet Laboratories), for design of magnets with both high field and high gradient for levitation (NASA Jet Propulsion Laboratory), for the application of electro-magnets to the removal of ordnance fragments from loose soil and shallow water (Air Force Research Laboratory, Tyndall Air Force Base), and for creating unique superconductor test facilities in support of the High Energy Physics magnet-development program (Lawrence Berkeley National Laboratory/U.S. Department of Energy, Office of Science) have been studied and are being moved to the proposal stage. A detailed proposal to the NSF for a high-field, asymmetric split magnet for neutron-scattering experiments at the High Flux Isotope Reactor, Oak Ridge National Laboratory was not funded.

Project: RESISTIVE MAGNETS

Objectives

The Resistive Magnet Program designs, builds, and maintains high field dc magnets for the scientific user community. The scope of activity ranges from Hybrid inserts providing fields to 45 T or higher and consuming up to 30 MW of power to small wire-wound coils that are inserted in the bore of high field magnets. The scientific community to whom we provide service consists primarily of the users of the Tallahassee powered magnet facility, but we have collaborated with various high-field facilities including the Grenoble, Tsukuba, and, most recently, Nijmegen magnet labs.

We have also made a great deal of progress on upgrading three classes of magnets to establish new international standards as indicated in Table I.

Once the new 50 mm bore magnet is operational, we intend to provide a modulation insert to provide ac ripple for de Haas van Alphen experiments as well as a gradient insert for magnetization experiments. These new inserts will be different from the existing modulation insert in that they will fit entirely inside the bore of the magnet; this should reduce the probability of an insert coil failure damaging the dc coils. In addition, the new inserts can be installed without opening the magnet housing, which should allow users to more rapidly change from one configuration to another. The first prototype modulation coil is complete and has been tested. The gradient coil has been wound. Final assembly is underway.

Maintenance and Upgrades

Over the past year we have been very fortunate in that the installed magnet coils have demonstrated unusually long lifetimes, and we have had to install only three new coils to maintain the seven resistive magnets and one hybrid insert in Tallahassee.

New Initiative: Split Magnet

To date all high field resistive magnets at the NHMFL have been solenoids with cylindrical bores. Historically, high field magnet labs have provided split magnets with field up to 18 T with 4-mm access ports[1] or 17 T with 19-mm ports[2]. Presently a project is underway to design and build a split magnet to provide field perpendicular to the access tube, using two of the NHMFL's dc power

Table 1. Schedule for upgrade projects

Project	50 mm bore	32 mm bore	50 ppm
Magnet Cell	5	12*	7
New Field [T]	32	35	28
Field Increase from Previous [T]	7	2	5
Start Date	Dec. '01	Nov. '02	Feb. '04
Coil Design Review	June '03	April '04	Sept. '04
Detailing Complete	April '04	July '04	Jan. '05
Magnet Operational	April '05	Q3 2005	Q4 2005
Magnet Operational (last year's schedule)	Q2 2005	Q3 2005	Q4 2005

*It has not yet been decided into which cell the first 35 T magnet will be installed. It could be cell 8, 9, or 12.

supplies. We anticipate the field of the magnet to be greater than 20 T and possibly greater than 30 T, depending upon the final configuration.

There is a large-bore, split, superconducting pair of coils presently at the NHMFL that would be suitable for use as the outsert of a hybrid system. Our calculations indicate, however, that a 2-power-supply resistive magnet would provide higher field at lower capital cost than a 1-power-supply hybrid using the existing superconducting pair. Hence, we expect the new magnet to be entirely resistive.

Presently, all our small bore, 2-power-supply resistive magnets have an outer coil diameter of 0.6 m. That dimension was chosen 13 years ago when the power supplies were only 8 MW each. By the time this new magnet is operational, the power supplies should provide 12 to 14 MW each. For this higher power, larger coils would be more efficient. Hence, the outer diameter of this new magnet might be as large as 1 m, similar to the 20 T, 200 mm bore magnet in cell 4 of the DC Field Facility in Tallahassee.

The magnet is expected to be of a "duplex" construction. The outer coils will be of Bitter type (either axially- or radially-cooled) and intended for long-term operation. The inner coils would be either Florida-Bitter or Poly-helix and will be designed to be easily replaced allowing fast replacement at end-of-life and also allowing inner coils of different bores to be installed.

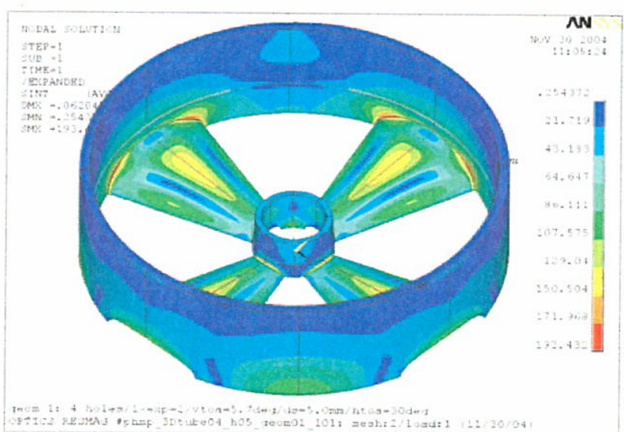


Figure 1. Preliminary stress plot of mid-plane "wheel" of split magnet.

We anticipate the bore tube and access ports will feature an innovative "wheel" configuration with a bore-tube section constituting the hub, conical or cylindrical access ports constituting the spokes, and an outer shell constituting the rim. The wheel would include electrical insulation inside and out and would separate cooling water of the magnet without from potential vacuum scattering space within. The wheel must be capable of supporting external water pressure and surviving various fault scenarios, while minimizing the gap between the coils. The coils would then be stacked above and below the wheel with cooling and power flowing between the spokes. A preliminary stress plot of half of a wheel configured for far-infrared scattering is shown in Figure 1.

We have not yet decided whether the magnet will be a small-gap, high-field magnet configured for photon scattering experiments or a larger-gap, more modest field magnet for rotation experiments. We expect to send the user community a preliminary design package in the first quarter of 2005 with recommendations regarding the magnet technology to be used along with sufficient information regarding attainable field in various configurations (gap, take-off and scattering angles, number of ports, bore, etc) to facilitate informed decision-making.

We would like to have a conceptual design review of the magnet configuration, schedule, and budget during the second quarter of 2005. We then plan to design, build, and test a prototype insert for the existing 20 T, 200 mm bore magnet to verify critical performance parameters. This insert would be a split system running in a 20 T background field and would prove the novel technologies required for the eventual user magnet. The prototype would not be usable as a split user facility as the gap would be blocked by the large-bore solenoid.

After testing of the insert prototype, final design decisions would be made for the first user magnet, the design package would be completed and fabrication would start.

[1] P. Rub and G. Maret, "A New 18-T Resistive Magnet w/ Radial Bores", *IEEE Trans. On Magn.*, Vol. 30, No. 4, July 1994.

[2] R.J. Weggel and M.J. Leupold, "A 17-Tesla Magnet with Multiple Radial Access Ports", *IEEE Trans. On Magn.*, Vol. 24, No. 2, March 1988.

Project: PULSED MAGNETS

Objectives

The program objectives are:

- The manufacture of pulse coils to sustain aggressive physics research programs at the NHMFL Pulsed Field Facility at Los Alamos
- The development and improvement of pulsed magnet technology
- The upgrade of magnet performance in terms of field, reliability, and pulse frequency
- The identification and pursuit of the needed engineering and materials R&D to continuously advance the magnet technology.

Accomplishments for 2004

We completed the first year of user operations with the 65 T gap-cooled magnets. User activity at the facility was up 8% despite a temporary suspension of operations at the pulsed field facility. Engineering development for user magnets focused upon production tooling to simplify the manufacturing process for the new magnet systems and to standardize the power feed structures based upon the new 75 T prototype geometry.

The pulsed magnet program is engaged in the concurrent technology development for the 100 T pulsed insert (see next project report) and the user magnet program at the pulsed science facility. We are also engaged in collaborations with Sandia National Laboratories to improve high strength composites for pulsed field application. Future user magnet development will focus on three areas. (1) Integration of Cu-Nb conductor technology to produce higher field user magnets. We have made substantial progress in this area with an operational 75 T prototype magnet. (2) The development of rapid cycling "Quick Cool" pulsed magnets for the user facility. We have completed a design study for a 58 T, 24 mm rapid cycling user magnet. (3) The development of a 60 T, 15 mm bore "Mid-pulse" magnet using the gap cooling technology developed for the 6 T magnets. These projects are on our technology development roadmap.

Project: 100 T Insert Magnet Development

Objective

The objective of this activity is to design, construct, and test a 15 mm bore, capacitor-powered insert coil for use with a long-pulse outer coil set operated at the Los Alamos facility. Together, the two systems will be capable of producing a total field of 100 T. Design, development, and production of the short pulse inner coil is the responsibility of the MS&T group in Tallahassee. The outer coil is sponsored by the Department of Energy and is being developed at Los Alamos.

Status

Technology development for the 100 T and short pulse programs entails concurrent development work to maximize resource use inside the NHMFL pulsed magnet program. The group is responsible for the maintenance and improvement of the user facility and the development of the 100 T insert. We identified several technical features requiring new engineering development for both the 100 T insert and the user magnet systems. The principal requirement was the development of a new fabrication technology to remove mechanically unstable layer-to-layer transitions. Secondary development work entailed the evaluation of the new assembly process to understand and accurately model accumulated tolerances in the design of high field coils. We are also systematically evaluating the operational limits of our reinforcement and bus-interconnect technology to the benefit of both NSF programs.

An important insert program objective is to gain as much operational experience as possible with low risk "insert-like" coils operating in the same temperature, stress, and strain range as will be encountered in the 100 T insert coil. This grounded, experience-based process is deemed essential to properly evaluate the materials and engineering design. We are following through with a classical engineering program based upon data gleaned from experiments. This incremental development process will mitigate the risks associated with 100 T operations.

We have, for this reason, created a small coil test program to evaluate the engineering structures and materials in a low risk environment. Our baseline pulsed magnet experience, at the start of the 100 T program, was with 50 T to 60 T monolithic coils operating at the 300 kJ to 500 kJ energy level. The 100 T insert will entail coil operation in the 1.5 MJ to 2.0 MJ range. This is an energy level 3 to 4 times above the existing technology. We also recognized that we are operating this system inside a 132 MJ magnet assembly. We are engaged in high risk technology development. Therefore we have to improve quality and upgrade our entire engineering and manufacturing organization to meet the 100 T challenge and the requirements for future upgrades of the user facility. The small coil program's present structure is outlined in Table II.

Table 2. Outline of technology development program for 100 T insert program

Dev.	Magnet System	Geometry	Inner Coil	Outer Coil	Benefit	Energy [MJ]	Prototype Testing	Status 05/11/04
1	65 T Gap Cooled	Nested Two Coil	Insert Structure	Improved Monolith	User & 100 T	1.3	Finished 10/15/03	User Operation
2	75 T Insert Development	Nested Two Coil	Improved Insert	Improved Monolith	User & 100 T	1.4	In Process 11/5/04	Trained 75 T
3	80 T Insert Development	Nested Two Coil	Improved Insert	Improved Monolith	User & 100 T	1.5	Scheduled 6/05	Design & Fab
4	90 T Insert (Version #1)	Insert Only	Improved Insert	N/A	100 T	1.4-2.0	Scheduled 6/06	Dev

The 75 T and 80 T coils required the full development of a totally new nested two-coil design template. 75 T magnet testing started November 5th with the capacitor bank configured to 2 mF for low-energy high-voltage testing. We then configured the capacitor bank to 15.2 mF for high-energy pulsed operations with the 75 T. Full-energy pulse testing started November 15th. We successfully trained the 75 T prototype to full field on Nov 17th. The required bank energy for a 75 T pulse is approximately 1.44 MJ. We energized the magnet ten times to 75 T in accordance with the test protocol. The 75 T "A" coil insert experiences mechanical stresses and peak temperatures comparable to a multi-shot (MS) insert energized to generate a 100 T pulse inside the MS outsert. This "100 T Intensity" phase of the testing protocol was completed on November 18th. The 75 T testing protocol will entail 100 to 200 pulses at 70 T to validate reliability at stress levels comparable to the MS insert at 90 T.

NHMFL pulsed field facility scientific staff will have magnet access during 70 T operations to benefit the NSF scientific user program. We have adjusted the crowbar resistor to add a longer tail to the waveform for better science.

Magnet training performance closely followed design predictions. The drive voltage calculation was within 50 volts of the measured experimental value. The 75 T prototype and the insert capacitor bank both operated together according to specification. The 100 T insert capacitor bank functioned flawlessly throughout training. We are optimistic and encouraged by the technical results obtained thus far.

Work on the 80 T pre-prototype and 90 T MS insert will proceed as there is now a source of experimental data and operational information to support the insert design program. We anticipate delivery of the 80 T pre-prototype in 6 to 8 months.

Summary

We are now in a hardware test and evaluation mode. Significant technical progress has been achieved. We have now operated magnets at intensities comparable to 100 T operations. The development projects will proceed benefiting both the NSF User and 100 T Multi-Shot Magnet programs.

Project: Ultra Wide Bore 900 MHz System

Objective

The NHMFL Ultra Wide Bore 900 MHz NMR (UWB 900) system was designed to achieve 21.1 T with superior uniformity and stability in an extremely large warm bore for magnets of this type. The UWB 900 magnet was conceived as a developmental pathway to the next generation of very high field superconductivity magnet that will require some portion to be constructed of high temperature superconductor (HTS) windings. It was built as a multi-coil set using only low temperature superconductors (LTS) but with the potential for replacement of the innermost coil with an HTS insert capable of operation to nearly 26 T as a standard-bore 1.1 GHz system. As built, it produces 21.1 T in a 105 mm warm bore. With the room temperature shim set in place, the clear bore is 89 mm, which is as large as the typical non-shimmed wide bore magnet.

Status

The UWB 900 was successfully brought to full field in July of 2004. The program is now in a commissioning phase where the magnet is being fully characterized, sample probes are being developed and tuned, and responsibility of the magnet system is transitioning from MS&T to the NMR Science group.

Concerns of superconducting stability arose in 2002 when the magnet was first tested in a bucket dewar in saturated helium at 2.2 K or higher and three high field quenches occurred. In the final cryostat, the situation is improved by operating in subcooled superfluid helium at 1.7 K and atmospheric pressure. Moreover, improved controls allowed the magnet to be ramped more slowly, allowing for flux penetration and settling, thereby reducing the chances of coil perturbations. As a result, the magnet was brought to full field without sustaining a quench.

The magnet was also designed to have a large uniformity volume to take advantage of its large bore. Measurements have been performed that show the field homogeneity has exceeded expectations. In comparison to a 54 mm bore, 900 MHz magnet, the UWB 900 magnet has five times the homogeneous volume. This allows for a wide range of applications: imaging, solid state NMR, and solution NMR.

The field stability was less desirable, and drift before compensation has been measured to be 525 Hz/hr. Two methods for compensating the drift were considered. The first method to be effectively implemented is the use of the B_0 coil of the room temperature shim set. This allows for operation up to one week with a compensated drift of 5.2 Hz/hr. A novel compensation method has also been developed and tested but not yet fully implemented. This injects current directly into one of the main superconducting coils to offset the field decay. The superconducting current injection method allows for uninterrupted operation for up to one month. Preliminary tests have shown that it can improve the drift to 2 Hz/hr. It is fully expected that this method will be the long-term solution for field stability.

The commissioning phase is slated to continue through spring of 2005. At that time the transition to the NMR Science group will be complete and the system will be part of the user infrastructure at the NHMFL.

Project: 45 T Hybrid

Objective

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

Status

Work to build the replacement for Coil A, the innermost Nb_3Sn coil of the superconducting outsert, has again been suspended until the fall of 2005. Effort on this project was initially postponed in November 2002 because technical staff had to be diverted to more critical projects. Because of this postponement, delays in the Nb_3Sn wire delivery were granted to the vendor, Outokumpu Advanced Superconductors. When wire was finally ready for delivery in May 2004, however, it was found to fall short of critical specifications (in particular, critical current and transition index) and was rejected. A new order for wire was placed with Oxford Superconducting Technology, who had bid only slightly higher than Outokumpu on the original RFQ, and delivery is now scheduled for no later than November 30, 2005. The coil-fabrication part of the project will be restarted in September 2005, in anticipation of the wire delivery.

During the brief period during 2004 that staff were available and before the failure of wire to meet specifications was known, some important activities were carried out to confirm the readiness of in-house equipment for fabricating cable-in-conduit conductor (CICC). In particular:

- 800 m (114, 7-m sections) of the specially produced tubing (modified 316LN steel with the precise dimensions required for the Coil-A CICC) were prepped and mounted on the cable-insertion equipment.
- The equipment was used to feed a 100-m length of dummy cable (identical cable pattern but all-copper strands) through all sections of tubing without significant incident.
- The dummy cable was left threading the last 100 m of tubing sections and these were processed through the butt-welding, leak-checking, tube-shaping, and CICC-takeup equipment. All worked flawlessly.

Although coil fabrication activities were suspended, some effort has continued on the design, development, production, and test of HTS current leads. The basic requirements for these leads are as follows:

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

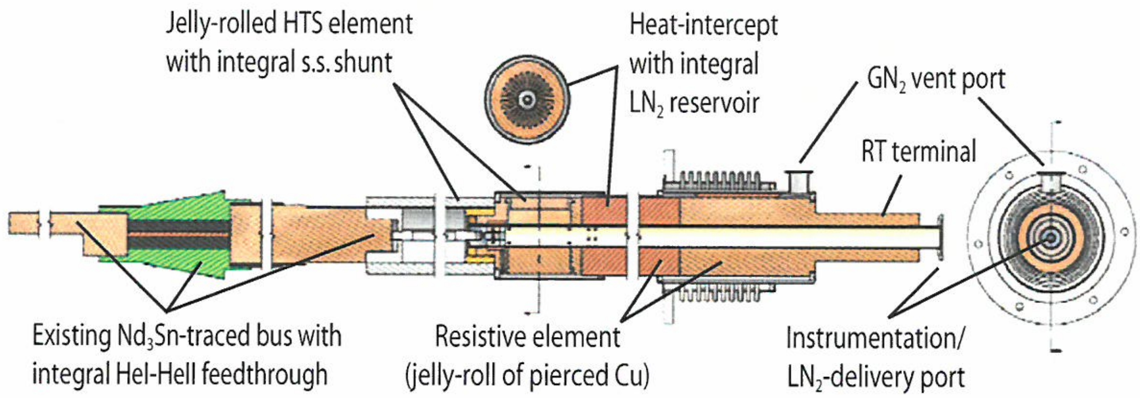


Figure 2. Sectional view of the HTS lead system showing principal components.

Figure 3. Heat-intercept with integral LN_2 reservoir.

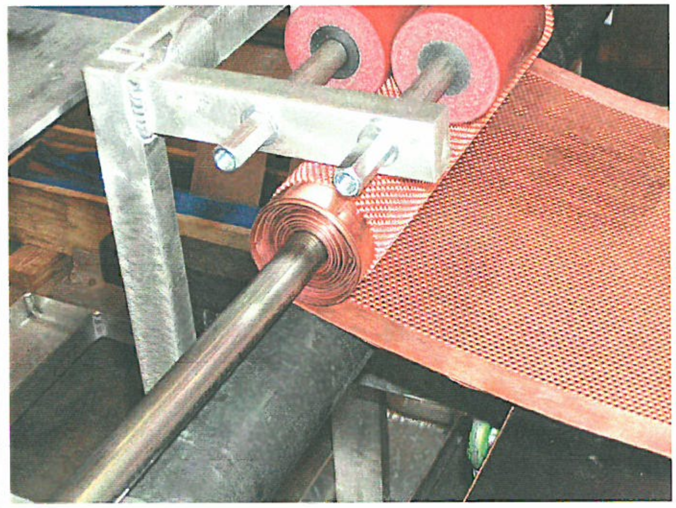


Figure 4. "Jelly-rolling" the resistive section.

To meet these requirements we have selected a design based on the following three principal elements:

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

A replacement lead with HTS section is illustrated (sectional view) in Fig. 2, components for the LN_2 reservoir are pictured in Fig. 3, and fabrication of the resistive element by "jelly-rolling" pierced-copper sheet is shown in Fig. 4. Various components have been performance-tested separately and preparations are underway for full system tests.

As mentioned above, we anticipate restarting the project in September 2005. Milestones and the schedule to complete the project are listed in Table III. The task of removing the existing Coil A is straightforward but projected to be a lengthy six months. With the continual demand for the 45 T Hybrid, it is important to coordinate that effort carefully with the manufacturing tasks to ensure minimal down time.

Table 3. Projected schedule for rebuilding Coil A of the 45 T Hybrid's superconducting outsert

Milestone	Current Schedule
800 m Conductor Jacketed	Jan. 2006
Coil Wound	May 2006
Coil Heat Treated	July 2006
Vacuum Pressure Impregnation Complete	Aug. 2006
Coil Form Removed, Coil Finished	
(Begin Coil-A extraction 6 mo. earlier)	Oct. 2006
Reassembly Complete	Dec. 2006
Outsert Reinstalled in Cryostat and Ready for Cooldown	March 2007

Chapter 5
IN-HOUSE RESEARCH PROGRAM

The National Science Foundation charged the National High Magnetic Field Laboratory with developing an in-house research program that utilizes the laboratory's facilities to carry out high quality research at the forefront of science and engineering and advances the facilities and their scientific and technical capabilities.

To this end, the NHMFL established an in-house research program in 1996 that stimulates magnet and facility development and provides intellectual leadership for experimental and theoretical research in magnetic materials and phenomena. The NHMFL In-House Research Program (IHRP) seeks to achieve these objectives by funding research projects of normally one- to two-year duration in the following categories:

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

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

Nine IHRP solicitations have now been completed with a total of 318 pre-proposals being submitted for review. Of the 318 proposals, 161 were selected to advance to the second phase of review, and 66 were funded (20% of the total number of submitted proposals).

2004 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. In 2001 two enhancements were made for the solicitation that significantly improved program management. These enhancements were utilized for a fourth year during 2004 and proved to be a great asset to the program overall.

The first dealt with the proposal review process. In the past the in-house component of the review of the proposals was carried out by a single committee comprised of scientists from all areas of research. In order to improve the quality of the review given each proposal, subcommittees were formed that reviewed only proposals in their area of expertise. The other major enhancement was the development and use of an online system for the submission, review, and management of the solicitation process. All proposals were submitted electronically; all reviewers (internal and external) had access to the IHRP Web site and performed their reviews online. Adopting the new technology saved money, saved time, and significantly enhanced program management and communications. The IHRP online management system will be expanded in the future to support the submission of the semi-annual reports as well.

Of the 22 pre-proposals received, the committee recommended that 13 pre-proposals be moved to the full proposal stage. Of the 13 full proposals, 7 proposals were awarded. A breakdown of the review results is presented in the following tables.

Table 1. IHRP Awards for 2004

Research Area	Pre-Proposals Submitted	Pre-Proposals Proceeding to Full Proposal	Projects Funded
Condensed Matter Science	9	5	4
Biological & Chemical Sciences	10	6	2
Magnet & Magnet Materials Technology	3	2	1
Total	**22**	**13**	**7**

Table 2. IHRP Funded Projects for 2004

Lead P.I.	NHMFL Institution	Project Title	Funding
Alexander Angerhofer	UF	New EPR Techniques Applied to Oxalate Decarboxylase and Model Systems	$165,000
Randolph Duran	UF	High Magnetic Gradient Studies of Multi-Component Core-Shell Particle Dynamics	$176,000
Marcelo Jaime	LANL	Detection of a Coherent Spin Fluid in Quantum Magnets	$182,000
David Reitze	UF	Ultrafast Coherent Control in High Magnetic Fields	$161,000
Dmitry Smirnov	NHMFL-FSU	Magneto Spectroscopy of and with IR and THz Quantum Cascade Lasers	$181,500
Yong-Jie Wang	NHMFL-FSU	Study of Submillimeter Wave and Infrared Radiation – Induced Resistance Oscillations in Ultra High Mobility 2D Electron Systems in High Magnetic Fields	$174,000
Yan Xin	NHMFL-FSU	High Strength-High Modulus Reinforcement Materials for Magnets	$206,000

2005 Solicitation

The 2005 Solicitation Announcement will be released in March 2005. Awards will be announced by the end of the year.

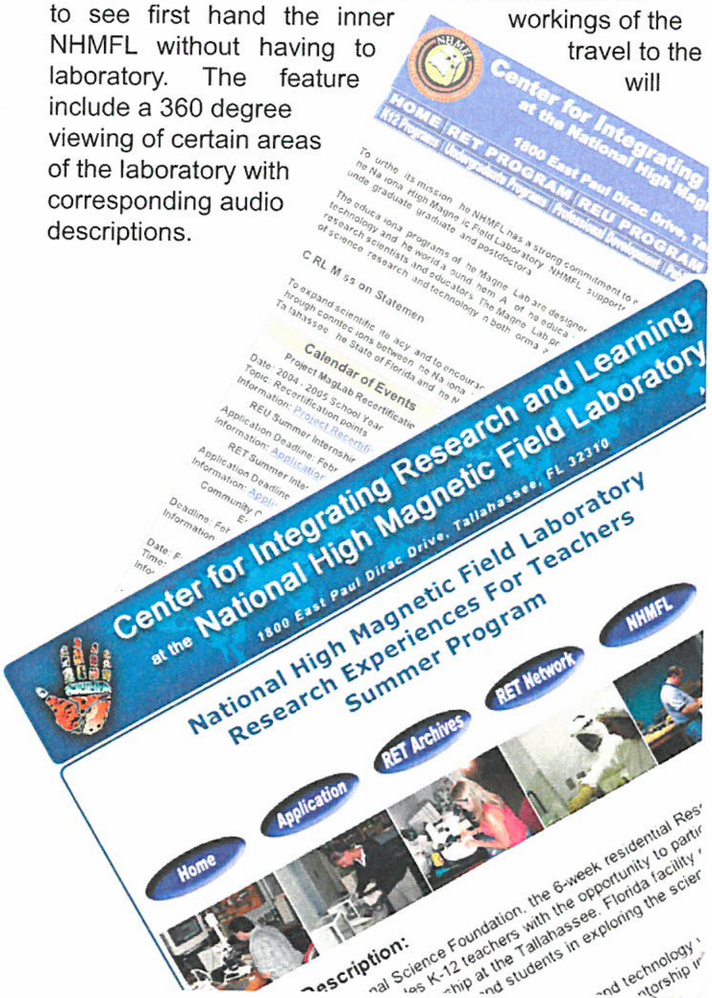
Chapter 6 – EDUCATION

Educational outreach activities present new challenges each year in response to the needs of teachers, students, the general public, and scientists and researchers at the NHMFL. Developing new ways to meet the needs of federal and state legislation and reconciling those requirements with the dynamic nature of research conducted at the NHMFL creates unique opportunities for the Center for Integrating Research and Learning. 2004 was a year for accommodation, change, and implementation of new ideas. It was also a year in which signature programs expanded and new programs began. This report provides a description of activities conducted across the seven areas of focus for the Center.

February 1, 2004, marked the arrival of a brand new look for the Center for Integrating Research & Learning's Web site: *http://education.magnet.fsu.edu*. The site has now become a more interactive and functional tool for students, teachers, researchers, and informal educators. We have created many new features in order to keep up with the ongoing demand of educational professionals from the local, state, and national levels. One such feature is the "Teacher Network." Teachers who have participated in the Research Experiences for Teachers (RET) summer internship program or teachers who have participated in other NHMFL administered workshops now have the ability to share lesson plans via the Web site with other teaching professionals from the comfort of their own homes. The "Teacher Network" also allows a Florida teacher to earn Florida in-service credit points by answering questions online regarding their professional development experiences. We at the Center for Integrating Research & Learning hope to take the teachers' feedback and utilize that information to enhance the learning and understanding of science and science research in both the formal and informal educational settings.

Another feature of the NHMFL Education Web site is the expanded *Resources* section that can be utilized by all visitors for educational purposes. Different printable resources provided by the **Center** include maps and driving directions to the laboratory, brochures that outline several of the Center's signature programs, an activity book appropriate for primary level students, and scavenger hunts appropriate for all ages that can be utilized on visits to the lab, including the annual Open House. Additionally there are pre/post visit activities that are used with the Center's outreach program and activities for various ages that can be done at home. The Center's featured Book of the Month, as well as the Literature in Science Bibliography, can also be accessed here.

Programs for future Web site development include facilitating teachers sharing lesson plans on science-related activities and educational java applets that provide an additional online educational platform for classroom and home use. The Center for Integrating Research & Learning will soon add a multimedia feature to the Web site that will allow visitors to the site to see first hand the inner workings of the NHMFL without having to travel to the laboratory. The feature will include a 360 degree viewing of certain areas of the laboratory with corresponding audio descriptions.



K12 Programs

Over 8,800 students, teachers, and members of the general public benefited from educational outreach and tours conducted by Center educators, NHMFL scientists, researchers, and staff. Thirty-four schools were visited, 434 members of community groups were visited, and countless hours were spent by NHMFL scientists, researchers, educators, and staff judging science fairs, giving talks, providing mentoring, assisting students and teachers, and providing resources. Visits by scientists and others from the lab accounted for 35 events with 1,194 participants. The 2004 Annual Open House attracted over 2,800 people who had the benefit of new interactive displays and activities. The number of tour groups, other than those directly associated with schools, was up 19% at 64, representing 970 members of the general public. Educational programs reached 9 counties and 3 states, not including professional development programs for teachers and undergraduate programs.

In spring 2004, 14 middle school students participated in a semester-long research experience that culminated in a public presentation of their work. Nine scientists from the NHMFL worked with the students for the entire 15-week experience. Seven high school students from four high schools completed externships at the lab, working on projects as diverse as investigating and analyzing cracks in bitter plates to magnet construction.

During summer 2004, the Center provided a 2-week research experience for 9 gifted high school students who were participants in the NSF-sponsored Regional Institute for Math and Science through Florida Agricultural and Mechanical University. Five undergraduate participants in the NHMFL's summer internship program worked with the talented high school students on projects related to superconductivity and geochemistry.

Undergraduate Programs

The Center continues its efforts to expand the NHMFL Research Experiences for Undergraduates (REU) program by recruiting new mentors, by providing educational and social support for increased numbers of participants, and by redesigning the REU Web site as a resource for students as well as an evaluative tool for the Center. All applications and most supporting documents are submitted online, making them available to interested mentors at all three sites – Tallahassee, Gainesville, and Los Alamos. In 2004, the Center sponsored two students to present their research at the Sandia National Laboratory Undergraduate Student Symposium. Mary Warren, who worked in Tallahassee with Justin Schwartz on different heat treatments of BSCCO wire, and Christy Amwake, a second year REU, who worked with Tom Mareci from Gainesville's McKnight Brain Institute on NMR probes, have indicated that the experience was very valuable to their personal education and career objectives. Julia Giblin from Florida State University continued her research through the fall semester and recently defended an honors thesis. Other 2004 research topics are presented in Table 1.

Table 1. Research Experiences for Undergraduates, 2004

Participant	*Institution*	*Research Topic*	*Mentor*
REUs at NHMFL-FSU in Tallahassee			
Colin Ashe	Northeastern University	Staphylococcal Nuclease Expression and Purification	Peter Fajer
Charles Bosse	University of Oregon	Magnetoresistance and Magnetization in Pulsed Magnetic Fields	James Brooks
Christopher Bradley	Florida State University	RF Generation and NMR: Integrating and Miniaturizing Tools for RF Generation and Data Collection	Arneil Reyes
Ran Chang	University of Maryland	Balancing a $^{1}H - ^{19}F$ NMR Probe Circuitry	William Brey
Kianna Ferguson	University of Florida	Change in the conformation of Troponin with the absence of Ca^{2+}	Peter Fajer
Julia Giblin	Florida State University	Strontium Isotope and Trace Element Analysis of Copper Age Human Skeletal Material from the Great Hungarian Plain	Vince Salters
Jesus Gonzalez	University of Colorado-Denver	Working with LabWindows CVI 7.0 and the Mascot Matrix Option	Chris Hendrickson
Sahara Hernandez	Smith College	Integration of Magnetization and Penetration Depth Measurements for Superconducting Samples	Stan Tozer/Eric Palm
David Lehr	Pennsylvania State University	Applicability of Functionalized Pentacene in Photovoltaic Devices	James Brooks

continued

Participant	Institution	Research Topic	Mentor
REUs at NHMFL-FSU in Tallahassee *(cont.)*			
John Macaluso	Richard Stockton College of New Jersey	Design and Construction of a High Resolution Quartz Capacitance Dilatometer Cell for Measurement of Thermal Expansion and Magnetostriction in High Magnetic Fields	Luis Balicas
Jason Mantei	University of Wisconsin-Madison	Infield Heat Treatment of Magnesium Diboride Tapes	Justin Schwartz
Shaun Murphy	Florida State University	Determination of Residual Stress and Strain in Nb_3Sn Using the Nano-Indentation Technique	Peter Kalu
Jonathan Sobota	Cornell University	Computer Simulation of Magnetic Exchange in Disordered Metals	Vladimir Dobrosavljevic
Ben Thayer	Florida State University	2D Metal Insulator Transition: Calculation of Electrostatic Potential in Wigner-Seitz Cell	Vladimir Dobrosavljevic
Mary Warren	University of Massachusetts-Amherst	Exploring the Heat Treatments of $Bi_2Sr_2CaCu_2O_{8+\delta}$/Ag Wires For Superconducting Properties	Justin Schwartz
Stephanie Wolin	Florida State University	Microscopy and Mitosis	Michael Davidson
REUs at NHMFL-UF in Gainesville			
Christine Amwake	Florida State University	NMR Probes	Tom Mareci
Westin Kurlancheek	Harvey Mudd College	An Electronic Paramagnetic Resonance Study of Various Octasilsesquioxanes	Alex Angerhofer

continued ☞

Participant	*Institution*	*Research Topic*	*Mentor*
REUs at NHMFL-UF in Gainesville *(cont.)*			
Lingyun Xiong	Duke University	EPR Spin-Trapping Experiments Involving Oxalate	Alex Angerhofer
REUs at NHMFL-Los Alamos			
Jennifer Kirchoff	Carnegie Mellon University	Optimizing the Deposition of Colloidal Quantum Dots onto GaAs Substrates	Scott Crooker
Winston Okraku	Occidental College	Low Temperature - High Magnetic Field Phase Diagram	Victor Correa
Brian Haines	New York University	Effects of High Magnetic Field on Phases of Ce	Charles Mielke

Two REU students, Christine Amwake and Julia Giblin, participated in an REU poster session hosted by the University of Florida in November. Their posters will be submitted to a national online REU poster session, further expanding the reach of the NHMFL REU program and strengthening connections among national programs.

Professional Development

The centerpiece of the Center's professional development program is its Research Experiences for Teachers program. Individual research projects are uniquely developed each year in response to participants' area of interest and teaching assignment. The 2004 program is described in Table 2.

Table 2. Research Experiences for Teachers, 2004

Teacher	*School*	*Research Topic*	*Mentor*
Lavonda Deale	Niceville High School, Niceville, FL	Optical Microscopy	Mike Davidson
Linda Ford	Seven Hills School, Cincinnati, OH	Applied Superconductivity	Justin Schwartz
Rhonda Gordon	Pre-service	Optical Perception	Bob Goddard
Mark Johnson	Lake Weir High School, Ocala, FL	Applied Superconductivity	Justin Schwartz
Soon Young Kim	Moanalua High School, Honolulu, HI	Overview of the MilliKelvin Lab	Eric Palm
Rob Krouch	Winston Park Elementary School, Tamarac, FL	Optical Perception	Bob Goddard
Jeri Martin	Thomas L. Nims Middle School, Pace, FL	Capacitors and Solar Surgery	James Brooks
Jodi Martin	Pre-service	Optical Perception	Bob Goddard
Amber Matthews	Pre-service	Capacitors and Solar Surgery	James Brooks
Nancy Reddick	Buck Lake Elementary School, Tallahassee, FL	Foraminifera	Philip Froelich

continued

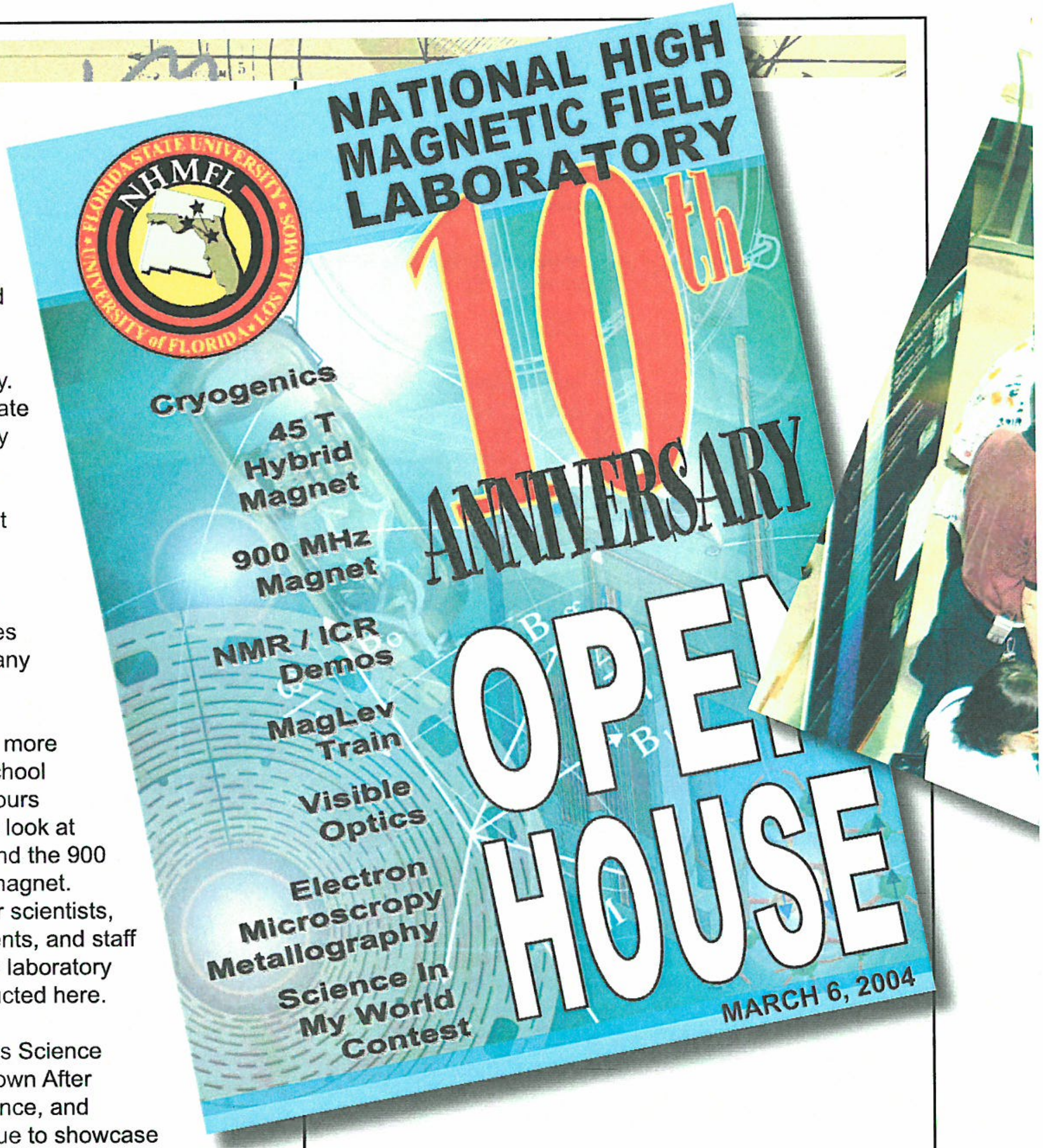
Teacher	School	Research Topic	*Mentor*
Farrell Rogers	Marshall Middle School, Lakeland, FL	Capacitors and Solar Surgery	James Brooks
Marcy Steele	Ruediger Elementary School, Tallahassee, FL	Foraminifera	Philip Froelich
Amanda Underwood	Robertson County School, Tollesboro, KY	Overview of the MilliKelvin Lab	Eric Palm
Josh Underwood	Deming Middle/High School, Tollesboro, KY	Optical Microscopy	Mike Davidson

In addition to the RET program, the Center conducts professional development programs on a local, regional, and national scale. In summer 2004, the Center offered two 4-day summer institutes for 50 local teachers covering topics that ranged from physics and chemistry to a day in the woods, to learning about the animal kitchen at the Tallahassee Museum of History and Natural Science. The workshops are based on a model that provides teachers with a chance to participate in activities, with materials to take back to their classrooms, and with new understandings of implementing inquiry-based experiences in the elementary and middle school classroom.

The first ever *Project Superconductivity* Teacher-Scientist Workshop was held at the Applied Superconductivity Conference (ASC) in Jacksonville, Florida on October 8, 2004. Twenty-four teachers from Florida, Georgia, Mississippi, Ohio, Kentucky, and Maryland attended the day-long session. During the morning half of the workshop, teachers participated in two short courses given by Justin Schwartz from the NHMFL and Ken Marken from Oxford Superconducting Technologies that provided them with the content necessary to feel comfortable implementing superconductivity activities in the classroom. The afternoon session was conducted by Gina LaFrazza and Carlos Villa of the Center. Ten scientists, including representatives from Australia, Italy, Scotland, and the United States, joined the teachers as they conducted two activities from the Teacher Guidebook, which is intended to introduce concepts of magnetism, electricity, and superconductivity into the high school classroom. In the first activity, teachers built electromagnets and measured their strength while varying temperature. In the second, teachers determined the critical temperature of a YBCO sample. During all activities, the scientists assisted the teachers by explaining concepts, while also enjoying the hands-on nature of science. Lively interactions between teachers and scientists added greatly to the day-long workshop. The workshop was co-sponsored by the Institute for Electrical and Electronic Engineers, Council on Superconductivity; the Office of Naval Research; the Department of Energy; and the Applied Superconductivity Conference, Inc.

Over 75 participants from North Florida and South Georgia take part in the NHMFL's long-standing Ambassador Program. Teachers, community partners, home school parents, and administrators meet three times a year to disseminate information about Magnet Lab programs to students and teachers and to learn new content and strategies for implementing inquiry-based activities. In 2004, we heard from a biological paleontologist from Florida State University and from representatives of the Florida Department of Environmental Protection.

Public Programs



The NHMFL's 2004 Tenth Anniversary Open House, held on March 6, 2004, attracted over 2,500 members of the general public to the laboratory. Scientists, researchers, graduate students, postdocs, community partners, students, educators, and area teachers provided interactive demonstrations that excited and engaged children and adults of all ages. The Geochemistry's popular slime pool and the physics of bubbles demonstration attracted as many adults as it did children.

During the course of the year, more than 900 people (excluding school groups) experienced guided tours through the NHMFL, getting a look at the 45 Tesla Hybrid magnet and the 900 Megahertz superconducting magnet. Tours continue to be a way for scientists, researchers, educators, students, and staff to participate in promoting the laboratory and the research being conducted here.

Other public programs such as Science Night at Borders, the Frenchtown After School Program, Girls in Science, and Partners in Excellence continue to showcase the laboratory's commitment to educational outreach at all levels.

Curriculum Development

In 2004, educators at the Center created new materials and continued to fine tune and promote products that are in progress. For example, *Project Superconductivity* that began in 2002 was disseminated to high school teachers and students and *Project Maglab Recertification* that began in 2003 was accepted statewide and is currently being used by several high school and middle school teachers.

One of the products of the RET program and internal collaborations was the development of the *Project Superconductivity* high school curriculum package. A multidisciplinary team from CIRL, Magnet Science & Technology, the Center for Advanced Power Systems, and the Research Experiences for Teachers program worked throughout the summer and fall of 2004 to create the NHMFL's newest curriculum offering. This program brings the science of superconductivity and related concepts to students through hands-on, inquiry-based activities and materials designed for use in high school classrooms. Topics include critical temperature, the Meissner Effect, and calorimetry. The package includes a teacher guidebook comprised of thirteen activities and a package of professional-grade materials with which to conduct the activities in a high school classroom.

As teachers become more and more accountable for their own professional development, *Project MagLab Recertification* provides activities that can be completed in their own classrooms, certified by a National Board Certified and/or Area Consortium, and used to apply to the State of Florida for recertification in science. The Center and participating educators are continuing to find ways to disseminate the materials and information to the four area consortia that provide professional development and recertification services to rural counties.

Materials created at the Center were used in 2004 by teachers and students nationwide; *MagLab: Alpha, Science, Optics & You* and *Science Tobacco & You* continue to attract attention from educators through our extensive Web site.

Partnerships

The Center maintains both formal and informal partnerships with schools, school districts, community groups, university programs and projects, and centers and laboratories that conduct educational outreach activities. In 2004, the Center actively participated in events with the following groups: Women in Math, Science, and Engineering, Partners in Excellence with a local elementary school and a local middle school, Community Classroom Consortium, Tallahassee Scientific Society, Leon Association for Science Teaching, RET Network, Applied Superconductivity Conference, Inc., Boys and Girls Clubs, Alabama Wiregrass Math and Science Consortium, and Newspapers in Education. Partnerships range from long-term commitments for outreach to serving on the Board of Directors and helping to structure policy that affects science education.

Educational Research

A reinvigorated research agenda in 2004 responds to NSF's efforts to learn what really happens after teachers participate in Research Experiences for Teachers (RET) or RET-like programs. What happens when they return to the classroom? Are their students affected by the intense, content-rich RET experience?

The Center is currently engaged in an evaluation of program outcomes. These outcomes include increased participant knowledge in both content knowledge and science process skills, changes in participants' attitudes toward science, increased ability to transfer learning to classroom applications, and more favorable attitudes toward science and higher science achievement in students instructed by RET participants. To this end, CIRL has undertaken a variety of assessment techniques including conducting multi-year focus groups of RET participants, quantitatively assessing student attitudes toward science and science careers, and examining teacher motivation with valid and reliable survey instruments.

Preliminary findings indicate that

- participants exit the program with higher self-efficacy, increased content knowledge, and a broader, more complex understanding of scientific inquiry
- students with RET-participating teachers have a more favorable attitude toward science and science careers than do their non-RET comparison students
- female students with RET-participating teachers have an equally favorable attitude toward science as do boys with non-RET-participating teachers. This is particularly important and suggests that strong programs can have an effect on what has been generally considered a gender gap in science interest.

Conference attendance by Center educators informs practice, programs, and Center policy. The Center continues to provide information for a national database of RET programs and participants through the national RET Network. In addition, in 2004 Center educators were active and enthusiastic participants and presenters at a variety of research-based conferences and symposia: National Science Teachers' Association, Florida Association of Science Teachers, School Science and Mathematics Association, and American Educational Research Association.

Chapter 7
COLLABORATIONS

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

NHMFL Private Sector Activities in the United States

Advanced Magnet Lab, Inc., Palm Bay, FL. Solenoidal magnets that have tilted coil geometry have the unique property that they produce magnetic fields with the field vector perpendicular to the solenoid axis. In addition, the generated magnetic fields are very homogeneous and cost effective. The cooperation with Advanced Magnet Lab, Inc. has the goal to develop industrial applications of this technology, such as material processing, superconductor test facilities, motors, and generators. (NHMFL contact: Hans Schneider-Muntau, Director's Office, Andrey Gavrilin, MS&T)

Advanced Technology Group (formerly, Florida Lasers Systems, Inc.), Stewart, FL. Advanced Technology Group in collaboration with the NHMFL has developed a solid hydrogen optical mass gauging system (SHOMGS) for investigations of sH_2 particle mass density in liquid helium. Solid hydrogen particles are under consideration by **NASA** as fuels for future space missions. The OMGS is being developed as a prototype for determining fuel quantity under reduced gravity conditions. The NHMFL Cryogenics group is providing the cryogenic test facility and instrument calibration. (NHMFL contact: Steve Van Sciver, MS&T)

American Superconductor Corporation (AMSC), Westborough, MA. The NHMFL has been collaborating with AMSC in the characterization of HTS conductors. These characterizations include the effects of mechanical stress and strain (both tensile and compressive) on the current-carrying capabilities of YBCO and BSCCO conductors, investigations of the stability margin and quench propagation behavior of YBCO coated conductors, and the magneto-mechanical behavior of YBCO conductors using magneto-optical imaging. (NHMFL contact: Justin Schwartz, MS&T)

Big Horn Valve, Sheridan, WY. The Cryogenics group of the NHMFL and Big Horn Valve, Inc. are working together on a Phase II NSF STTR-funded project to develop a magnetically-actuated fluid handling valve that could have wide applications in the fluid processing industry. The potential outcome from this project is a valve that is completely sealed so that there will be no leakage into the environment.
(NHMFL contact: Steve Van Sciver, MS&T)

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

Bruker Instruments, Billerica, MA. The NHMFL NMR Instrumentation Program, the Advanced Magnetic Resonance Imaging and Spectroscopy Facility at UF, and Bruker Biospin, with support from the **National Institutes**

of Health, are collaborating on the development of a high temperature superconducting probe for liquid-state NMR applications. The 600 MHz triple resonance probe will be used at the University of Florida McKnight Brain Institute. (NHMFL contact: Bill Brey, NMR)

Capital Avionics, Inc., Tallahassee, FL. This company develops a wireless digital compass. A sensor/transmitter and a receiver are used to align magnetic-field-based heading systems in aircrafts. Part of the project was the design of a calibrator for the compass. The NHMFL assisted in measuring the earth's simulated magnetic field in three axises in a pair of Helmholtz coils, which allowed for the accurate calibration of the magnetic compass.
(NHMFL contact: Hans Schneider-Muntau, Director's Office)

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

Cymetech, LLC, Huntsville, TX. Cymetech is a manufacturer and the leader in developing special polymeric materials from strained ring compounds such as dicyclopentadiene (DCPD). Engineers at Cymetech are collaborating with the NHMFL in a low temperature materials characterization program. The work is part of a Phase II **DARPA** study to assess the suitability of the advance polymer and a carbon fiber reinforced composite version for liquid oxygen and liquid hydrogen storage tank applications.
(NHMFL contact: Bob Walsh, MS&T)

ExxonMobil Corporation, Irving, TX. The National High-Field FT-ICR Facility at the NHMFL has an ongoing collaboration with this oil company to explore new mass spectrometric techniques for characterization of petroleum crude oil and its products. Current efforts involve application of field desorption/field ionization, atmospheric pressure photoionization, 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: Alan Marshall, ICR)

Foveon, Santa Clara, CA. An innovative corporation exploring true color CMOS image sensor technology, Foveon is involved with developing educational tutorials with the NHMFL that explain their cutting-edge technology in image sensor design. Scientists at the NHMFL are developing image galleries using a variety of optical contrast-enhancing techniques in the microscope.
(NHMFL contact: Mike Davidson, Optical Microscopy)

Haynes International, Inc., Kokomo, IN. This manufacturer of specialty alloys is collaborating with the NHMFL's Materials Development and Characterization Group to investigate new alloys for use in conduit alloy applications in Cable-in-Conduit Conductor (CICC) superconducting magnets. Currently metallurgists from the company have recommended and supplied samples of commercially available alloys that may meet the stringent requirements in CICC applications. Screening tests conducted at NHMFL have shown superior performance of Haynes alloys compared to the traditionally used 316LN alloys.
(NHMFL contact: Bob Walsh, MS&T)

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

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

MRI Devices, Inc., Gainesville, FL. Electromagnetic simulations at the NHMFL of high field MRI coils have been developed in conjunction with Dr. Charles Saylor at MRI Devices, Inc.
(NHMFL contact: Saikat Saha, NMR)

BRUKER capital avionics CHROMA ExxonMobil FOVEON

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

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

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

Oxford Superconducting Technology, Carteret, NJ. The NHMFL and OST successfully developed an HTS insert coil that generated 5.11 T in the 19.94 T large bore resistive magnet, generating 25.05 T in total. This insert coil, which required approximately 2.2 kilometers of HTS conductor, is an important development on the path to 25 T superconducting magnets for the user facility. OST provided powder-in-tube BSCCO 2212 conductor for the program. After OST fabricated and reacted the conductor, the NHMFL designed and wound the coils. The 25.05 T was the first time that a superconducting magnet has generated a magnetic field greater than 25 T, establishing many new world records in the process. Collaborations continue on new endeavors.
(NHMFL contact: Justin Schwartz, MS&T)

Oxford Superconductor Technologies (OST) Carteret, NJ. The NHMFL's Materials Development and Characterization Group has developed a superconductor wire test facility designed for tests of the critical current versus strain behavior of low temperature A15 type superconductors. Materials scientists at Oxford are assisting by providing the latest high performance superconductors and consultation with respect to test methodology and data analysis. The high performance superconductors are the most challenging to properly characterize because their high current density places demanding requirements on the test apparatus and instrumentation.
(NHMFL contact: Bob Walsh, MS&T)

Raytheon, Tucson, AZ. We have been working with Abram Young and Delmar Barker at Raytheon to perform GHz frequency transmission studies of three dimensional photonic band gap structures. This collaboration is both beneficial to their research program, providing feedback to the design of photonic structures, and to the development of pulsed field GHz frequency apparatus at the NHMFL-Los Alamos.
(NHMFL contact: Ross McDonald, Pulsed Field Facility, LANL)

Stereotaxis, Inc., St. Louis, MO. Stereotaxis is leading in the development of intravascular navigation systems for heart and brain surgery and drug delivery. The catheters are magnetically guided. Stereotaxis has teamed with the NHMFL to develop a new generation of catheters, which are flexible to ease the navigation around sharp corners or for large bending angles. The heat treatment of the CoPt wire, which constitutes the flexible catheter tip, has been optimized to maximize coercivity. An improvement of 50% has been achieved. Stereotaxis also supports the development of new magnetic materials. We are investigating a nanostructured $Nd_2Fe_{14}B$/a-Fe-type system with the goal to achieve very high energy products through high temperature annealing in a magnetic field.
(NHMFL contacts: Ke Han, MS&T, and Hans Schneider-Muntau, Director's Office)

Supercon, Inc., Shrewsbury, MA. The NHMFL and Supercon are collaborating through a Phase I SBIR from the **U.S. Department of Energy**. The focus of the R&D is the development of Bi2212 round wires using continuous magnetic field processing. Supercon is manufacturing unreacted Bi2212 round wires and providing them to the NHMFL for heat treatment in a DC magnetic field and subsequent electrical characterization.
(NHMFL contact: Justin Schwartz, MS&T)

HAYNES International MediaCybernetics Molecular Probes invitrogen detection technologies MRI Devices Corporation AN INTERMAGNETICS COMPANY Nikon OLYMPUS

Training Solutions Interactive, Inc., Atlanta, GA & Washington, DC. TSI and the Center 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. Due to the overwhelming success of *Science, Tobacco & You*, TSI and the Center maintain an active and dynamic business relationship.
(NHMFL contact: Pat Dixon, Educational Programs)

NHMFL Inter-Agency & Inter-Institutional Activities

Ames Laboratory, Iowa State University, Ames, IA. The purpose of the collaboration between the NHMFL and the Ames Laboratory is the investigation of the elastic properties of ternary Gd-based alloys related to $Gd_5(Si_2Ge_2)$. These alloys are promising candidates for a new generation of energy efficient sub-room temperature refrigeration based on the magnetocaloric effect. The colossal strain also gives these alloys a potential for future use in magnetic actuators.
(NHMFL contact: Alexei Souslov, Instrumentation & Operations)

Argonne National Laboratory, Argonne, IL. Electromagnetic field simulations at the NHMFL are supporting the development of toroidal cavity resonators in the laboratory of Dr. Rex Gerald to improve the spectroscopy of thin films.
(NHMFL contact: Saikat Saha, NMR)

Columbia University, University of California Santa Barbara, Stanford, CA. The Center continues its collaboration with other institutions that conduct educational outreach with teachers. Through the RET Network, the Center maintains a national presence among other laboratories, centers, and universities that conduct Research Experiences for Teachers and other Teacher Enhancement programs. In 2004-2005, 12 Research Experiences for Teachers sites that received funding from **NSF**, began a collaborative project to determine the effects of RET and RET-like experiences on teachers and students once they return to the classroom.
(NHMFL contact: Pat Dixon, Educational Programs)

Institute for Electrical and Electronic Engineers-Council on Superconductivity, Office of Naval Research, Department of Energy and the Applied Superconductivity Conference, Inc. co-sponsored a Teacher-Scientist Workshop on Applied Superconductivity, at the Applied Superconductivity Conference in Jacksonville, Florida on October 8, 2004. The workshop highlighted the *Project Superconductivity* curriculum package developed at the NHMFL. Twenty-four teachers from six states attended the day-long session. During the morning half of the workshop, teachers participated in two short courses given by Justin Schwartz from the NHMFL and Ken Marken from **Oxford Superconducting Technologies** that provided them with the content necessary to feel comfortable implementing superconductivity activities in the classroom. The afternoon session was conducted by Gina LaFrazza and Carlos Villa of the NHMFL. Ten scientists, including those from Australia, Italy, Scotland and the U.S., joined the teachers as they conducted two activities from the Teacher Guidebook that is intended to introduce concepts of magnetism, electricity, and superconductivity into the high school classroom.
(NHMFL contact: Gina LaFrazza, Educational Programs)

Leon County Schools, Tallahassee, FL. The Center facilitates science workshops and summer institutes for the Leon County Schools. In the wake of standardized testing in science, the Center has responded to the call of teachers and schools to provide quality professional development and workshops. Working with community partners, the Center provides 1-day and 4-day opportunities at which teachers learn content as well as methods for conducting hands-on minds-on science activities.
(NHMFL contact: Pat Dixon, Educational Programs)

Los Alamos National Laboratory, Los Alamos, NM. Researchers from the NHMFL and Los Alamos have been working on nanostructured Cu-Ag materials. The materials have unique nanostructure and performance, which can be achieved by subcooling, resulting in high cooling rate, and following deformation. These conductors will be of great importance for future generations of pulsed magnets.
(NHMFL contact: Hans Schneider-Muntau, Director's Office)

National Superconducting Cyclotron Laboratory (NSCL), Michigan State University, East Lansing, MI. The NHMFL has designed and built a 4 T superconducting sweeper magnet for installation and use in nuclear physics experiments at the NSCL. The magnet is referred to as a sweeper because it "sweeps" charged particles out of a multi-particle beam and into a mass spectrometer built by the NSCL. It bends beams of high rigidity 40° on a 1 meter radius. The magnet consists of 2 "D"-shaped coils with a split of 140 mm. The conductor is epoxy-impregnated niobium titanium operating at 4.5 K. The magnet was successfully tested at the NHMFL in March 2004 with only one training quench and the first physics experiment was conducted in June at the NSCL. To our knowledge, this large-gap dipole has the largest stored energy of any built to date. The exceptionally good performance of this magnet is believed to be due to the extreme attention to detail that was provided by the magnet design staff of the NHMFL. Numerous innovations were developed that we believe result in a more robust system.
(NHMFL contact, Mark Bird, MS&T)

North Carolina State University, Raleigh, NC. We developed a new solid-state NMR technique (in collaboration with Prof. Alex Smirnov) to study proteins in membrane environment on solid-state nanoporous support. The new supporting material has a large surface-to-volume ratio and therefore the lipid bilayers inserted in the nanopores are accessible by solvent permitting a wider range of structural and functional studies of membrane proteins in the native-like environment by means of solid-state NMR.
(NHMFL contact: Eduard Chekmenev, NMR)

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

Sandia National Laboratory, Albuquerque, NM. The purpose of the collaboration between the NHMFL and the Beam Applications & Magnetic Propulsion Initiatives Department at Sandia National Laboratory is the design, analysis, development, and testing of highly loaded electromagnetic propulsion magnet coils and associated materials and systems.
(NHMFL contact: James R. Sims, NHMFL at Los Alamos)

University of Alabama at Birmingham, AL. The Department of Microbiology of UAB and the NHMFL FT-ICR Facility are collaborating on the use of high resolution FT-ICR and unique fragmentation abilities of FT-ICR to map changes in specific post-translational modifications (glycosylations) in IgA nephropathy (a fatal kidney disease).
(NHMFL contact: Mark Emmett)

University of Houston (TX) and the University of Wisconsin at Madison. The NHMFL is collaborating with these universities on the development of a traveling science museum exhibit on superconductivity. The first phase of the activity was the development of a four-foot and a twelve-foot traveling I-Wall, which is an interactive multi-media display technology that covers the history of superconductivity, what-is-superconductivity, making superconductors and applications of superconductivity in medicine, energy, and research. The twelve-foot IWall is housed in the lobby of the NHMFL; the four-foot IWall is used for outreach and for conference displays.
(NHMFL contact: Gina LaFrazza, Educational Programs)

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

NHMFL International Activities

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

Free Electron Laser Facility, F.O.M. Institute, Nieuwegein, The Netherlands. The National High-Field FT-ICR Facility at the NHMFL is collaborating with the Dutch facility. A 4.7 T FT-ICR instrument, constructed at the University of Florida by Dr. John Eyler, has been installed at the Free Electron Laser for Infrared eXperiments (FELIX) in Nieuwegein. The FELIX facility is a world leader in producing intense, conveniently tunable radiation in the infrared spectral range (500 to 2000 cm^{-1}), which spans typical chemical bond vibrational frequencies. The ultra-high mass resolving power of the FT-ICR instrument, combined with the capabilities of FELIX, provides a unique capability for determination of the infrared absorption spectra of gas-phase ions. Supplemental funding has been obtained from NSF to support travel of U.S. researchers to the Dutch facility. To date, research visits by scientists from **U. Minnesota**, **U. Delaware**, **U. Florida**, **Case Western Reserve University**, and the **Idaho National Engineering and Environmental Laboratory** have been supported.
(NHMFL contact: John Eyler, UF Chemistry)

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

Grenoble High Magnetic Field Laboratory, Grenoble, France. Since the start of the NHMFL, the cooperation between the two high field laboratories has been very successful and productive. Accomplishments include the 20 T, 50 mm bore magnets at the NHMFL and the joint development of the 20 T, 20 cm bore magnet at the NHMFL along with a similar magnet in Grenoble. Discussions have started to repeat this cost-saving approach for the design of split-coil magnets for the two laboratories.
(NHMFL contact, Mark Bird, MS&T)

Hahn-Meitner Institute, Berlin, Germany. HMI and the NHMFL have collaborated for several years on a proposal for a major resistive magnet facility installation in Berlin. Presently HMI is pursuing 25 T superconducting solenoids with either large or conical bores to facilitate neutron scattering. The NHMFL is developing series-connected hybrid magnet systems that might be ideal for future collaborations with HMI.
(NHMFL contact, Mark 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 2003 the Nijmegen lab dedicated its new 20 MW facility featuring three of the 33 T, 32 mm bore Florida-Bitter magnets designed in Tallahassee. We are discussing collaborations on other future magnet systems, such as 50 mm bore magnets, 30 T magnets suitable for condensed matter NMR, and hybrid inserts.
(NHMFL contact, Mark Bird, MS&T)

Institute of Electrical Engineering, Slovak Academy of Sciences, Bratislava, Slovakia. The NHMFL and IEE-SAS are collaborating on the behavior of HTS conductors and coils, including quench propagation and AC losses.
(NHMFL contact: Justin Schwartz, MS&T)

Laboratoire de Physique de l'Ecole Normale Superieure, Paris, France. We are working with Professor Philippe Goy to extend the frequency coverage of our high frequency spectrometer at the University of Florida from 200 GHz to 550 GHz, and to develop time resolution capabilities, i.e., pulsed EPR capabilities. Philippe Goy is an expert in microwave signal processing, and has a patent for the network analyzer that is used at UF.
(NHMFL contact: Stephen Hill, UF Physics)

Linkam, Surrey, United Kingdom. Scientists at the NHMFL collaborate with Linkam engineers to design

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heating and cooling stages for observation of liquid crystalline phase transitions in the optical microscope. In addition, NHMFL researchers are assisting Linkam in introducing a new heating stage for live-cell imaging in fluorescence microscopy.
(NHMFL contact: Mike Davidson, Optical Microscopy)

National Institute of Chemical Physics and Biophysics, Tallinn, Estonia. The NHMFL NMR program is sponsoring the development of cryogenic magic angle spinning (MAS) probes for NMR under the direction of Professor Ago Samosan. Professor Samosan collaborates with Dr. Zhehong Gan on solids NMR applications.
(NHMFL contact: Zhehong Gan, NMR)

Olympus Corporation, Tokyo, Japan. Investigators at the NHMFL have been involved in a collaboration with engineers at Olympus, Tokyo for 18 months to develop and test new optical microscopy systems for education and research. In addition to pacing the microscope prototypes through basic protocols, the NHMFL is developing technical support and educational Web sites as part of the partnership.
(NHMFL contact: Mike Davidson, Optical Microscopy)

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

QMC Instruments Ltd, Department of Physics and Astronomy, Cardiff University, United Kingdom. We have worked with Dr. Richard Wylde to develop a quasioptical setup in order to couple the higher frequency sources (200+ GHz) to our low-temperature/high-field environment.
(NHMFL contact: Stephen Hill, UF Physics)

Seoul National University, Korea. The NHMFL and the Condensed Matter Research Institute in the School of Physics of Seoul National University have agreed to collaborative research involving high magnetic fields in condensed matter physics. The collaboration, begun in 2000 and recently extended to 2010, includes exchange of professors, research scholars, graduate students, scientific documentation, publications, and information. The collaboration is funded by the "Brain Korea 21" program of the Korean Research Council and the NHMFL. Graduate students and faculty from Seoul National University have come to the NHMFL to pursue their research in high magnetic fields, and students, faculty, and research staff from the NHMFL have traveled to Korea for collaborative research visits and conferences.
(NHMFL contact: Bruce Brandt, Instrumentation & Operations)

Seoul National University, Korea. In the framework of the cooperation between the Condensed Matter Research Institute in the Department of Physics of Seoul National University and the NHMFL, we organized the "International Workshop on the Latest Developments in Magnet Technology for Nano and Bio Science Opportunities," which was held at the Seoul National University on November 18–19, 2004. It included a round table discussion. Invited speakers from all major magnet laboratories presented their programs and facilities. The collected information will help the University of Seoul and the Korean Basic Science Institute (KBSI) prepare a proposal for a Korean High Magnetic Field Laboratory.
(NHMFL contact: Hans Schneider-Muntau, Director's Office)

Tsukuba Magnet Laboratory, Tsukuba, Japan. The Japanese TML purchased a 30 T resistive magnet from the NHMFL in 1996 that was delivered in 1997. We have since delivered a spare set of coils under separate contract (with the last coil being delivered in 2003) and will continue to provide coils as needed in the future. Preliminary discussions have begun regarding a new insert for their 40 T class hybrid magnet.
(NHMFL contact, Mark Bird, MS&T)

University of Bologna (Italy), CSIRO (Australia) and the University of Wisconsin, Madison, are collaborating with the NHMFL to expand the number of activities in the *Project Superconductivity* curriculum to include applications of thin film superconductors, and to translate the entire curriculum package into Italian for a workshop planned for the MT-19 conference to be held in Genova, Italy, in September, 2005.
(NHMFL contact: Gina LaFrazza, Educational Programs)

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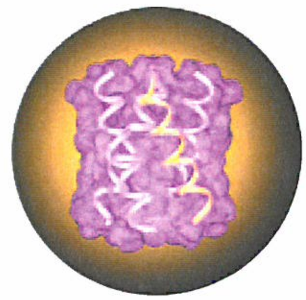
University of Helsinki, Finland. The Department of Biosciences/Institute of Biotechnology of the University of Helsinki and the NHMFL FT-ICR Facility are collaborating on the use of solution phase Hydrogen/Deuterium exchange with high resolution FT-ICR analysis for determination of the mechanism of RNA insertion into viral capsids.
(NHMFL contact: Mark Emmett, ICR)

Université de Reims, France. The collaboration between the NHMFL and the Université de Reims is related to the characterization of nano-structure materials. The materials include Cu-Nb used for pulsed magnets and Fe-FeNdB nanocomposites that have unique magnetic properties.
(NHMFL contact: Ke Han, MS&T)

Chapter 8
CONFERENCES & WORKSHOPS

5th Biennial Structural Biology Symposium
-- Membranes: A Challenge for Protein Magnetic Resonance



January 23-24, 2004
Tallahassee, Florida
Meeting Site: Turnbull Florida State University Conference Center
Hotel Headquarters: DoubleTree Hotel
Symposium Chairs: Peter Fajer and Tim Cross

Over 120 people met for this workshop hosted by the FSU Institute of Molecular Biophysics with generous additional support from the Department of Chemistry and Biochemistry and the NHMFL. Attendees came from Australia, Europe, and Canada, as well as the United States.

The scientific program marked the significant progress that is being made in the structural, dynamic, and functional characterization of membrane proteins by electron spin resonance, solution-state NMR, and solid state NMR spectroscopy. In addition, participants heard about the excellent progress being made in developing robust protocols for the expression and purification of membrane proteins—long considered one of the major bottlenecks in this research arena.

44th Sanibel Symposium

February 28 - March 5, 2004
St. Augustine, Florida
Meeting Site: St. Johns County Convention Center
Hotel Headquarters: World Golf Village Renaissance Resort
Symposium Chair: Sam Trickey

Despite visa-restriction problems, nearly 250 participants from 20 nations attended the 2004 Sanibel Symposium--sustaining the hallmark international character of the meeting. Attendees were principally theorists and computationalists, including molecular and condensed matter physicists, quantum chemists, and molecular biologists. These diverse specialties share common interests in the development of theory and computational methods and their application to chemical and physical processes using large-scale computations.

As usual, the faculty, students, and staff of the University of Florida Quantum Theory Project (QTP) planned, organized, and ran the Symposium. The plenary lectures and poster sessions make it possible for virtually everyone to present his/her work and to discuss it with experts from a wide range of research areas. Breaks in the scheduled events and the various social functions made possible personal interactions between junior and senior scientists from around the world, and collaborative research and employment opportunities derived from these contacts.

A distinguishing characteristic of the Sanibel Symposia is that they embrace many different scientific backgrounds, methodologies, and even conceptual structures. It is common to observe heated discussions between formal mathematicians and physical chemists, or between theoretical physicists and theoretical chemists. In particular, it is notable how in recent years biological and physical scientists interact and increasingly are beginning to learn from each other's vocabulary. This catholic flavor of the Symposia distinguishes them among scientific conferences in these times of increasing specialization. In addition, the Symposia mix senior, well-established scientists with graduate students and aspiring postdoctorals. The popular poster sessions, which by tradition open with a plenary session giving each scientist two minutes to advertise his/her poster, attracts presentation by young and old from undergraduates to Nobel Laureates.

The Symposia proceedings are published by the International Journal of Quantum Chemistry, (John Wiley and Sons) and edited by QTP faculty. These proceedings have a wide circulation and cover the science exhibited both in the plenary sessions and the poster presentations. This year's proceedings contain over fifty-five papers.

Solid State NMR and Material Applications at High Magnetic Fields

March 12-13, 2004
Tallahassee, Florida
Meeting Site: NHMFL
Hotel Headquarters: Holiday Inn Downtown
Workshop Chair: Zhehong Gan

This meeting gathered researchers from Australia, Canada, England, France, Korea, The Netherlands, Russia, and the United States who apply solid state NMR spectroscopy of quadrupolar nuclei for the study of materials ranging from glass, zeolite, catalyst, and biological macromolecules. High magnetic fields reduce the second-order quadrupolar shift, the major source of line broadening, and are essential for better spectral resolution and sensitivity for quadrupolar nuclei NMR. In addition to scientific presentations, the participants gave many good suggestions and comments for the future development of solid state NMR capabilities and the unique utilization of high magnetic fields at the NHMFL.

International Workshop on Materials Analysis and Processing in Magnetic Fields

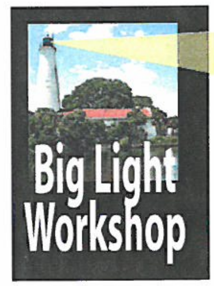
March 17-19, 2004
Tallahassee, Florida
Meeting Site: NHMFL
Hotel Headquarters: Wingate Inn
Workshop Chair: Hans Schneider-Muntau

In spite of the short notice, 55 researchers attended this materials workshop—9 from Europe, 19 from Japan, and 27 from the United States. Six participants represented various private companies. Forty-one very outstanding presentations covered many areas of magnetic field effects in physics, chemistry, and biology.

Over the last decade, new science opportunities and research activities have arisen due to the impressive progress made in the generation of high magnetic fields. Materials analysis and processing in magnetic fields is a rapidly expanding research area with a wide range of promising applications in materials development and design. In response, industry now offers a variety of superconducting magnets, many specifically designed for this purpose and equipped with cryocoolers that dispense the need for cryogenic fluids. Numerous research centers dedicated to materials research and processing in magnetic fields have been created around the world, their magnets covering a wide range of experimental space and field strength.

This workshop was organized to review the most recent activities in this field. Magnetic fields are at the origin of many effects in materials, of which the following are a few examples. The high fields available now allow us to levitate diamagnetic matter with the advantage of containerless processing of materials, or control gravity on earth from – g to + g. Magnetic anisotropy can be used for aligning fibers, polymers, and carbon nanotubes, resulting in matrix systems with superior quality. The magnetic field has an impact on texturing of materials during a phase transition, both liquid-to-solid and solid-to-solid state transitions. Grain boundary migration and change of their mobility have been demonstrated in Bi and Zn crystals, giving us the perspective for texture development in metals. The damping effect of magnetic fields on conductive liquids is exploited for improved crystal growth quality. Magnetic fields can help manipulate cells and cellular processes, such as cell divisions. Nanomagnetic particles can be mixed with biological blood components for treatment, through magnetic blood cell separation or as a marker. Magnetic fields are also used to reduce defects in crystalline and carbon fibers.

"Big Light" Workshop: Exploring the Combination of High Magnetic Fields and Bright Light Sources



May 6-7, 2004
Tallahassee, Florida
Meeting Site: Turnbull Florida State University Conference Center
Hotel Headquarters: Wingate Inn
Workshop Chair: Louis-Claude Brunel

The NHMFL is interested in bringing together intense magnetic fields and bright light sources. This endeavor is wide open, and we are considering everything from building a small light source (or sources) at Tallahassee to providing big magnets at existing light source(s) facilities. The purpose of the workshop was to collect a wide spectrum of potential future experiments and techniques prior to forming a steering committee to oversee the birth of the project. Besides 29 talks by experts from the United States and Europe, there was time within the question and discussion sessions for informal airing of views and ideas.

The first result of the workshop was a collaboration between NHMFL Magnet Science and Technology and the Argonne Photon Source. NHMFL engineers evaluated the design of undulators to be used at APS, and their suggestions are resulting in meaningful performance improvements.

Currently, J. (Hans) van Tol, John Singleton, and Louis Claude Brunel of the NHMFL, are working on a "Conceptual Engineering Design" grant proposal to be submitted to the Instrumentation for Materials Research - Major Instrumentation Projects (IMR-MIP) NSF program. If approved, that CED for a light source made of three free electron lasers will be followed by a grant proposal for the construction of the machines.

Fluctuations and Noise in Materials

May 25-28, 2004
Maspalomas, Gran Canaria, Spain
Meeting Site and Hotel Headquarters: Gran Hotel Costa Meloneras
Conference Chair: Dragana Popović

This conference was one of seven parallel conferences of the SPIE Second International Symposium on Fluctuations and Noise. This new symposium series tries to address the huge field of noise research, including biology, biomedicine, materials, magnetism, devices, reliability, circuits, optics, nonlinear systems, environment, nanotechnology, classical and quantum information, quantum computing, communication, wireless, etc. By having seven parallel conferences, the symposium organizers have sought to reflect the truly interdisciplinary nature of this emerging and dynamic field. Both the first symposium, held in Santa Fe, New Mexico, USA in 2003, and this second one had over 300 presentations from 35 countries, and they were both great successes—the largest meetings on noise and fluctuations processes so far. The participants were free to attend any of the parallel conferences, which also had one common plenary session.

The conference on Fluctuations and Noise in Materials brought together experts from various fields of condensed matter physics with the common interest in using noise to probe the properties of materials, thus providing a unique opportunity for the exchange and cross-fertilization of ideas among researchers in these different fields. The conference had about 50 registered attendees with 44 presentations, including 25 invited talks, 11 contributed talks, and 8 posters. The presented papers represented 13 countries: France (9 papers), Germany (1), Hungary (1), India (5), Israel (1), Italy (2), Japan (2), the Netherlands (1), Russia (1), Sweden (1), Switzerland (1), United Kingdom (2), and the United States (17). The papers have been published in the Proceedings of the SPIE, and selected papers will be published in the journal *Fluctuations and Noise Letters*. The partial funding for this conference was also provided by the U.S. National Science Foundation.

The emphasis of the conference program was on the following: magnetic systems, strongly correlated electron systems, including Coulomb glasses and high temperature superconductors, soft materials, structural glasses, and mesoscopic conductors. It turned out that glassy behavior emerges as a common theme in many of these systems, and that the study of fluctuations is becoming an increasingly powerful tool for revealing the microscopic processes underlying many striking macroscopic phenomena. There was a good balance between the number of theoretical and experimental papers presented. The latter described a broad range of experimental techniques used to probe the fluctuations.

The conference was a huge success. It attracted scientists at the cutting edge of noise research, and provided a unique opportunity for the exchange of ideas among communities that normally do not have a chance to interact but that, nevertheless, share many common interests. It has already led to an increased communication among scientists from several subfields of condensed matter physics from all over the world, and encouraged possible future collaborations. In order to maintain and further develop these valuable ties, and enhance scientific and educational activities, the next SPIE Symposium on Fluctuations and Noise is scheduled to take place in Austin, Texas, May 23-26, 2005.

16th International Conference on High Magnetic Fields in Semiconductor Physics

August 2-6, 2004
Tallahassee, Florida
Meeting Site: Main Conference Hall, FSU University Center
Hotel Headquarters: Holiday Inn Select
Conference Chair: Yong-Jie Wang

The NHMFL was extremely pleased to host the 16th International Conference on High Magnetic Fields in Semiconductor Physics. This prestigious conference has been held every other year, rotating among countries in Europe, North America, and Asia (mainly in Japan). Recent conferences have been held in Vancouver, Canada (1994), Wurzburg, Germany (1996), Nijmegen, The Netherlands (1998), Matsue, Japan (2000), and Oxford, England (2002).

About 130 people from 18 different countries attended SemiMag16. The scope of the conference was mainly magneto optical and transport studies on different semiconductor systems. The topics included: quantum Hall effect, magnetic semiconductors, organic conductors and nano-structure materials, semiconductor quantum dots and wires, semiconductor quantum wells and heterostructures, coupled systems, quantum nanostructures, many-body effects, and tunneling effects. The meeting combined technological and scientific aspects of semiconductor physics; system optimization; magnet analysis and design strategies; new instrumentation; and related issues.

Mini-Symposium on Quantum Computing

August 20, 2004
Tallahassee, Florida
Meeting Site: NHMFL
Symposium Chair: James Brooks

MINI-SYMPOSIUM ON QUANTUM COMPUTING

The purpose of this brief symposium was to bring together researchers from the Quantum Computing effort at the University of New South Wales and the University of Queensland with researchers here at the NHMFL/FSU/FAMU and at the University of Florida. In addition to the speakers, approximately 30 faculty and staff from the Florida University Systems attended the presentation. Incidental costs associated with the conference were supported through the National Science Foundation (NSF-DMR-0203532, Brooks).

The list of speakers and talks provides a flavor for the workshop and the productive discussions that were held throughout the day:

- Prof. Bob Clark, UNSW - *Overview: Summary of Key Progress in Solid State QC (excluding superconductors) Around the World, and Which Gives a Sense of the Recent History*
- Prof. Andrew Dzurak, UNSW - *P:Si Qubits*
- Dr. Jeremy O'Brien, UQ - *Encoding and Processing Quantum Information in Photons*
- Prof. Nick Bonesteel, FSU - *QC and QI Theory*
- Dr. Irinel Chiorescu, MSU - *Coherent Dynamics of a Flux Qubit Coupled to a Harmonic Oscillator*
- Prof. Steve Hill, UF - *Quantum Coherence in an Exchange-Coupled Dimer of Single-Molecule Magnets*
- Hans von Tol, NHMFL - *EPR, ENDOR, and DNP of Solid State Spin Systems with Long Relaxation Rates: Si:P and N@C60*

Applied Superconductivity Conference

October 3-8, 2004
Jacksonville, Florida
Hotel Headquarters: Adam's Mark Hotel
Conference Chair: Justin Schwartz

ASC/04

Despite the hurricanes that battered Florida in the weeks before, the conference was a tremendous success—hosting 1,435 registered attendees, representing 36 countries from around the world. Forty percent of the attendees were from the United States; Japan was the second largest population with 24% of attendees. The conference included oral and poster sessions in Electronics, Materials and Large Scale. In total, 1,345 presentations were made and 965 manuscripts were submitted to the *IEEE Transactions on Applied Superconductivity* for publication. These manuscripts will go through a peer-review process to determine if they will be accepted for publication.

The conference offered three short-courses before the technical sessions began, and these were also very successful—attracting 58 regular and 29 student participants. There was also a large exhibit with 53 booths representing companies from around the world. Each morning the conference began with keynote plenary speakers.

Deviating from past ASC conferences, ASC '04 had one speaker from outside the field of superconductivity: Dr. Bernard Kouchner, the founder of the Nobel Prize-winning Doctors Without Borders spoke on *Globalization and New World Order: Are We Ready for "Scientists Without Borders"*?. Dr. Kouchner also met with the local media after his talk. Other plenary speakers included G. Boebinger, NHMFL; J. Minervini, MIT; C. Foley, CSIRO Australia; J. Vrba, CTF Systems, Canada; S. Akita, CRIEPI, Japan; H. Padamsee, Cornell University; and C. Eom, University of Wisconsin.

In 2004, the ASC expanded beyond its historic mission of being the premiere conference in applied superconductivity by hosting the first-ever *Project Superconductivity* Teacher-Scientist Workshop. This exciting event, developed and organized by the NHMFL, gave ASC attendees the opportunity to work directly with high school teachers, educating the teachers on superconductivity so that they can bring it to their classrooms, and educating scientists on more effective ways of reaching younger audiences.

15th Conference of the International Society of Magnetic Resonance

October 24-28, 2004
Ponte Vedra Beach, Florida
Hotel Headquarters: Sawgrass Marriott Resort
Conference Chair: Tim Cross

The 15th ISMAR conference attracted representatives from more than 20 nations to a beautiful location south of Jacksonville, Florida. The broad-ranging scientific program, developed by Prof. Robert Griffin (MIT) and others, included more than 130 oral presentations and nearly 200 poster presentations.

The program for ISMAR 2004 emphasized exciting new developments in technology ranging from magnetic resonance force microscopy to laser assisted NMR; from very fast MAS to rapid scan EPR; and much, much more. Exciting applications in the spectroscopy of supercooled samples were also featured, along with new opportunities for spectroscopy of quadrupolar nuclei, and membrane proteins and other proteins or protein aggregates that are difficult or impossible to crystallize.

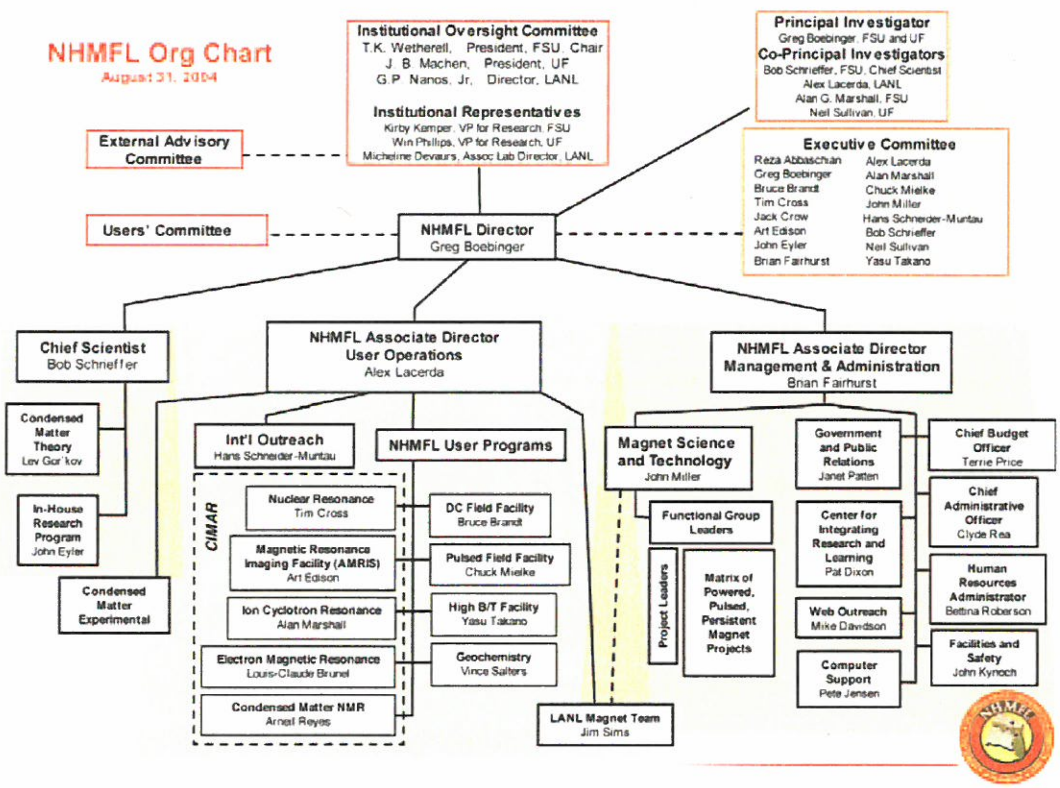
Conference participants had numerous opportunities for cross fertilization among the different magnetic resonance technologies and the scientific disciplines that were represented. The conference was generously supported by a number of key vendors, Florida State University, and the University of Florida.

Chapter 9
MANAGEMENT & ADMINISTRATION

The NHMFL is operated for the National Science Foundation (NSF) by a collaboration of institutions comprising Florida State University (FSU), the University of Florida (UF), and Los Alamos National Laboratory (LANL) under a **Cooperative Agreement** that sets forth the goals and objectives of the NHMFL. FSU, as the signatory of the Cooperative Agreement, has the responsibility for establishing and maintaining the appropriate administrative and financial oversight and ensuring that the operations of the laboratory are of high quality and consistent with the broad objectives of the Cooperative Agreement.

Organization

As shown in the NHMFL Organization chart, Dr. Gregory Boebinger reports to the **Institutional Oversight Committee** (IOC) and serves as the principal investigator and Director of the NHMFL. The IOC meets annually, or as necessary, to review the relationships between the NHMFL and the participating institutions. The committee provides the laboratory with policy guidance and advice and may request and receive periodic reports from management on certain issues. Within the FSU structure, the NHMFL is a department in the university's Office of Research.



Additional oversight of the NHMFL is provided by the **External Advisory Committee** (EAC) and **Users' Committee** (UC). The EAC provides an outside evaluation of the NHMFL and recommends changes, as appropriate. The committee comprises representatives from academic, government, and industrial organizations and includes the chairman of the UC. It meets annually, or as necessary, to review the quality of the In-House Research Program (IHRP), cooperation with industry, educational activities, and the relationship between FSU and the NHMFL. The members of UC are elected by the NHMFL user community and reflect a broad range of users including the users of continuous field and pulsed field facilities, the ultra high B/T facilities and the Center for Interdisciplinary Magnetic Resonance (CIMAR) instruments. The UC meets twice each year to provide guidance on the development and use of NHMFL facilities and services in support of the users. The Chair of the UC represents users' interests during NSF Site Visits and is a member of the External Advisory Committee. The activities of the UC are supported by the Director of the Pulsed Field facilities and the Director of Continuous Fields.

Three senior faculty members serve as co-principal investigators: Alan Marshall (FSU), J. Robert Schrieffer (FSU and UF), and Neil Sullivan (UF). The Director of the NHMFL (and principal investigator) makes the budgetary and operational decisions of the laboratory based on various formal and informal mechanisms for input and advice. A key committee used to support this process is the **Executive Committee** (EC), which is chaired by the Director of the NHMFL. Other committee members include the Co-PI's, the Chief Scientist, Associate Directors and the leaders of the NHMFL functional organizations. The EC advises the Director of the NHMFL in areas of policy and broad objectives regarding operations, staffing, resource allocation, visiting scientist support, and research. It assists in developing interactions with the private sector and participates in the development of multi-agency federal collaborations. The EC advises the Director on NHMFL responses to directions and advice received from outside oversight committees.

In August 2004, a new organizational structure was implemented that emphasizes the three-site nature of the NHMFL and which provides the Director day-to-day assistance and counsel in allocating resources to the various laboratory functions, setting goals and objectives for the operating functions. Two new positions - Associate Directors - have been established, which replace the Deputy Director and Chief Administrative Officer positions. In addition, these new positions have an increased span of control relative to the positions being replaced and reduce the number of direct reports to the Director. Alex Lacerda maintains his appointment as Director of the Pulsed Field Facility and assumed NHMFL-wide responsibilities as **Associate Director for User Operations**. Brian Fairhurst is the **Associate Director for Management and Administration.**

Budget

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.[3] The renewal period is from January 1, 2001 through December 31, 2007 (in 2004 the NSF approved two additional years of funding). Table 1 provides a comparison of the current NSF award with the previous five-year award. Table 2 presents the NSF funding for the five-year period.

Table 1. NHMFL NSF Budget Comparison (with overhead distributed to programs)

Division/Program	**1996 - 2000 5-Yr NSF Summary**	**% of BGT**	**2001 - 2007 7-Yr NSF Summary**	**% of BGT**
Director	$2,912,811	3.33%	$7,098,245	4.13%
Unassigned Budget	0	0.00%	(126,968)	(.07)%
Facilities & Admin	5,698,737	6.51%	13,226,803	7.69%
Instruments & Operations	18,366,654	20.99%	29,053,666	16.89%
Instruments & Operations				
Electrical Power for DC Facility	7,918,471	9.05%	20,965,943	12.19%
Magnet Science & Technology	22,122,487	25.28%	32,364,499	18.81%
FSU - IHRP	7,343,739	8.39%	8,645,988	5.03%
LANL	20,838,959	23.82%	37,190,617	21.62%
LANL – IHRP[1]			985,701	0.57%
CIMAR – NMR -FSU	361,550	0.41%	7,159,731	4.16%
CIMAR - EMR	248,902	0.28%	1,706,194	0.99%
CIMAR – ICR[2]	175,650	0.20%	6,902,263	4.01%
CIMAR –NMR -UF - AMRIS	812,414	0.94%	3,332,327	1.94%
UF - High B/T	699,626	0.80%	1,486,792	.86%
UF – IHRP[1]			2,029,388	1.18%
Total NSF Cooperative Agreement[3]	**$87,500,000**	**100.00%**	**$172,021,189**	**100.00%**

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

2 ICR Facilities
although all the funding was received by 12/31/2003.

3

Baseline budget	$117,500,000
Amendments:	
Eglin AFB	49,917
Electricity	1,470,000
RET Program	501,272
Additional 2 years funding	52,500,000
Amended Budget	$172,021,189

Table 2. NHMFL NSF Budget by Program (with overhead separate from programs)

Division/Program	2001	2002	2003	2004	2005	2006	2007	Total Budget
Director	$407,208	$313,320	$115,223	$478,672	$719,507	$723,195	$736,192	$3,493,317
CIRL	225,379	198,611	142,872	329,769	201,040	200,586	204,598	1,502,855
Unassigned Budget[1]	(2,780,994)	(596,653)	2,071,302	1,441,535	716,252	(384,873)	(97,291)	369,278
Facilities & Admin	1,374,631	1,253,506	960,122	1,314,968	1,503,092	1,503,983	1,525,926	9,436,228
Instruments & Operations	2,771,403	3,888,227	2,326,974	2,913,482	2,792,733	2,725,650	2,773,346	20,191,815
Instruments & Operations – Electricity for DC Facility	1,900,000	1,600,000	3,020,000	3,074,000	3,606,809	3,787,149	3,976,507	20,964,465
Magnet Science & Technology[5]	4,130,929	4,906,176	3,650,610	3,312,840	1,811,123	3,109,688	3,148,456	24,069,822
Science	880,889	1,037,627	813,047	874,041	800,767	1,758,806	1,291,140	7,456,317
LANL[2]	4,575,655	6,436,905	5,083,545	5,164,502	5,232,012	5,302,063	5,395,935	37,190,617
LANL IHRP[3]	397,107		209,802	92,000	286,792			985,701
CIMAR–NMR-FSU	338,597	595,990	501,271	832,097	1,015,906	989,881	996,662	5,270,404
CIMAR-EMR	81,473	95,650	135,388	221,880	218,258	216,075	216,692	1,185,416
CIMAR-ICR[4]	1,533,358	49,248	46,311	370,541	1,084,451	1,081,622	1,095,283	5,260,814
CIMAR-NMR-UF-AMRIS	303,110	312,202	320,288	291,161	634,532	699,423	771,611	3,332,327
UF–High B/T[2]	182,527	188,003	597,352	(147,833)	218,879	222,226	225,640	1,486,794
UF IHRP[3]	148,199	219,090	434,810	572,470	654,819			2,029,388
Overhead	3,686,446	4,578,098	3,677,083	3,547,147	4,003,028	4,064,526	4,239,303	27,795,631
Total	**$20,155,917**	**$25,076,000**	**$24,106,000**	**$24,683,272**	**$25,500,000**	**$26,000,000**	**$26,500,000**	**$172,021,189**

1 Projected budget balance in Unassigned Budget will be used primarily to offset unanticipated electricity cost increases, as well other unanticipated costs.

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

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

4 ICR Facilities budget does not inc[illegible]
funding was received by 12/31/2003.

5 In 2005 MS&T's budget allocation was reduced due to carry-forward budget from previous years.

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. The significant increase in funding between the two fiscal years is due to funding provided by the Florida Legislature to the NHMFL for infrastructure upgrades. This $10M investment by the State of Florida will bring the DC power generation up-to-date by refurbishing and **increasing both electrical and cooling capacities** to run existing magnets for longer experiments and to provide the platform for future research at magnetic fields unattainable with our current 40 MW capacity. These funds were secured only through the considerable efforts of the highest administrators at both Florida State University and the University of Florida, including FSU President Wetherell and UF President Machen.

Table 3. Fiscal Year 2004/2005 State of Florida Matching and Contribution

	State Matching	State Contribution	Total State Funding
State of Florida recurring funds cost sharing	$4,492,318	$2,454,801	$6,947,119
State of Florida infrastructure funding		10,000,000	10,000,000
Indirect Cost (51%)	2,291,082	6,351,949	8,643,031
Total	**$6,783,400**	**$18,806,750**	**$25,590,150**

Program Budget Discussion

Calendar year 2004 is the fourth year of the current grant award from the National Science Foundation, in the amount of $24,683,272. This includes the National Science Board approved allocation of $24,500,000 plus supplemental funding in the amount of $183,272 for the RET (Research Experience for Teachers) Program. The NHMFL also receives an annual operating budget from the State of Florida through Florida State University. In fiscal year 2003/2004, the State budget was $6,835,981, and was $16,947,119 for fiscal year 2004/2005 (excluding overhead).

TABLE 4. NHMFL Program Budget by Source (budget allocation by program)

Program	NSF Budget Calendar Year 2004	State Matching Fiscal Year 2004/2005	State Contributed Fiscal Year 2004/2005	Total Budget
Director	$478,672	$1,720,147	$800,241	$2,999,060
CIRL	329,771	102,600	47,731	480,102
Unassigned Budget	1,441,535			1,441,535
Facilities & Admin	1,314,968	306,300	142,496	1,763,764
Instruments & Operations	2,913,482	430,584	200,315	3,544,381
Instruments & Operations - Electrical Power for DC Facility	3,074,000			3,074,000
M S & T	3,312,840	331,969	426,347	4,071,156
Science	874,041	600,561	279,391	1,753,993
LANL (Subcontract)[1]	5,164,502			5,164,502
LANL IHRP	92,000			92,000
CIMAR - Administration		3,071	1,429	4,500
CIMAR - NMR	832,097	453,557	303,992	1,589,646
CIMAR - EMR	221,880	244,808	113,889	580,577
CIMAR - ICR Facilities	370,541	232,242	108,043	710,826
CIMAR - Geochemistry		66,479	30,927	97,406
CIMAR - NMR @ UF - AMRIS[2]	291,161			291,161
UF- High B/T[3]	(147,834)			(147,834)
UF IHRP	572,470			572,470
Infrastructure			10,000,000	10,000,000
Overhead[4]	3,547,146	2,291,082	6,351,949	12,190,177
Total	**$24,683,272**	**$6,783,400**	**$18,806,750**	**$50,273,422**

1 LANL's contribution to the Pulsed Magnet Program was $5M in 2004.
2 UF's contribution to AMRIS was $0.3 million in 2004.
3 UF's contribution to the High B/T program was $0.5M in 2004. The negative budget balance reflects adjustments to budgets for prior years.
4 The NSF Budget includes overhead, and the equivalent overhead is included in the state budget to reflect the total state support. FSU's federally negotiated overhead rate is 51%.

Table 5 summarizes the NHMFL budget position at the end of 2004. The budget balance represents major equipment purchases that were deferred in 2002 through 2004, and which are projected to be spent in 2005.

Table 5. Cumulative NSF Budget and Expenses (1/1/2001 – 12/31/2004)

Expense Classification	Budget	Spent and Encumbered	Balance 12/31/2004
Salaries, Wages & Benefits	$21,932,775	$20,869,980	$1,062,795
Subcontracts	26,541,463	25,656,346	885,117
Capital Equipment	10,019,977	8,791,244	1,228,733
Other Direct Cost	20,038,199	18,060,518	1,977,681
Subtotal	**78,532,414**	**73,378,088**	**5,154,326**
Overhead	15,488,774	14,452,940	1,035,834
Total	**$94,021,188**	**$87,831,028**	**$6,190,160**
Program Income	$336,048		

Program Budgets

Director's Office

The Director's Office includes the Director, Associate Director for Management and Administration, Budget Administration, Government and Public Relations, 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 Government and Public Relations is responsible for the NHMFL's public relations and support including monitoring legislative issues, web application development and upgrades, media graphics and publication support. The Visiting Scientist's 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 2004	State Matching Budget 2004/2005
Director - Admin	400,439	1,153,187
Budget Administration	37,772	120,240
Visitor's Program	0	261,919
Director's Research	40,461	85,664
Unallocated Budget	1,441,535	
Total	**1,920,207**	**1,621,010**
State Contribution		754,122

Center for Integrating Research and Learning (CIRL)

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

The Optical Microscopy Resource Center (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. Eighty percent of the costs associated with the OMRC are offset with funding from other sources.

Table 7. Center for Integrating Research and Learning Program Budget

Program	NSF Budget 2004	State Matching Budget 2004/2005
Education	254,618	102,600
REU Program	70,725	
Optical Microscopy		99,137
Total	**329,769**	**201,737**
State Contribution		93,851

Facilities and Administration

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

Table 8. Facilities and Administration Program Budget

Program	NSF Budget 2004	State Matching Budget 2004/2005
UBA	636,898	114,007
Facilities	575,043	153,257
Safety	103,027	39,036
Total	**1,314,968**	**306,300**
State Contribution		142,496

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, as well as the Millikelvin facility. This unit also provides machine shop, electronics, cryogenic systems support, and computer networking support. Most of the staff is dedicated to supporting user activities. 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 2004	State Matching Budget 2004/2005
Administration	253,139	20,475
Computer Services	262,807	
Cryogenics	398,003	
Electronics	246,861	
Magnet Operations	310,929	
Electrical Power for DC Magnets	3,074,000	
Mechanical Instruments	272,098	
User Services	1,169,645	410,109
Total	**5,987,482**	**430,584**
State Contribution		200,315

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 2004	State Matching Budget 2004/2005
Admin/Operations	1,267,302	331,969
Pulsed Magnets	538,801	
Powered Magnets	1,224,712	
Persistent Magnets	113,154	
Work for Others	168,871	
Total	**3,312,840**	**331,969**
State Contribution		426,347

Science Program

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

Table 11. Science Program Budget

Program	NSF Budget 2004	State Matching Budget 2004/2005
Administration	74,046	204,748
In-House Research Program	799,995	
Condensed Matter Theory		265,701
Condensed Matter Experimental		130,112
Total	**874,041**	**600,561**
State Contribution		279,391

Pulsed Field Facility – Los Alamos

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 overhead 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 works closely with members of the NHMFL Magnet Science and Technology group in Tallahassee to advance pulsed magnet technology and materials for these unique systems. Special staffing is also required to maintain the 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 2004	State Matching Budget 2004/2005
Facilities & Admin	2,587,964	
User Operations	1,953,493	
Pulsed Magnets	623,045	
IHRP	92,000	
Total	**5,256,502**	
LANL Contribution		5,064,000

Center for Interdisciplinary Magnetic Resonance

CIMAR represents all areas of magnetic resonance techniques and has made significant advances in building a user program that involves interdisciplinary activities with physics, geochemistry, chemistry, biology, and engineering. The program focuses on nuclear magnetic resonance (NMR), electron magnetic resonance (EMR), ion cyclotron resonance mass spectroscopy (ICR-MS), 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 ICR-MS facilities are primarily supported by a separate Chemistry Division NSF Facilities grant award. The ICR Facilities award began being rolled into the funding of the current NHMFL core grant beginning in FY2003. 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 2004	State Matching Budget 2004/2005
Administration		3,071
NMR Program	832,097	453,557
ICR Program	370,541	232,242
EMR Program	221,880	244,808
Geochemistry		66,479
AMRIS (UF)	291,161	
Total	**1,715,679**	**1,000,157**
State Contribution		558,280
UF Contribution		321,077

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 14/15.5 T magnet to conduct experiments at both high magnetic fields and low temperatures simultaneously, namely at a few 100's microkelvin. The negative budget balance is a result of budget adjustments to prior years.

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 initial 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 the fractional quantum Hall effect, transport in polarized Fermi liquids, non-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.

Table 14. High B/T Program Budget

Program	NSF Budget 2004	State Matching Budget 2004/2005
High B/T User Support	(147,834)	
IHRP	572,470	
Total	**424,636**	
UF Contribution		494,348

Program Budgets

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

Overhead Rates: The Florida State University's federally negotiated overhead rate is 51% for 2004. The institutional overhead rate used for costs at University of Florida is 45%, and for Los Alamos it is 96.5% (which includes infrastructure tax, division tax, and general and administrative tax).

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

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

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

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

Fringe Benefits: Fringe benefits for Florida personnel are based on actual costs of fringe benefits for permanent employees (averaging 28%) and temporary employees (8% average). Fringe benefit costs for LANL employees are included in the average salary rates for each class.

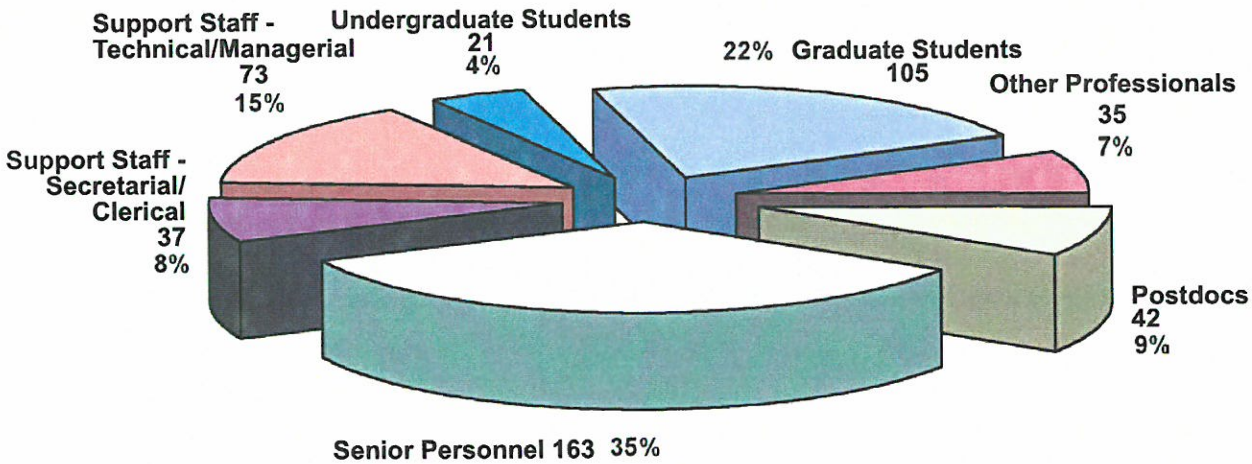
Administrative and Facility Maintenance Costs: Certain administrative and facility maintenance costs are accrued solely for the benefit and function of the NHMFL. These costs are included as direct costs in the budget estimates as allowed by the OMB regulations.

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

Staffing

The NHMFL annually evaluates staffing levels and distribution relative to the priorities of the laboratory and user activities. During 2004, NHMFL Staff comprised 476 faculty, staff, and affiliates; this was a small increase from the 2003 level of 471 faculty, staff, and affiliates. During the past year, the NHMFL played a major role in the **hiring of new Florida State University faculty:** in Chemistry and Biochemistry (Rafael Brüschweiler), Geochemistry (Professor Munir Humayun) and Physics (Irinel Chiorescu). In addition, the NHMFL is playing a role in several promising ongoing searches: in Physics, Mechanical Engineering, Chemical and Biomedical Engineering, and Industrial Engineering. Last year, the NHMFL also attracted to Florida State University **four new Scholar-Scientists** of outstanding capability in the areas of nuclear magnetic resonance, condensed matter thermodynamics, ultrasound and infrared spectroscopy. Two additional Scholar-Scientist searches are underway, in magnetic resonance imaging and in condensed matter physics magnetization.

NHMFL Staffing
Personnel at FSU, UF, and LANL
Distribution By NSF Classification
December 31, 2004
Total Personnel = 476



In June 2004, the NHMFL launched a College Outreach – Workforce Initiative (CO-WIN) Program to help ensure diversity in future generations of scientists, engineers, and educators. In addition to sponsoring lectures at historically Black, Hispanic and Native American colleges and universities, three NHMFL educational programs are helping to increase diversity in NHMFL research programs. These are the NHMFL Research Experiences for Undergraduates (REU) program, the NHMFL Research Experiences for Teachers (RET) program, and the NHMFL Visiting Scientist Program (VSP).

The NHMFL management is committed to expanding and maintaining a diverse and inclusive organization to ensure a broad pool of highly qualified candidates and to retain the critical and high-performance skills needed to operate the laboratory. It is also committed to providing an enriching environment for undergraduate and graduate students to explore research opportunities and to encourage them to remain committed to securing the highest degree possible.

Specific activities during 2004 concerning the CO-WIN Program included selecting members and convening the Diversity Task Force (October 11, 2004) and Diversity Steering Committee (November 8, 2004).

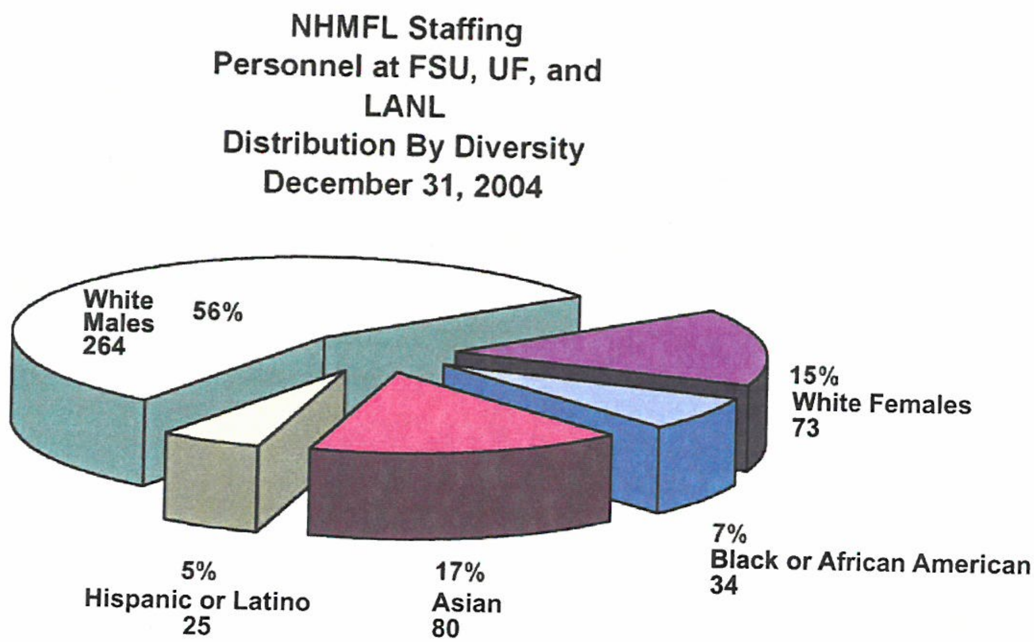
The NHMFL has a Diversity Lectures web page titled **College Outreach - Workforce Initiative (CO-WIN) Program (**http://education.magnet.fsu.edu/**).** This Web site is available to: (a) to advertise this program; and (b) for students at the institutions visited to provide feedback. Under the **CO-WIN program**, NHMFL scientists and engineers travel to Women's Colleges, Historically Black Colleges and Universities, and Minority Serving Institutions to present directly to undergraduate student audiences the wide range of NHMFL-related career development opportunities available in collaboration with the academic degree programs at Florida State University and Florida A&M University.

The laboratory also hosted the final Florida-Georgia Louis Stokes Alliance for Minority Participation event of the year on December 1, 2004. There was a short presentation from several scientists from the lab. Following the program these scientists talked individually with the students in attendance. Students were able to inquire about research internships and get answers to questions about career paths in science, technology, engineering and math (STEM). There were approximately 35 students in attendance, mainly from Florida State University and Florida A&M University.

A review of NHMFL Staff distribution by diversity (Table 15) provides a comparison between 2003 and 2004 staffing levels.

Table 15. Diversity Distribution of NHMFL Staff

	2003	2004
White	344 (74%)	337 (71%)
Hispanic or Latino	21 (4%)	25 (5%)
Asian	76 (16%)	80 (17%)
Black or African American	30 (6%)	34 (7%)



Chapter 10
Science & Research Productivity

The laboratory continued its strong record of publication, presentations, and related activities. The table below summarizes these activities; the citations follow in this chapter. For additional information, to search the laboratory's publication database, and to read many articles online, refer to the NHMFL Web site: www.magnet.fsu.edu (/search/publications/).

2004 NHMFL Activities

	Number Reported	Page No. for Citations List
Publications in Peer-Reviewed Journals	392	118
Presentations, Posters, & Other Publications	433	128
Books & Book Chapters	6	142
Internet Disseminations	3	143
Patents	6	143
Awards	20	143
Dissertations, Ph.D.	16	143
Theses, Master	5	144

Of the 392 publications reported by NHMFL-affiliated faculty and users, 117 appeared in some of the most significant science and major disciplinary journals:

- *5 articles in Analytical Chemistry*
- *3 Europhysics Letters*
- *3 Journal of Biological Chemistry*
- *10 Journal of Magnetic Resonance*
- *1 Journal of Neuroscience*
- *6 Journal of the American Chemical Society*
- *2 Journal of the American Society for Mass Spectrometry*
- *2 Magnetic Resonance in Medicine*
- *3 Nature*
- *1 Nature Structural & Molecular Biology*
- *46 Physical Review B*
- *29 Physical Review Letters*
- *1 Proceedings of the National Academy of Sciences of the United States of America*
- *5 Science*

Grant information, which was received from the Florida State University and University of Florida's respective Offices of Sponsored Research, is also presented in this chapter beginning on page 144.

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Cao, J., *Femtosecond electron diffraction probing of lattice dynamics (Talk)*, 2004 Workshop on Ultrafast X-Ray Science, San Diego, CA, April 29 - May 1 (2004)

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Xiong, Y.; Chalmers, M.J.; Gao, F.P.; Cross, T.A. and Marshall, A.G., *ESI FT-ICR and LC-LTQ Mass Spectrometry Identification of Mycobacterium tuberculosis H37Rv Membrane Proteins*, 52nd American Society for Mass Spectrometry Annual Conference on Mass Spectrometry and Allied Topics, Nashville, TN, May 23-27 (2004)

Xu, J.; Celik, D.; Hussaini, M.Y. and Van Sciver, S.W., *Liquid Hydrogen Droplet Generation from a Vibrating Orifice*, ICEC-20, Beijing, China, May 11-14 (2004)

Yang, K., *Theory of Ferromagnetic Transition in One-Dimensional Itinerant Electron Systems*, 4th annual workshop of the International Center for Quantum Structures of Academia Sinica, Beijing, China, June 15 (2004)

Yang, K., *Theory of Ferromagnetic Transition in One-Dimensional Itinerant Electron Systems*, 4th Joint Meeting of Chinese Physicists World-Wide, Shanghai, China, June 30 (2004)

Yang, K., *Theory of Ferromagnetic Transition in One-Dimensional Itinerant Electron Systems*, Yukawa International Seminar 2004: Physics of Strongly Correlated Electron Systsms, Kyoto, Japan, November 15 (2004)

Yang, K., *Valence Bond Glass States in Disordered Spin Systems*, Symposium on Valence Bonds in Condensed Matter, Princeton, NJ, December 3 (2004)

Yang, K.; Wan, X.; Melikidze, A. and Rezayi, E., *Reconstruction of Fractional Quantum Hall Edges*, 16th Int. Conf. on High Magnetic Fields in Semiconductor Physics, Tallahassee, FL, August 2 (2004)

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Yanofsky, C.M.; Kearney, R.E.; Bell, A.W.; Morales, F.; Lam, T.-K.T.; Blakney, G.T.; Marshall, A.G.; Carrillo, B.; Lekpor, K. and Boismenu, D., *Determination of the Systematic and Random Measurement Error in an LC-FTICR Mass Spectrometry Analysis of a Partially Characterized Complex Peptide Mixture*, 26th Annual International Conference IEEE Engineering in Medicine and Biology Society., San Francisco, CA, September 1-5 (2004)

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McDonald, R.D.; Harrison, N.; Goddard, P.; Singleton, J. and Chi, X., *Absence of field-induced charge-density wave states in $(Per)_2Pt(mnt)_2$*, http://arXiv.org/abs/ cond-mat/0408408, (2004)

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Patents & Other Products

Akhmeteli, A.M. and Gavrilin, A.V., *"Layered Shell Vacuum Balloons"*, US Patent Application Serial No. 60/570753, Filing Date of 05/13/2004. (2004)

Beu, S.C.; Blakney, G.T.; Quinn, J.P.; Hendrickson, C.L. and Marshall, A.G., *"Phase Correction of FT-ICR Mass Spectra via Simultaneous Excitation and Detection"*, Disclosure submitted February 2004. U.S. Provisional Patent Application No. 60/542,213 (2004)

Bird, M.D.; Dixon, I.R.; Eyssa, Y.M.; Gavrilin, A.V., and Gundlach, S.R., *"Repeating Pulsed Magnet"*, U.S. Patent No. 6,720,552 B2 Awarded April 13 (2004)

Harrison, N.; Singleton, J. and Migliori, A., *"Quantum coherent switchutilizing commensurate nanoelectrode and charge density periodicities"*, U.S. patent 60/485,370 (2003). Converted to full patent July 2004. (2004)

Markiewicz, W.D.; Dixon, I.R.; Swenson, C.A.; Marshall, W.S.; Walsh, R.P.; Painter, T.A. and Van Sciver, S., *"Method of manufacturing a superconducting magnet"*, U.S. Patent No. 6,735,848 B1 Awarded May 18, 2004 (2004)

Painter, T.A., *"Wire-In-Conduit Magnetic Conductor Technology"*, Patent application Serial # 60/557,604 (2004)

Awards, Honors & Service

Alverez, Gonzalo, Outstanding Dissertation Award in Magnetism from the APS Magnetism Topical Group (2004)

Ascher, Jennifer, Florida State University Presidential Research Fellowship (2004)

Bowers, Clifford R., Alliance for Graduate Education and the Professoriate, The University of Florida-National Science Foundation (2004)

Gao, Xuan, 2004 Robert Simon Memorial Prize awarded by Columbia University's Department of Applied Physics and Applied Mathematics (2004)

Gor'kov, L.P., Eugene Feenberg Medal (2004)

Håkansson, K., Searle Scholar (2004)

Hebard, Arthur, University of Florida Research Foundation Professor (2004-2007)

Hirschfeld, Peter J., American Physical Society Fellow (2004)

Hu, Jun, ENC Student Travel Award (2004)

Lee, Yoonseok, Alfred P. Sloan Research Fellow (2004-2006)

Manousakis, Efstratios, Florida State University Donald Robson Professor of Physics (2004)

Marshall, Alan, Society for Applied Spectroscopy Fellow (2004)

Marshall, Alan, Southern Chemist Award, awarded by the American Chemical Society Memphis Section (2004)

Rikvold, Per Arne, Elected Member of Norwegian Academy of Science and Letters (2004)

Schrieffer, J. Robert, Florida State University Robert A. Holton Medal for Distinguished Research Service (2004)

Schwartz, J., Institute of Electrical and Electronics Engineers Fellow (2004)

Song, Likai, Florida State University Biology Department Outstanding Graduate Student Award (2004)

Song, Likai, Student Achievement Award of the Biophysical Society (2004)

Stewart, Greg, University of Florida College of Liberal Arts and Sciences, Term Professorship Award (2004)

Wang, Yayu, Miller Research Fellowship, University of California at Berkeley Pappalardo Fellowships in Physics, MIT (declined) (2004-2007)

Ph.D. Dissertations

Caldwell, Joshua D., *"Investigations of Electron-Nuclear Spin Interactions in Two-Dimensional Electron Systems via Magnetoresistively Detected Magnetic Resonance"*, University of Florida, Chemistry, advisor: Clifford R. Bowers (2004)

Caldwell, Tod, *"Nuclear Magnetic Resonance Studies of Field Effects on Single Crystal SmB_6"*, Florida State University, Physics, advisors: Arneil P. Reyes and William G. Moulton (2004)

Green, Terry, *"Structure-Function Studies of IA3, a Potent Inhibitor of Yeast Proteinase A"*, University of Florida, Interdisciplinary Program in Biomedical Sciences, advisor: Art Edison (2004)

Kang, Haeyong, *"Study of the Effect of Weak Periodic Potential on the Low-Dimensional Electronic Transport"*, Ewha University, Physics, advisor: Woun Kang (2004)

Lee, Jong Seok, *"Optical Investigation on Novel Phenomena of the Perovskite and Pyrochlore Ruthenates"*, Seoul National University, Physics, advisor: T. W. Noh (2004)

McFarland, Melinda, *"Fourier Transform Ion Cyclotron Resonance Mass Spectrometry Instrumentation and Methods for Structural Characterization of Trapped Biomolecular Ions: Innovative MS/MS Techniques, Gas-Phase Hydrogen/D"*, Florida State University, Chemistry and Biochemistry, advisor: Alan G. Marshall (2004)

Ozarslan, E., *"Developments in Diffusion Weighted Magnetic Resonance Imaging (MRI) with Applications to Neural Tissue"*, University of Florida, Physics, advisor: Thomas H. Mareci (2004)

Park, Jung-Ho, *"Electronic and Scanning Tunneling Spectroscopic Studies of Conducting Polymer Nanostructures: Polyacetylene Nanofibers, PPV Nanotubes, and MEH-PPV Nanowires"*, Seoul National University, Physics, advisor: Yung Woo Park (2004)

Patel, Anilkumar, *"Nuclear magnetic resonance study of optically pumped semiconductors"*, University of Florida, Chemistry, advisor: Clifford R. Bowers (2004)

Schaub, Tanner, *"Field Desorption Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry"*, Florida State University, Chemistry and Biochemistry, advisor: Alan G. Marshall (2004)

Su, Jianhua, *"Fabrication and Characterization of Mercurocuprate Superconductors on Silver Substrates"*, Florida State University, Mechanical Engineering, advisor: Justin Schwartz (2004)

van der Laan, Daniel C., *"Flux Pinning and Connectivity in Polycrystalline High-Temperature Superconductors"*, University of Twente, Applied Physics & Low Temperature Division, advisor: Justin Schwartz (2004)

Wang, Yayu, *"The Nernst Effect in High Temperature Superconductors"*, Princeton University, Physics, advisor: Nai-Phuan Ong (2004)

Wu, Zhigang, *"Compositional Analysis of Complex Organic Mixtures by Electrospray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry"*, Florida State University, Chemistry and Biochemistry, advisor: Alan G. Marshall (2004)

Xu, Du, *"Magnetotransport and Tunneling Study of the Semimetals Bismuth and Graphite"*, University of Florida, Physics, advisor: Arthur F. Hebard (2004)

Zhou, Zhixian, *"Studies of Weakly Magnetic Systems of Transition Metal Oxides"*, Florida State University, Physics, advisor: Jack E. Crow (2004)

Master Theses

Castillo, Oscar, *"Microstructural and Superconducting Properties of V-doped MgB_2 Bulk and Wires"*, Florida State University, Mechanical Engineering, advisor: Justin Schwartz (2004)
Haraldsen, Jason, *"Low Energy Excitations in Spin Clusters and Molecular Solids"*, University of Tennessee, Physics, advisor: Janice L. Musfeldt (2004)
May, Shanna Marie, *"Gd-nitroxide Pairs for Protein-Membrane Studies: A Multifrequency EPR Approach"*, North Carolina State University, Chemistry, advisor: Tatyana I. Smirnova (2004)
Shetty, K.K., *"A Novel Algorithm for Uplink Interference Suppression using Smart Antennas in Mobile Communications"*, Florida State University, Electrical Engineering, advisor: Frank Gross (2004)
Wesolowski, Roman, *"Understanding the Dynamics of Molecular Solids"*, University of Tennessee, Physics, advisor: Janice L. Musfeldt (2004)

Grants Awarded to NHMFL-Affiliated Faculty at the Florida State University

As reported by FSU Office of Sponsored Research for calendar year 2004

PI: Bird, M.D.
Grant Title: Series Connected Hybrid
Agency: National Science Foundation
Project Dates: 7/15/2004-6/30/2005
Award: $908,438.00

PI: Boebinger, G.S.
Grant Title: Program Income for Mag Lab
Agency: Various Sources (Royalties/Other)
Project Dates: 12/2/1995-6/30/2004
Award: $10,420.19

PI: Boebinger, G.S.
Grant Title: National High Magnetic Field Laboratory
Agency: National Science Foundation
Project Dates: 1/1/2001-12/31/2005
Award: $24,500,000.00

PI: Boebinger, G.S.
Grant Title: Research Experiences for Teachers Summer Internship Program
Agency: National Science Foundation
Project Dates: 4/1/2002-12/31/2005
Award: $183,272.00

PI: Bonesteel, N.E.
Grant Title: Correlated Electrons in Reduced Dimensions
Agency: U. S. Department of Energy
Project Dates: 6/1/1997-7/31/2005
Award: $398,215.00

PI: Bonesteel, N.E.
Grant Title: Zeoitic Materials for Nanoscale Electronics and Quantum Computation
Agency: Ohio University
Project Dates: 8/1/2001-7/31/2005
Award: $219,237.00

PI: Bonesteel, N.E.
Grant Title: PEG - Quantum Computing with Biomolecules
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2004
Award: $65,000.00

PI: Bonesteel, N.E.
Grant Title: Quantum Computing with Biomolecules
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2005
Award: $35,000.00

PI: Brandt, B.L.
Grant Title: Series Connected Hybrid
Agency: National Science Foundation
Project Dates: 7/15/2004-6/30/2005
Award: $908,438.00

PI: Brey, W.W.
Grant Title: High Field Magnetic Resonance Research and Technology
Agency: University of Florida
Project Dates: 5/1/2002-4/30/2005
Award: $114,331.00

PI: Brooks, J.S.
Grant Title: A Solid State Phonon Engineering Approach to Organic Superconductors
Agency: University of Kentucky Research Foundation
Project Dates: 6/26/2002-6/25/2004
Award: $177,231.00

PI: Brooks, J.S.
Grant Title: Electronic Magnetic and Thermodynamic Properties of Molecular Solids
Agency: National Science Foundation
Project Dates: 11/1/2002
10/31/2005
Award: $230,000.00

PI: Brunel, L.C.
Grant Title: PEG - Quantum Computing with Biomolecules
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2004
Award: $65,000.00

PI: Brunel, L.C.
Grant Title: Quantum Computing with Biomolecules
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2005
Award: $35,000.00

PI: Cao, J.
Grant Title: PEG - The Study of Nanomaterials and Strongly Correlated Systems with Femtosecond Spectroscopy and Electron Diffraction
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2004
Award: $93,000.00

PI: Cao, J.
Grant Title: The Study of Nanomaterials and Strongly Correlated Systems with Femtosecond Spectroscopy and Electron Diffraction
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-5/31/2005
Award: $7,000.00

PI: Cao, J.
Grant Title: The Study of Ultrafast Structural Dynamics in Solid Materials with Femtosecond Electron Diffraction
Agency: National Science Foundation
Project Dates: 6/1/2003-5/31/2005
Award: $243,666.00

PI: Chapman, M.S.
Grant Title: Phosphagen Kinase Structure, Mechanism and Specificity
Agency: National Institute of General Medical Sciences
Project Dates: 3/1/1998-2/29/2004
Award: $745,733.00

PI: Chapman, M.S.
Grant Title: COE - Center for Biomolecular Computer Modeling and Simulation
Agency: Florida State University Research Foundation
Project Dates: 4/22/2000-6/30/2006
Award: $790,107.00

PI: Chapman, M.S.
Grant Title: Membrane Protein Structural Genomics: M. tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/2001-8/31/2005
Award: $4,646,231.87

PI: Chapman, M.S.
Grant Title: Structure-Function of AAV-A Viral Gene Therapy Vector
Agency: National Institute of General Medical Sciences
Project Dates: 12/16/2002-1/31/2005
Award: $542,648.00

PI: Chapman, M.S.
Grant Title: Lombricine Kinase Structure and Substrate Specificity
Agency: American Heart Association
Project Dates: 7/1/2003-6/30/2005
Award: $38,000.00

PI: Chapman, M.S.
Grant Title: A Computational Model of the Arginine Kinase Reaction
Agency: American Heart Association
Project Dates: 7/1/2004-6/30/2006
Award: $40,000.00

PI: Chapman, M.S.
Grant Title: Functional Dynamics of Arginine Kinase
Agency: American Heart Association
Project Dates: 7/1/2004-6/30/2006
Award: $40,000.00

PI: Cross, T.A.
Grant Title: Correlations: Structure Dynamics Functions in Channels
Agency: National Institute of Allergy & Infectious Diseases
Project Dates: 3/1/2000-2/28/2005
Award: $870,840.00

PI: Cross, T.A.
Grant Title: Membrane Protein Structural Genomics: M. tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/2001-8/31/2005
Award: $5,767,363.00

PI: Cross, T.A.
Grant Title: Membrane Protein Solid State NMR: PISEMA Development and the M2 Tetramer Structure
Agency: National Science Foundation
Project Dates: 2/1/2003-1/31/2006
Award: $516,254.00

PI: Cross, T.A.
Grant Title: Series Connected Hybrid
Agency: National Science Foundation
Project Dates: 7/15/2004-6/30/2005
Award: $908,438.00

PI: Dalal, N.S.
Grant Title: Undergraduate Education in Chemistry
Agency: Chemical Education Resources, Inc.
Project Dates: 6/13/1995-6/30/2004
Award: $4,258.50

PI: Dalal, N.S.
Grant Title: Undergraduate Education in Chemistry
Agency: Thomson Learning
Project Dates: 6/13/1995-6/30/2004
Award: $4,656.00

PI: Dalal, N.S.
Grant Title: Undergraduate Education in Chemistry
Agency: Various Sources (Business/Industry)
Project Dates: 6/13/1995-6/30/2007
Award: $14,362.56

PI: Dalal, N.S.
Grant Title: Compound Isolate Library
Agency: Alteon, Inc.
Project Dates: 7/1/1996-6/30/2006
Award: $8,500.00

PI: Dalal, N.S.
Grant Title: Quantum Effects in Single Molecule Magnets
Agency: New York University
Project Dates: 7/15/2001-6/30/2005
Award: $328,250.00

PI: Dalal, N.S.
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/2002-3/31/2012
Award: $68,774.00

PI: Dalal, N.S.
Grant Title: Electrical Transport and Raman Scattering Measurements on Single-Molecule Magnets
Agency: Ames Laboratory
Project Dates: 1/1/2003-9/30/2004
Award: $20,000.00

PI: Dalal, N.S.
Grant Title: Hydrides of Rare-Earth Metals and Their Alloys: Influence of Hydrogen Ordering on Physical Properties
Agency: U.S. Civilian Research & Development Foundation
Project Dates: 4/1/2003-9/30/2004
Award: $6,000.00

PI: Dalal, N.S.
Grant Title: Polynuclear Clusters of 3d and 4f Elements as Quantum Computing Materials
Agency: U.S. Civilian Research & Development Foundation
Project Dates: 4/1/2003-3/31/2005
Award: $1,400.00

PI: Dalal, N.S.
Grant Title: Nano-FRET: Analysis of Nucleoprotein Complexes
Agency: Nat'l. Institute of Biomedical Imaging and Bioengineering
Project Dates: 11/16/2003-3/31/2005
Award: $367,657.00

PI: Davidson, M.W.
Grant Title: Construction of Interactive Tutorials
Agency: Olympus America
Project Dates: 4/1/2000-3/31/2005
Award: $75,000.00

PI: Davidson, M.W.
Grant Title: MicroscopyU-Donated Equipment
Agency: Various Sources (Misc./Private)
Project Dates: 4/1/2000-3/31/2005
Award: $109,708.00

PI: Davidson, M.W.
Grant Title: MicroscopyU
Agency: Olympus America
Project Dates: 4/1/2000-3/31/2005
Award: $150,000.00

PI: Davidson, M.W.
Grant Title: Java and Web Interface Development for the Mic-D Microscope
Agency: Olympus Corporation
Project Dates: 4/1/2000-3/31/2005
Award: $177,500.00

PI: Davidson, M.W.
Grant Title: Olympus America Optical Microscopy Resource Center Website
Agency: Olympus America
Project Dates: 4/1/2000-3/31/2005
Award: $450,000.00

PI: Davidson, M.W.
Grant Title: MicroscopyU
Agency: NIKON, INC.
Project Dates: 4/1/2000-3/31/2005
Award: $817,642.33

PI: Dixon, P.J.
Grant Title: Research Experiences for Teachers
Agency: National Science Foundation
Project Dates: 4/1/2000-12/31/2005
Award: $212,000.00

PI: Dixon, P.J.
Grant Title: National High Magnetic Field Laboratory's Research Experiences for Teachers
Agency: National Science Foundation
Project Dates: 4/1/2002-3/31/2005
Award: $212,000.00

PI: Dixon, P.J.
Grant Title: Research Experiences for Teachers Summer Internship Program
Agency: National Science Foundation
Project Dates: 4/1/2002-12/31/2005
Award: $183,272.00

PI: Dobrosavljevic, V.
Grant Title: Theory of Metal-Insulator Transitions in Strongly Correlated Electronic Systems
Agency: National Science Foundation
Project Dates: 1/1/2003-12/31/2005
Award: $240,000.00

PI: Emmett, M.R.
Grant Title: PEG - Molecular Analysis of Smooth Muscle and Nonmuscle Cell Contractile Apparatus Proteins
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2005
Award: $100,000.00

PI: Engel, L.W.
Grant Title: Study of Composite Fermions in High Magnetic Fields at Low Temperatures
Agency: Princeton University
Project Dates: 1/15/2003-1/14/2006
Award: $111,000.00

PI: Fajer, P.G.
Grant Title: Orientation and Dynamics of Myosin Head Regulatory Domain
Agency: National Science Foundation
Project Dates: 9/1/1998-8/31/2004
Award: $851,000.00

PI: Fajer, P.G.
Grant Title: REU Supplement: Orientation and Dynamics of Myosin Head Regulatory Domain
Agency: National Science Foundation
Project Dates: 9/1/1998-8/31/2004
Award: $12,000.00

PI: Fajer, P.G.
Grant Title: PEG: Program in Real-Time Electron Paramagnetic Resonance for the Life and Chemical Sciences
Agency: Florida State University Research Foundation
Project Dates: 4/9/2001-9/30/2004
Award: $200,000.00

PI: Fajer, P.G.
Grant Title: Conformational Changes of Troponin Complex in Muscle Contraction
Agency: American Heart Association
Project Dates: 7/1/2003-6/30/2005
Award: $76,000.00

PI: Fajer, P.G.
Grant Title: EPR Studies of Protein-Protein Interactions: Distances, Orientation and Molecular Modeling
Agency: National Science Foundation
Project Dates: 3/1/2004-2/28/2006
Award: $794,212.00

PI: Fajer, P.G.
Grant Title: Conformational Change of Troponin I and its Interaction with Tropomyosin during Muscle Activation
Agency: American Heart Association
Project Dates: 7/1/2004-6/30/2005
Award: $80,000.00

PI: Fajer, P.G.
Grant Title: CW and Pulsed EPR Studies: Rotation of Regulatory Domain of Myosin in Contractile Cycle and Structure of the Two Heads in Smooth Muscle Myosin
Agency: American Heart Association
Project Dates: 7/1/2004-6/30/2006
Award: $80,000.00

PI: Fajer, P.G.
Grant Title: Structure and Function of Myosin Binding Protein C and Its Role in Familial Hypertrophic Cardiomyopathy
Agency: American Heart Association
Project Dates: 7/1/2004-6/30/2006
Award: $360,000.00

PI: Froelich, P.N.
Grant Title: Francis Eppes Professorship
Agency: Florida State University Research Foundation
Project Dates: 8/8/2003-12/31/2008
Award: $80,000.00

PI: Froelich, P.N.
Grant Title: Seawater History of Lithium Isotopes through the Mid-Cretacious
Agency: American Chemical Society
Project Dates: 9/1/2003-8/31/2005
Award: $79,000.00

PI: Froelich, P.N.
Grant Title: Cenozoic History of Lithium Isotopes
Agency: National Science Foundation
Project Dates: 11/1/2004-3/31/2005
Award: $14,087.00

PI: Fu, R.
Grant Title: Correlations: Structure Dynamics Functions in Channels
Agency: National Institute of Allergy & Infectious Diseases
Project Dates: 3/1/2000-2/28/2005
Award: $870,840.00

PI: Fu, R.
Grant Title: Membrane Protein Solid State NMR: PISEMA Development and the M2 Tetramer Structure
Agency: National Science Foundation
Project Dates: 2/1/2003-1/31/2006
Award: $516,254.00

PI: Fu, R.
Grant Title: *In-Situ* NMR Imaging of Lithium-Polymer Batteries during Charge and Discharge Cycle
Agency: General Technical Services
Project Dates: 3/15/2003-3/14/2004
Award: $30,840.00

PI: Gaffney, B.J.
Grant Title: Reactive Intermediates in Lipoxygenase Pathways
Agency: National Institute of General Medical Sciences
Project Dates: 4/10/2003-3/31/2005
Award: $844,546.00

PI: Gorkov, L.P.
Grant Title: Produce One 500 MHz 15N/1H PISEMA NMR Probe and One 500 MHz 31P/1H NMR Probe
Agency: Pacific Lutheran University
Project Dates: 7/14/2004-5/15/2005
Award: $28,000.00

PI: Gorkov, L.P.
Grant Title: 300 MHz PISEMA Solid State NMR Probe for Oriented Membrane Proteins
Agency: University of Massachusetts - Amherst
Project Dates: 10/1/2004-4/1/2005
Award: $16,177.00

PI: Hendrickson, C.L.
Grant Title: National High Field FT-ICR Mass Spectroscopy Facility
Agency: National Science Foundation
Project Dates: 1/1/2000-12/31/2004
Award: $3,317,724.00

PI: Humayun, M.
Grant Title: Platinum Group Element Geochemistry of High MGO Lavas
Agency: National Science Foundation
Project Dates: 7/1/2004-6/30/2005
Award: $81,016.00

PI: Kalu, P.N.
Grant Title: Cummins IUCRC Membership
Agency: Cummins Engine Co., Inc.
Project Dates: 8/1/2002-12/31/2004
Award: $80,000.00

PI: Kalu, P.N.
Grant Title: Magnetic Processing Influence on Phase Transformation Sequencing and Kinetics
Agency: UT-Battelle, LLC
Project Dates: 6/1/2003-9/30/2004
Award: $10,000.00

PI: Kalu, P.N.
Grant Title: Production of Seamless Superconducting Radio Frequency Cavities from Fine Grained Niobium
Agency: Black Laboratories, L.L.C.
Project Dates: 9/8/2004-3/31/2005
Award: $30,000.00

PI: Kuhns, P.
Grant Title: Studies of Ferromagnetic Films, Multilayers, and Interfaces by NMR in Systems of Importance for Spintronics Applications
Agency: Defense Advanced Research Projects Agency
Project Dates: 2/6/2003-5/5/2005
Award: $151,000.00

PI: Landing, W.M.
Grant Title: PEG: Developing Solid-State Microelectrode and Optical Waveguide Sensors for Measuring Trace Elements and Redox Species in Natural and Contaminated Waters
Agency: Florida State University Research Foundation
Project Dates: 4/22/2000-4/30/2004
Award: $42,810.00

PI: Landing, W.M.
Grant Title: REU Supplement Request: NSF OCE-0117655
Agency: National Science Foundation
Project Dates: 9/1/2001-8/31/2004
Award: $5,000.00

PI: Landing, W.M.
Grant Title: REU Supplement Request for NSF OCE-01117655
Agency: National Science Foundation
Project Dates: 9/1/2001-8/31/2005
Award: $5,000.00

PI: Landing, W.M.
Grant Title: Collaborative Research: Biogeochemistry of Trace Elements in the Western Pacific: Atmospheric Input and Upper Ocean Cycling
Agency: National Science Foundation
Project Dates: 9/1/2001-8/31/2005
Award: $248,268.00

PI: Landing, W.M.
Grant Title: Natural Mercury Isotopes as Tracers of Sources, Cycling, and Deposition of Atmospheric Mercury
Agency: Environmental Protection Agency
Project Dates: 10/1/2002-12/31/2005
Award: $827,147.00

PI: Landing, W.M.
Grant Title: REU Supplement Request for NSF OCE-0223378
Agency: National Science Foundation
Project Dates: 2/1/2003-1/31/2006
Award: $5,000.00

PI: Landing, W.M.
Grant Title: Collaborative Research: Global Ocean Survey of Dissolved Iron and Aluminum and Aerosol Iron and Aluminum Solubility Supporting the Repeat Hydrography (CO2) Project
Agency: National Science Foundation
Project Dates: 2/1/2003-1/31/2006
Award: $305,277.00

PI: Landing, W.M.
Grant Title: Apalachicola NERRS Nutrient Analysis Project 2003-2004
Agency: Florida Department of Environmental Protection
Project Dates: 3/1/2003-2/28/2004
Award: $24,900.00

PI: Landing, W.M.
Grant Title: IDS - A Workshop and Seminar Series Supporting the FSU Interdisciplinary Program in Biogeochemical Dynamics
Agency: Florida State University Council on Research Creativity
Project Dates: 2/1/2004-6/30/2005
Award: $24,943.00

PI: Landing, W.M.
Grant Title: Apalachicola NERRS Nutrient Analysis Project 2004-2050
Agency: Florida Department of Environmental Protection
Project Dates: 2/29/2004-2/28/2005
Award: $24,900.00

PI: Logan, T.M.
Grant Title: Support of General Research Projects
Agency: Lonza Biologics
Project Dates: 7/1/1999-12/31/2004
Award: $773.65

PI: Logan, T.M.
Grant Title: PEG: Program in Real-Time Electron Paramagnetic Resonance for the Life and Chemical Sciences
Agency: Florida State University Research Foundation
Project Dates: 4/9/2001-9/30/2004
Award: $100,000.00

PI: Logan, T.M.
Grant Title: High Field Magnetic Resonance Research and Technology
Agency: University of Florida
Project Dates: 5/1/2002-4/30/2005
Award: $228,662.00

PI: Logan, T.M.
Grant Title: Thermodynamic Characterization of SH3-like C-terminal Domain of Diptheria-toxin Repressor (DtxR) Binding to Internal Proline-rich Peptide
Agency: American Heart Association
Project Dates: 7/1/2002-6/30/2004
Award: $73,500.00

PI: Logan, T.M.
Grant Title: CW and Pulsed EPR Studies of DtxR: Tertiary Structure and Induced Conformational Changes upon Metal Binding
Agency: American Heart Association
Project Dates: 7/1/2003-6/30/2005
Award: $38,000.00

PI: Logan, T.M.
Grant Title: Bess Ward Fellowship and Thesis Awards
Agency: University Honors Program
Project Dates: 5/1/2004-6/30/2005
Award: $8,800.00

PI: Luongo, C.A.
Grant Title: Computer Simulation of Quench
Agency: Office of Naval Research
Project Dates: 11/9/2001-5/31/2007
Award: $651,881.62

PI: Luongo, C.A.
Grant Title: Development of Plastic Models for Micro-Scale Rotary Bearings
Agency: Sandia National Laboratories
Project Dates: 10/1/2004-7/30/2005
Award: $5,000.00

PI: Manousakis, E.
Grant Title: Predicting Static and Dynamic Critical Properties of Bulk and Confined Helium
Agency: National Aeronautics & Space Administration
Project Dates: 4/26/2001-4/30/2006
Award: $203,618.00

PI: Manousakis, E.
Grant Title: Solar-Hydrogen Energy System
Agency: Florida State University Research Foundation
Project Dates: 4/6/2004-6/30/2006
Award: $100,000.00

PI: Marshall, A.G.
Grant Title: National High Field FT-ICR Mass Spectroscopy Facility
Agency: National Science Foundation
Project Dates: 1/1/2000-12/31/2004
Award: $3,317,724.00

PI: Marshall, A.G.
Grant Title: REU Supplement to National High Field FT-ICR Mass Spectroscopy Facility
Agency: National Science Foundation
Project Dates: 1/1/2000-12/31/2005
Award: $24,690.00

PI: Marshall, A.G.
Grant Title: Travel Support for the Free Electron Laser-Fourier Transform Mass Spectrometer Facility in Nieuwegein, The Netherlands
Agency: National Science Foundation
Project Dates: 1/1/2000-12/31/2005
Award: $47,875.00

PI: Marshall, A.G.
Grant Title: National High Magnetic Field Laboratory
Agency: National Science Foundation
Project Dates: 1/1/2001-12/31/2005
Award: $43,500,000.00

PI: Marshall, A.G.
Grant Title: Membrane Protein Structural Genomics: M. tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/2001-8/31/2005
Award: $4,391,314.87

PI: Marshall, A.G.
Grant Title: ASMS (American Society for Mass Spectrometry) Activities
Agency: American Society for Mass Spectrometry
Project Dates: 9/20/2002-12/31/2005
Award: $8,400.00

PI: Marshall, A.G.
Grant Title: Dow Unrestricted Grant
Agency: Dow Chemical Company
Project Dates: 9/20/2002-12/31/2005
Award: $30,000.00

PI: Marshall, A.G.
Grant Title: Exxon Unrestricted Grant
Agency: Exxon Chemical Company
Project Dates: 9/20/2002-12/31/2005
Award: $30,000.00

PI: Marshall, A.G.
Grant Title: Exxon Unrestricted Grant
Agency: Exxon Mobile Foundation
Project Dates: 9/20/2002-12/31/2005
Award: $40,000.00

PI: Marshall, A.G.
Grant Title: Unrestricted funds from Schlumberger Doll Research
Agency: Schlumberger Doll Research
Project Dates: 9/20/2002-12/31/2005
Award: $40,000.00

PI: Marshall, A.G.
Grant Title: Proteomic Analysis of the Cardioprotective Mechanism Underlying Cariporide Inhibition of the Sodium Hydrogen Exchanger
Agency: American Heart Association
Project Dates: 7/1/2003-6/30/2005
Award: $74,000.00

PI: Marshall, A.G.
Grant Title: Membrane Protein structural Genomics: M. Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/1/2003-8/31/2005
Award: $71,864.00

PI: Marshall, A.G.
Grant Title: ExxonMobil Unrestricted Grant
Agency: Exxon Chemical Company
Project Dates: 9/20/2003-12/31/2005
Award: $30,000.00

PI: Marshall, A.G.
Grant Title: Program Income for 502460922
Agency: Various Sources (Royalties/Other)
Project Dates: 11/26/2003-12/31/2004
Award: $6,000.00

PI: Marshall, A.G.
Grant Title: Research Agreement between Korea Basic Science Institute and National High Magnetic Field Laboratory
Agency: Korea Basic Science Institute
Project Dates: 5/15/2004-11/15/2005
Award: $222,506.00

PI: Marshall, A.G.
Grant Title: Dissertation Enhancement Activities of Mr. Jose Valle for the Fall Semester 2004
Agency: National Science Foundation
Project Dates: 9/15/2004-8/31/2005
Award: $13,532.00

PI: Miller, J.R.
Grant Title: Series Connected Hybrid
Agency: National Science Foundation
Project Dates: 7/15/2004-6/30/2005
Award: $908,438.00

PI: Miller, J.R.
Grant Title: MTECH STTR
Agency: MTECH Laboratories, LLC
Project Dates: 12/1/2004-7/31/2005
Award: $30,000.00

PI: Moerland, T.S.
Grant Title: Research and Development
Agency: FSURF SRAD Distribution
Project Dates: 4/18/2002-3/31/2012
Award: $4,167.00

PI: Moerland, T.S.
Grant Title: High Field Magnetic Resonance Research and Technology
Agency: University of Florida
Project Dates: 5/1/2002-4/30/2005
Award: $114,331.00

PI: Moerland, T.S.
Grant Title: Actomyosin-Based Nano-Actuators
Agency: Defense Advanced Research Projects Agency
Project Dates: 6/27/2002-1/31/2004
Award: $427,851.00

PI: Moerland, T.S.
Grant Title: Muscle Fiber Size as a Determinant of Metabolic Design
Agency: National Science Foundation
Project Dates: 8/15/2003-7/31/2007
Award: $116,452.00

PI: Moerland, T.S.
Grant Title: Muscle Fiber Size as a Determinant of Metabolic Design
Agency: National Science Foundation
Project Dates: 8/15/2003-7/31/2007
Award: $167,348.00

PI: Moerland, T.S.
Grant Title: Cold Body Temperature as an Evolutionary Shaping Force in the Physiology of Antarctic Fishes
Agency: University of Maine
Project Dates: 9/1/2003-8/31/2005
Award: $12,162.00

PI: Moerland, T.S.
Grant Title: Structural and Functional Characterization of the Calcium Binding Protein Parvalbumin
Agency: American Heart Association
Project Dates: 7/1/2004-6/30/2005
Award: $20,000.00

PI: Moerland, T.S.
Grant Title: A Model System for Induced Hypothermia: Cardiac Ultrastructure and Troponin Function in a Fish that Experiences Acute Temperature Change
Agency: American Heart Association
Project Dates: 7/1/2004-6/30/2006
Award: $98,585.00

PI: Moulton, W.G.
Grant Title: Studies of Ferromagnetic Films, Multilayers, and Interfaces by NMR in Systems of Importance for Spintronics Applications
Agency: Defense Advanced Research Projects Agency
Project Dates: 2/6/2003-5/5/2005
Award: $151,000.00

PI: Odom, A.L.
Grant Title: Natural Mercury Isotopes as Tracers of Sources, Cycling, and Deposition of Atmospheric Mercury
Agency: Environmental Protection Agency
Project Dates: 10/1/2002-12/31/2005
Award: $827,147.00

PI: Popovic, D.
Grant Title: Study of Correlated Insulators and Metals in Two Dimensions
Agency: National Science Foundation
Project Dates: 5/1/2000-4/30/2005
Award: $317,650.00

PI: Popovic, D.
Grant Title: Travel Grant: Conference on Fluctuations and Noise in Materials
Agency: National Science Foundation
Project Dates: 5/1/2004-4/30/2005
Award: $8,000.00

PI: Quine, J.R.
Grant Title: Membrane Protein Structural Genomics: M Tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/2001-8/31/2005
Award: $254,917.00

PI: Quine, J.R.
Grant Title: Membrane Protein Structural Genomics: M. tuberculosis
Agency: National Institute of General Medical Sciences
Project Dates: 9/28/2001-8/31/2005
Award: $4,391,314.87

PI: Quine, J.R.
Grant Title: Membrane Protein Solid State NMR: PISEMA Development and the M2 Tetramer Structure
Agency: National Science Foundation
Project Dates: 2/1/2003-1/31/2006
Award: $516,254.00

PI: Reyes, A.P.
Grant Title: Studies of Ferromagnetic Films, Multilayers, and Interfaces by NMR in Systems of Importance for Spintronics Applications
Agency: Defense Advanced Research Projects Agency
Project Dates: 2/6/2003-5/5/2005
Award: $51,000.00

PI: Rikvold, P.A.
Grant Title: Computational Studies of Dynamical Phenomena in Nanoscale Ferromagnets
Agency: Mississippi State University
Project Dates: 12/1/2001-11/30/2004
Award: $354,416.00

PI: Rikvold, P.A.
Grant Title: Computational Studies in Electrochemical Materials Science by Statistical-mechanical and Ab-initio Methods
Agency: National Science Foundation
Project Dates: 3/15/2003-2/28/2006
Award: $540,000.00

PI: Salters, V.J.
Grant Title: Collaborative Research: Experimental Determinations of Trace Elements Distributions between Melts and Mantle Phases at P, T and X Relevant to MORBS Genesis
Agency: National Science Foundation
Project Dates: 11/15/2000-10/31/2004
Award: $70,378.00

PI: Salters, V.J.
Grant Title: Hf-Isotopes in Ocean Island Basalts and Meteorites
Agency: National Science Foundation
Project Dates: 12/1/2001-11/30/2004
Award: $144,944.00

PI: Salters, V.J.
Grant Title: Natural Mercury Isotopes as Tracers of Sources, Cycling, and Deposition of Atmospheric Mercury
Agency: Environmental Protection Agency
Project Dates: 10/1/2002-12/31/2005
Award: $827,147.00

PI: Salters, V.J.
Grant Title: Collaborative Research: Isotopic Constraints on the Mineralogy of the MORB Source
Agency: National Science Foundation
Project Dates: 3/1/2003-2/28/2005
Award: $190,491.00

PI: Salters, V.J.
Grant Title: Collaborative Research: Insights into Plume-Lithosphere Interactions from Hawaiian Mantle Xenoliths
Agency: National Science Foundation
Project Dates: 3/1/2003-2/28/2006
Award: $45,240.00

PI: Salters, V.J.
Grant Title: Acquisition of a Stable Isotope Ratio Mass Spectrometer
Agency: National Science Foundation
Project Dates: 7/1/2003-6/30/2005
Award: $215,112.00

PI: Schlottmann, P.U.
Grant Title: Strongly Correlated Electron Systems
Agency: National Science Foundation
Project Dates: 6/1/1998-6/30/2005
Award: $219,000.00

PI: Schlottmann, P.U.
Grant Title: Strongly Correlated Electron Systems
Agency: U.S. Department of Energy
Project Dates: 8/15/1998-8/14/2004
Award: $214,000.00

PI: Schlottmann, P.U.
Grant Title: Correlated Electrons
Agency: U.S. Department of Energy
Project Dates: 8/15/1998-8/14/2005
Award: $50,000.00

PI: Schneider-Muntau, H.J.
Grant Title: PEG - Investigation and Development of Bucky Paper Preforms and Nanocomposites with Carbon Nanotubes
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2004
Award: $57,131.00

PI: Schneider-Muntau, H.J.
Grant Title: Investigation and Development of Bucky Paper Preforms and Nanocomposites with Carbon Nanotubes
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2005
Award: $41,721.00

PI: Schneider-Muntau, H.J.
Grant Title: Civilian Research and Development Foundation for the Independent States of the Former Soviet Union (FSU) and U.S. Representation
Agency: U. S. Civilian Research & Development Foundation
Project Dates: 8/23/2002-12/31/2004
Award: $14,000.00

PI: Schneider-Muntau, H.J.
Grant Title: Research of Nanocomposites with Outstanding Magnetic Performance
Agency: Stereotaxis, Inc.
Project Dates: 5/1/2004-4/30/2005
Award: $12,000.00

PI: Schrieffer, J.R.
Grant Title: Eminent Scholar chair
Agency: Florida State University Foundation
Project Dates: 7/18/2000-12/31/2005
Award: $249,516.00

PI: Schrieffer, J.R.
Grant Title: National High Magnetic Field Laboratory
Agency: National Science Foundation
Project Dates: 1/1/2001-12/31/2005
Award: $43,500,000.00

PI: Schrieffer, J.R.
Grant Title: Electron Interactions in Actinides and Related Systems under Extreme Conditions
Agency: U.S. Department of Energy
Project Dates: 11/15/2002-11/14/2004
Award: $1,195,000.00

PI: Schwartz, J.
Grant Title: Stability and Quench Protection of YBCO Wires and Coils
Agency: UT-Battelle, LLC
Project Dates: 6/1/2000-5/31/2005
Award: $216,285.00

PI: Schwartz, J.
Grant Title: A Large-Bore, High Field Liquid Neon Facility for High Temperature Superconductor Materials and Component Testing
Agency: Office of Naval Research
Project Dates: 10/15/2000-5/31/2007
Award: $433,627.43

PI: Schwartz, J.
Grant Title: YBCO Coated Conductor Development by Non-Vacuum Chemical Processes
Agency: Air Force Office of Scientific Research
Project Dates: 6/1/2001-11/30/2004
Award: $200,000.00

PI: Schwartz, J.
Grant Title: Thermo-Magnetic Continuous Processing of Bi-2212 Cable for HEP
Agency: Supercon, Inc.
Project Dates: 8/26/2003-3/30/2004
Award: $20,000.00

PI: Schwartz, J.
Grant Title: Interactive Classroom and Museum Exhibit on Superconductivity
Agency: Institute of Electrical and Electronics Engineers, Inc.
Project Dates: 10/1/2003-12/31/2004
Award: $10,000.00

PI: Schwartz, J.
Grant Title: 2004 Applied Superconductivity Conference, Inc.
Agency: Applied Superconductivity Conference, Inc.
Project Dates: 1/15/2004-12/31/2004
Award: $20,000.00

PI: Schwartz, J.
Grant Title: Quench Behavior of YBCO Coated Conductors
Agency: University of Wisconsin
Project Dates: 7/1/2004-3/31/2005
Award: $29,164.00

PI: Schwartz, J.
Grant Title: High Field Magnets for MRI Applications
Agency: Supercon, Inc.
Project Dates: 9/14/2004-8/31/2005
Award: $15,000.00

PI: Schwartz, J.
Grant Title: Coil Simulator for AC Conductors: FSU Subcontract
Agency: American Superconductor
Project Dates: 10/5/2004-6/30/2005
Award: $45,000.00

PI: Swenson, C.A.
Grant Title: FSU Support of Sandia LDRD for Coil Gun Development
Agency: Sandia National Laboratories
Project Dates: 10/1/2003-9/30/2004
Award: $87,584.00

PI: Tozer, S.W.
Grant Title: Electron Interactions in Actinides and Related Systems under Extreme Conditions
Agency: U. S. Department of Energy
Project Dates: 11/15/2002-11/14/2004
Award: $55,000.00

PI: Van Sciver, S.W.
Grant Title: Liquid Helium Fluid Dynamics Studies
Agency: U. S. Department of Energy
Project Dates: 7/1/1992-12/31/2004
Award: $2,570,000.00

PI: Van Sciver, S.W.
Grant Title: REU in Visualization Studies of Heat and Mass Transfer in Forced Flow He II
Agency: National Science Foundation
Project Dates: 8/15/2000-7/31/2004
Award: $5,000.00

PI: Van Sciver, S.W.
Grant Title: REU on Visualization of Heat and Mass Transfer in Forced Flow He II
Agency: National Science Foundation
Project Dates: 8/15/2000-7/31/2004
Award: $5,000.00

PI: Van Sciver, S.W.
Grant Title: Visualization Studies of Heat and Mass Transfer in Forced Flow He II
Agency: National Science Foundation
Project Dates: 8/15/2000-7/31/2004
Award: $260,000.00

PI: Van Sciver, S.W.
Grant Title: PEG - Particle Image Studies of High Reynolds Number Liquid Helium Flows
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2004
Award: $50,000.00

PI: Van Sciver, S.W.
Grant Title: Particle Image Studies of High Reynolds Number Liquid Helium Flows
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2005
Award: $50,000.00

PI: Van Sciver, S.W.
Grant Title: New and Innovative Valving Technology for Cryogenic Applications
Agency: Big Horn Valve, Inc.
Project Dates: 3/28/2002-3/28/2004
Award: $49,900.00

PI: Van Sciver, S.W.
Grant Title: Densified LH2 and LO2: Transport Properties, Density and Flow Studies of Subcooled Liquids and Solid Particles
Agency: University of Central Florida
Project Dates: 6/1/2002-12/31/2004
Award: $1,350,000.00

PI: Van Sciver, S.W.
Grant Title: Integration of Magnetic Actuation Using VOST Design
Agency: Big Horn Valve, Inc.
Project Dates: 8/1/2002-7/31/2005
Award: $169,999.00

PI: Van Sciver, S.W.
Grant Title: FSU Support of Sandia LDRD for Coil Gun Development
Agency: Sandia National Laboratories
Project Dates: 10/1/2003-9/30/2004
Award: $87,584.00

PI: Van Sciver, S.W.
Grant Title: Cymetech/Educational Research Agreement
Agency: Cymetech, LLC
Project Dates: 11/1/2003-4/30/2004
Award: $28,750.00

PI: van Tol, J.
Grant Title: PEG - Quantum Computing with Biomolecules
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2004
Award: $65,000.00

PI: van Tol, J.
Grant Title: Quantum Computing with Biomolecules
Agency: Florida State University Research Foundation
Project Dates: 3/11/2002-6/30/2005
Award: $35,000.00

PI: Wang, Y.
Grant Title: Isotopic Evidence for Late Cenozoic Climate and Ecosystem Changes in China
Agency: National Science Foundation
Project Dates: 7/1/2002-12/31/2005
Award: $153,833.00

PI: Wang, Y.
Grant Title: Acquisition of a Stable Isotope Ratio Mass Spectrometer
Agency: National Science Foundation
Project Dates: 7/1/2003-6/30/2005
Award: $215,112.00

PI: Wang, Y.
Grant Title: Study of Oxygen Isotopic Composition of Phosphate in STA-1W
Agency: South Florida Water Management District
Project Dates: 4/16/2004-5/31/2005
Award: $49,976.00

PI: Xin, Y.
Grant Title: Monolithic Integration of Strongly Correlated Transition Metal Oxides with Complementary Functionalities through Thin Film Nano-Engineering
Agency: Florida State University Research Foundation
Project Dates: 3/24/2003-12/31/2005
Award: $90,000.00

PI: Yang, K.
Grant Title: Effects of Disorder and Fluctuations in Fulde-Ferrell-Larkin-Ovchinnikov Superconductors
Agency: Research Corporation
Project Dates: 11/17/2000-11/16/2005
Award: $35,000.00

PI: Yang, K.
Grant Title: Role of Disorder in Strongly Correlated Low-Dimensional Systems
Agency: National Science Foundation
Project Dates: 12/1/2002-11/30/2005
Award: $240,000.00

PI: Yang, K.
Grant Title: Theoretical Study of Spintronics in Nanometer Scale Systems and Other Novel Materials
Agency: Florida State University Research Foundation
Project Dates: 4/6/2004-6/30/2006
Award: $70,000.00

PI: Yang, K.
Grant Title: COFRS - Theoretical Study of Spintronics in Nanometer Scale Systems
Agency: Florida State University Council on Research Creativity
Project Dates: 5/7/2004-8/5/2004
Award: $8,000.00

Grants Awarded to NHMFL-Affiliated Faculty at the University of Florida

As reported by the UF Office of Sponsored Research for calendar year 2004

PI: Abbaschian, R.
Grant Title: Graduate Research Fellowship Program – Education Allowance
Agency: National Science Foundation
Project Dates: 10/01/1998-08/31/2007
Award: $4,000.00

PI: Abernathy, C.
Grant Title: Optical Characterization of Spin Injection in Wide Bandgap Spintronic Devices
Agency: U.S. Army
Project Dates: 05/01/2004-04/30/2005
Award: $95,000.00

PI: Abernathy, C.
Grant Title: Synthesis, Characterization and Application of ALGALGAMNN
Agency: National Science Foundation
Project Dates: 09/15/2002-08/31/2005
Award: $81,647.00

PI: Abernathy, C.
Grant Title: Development of Passivation Technology for Improved GAN/ ALGANHEMT Performance and Reliability
Agency: U.S. Air Force
Project Dates: 08/01/2002-12/31/2004
Award: $86,161.00

PI: Abernathy, C.
Grant Title: Dielectrics for Improved Compound Semiconductor Device Performance
Agency: U.S. Navy
Project Dates: 12/01/2004-11/30/2007
Award: $108,801.00

PI: Abernathy, C.
Grant Title: Workshop on Wide Bandgap Semiconductors Materials for Room Temperature Spintronic Applications
Agency: Battelle
Project Dates: 09/27/2004-09/26/2005
Award: $14,178.00

PI: Abernathy, C.
Grant Title: Development of Passivation Technology for Improved GAN/ ALGANHEMT Performance and Reliability
Agency: U.S. Air Force
Project Dates: 08/01/2002-07/31/2005
Award: $25,463.00

PI: Adams, E.D.
Grant Title: Magnetic and Thermodynamic Study of Solid ^{3}He
Agency: National Science Foundation
Project Dates: 03/15/2001-08/31/2004
Award: $50,000.00

PI: Biswas, A.
Grant Title: Investigation of the Normal State of Electron-Doped Cuprates in High Magnetic Fields
Agency: Florida State University
Project Dates: 10/01/2003-10/01/2005
Award: $67,310.00

PI: Blackband, S.J.
Grant Title: NMR Microscopy of Single Neural Cells and Brain Slices
Agency: National Institutes of Health
Project Dates: 03/01/2002-01/31/2006
Award: $276,133.00

PI: Blackband, S.J.
Grant Title: High Field Magnetic Resonance Research and Technology (Continuation)
Agency: National Institutes of Health
Project Dates: 05/01/2001-04/30/2006
Award: $809,452.00

PI: Blackband, S.J.
Grant Title: High-Field MRI: Limitations and Solutions
Agency: Pennsylvania State University
Project Dates: 09/03/2002-08/31/2004
Award: $3,843.00

PI: Blackband, S.J.
Grant Title: The National High Magnetic Field Laboratory
Agency: Florida State University
Project Dates: 11/01/2001-12/31/2005
Award: $327,673.00

PI: Blackband, S.J.
Grant Title: High-Field MRI: Limitations and Solutions
Agency: Pennsylvania State University
Project Dates: 09/03/2002-08/31/2005
Award: $259,517.00

PI: Bowers, C.R.
Grant Title: Study of the Electron-Nuclear Spin Interaction in Semiconductor Systems: Towards Spintronic Memory Devices
Agency: National Science Foundation
Project Dates: 01/15/2004-12/31/2005
Award: $18,000.00

PI: Brennan, A.B.
Grant Title: The Chemical-Mechanical Control of Marine Biofouling/Foul Release with Engineered Topographies
Agency: U.S. Navy
Project Dates: 03/01/2002-09/30/2006
Award: $125,000.00

PI: Brennan, A.B.
Grant Title: The Chemical-Mechanical Control of Marine Biofouling/Foul Release with Engineered Topographies
Agency: U.S. Navy
Project Dates: 03/01/2002-09/30/2006
Award: $193,750.00

PI: Cheng, H.P.
Grant Title: Interfacial Phenomena in Nobel Metal-C60 Interactions
Agency: U.S. Department of Energy
Project Dates: 12/01/2003-11/30/2006
Award: $56,585.00

PI: Cheng, H.P,
Grant Title: Molecular- and Nano-Wires: Properties and Control
Agency: U.S. Department of Energy
Project Dates: 09/01/2002-08/31/2005
Award: $106,023.00

PI: Cheng, H.P.
Grant Title: Molecular- and Nano-Wires Properties and Control
Agency: UT-Battelle
Project Dates: 08/16/2004-08/23/2005
Award: $3,500.00

PI: Christou, G.
Grant Title: Transition Metal Clusters as Single-Molecule Magnets
Agency: National Science Foundation
Project Dates: 08/01/2004-07/31/2007
Award: $168,000.00

PI: Christou, G.
Grant Title: Quantum Effects in Single Molecule Magnets
Agency: New York University
Project Dates: 07/15/2001-06/30/2005
Award: $72,000.00

PI: Constantinidis, I.
Grant Title: A Study of Model B-Cells in Diabetes Treatment
Agency: National Institutes of Health
Project Dates: 05/15/2002-02/28/2005
Award: $261,859.00

PI: Dorsey, A.T.
Grant Title: Microwave Spectroscopy of 2d Electronic Systems in Tilted Magnetic Fields
Agency: Florida State University
Project Dates: 10/01/2003-09/30/2005
Award: $26,637.00

PI: Douglas, E.P.
Grant Title: Development of Project Based Introductory to Materials Engineering Modules
Agency: San Jose State University
Project Dates: 05/01/2004-04/30/2007
Award: $72,689.00

PI: Dufty, J.W.
Grant Title: Time Dependent Hartree-Fock Theory: Gateway to Nonequilibrium Plasma Physics
Agency: U.S. Department of Energy
Project Dates: 08/01/2002-07/31/2005
Award: $50,000.00

PI: Edison A S
Grant Title: Characterization of Endogenous G-Protein Coupled Receptor Antagonists
Agency: National Institutes of Health
Project Dates: 04/01/2003-02/28/2007
Award: $14,832.00

PI: Edison, A.S.
Grant Title: Addressable Immobilized Ion Channels
Agency: U.S. Air Force
Project Dates: 07/01/2003-12/31/2004
Award: $121,138.00

PI: Edison, A.S.
Grant Title: Core 3: High Field Magnetic Resonance Research and Technology
Agency: National Institutes of Health
Project Dates: 05/01/2001-04/30/2006
Award: $194,202.00

PI: Edison, A.S.
Grant Title: Evaluation of MARCKS Peptide Structure Using Restricted Molecular Dynamic Simulations
Agency: U.S. Department of Veterans Affairs
Project Dates: 09/01/2001-08/31/2005
Award: $15,000.00

PI: Eyler, J.R.
Grant Title: Dissertation Enhancement Activities of Mr. Jose Valle for Fall Semester
Agency: Florida State University
Project Dates: 09/15/2004-08/31/2005
Award: $13,532.00

PI: Eyler J R
Grant Title: Target Assisted Combinatorial Synthesis
Agency: National Institutes of Health
Project Dates: 09/15/2003-08/31/2005
Award: $21,750.00

PI: Fitzsimmons, J.R.
Grant Title: Dental Fear and Anticipation of Pain: Imaging the Brain
Agency: National Institutes of Health
Project Dates: 04/15/2001-03/31/2006
Award: $9,527.00

PI: Fitzsimmons, J.R.
Grant Title: Core 1: High Field Magnetic Resonance Research and Technology
Agency: National Institutes of Health
Project Dates: 05/01/2001-04/30/2006
Award: $214,299.00

PI: Fitzsimmons, J.R.
Grant Title: Optic Neuritis: Gene Therapy
Agency: National Institutes of Health
Project Dates: 07/01/2001-06/30/2005
Award: $24,403.00

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: 07/15/2004-06/30/2008
Award: $149,994.00

PI: Hebard, A.F.
Grant Title: Magnetic Phenomena in Ultra-Thin Films and at Thin-Film Interfaces
Agency: National Science Foundation
Project Dates: 09/01/2004-08/31/2007
Award: $119,784.00

PI: Hebard, A.F.
Grant Title: Surface Plasmon Coupling For Enhanced Transmission in Diffractive Optics
Agency: Raytheon Company
Project Dates: 03/22/2004-12/01/2004
Award: $45,000.00

PI: Hebard, A.F.
Grant Title: Simultaneous Multiple Wavelength, Multiple Field of View Imaging System
Agency: U.S. Army
Project Dates: 01/01/2004-05/16/2007
Award: $129,954.00

PI: Hebard, A.F.
Grant Title: Surface Plasmon Coupling for Enhanced Transmission in Diffractive Optics
Agency: Raytheon Company
Project Dates: 03/22/2004-12/01/2004
Award: $40,000.00

PI: Hill, S.O.
Grant Title: Development of a Pulsed Broadband High-Field/High-Frequency EPR Spectrometer
Agency: Florida State University
Project Dates: 06/01/2004-03/31/2006
Award: $87,605.00

PI: Hill, S.O.
Grant Title: Development of a Transient Spectrometer for Education and Research into Quantum Coherence in Molecular Nanomagnets
Agency: National Science Foundation
Project Dates: 08/15/2004-07/31/2007
Award: $198,000.00

PI: Hill, S.O.
Grant Title: Career: Magnetic Resonance - From Materials Research to Science Education
Agency: National Science Foundation
Project Dates: 05/01/2003-04/30/2008
Award: $90,000.00

PI: Hill, S.O.
Grant Title: Quantum Effects in Single Molecule Magnets
Agency: New York University
Project Dates: 07/15/2001-06/30/2005
Award: $72,000.00

PI: Hirschfeld, P.J.
Grant Title: Theory of Grain Boundaries and Surfaces of High Temperature Semiconductors
Agency: National Science Foundation
Project Dates: 01/01/2004-12/31/2005
Award: $37,000.00

PI: Hirschfeld, P.J.
Grant Title: Theory of Defects in Cuprate Superconductors
Agency: U.S. Navy
Project Dates: 10/01/2003-09/30/2006
Award: $1,500.00

PI: Hirschfeld, P.J.
Grant Title: Theory of Defects in Cuprate Superconductors
Agency: U.S. Navy
Project Dates: 10/01/2003-09/30/2006
Award: $84,342.00

PI: Ingersent, J.K.
Grant Title: An REU Site in Physics at the University of Florida
Agency: National Science Foundation
Project Dates: 04/01/2002-03/31/2005
Award: $90,000.00

PI: Lee, Y.
Grant Title: Nature of Pure & Dirty Liquid ^{3}He-Fundamental Investigations and Educational Activities
Agency: National Science Foundation
Project Dates: 02/15/2003-01/31/2007
Award: $89,134.00

PI: Lee, Y.
Grant Title: 2004 Alfred P. Sloan Research Fellowship
Agency: Sloan Foundation, Alfred P
Project Dates: 09/16/2004-09/15/2006
Award: $40,000.00

PI: Lee, Y.
Grant Title: Effect of Strong Magnetic Fields on Dirty Superfluid ^{3}He
Agency: Florida State University
Project Dates: 01/01/2003-12/31/2004
Award: $60,543.00

PI: Liu, Y.
Grant Title: Functional MRI Investigation of Impaired Leptin Regulation Due to Secondhand Smoking
Agency: Flight Attendant Medical Research Institute
Project Dates: 07/01/2004-06/30/2006
Award: $108,500.00

PI: Liu Y
Grant Title: Time-Dependent Effects of Acute Alcohol Administration in the Human Brain
Agency: Alcoholic Beverage Medical Research Foundation
Project Dates: 06/01/2002-11/30/2004
Award: $9,800.00

PI: Liu, Y.
Grant Title: fMRI of Serotonergic Genetic Variation in Autism
Agency: National Institutes of Health
Project Dates: 01/01/2005-12/31/2007
Award: $42,976.00

PI: Liu, Y.
Grant Title: Effects of Growth Hormone on Metabolism and Satiation in Prader-Willi Syndrome
Agency: Lawson Wilkins Pediatric Endocrinology Society
Project Dates: 07/01/2004-06/30/2006
Award: $10,193.00

PI: Long, J.R.
Grant Title: Development of Techniques for Solid State NMR Structural Measurements at High Magnetic Fields
Agency: Florida State University
Project Dates: 08/01/2004-03/31/2006
Award: $40,924.00

PI: Mareci, T.H.
Grant Title: High Field Magnetic Resonance Research and Technology Admin
Agency: National Institutes of Health
Project Dates: 05/01/2002-04/30/2006
Award: $20,037.00

PI: Mareci, T.H.
Grant Title: *In Vivo* Evaluation of Spinal Cord Injury Neuro Protection Algorithms for Automatic Fiber Tract Mapping in the CNS
Agency: National Institutes of Health
Project Dates: 04/01/2002-03/31/2006
Award: $39,642.00

PI: Mareci, T.H.
Grant Title: CRCNS: Evolution into Epilepsy
Agency: National Institutes of Health
Project Dates: 09/01/2004-06/30/2008
Award: $85,029.00

PI: Maslov, D.
Grant Title: Interactions and Disorder in One, Two, and Three Dimensions
Agency: National Science Foundation
Project Dates: 07/15/2003-06/30/2006
Award: $80,000.00

PI: Meisel, M.W.
Grant Title: Magnetism of Quantum Spins Systems in Low Dimensions
Agency: National Science Foundation
Project Dates: 07/15/2003-06/30/2006
Award: $95,000.00

PI: Meisel, M.W.
Grant Title: Dr. James Sauls, Visiting Scientist to University of Florida
Agency: Florida State University
Project Dates: 01/01/2005-06/30/2005
Award: $5,000.00

PI: Monkhorst, H.J.
Grant Title: Research for the Direct Energy Converter and Resonance Mode of the P-11b Plasma Energy Generator
Agency: University of California
Project Dates: 07/01/2003-06/30/2005
Award: $47,673.00

PI: Pearton, S.J.
Grant Title: Materials Processing for ZNO
Agency: National Science Foundation
Project Dates: 04/01/2004-03/31/2005
Award: $79,871.00

PI: Pearton, S.J.
Grant Title: Nanoscale Arrays for Direct RNA Profiling in Single Cells and Their Compartments
Agency: National Science Foundation
Project Dates: 09/01/2003-08/31/2004
Award: $21,750.00

PI: Pearton, S.J.
Grant Title: Use of Ion Implantation to Synthesize Wide Bandgap Ferromagnetic Semiconductors and Oxides
Agency: U.S. Army
Project Dates: 10/01/2002-01/31/2005
Award: $100,000.00

PI: Pearton, S.J.
Grant Title: 1.55 Vertical Cavity Surface Emitting Laser with Dielectic
Agency: U.S. Army
Project Dates: 09/15/2001-09/14/2004
Award: $20,000.00

PI: Pearton, S.J.
Grant Title: High Density Three-Dimensional Packaging Technology for Rf Devices
Agency: International Technology Corp
Project Dates: 05/18/2004-05/17/2005
Award: $138,079.00

PI: Pearton, S.J.
Grant Title: Nanoscale Arrays for Direct RNA Profiling in Single Cells and Their Compartments
Agency: National Science Foundation
Project Dates: 09/01/2003-11/30/2006
Award: $21,750.00

PI: Pearton, S.J.
Grant Title: Nanoscopic, Biological and Evolutionary Analysis of Neuronal Diversity
Agency: Packard Foundation
Project Dates: 10/01/2002-10/31/2005
Award: $40,250.00

PI: Pearton, S.J.
Grant Title: ZNO PN Junctions for Highly-Efficient, Low-Cost Light Emitting Diodes
Agency: U.S. Department of Energy
Project Dates: 10/01/2004-09/30/2007
Award: $89,717.00

PI: Pearton, S.J.
Grant Title: Materials Processing for ZNO
Agency: National Science Foundation
Project Dates: 04/01/2004-03/31/2006
Award: $81,976.00

PI: Reitze, D.H.
Grant Title: High Average Power, Compact Ultrashort Pulse Lasers for Applications in Nano-Photonics and Laser
Agency: University of Central Florida
Project Dates: 03/04/2004-03/31/2005
Award: $36,000.00

PI: Reitze, D.H.
Grant Title: Development of New Diagnostic Techniques for Preliminary and *in Situ* Characterization of Advanced LIGO Optical Components
Agency: National Science Foundation
Project Dates: 09/01/2002-08/31/2005
Award: $110,000.00

PI: Richards, N.G.
Grant Title: Biochemical Studies of Oxalate Decarboxylase
Agency: National Institutes of Health
Project Dates: 04/01/2003-01/31/2007
Award: $163,788.00

PI: Richards, N.G.
Grant Title: Measuring Asparagine Synthetase Expression in Leukemia
Agency: National Institutes of Health
Project Dates: 06/01/2004-05/31/2006
Award: $29,819.00

PI: Rinzler, A.G.
Grant Title: Methods of Single-Wall Carbon Nanotube Purification and Transparent Film Production
Agency: Lockheed Martin
Project Dates: 04/02/2004-06/30/2004
Award: $40,000.00

PI: Rinzler, A.G.
Grant Title: Methods of Single-Wall Carbon Nanotube Purification and Transparent Film Production
Agency: Lockheed Martin
Project Dates: 04/02/2004-12/30/2004
Award: $20,000.00

PI: Sheplak, M.
Grant Title: Graduate Student Researchers Program (GSRP): Active Liner Technology for Engine Nacelles (Student: Todd Schultz)
Agency: NASA
Project Dates: 07/01/2004-06/30/2005
Award: $24,000.00

PI: Sheplak, M.
Grant Title: SST: Micromachined Sensors for the Direct Measurement of Wall Shear Stress
Agency: National Science Foundation
Project Dates: 09/01/2004-08/31/2007
Award: $380,000.00

PI: Sheplak, M.
Grant Title: The Development of a Tunable Electromechanical Acoustic Liner for Engine Nacelles
Agency: NASA
Project Dates: 03/04/2004-06/01/2007
Award: $114,214.00

PI: Sheplak, M.
Grant Title: Nonlinear Dynamics & Closed Loop Control of Supercavitating Vehicles
Agency: U.S. Navy
Project Dates: 11/15/1999-09/30/2004
Award: $38,143.00

PI: Sheplak, M.
Grant Title: Moire-Based Optical MEMS Shear Stress Sensor Technology
Agency: U.S. Navy
Project Dates: 11/01/2004-10/31/2007
Award: $71,980.00

PI: Sheplak, M.
Grant Title: MEMS-Based Electromechanical Acoustic Energy Harvester
Agency: Sandia National Laboratories
Project Dates: 06/01/2004-12/15/2004
Award: $12,000.00

PI: Sheplak, M.
Grant Title: Embedded Instrumentation for Test and Evaluation
Agency: Taitech Research & Engineering
Project Dates: 05/25/2004-06/30/2005
Award: $100,063.00

PI: Sheplak, M.
Grant Title: Micromachined Floating Element Hydrogen Flow Rate Sensor
Agency: NASA
Project Dates: 09/30/2004-08/02/2005
Award: $70,000.00

PI: Stanton, C.J.
Grant Title: Dissertation Fellowships
Agency: UF Foundation
Project Dates: 04/01/1999-05/31/2005
Award: $10,601.00

PI: Stanton, C.J.
Grant Title: Optical Control and Opto-Spintronics in Ferromagnetic III-V Semiconductors for Q
Agency: Rice University
Project Dates: 05/24/2004-05/23/2005
Award: $34,900.00

PI: Stewart, G.R.
Grant Title: Novel Strongly Correlated (Primarily F-) Electron Behavior
Agency: U.S. Department of Energy
Project Dates: 12/01/2003-11/30/2006
Award: $107,411.00

PI: Sullivan, N.S.
Grant Title: The National High Magnetic Field Laboratory
Agency: Florida State University
Project Dates: 01/01/2001-12/31/2005
Award: $227,784.00

PI: Talham, D.R.
Grant Title: Role of Biopolymers and Lipids in Kidney Stone Formation
Agency: National Institutes of Health
Project Dates: 07/15/2001-04/30/2005
Award: $59,887.00

PI: Tanner, D.B.
Grant Title: Electrochromic Adaptive Infrared Camouflage
Agency: University of California
Project Dates: 08/01/1999-01/31/2005
Award: $15,000.00

PI: Tanner, D.B.
Grant Title: Infrared Studies of Cuprate Superconductors
Agency: National Science Foundation
Project Dates: 08/15/2003-07/31/2006
Award: $48,396.00

PI: Tanner, D.B.
Grant Title: Time-Resolved Far-Infrared Experiments: Implications for Nanotechnology
Agency: U.S. Department of Energy
Project Dates: 05/15/2002-05/14/2005
Award: $125,000.00

PI: Tanner, D.B.
Grant Title: Infrared Studies of Cuprate Superconductors
Agency: National Science Foundation
Project Dates: 08/15/2003-07/31/2006
Award: $47,487.00

PI: Trickey, S.B.
Grant Title: Partial Financial Support for the 2004 Sanibel Symposium
Agency: U.S. Navy
Project Dates: 02/01/2004-09/30/2004
Award: $15,525.00

PI: Tanner, D.B.
Grant Title: Supplemental Request to the 2004 Sanibel Symposium
Agency: U.S. Army
Project Dates: 09/22/2003-03/15/2005
Award: $15,000.00

PI: Tanner, D.B.
Grant Title: ITR: Large-Scale, Grid-Enabled Gaussian Orbital Implementation of Current Density and Spin Density Functional Theory
Agency: National Science Foundation
Project Dates: 08/15/2002-07/31/2005
Award: $112,000.00

PI: Tanner, D.B.
Grant Title: Supplemental Request to the 2004 Sanibel Symposium
Agency: U.S. Army
Project Dates: 09/22/2003-03/15/2005
Award: $3,000.00

PI: Vandenborne, K.H.
Grant Title: LGF-1 Gene Transfer to Accelerate Muscle Recovery Following Disuse
Agency: National Institutes of Health
Project Dates: 02/01/2002-01/31/2006
Award: $194,719.00

PI: Vandenborne, K.H.
Grant Title: Molecular Signatures of Muscle Rehabilitation after Limb Disuse
Agency: National Institutes of Health
Project Dates: 09/28/2004-07/31/2009
Award: $336,430.00

PI: Vandenborne, K.H.
Grant Title: Interdisciplinary Training in Rehabilitation and Neuromuscular Plasticity
Agency: National Institutes of Health
Project Dates: 06/11/2003-04/30/2008
Award: $161,183.00

PI: Vandenborne, K.H.
Grant Title: Metabolic and Transport Pathways in Skeletal Muscle
Agency: University of Pennsylvania
Project Dates: 07/01/2001-04/30/2005
Award: $82,126.00

PI: Vandenborne, K.H.
Grant Title: Noninvasive Monitoring and Tracking of Muscle Stem Cells
Agency: National Institutes of Health
Project Dates: 09/22/2004-08/31/2008
Award: $27,526.00

PI: Walter, G.A.
Grant Title: Bioengineering Research Partnership Directed at Muscular Dystrophy
Agency: University of Pennsylvania
Project Dates: 09/01/2001-08/31/2005
Award: $92,942.00

PI: Walter, G.A.
Grant Title: Noninvasive Monitoring and Tracking of Muscle Stem Cells
Agency: National Institutes of Health
Project Dates: 09/22/2004-08/31/2008
Award: $248,234.00

PI: Walter, G.A.
Grant Title: LGF-I Gene Transfer to Accelerate Muscle Recovery Following Disuse
Agency: National Institutes of Health
Project Dates: 02/01/2002-01/31/2006
Award: $34,444.00

PI: Walter, G.A.
Grant Title: Project 2: Gene Therapy Using Viral Vector for Lung and Cardiovascular Disease
Agency: National Institutes of Health
Project Dates: 09/01/2002-08/31/2007
Award: $35,923.00

PI: Walter, G.A.
Grant Title: Project 4: Gene Therapy Using Viral Vector for Lung and Cardiovascular Disease
Agency: National Institutes of Health
Project Dates: 09/01/2002-08/31/2007
Award: $12,581.00

PI: Walter, G.A.
Grant Title: Bioengineering Research Partnership Directed at Muscular Dystrophy
Agency: University of Pennsylvania
Project Dates: 09/01/2001-08/31/2005
Award: $94,568.00

Appendix A
RESEARCH REPORTS BY CATEGORY

NHMFL users and affiliated faculty submitted 335 brief research reports describing activities in 2004. *All* reports are available on the Web at http://www.magnet.fsu.edu/publications/2004annualreport/. The following table lists the reports by category and provides essential information.

Biochemistry - 40 Reports

Facility	PI Name	Report Title
ICR Facility	Eyler, J.R.	FEL-FTICR Instrumentation to Obtain IRMPD Spectra of Biomolecules
ICR Facility	Marshall, A, G	Identification of Sites of Ubiquitination in Proteins: A Fourier Transform Ion Cyclotron Resonance Mass Spectrometry Approach
ICR Facility	Marshall, A. G.	Chemical Cross-Linking of the Urease Complex from Helicobacter pylori and Analysis by Fourier Transform Ion Cyclotron Resonance Mass Spectrometry and Molecular Modeling
ICR Facility	Marshall, A. G.	Expression, Purification, and Characterization of Avian Thy-1 from Lec1 Mammalian and Tn5 Insect Cells
ICR Facility	Marshall, A. G.	Key Interactions in HIV-1 Maturation Identified by Mass Spectrometry Based H/D Exchange
ICR Facility	Marshall, A. G.	Characterization of Tetrahymena Histone H2B Variants and Posttranslational Populations by Electron Capture Dissociation (ECD) Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR MS)
ICR Facility	Marshall, A. G.	Identification and Analysis of Phosphopeptides
ICR Facility	Marshall, A. G.	Electron Capture Dissociation Fourier Transform Ion Cyclotron Resonance Mass Spectrometry of Cyclodepsipeptides, Branched Peptides and Epsilon-Peptides
ICR Facility	Marshall, A. G.	Glycoproteomics of Cerebrospinal Fluid in Neurodegenerative Disease
ICR Facility	Marshall, A. G.	Improved Mass Analysis of Oligoribonucleotides by 13C, 15N Double Depletion and Electrospray Ionization FT-ICR Mass Spectrometry
EMR Facility	Beth, AH	Double Electron-Electron Resonance Studies of the Cytoplasmic Domain of Band 3 Protein
EMR Facility	Nesmelov, Y.E.	Structural dynamics of phospholamban in a membrane
EMR Facility	Sienkiewicz, A	High Field ESR Investigation of Iron FeIII Center in Malarial Pigment and its Synthetic Substitute Beta-hematin
EMR Facility	Telser, J.	High-Field Electron Paramagnetic Resonance of Iron Superoxide Dismutase
NMR Facility	Chapman, MS	Functional dynamics of arginine kinase
NMR Facility	Cross, T. A.	Binding of amantadine decreases the proton affinity of histidine-37 in the M2 channel from the influenza A virus
NMR Facility	Cross, T. A.	17O Study of Ion Channels at 21.2 T 105mm Ultra-wide Bore Superconducting NMR Magnet
NMR Facility	Cross, T. A.	Atomic structure determination of the M2TMD-amantadine complex
NMR Facility	Cross, T.A.	Ion binding study of carbonyl oxygen by solid-state 17O NMR spectroscopy in model peptide system gly-(17O-gly)-gly
NMR Facility	Cross, T.A.	Initial structural assignment of mycobacterium tuberculosis integral membrane protein rv1761c
NMR Facility	Cross, T.A.	Expression, Purification, and Initial Structural Characterization of Multiple Integral Membrane Proteins from Mycobacterium tuberculosis
NMR Facility	Cross, T.A.	Production of Membrane Proteins from Mycobacterium tuberculosis in Escherichia coli as Fusions with Maltose Binding Protein
NMR Facility	Cross, TA	High-Throughput Cloning and Over-Expression of Integral Membrane Proteins from Mycobacterium tuberculosis for NMR Structural Genomics Studies
NMR Facility	Cross, TA	Structural Characterization of the M2 Proton Channel from Influenza A Virus in Detergent Micelles by Solution NMR Spectroscopy at 900 MHz
NMR Facility	Fu, RF	High field 19F solid-state NMR spectroscopy for structural and conformational study of m2 membrane protein
NMR Facility	Greenbaum, N.L.	Interaction of Spliceosomal Proteins SF3b p14 and Sf3b155 with the pre-mRNA branch site
NMR Facility	Hanson, P	Structural investigations of apolipoprotein-e fragments by NMR
NMR Facility	Kern, D.	Structural Investigations of the Enzyme Cyclophilin-A During Catalysis

NMR Facility	Logan, T.M.	Triple resonance assignments of highly-symmetric core mutant of fgf-1, sym6dd
NMR Facility	Logan, T.M.	Measuring dynamics of the intra-molecular ligand binding by the sh3-like domain of the diphtheria toxin repressor
NMR Facility	Logan, TM	Sequence and structural characterization of metal binding in activation of Diphtheria toxin repressor (DtxR)
MBI-UF AMRIS	Barbar, E	NMR Studies on Folding Coupled to Vinding of the Intrinsically Unfolded Domain of Cytoplasmic Dynein Intermediate Chain
MBI-UF AMRIS	Constantinidis, I.	Probing mitochondrial disorders by NMR spectroscopy
MBI-UF AMRIS	Constantinidis, I.	13C isotopomer studies of insulin secreting cells: the role of anaplerosis
MBI-UF AMRIS	Edison, AS	Structure-activity relations of npr-1 neuropeptides from c. Elegans
MBI-UF AMRIS	Gamcsik, MP	Non-invasive Monitoring of Glutathione Metabolism and Heterogeneity in Rat Tumor Tissue
MBI-UF AMRIS	Haskell-Luevano, C	Conformational analysis of Agouti-related protein (AGRP)-based melanocortin receptor antagonist
MBI-UF AMRIS	Long, J.R.	Structural studies of the lung surfactant peptide kl4 using MAS SSNMR
MBI-UF AMRIS	Silverman, D N	Fluorine-19 NMR reveals regions of thermal stability in human manganese superoxide dismutase
UF Physics	Angerhofer, A	ESR spin trapping of the reaction products of urate and peroxynitrite

Biology - 16 Reports

Facility	PI Name	Report Title
DC Field Facility	Valles, J	Manipulation of Protists Using Static Magnetic Fields
EMR Facility	Smirnova, T. I.	GD(III)-nitroxide interactions: a multifrequency EPR study
NMR Facility	Veglia, GV	Protein-Protein Interactions by Solid-State NMR spectroscopy
MBI-UF AMRIS	Blackband, SJ	Diffusion Changes in Frontal White Matter in Prenatally Cocaine Exposed Children
MBI-UF AMRIS	Blackband, SJ	Fixative effects on the MR properties of isolated rat brain slices
MBI-UF AMRIS	Blackband, SJ	DTI of the isolated human hippocampus at high spatial resolution
MBI-UF AMRIS	Byrne, B	Non-invasive Characterization of Dystrophic Skeletal and Cardiac Muscle.
MBI-UF AMRIS	Constantinidis, I	NMR studies of insulin secreting cells: biochemical consequences of cell encapsulation
MBI-UF AMRIS	Constantinidis. I.	Alginate assessment by NMR microscopy
MBI-UF AMRIS	Mariani, C. L.	Imaging of Clinical Veterinary Patients at the University of Florida AMRIS Facility
MBI-UF AMRIS	Monk, T	The Influence of Tourniquet Time on Cerebral Embolic Events in Elderly Patients Undergoing Total Knee Arthroplasty
MBI-UF AMRIS	Price, C	Neuroanatomical and Neurocognitive Predictors of Post-Operative Cognitive Dysfunction in Non-Demented Older Adults.
MBI-UF AMRIS	Shaw, CA	MR Microscopy of Neurodegeneration in an ALS-PDC Model at 17.6 Tesla
MBI-UF AMRIS	Sullivan, S.M.	Imaging of syngeneic rat brain tumor model
MBI-UF AMRIS	Vandenborne, K	31P Magnetic Resonance Spectroscopy of Mouse Skeletal Muscle Following Hind Limb Cast Immobilization
MBI-UF AMRIS	Vandenborne, K	Noninvasive monitoring of muscle damage during reloading following limb disuse

Chemistry - 18 Reports

Facility	PI Name	Report Title
DC Field Facility	Telser, J	Tunable-Frequency Electron Paramagnetic Resonance of the High-Spin Cobalt(III) Ion
ICR Facility	Dunbar, R.C.	Gas-phase cr+ complexes of aromatic ligands: site of binding and spin state of the metal ion characterized by infrared spectroscopy using the felix free-electron laser
ICR Facility	Groenewold, G. S.	IRMPD of Cationic Uranyl Complexes in the Gas Phase
ICR Facility	Marshall, A G.	Two and Three Dimensional van Krevelen Diagrams: A Graphical Analysis Complementary to the Kendrick Mass Plot for Sorting Elemental Compositions of Complex Organic Mixtures Based on Ultrahigh-Resolution Broadband FT-ICR Mass Measurements
ICR Facility	Marshall, A.G.	Characterization of Vegetable Oils: Detailed Compositional Fingerprints Derived from Electrospray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry

ICR Facility	Marshall, A.G.	Structurally Related Non-Covalent Complexes Examined by Quadrupole Ion Trap (QIT) MS2 and Infrared Multiphoton Dissociation Fourier Transform Ion Cyclotron Resonance Mass Spectrometry IRMPD-FT-ICR MS: Evidence for Salt-Bridge Structures in the Gas Phase
ICR Facility	Marshall, A.G.	Probing Molecular-Level Transformations of Dissolved Organic Matter: Insights on Photochemical Degradation and Protozoan Modification of DOM from Electrospray Ionization Fourier-Transform Ion Cyclotron Resonance Mass Spectrometry
ICR Facility	Ridge, D.P.	IRMPD Spectroscopy of Anionic Iron Carbonyl Clusters
EMR Facility	Kispert, L.D.	Multifrequency Electron Paramagnetic Resonance Measurements of Organic Radicals in the Presence of Metal Ions
EMR Facility	Ozarowski, A	High-Frequency And -Field Epr Of A Pseudo-Octahedral Complex Of High-Spin Fe(Ii): Bis(2,2'-Bi-2-Thiazoline)B is(Isothiocyanato)Iron(Ii)
EMR Facility	Ozarowski, A	High-Field High-Frequency Studies On Metal-Metal Interactions In Binuclear Oxygen-Bridged Iron(III) Compounds.
EMR Facility	Ozarowski, A	High-frequency, high-field EPR, magnetic susceptibility and x-ray studies on a ferromagnetic complex of diethanolamine (h2l), [cu4(nh3)4(hl)4][cdbr4]br2·3dmf·h2o
NMR Facility	Barberon, F	High-field 33s, 35cl and 25mg MAS NMR in cementitious materials: description of phases, stability and reactivity
NMR Facility	Cioffi, E.A.	Microwave-promoted C-H Bond Activation and Isotopic Exchange in Glycoconjugates
NMR Facility	Fu, RF	Molecular dynamics of poly(l-lactide) biopolymer studied by wide-line solid-state 1h and 2h nmr spectroscopy
NMR Facility	Fu, RF	High Resolution 15N and 75As NMR of Antiferroelectric Phase Transition in a Single Crystal of Ammonium Dihydrogen Arsenate, NH4H2AsO4
NMR Facility	Lapina , O	93Nb NMR chemical shift scale for niobia compounds
NMR Facility	Wu, G	Solid-state 39K NMR Spectroscopy for Organic Salts at 19.6 T

Engineering Materials - 17 Reports

Facility	PI Name	Report Title
DC Field Facility	Liu, J.P.	Magnetic-field-induced Crystallographic Texture Enhancement in Cold-deformed FePt Nanostructured Magnets
DC Field Facility	Ludtka, G. M.	Modifying the phase transformation mechanism in a high carbon steel using a high magnetic field
DC Field Facility	Molodov, D.A.	Magnetically Driven Selective Grain Growth
DC Field Facility	Molodov, D.A.	Magnetically Controlled Texture Development during Grain Growth in Commercially Pure Titanium
DC Field Facility	Parker, M. R.	Enhancement of Mechanical Properties of Epoxy-Based Nanocomposites Using High Magnetic Fields
DC Field Facility	Wang, B.	Preparation and Characterization of Highly Oriented Carbon Nanotube/Epoxy Nanocomposites Using Magnetically Aligned SWNT Buckypapers
Pulsed Field Facility	Bass, HB	Resonant Ultrasound Spectroscopy of Bulk Metallic Glasses
Pulsed Field Facility	McDonald, RD	GHz-frequency transmission studies of three dimensional photonic band gap structures.
Pulsed Field Facility	Schmiedeshoff, G.M.	Thermal Expansion and Magnetostriction of Be6Cu
Pulsed Field Facility	Singleton, J	A field effect transistor device base upon the charge density wave material Per2Au(mnt)2.
EMR Facility	Eichel, R. A.	High-Frequency EPR On Functional Centers In Ferroelectric Ceramics
NMR Facility	An, L.	NMR Studies on Structures of Polymer-Derived Amorphous SiAlCN Ceramics and Structures of Oxide Layer Thermally Formed on The SiAlCN
NMR Facility	Wu, Y	Characterization of local structure in metallic glass systems using high-field NMR
MS & T	Han, K.	Deformation Behavior of Nb3Sn Type Superconductors
MS & T	Han, K.	Internal Stresses in Cold-Deformed Cu-Ag and Cu-Nb Wires
MS & T	Miller, J. R.	Study of Reinforcement Materials for High Field Magnets
MS & T	Walsh, R. P.	77 K Fatigue Life of Materials Used in the 60 T Long-Pulse Magnet Program

Geochemistry - 19 Reports

Facility	PI Name	Report Title
ICR Facility	Marshall, A. G.	Acidic and Neutral Polar NSO Compounds in Smackover Oils of Different Thermal Maturity Revealed by Electrospray High Field Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
ICR Facility	Marshall, A. G.	Compositional Determination of Acidic Species in Illinois #6 Coal Extracts by Electrospray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
Geochemistry Facility	Das, R.	Geodynamic evolution of the pumpkinvine creek formation and associated rock assemblages: structural, petrologic, and geochemical evidence of a paleozoic accreted arc terrane in the southern appalachians
Geochemistry Facility	Froelich, PE	Arsenic, selenium and antimony discharge from coal-fired power plants yates and wanlsey to the Chattahoochee-Apalachicola river
Geochemistry Facility	Froelich, PN	On the origin of methylated germanium compounds in natural waters
Geochemistry Facility	Humayun, M	Precise Rb/Sr determinations by magnetic-sector mass spectrometry
Geochemistry Facility	Humayun, M	Iron/manganese ratios of volcanic rocks as probes of the iron budget of earth's deep interior
Geochemistry Facility	Landing, W.M.	Iron Analysis by Isotope Dilution ICP-MS
Geochemistry Facility	Odom, A.L.	A new and precise determination of the isotopic abundances and atomic weight of mercury
Geochemistry Facility	Odom, A.L.	The age of he tres piedras granite, nm, usa: a case of large scale isotopic homogenization
Geochemistry Facility	Salters, V.J.M	Complexation of tetravalent metals by humic substances determined by capillary electrophoresis-inductively coupled plasma mass spectrometry (CE-ICPMS) and equilibrium dialysis exchange
Geochemistry Facility	Salters, VJM	Isotope and trace element characteristics of walvis ridge basalts: subcontinental lithosphere?
Geochemistry Facility	Salters, VJM	The origin of the koolau component: evidence against the involvement of recycled pelagic sediments
Geochemistry Facility	Salters, VJM	Lu-Hf and Sm-Nd Isotopic Systematics in Chondrites And Their Constraints Cn The Lu-Hf Properties Of The Earth
Geochemistry Facility	Sen, G	Radiogenic hf and undariogenic os isotopes in the Hawaiian lithosphere: evidence for an ancient recycled lithosphere
Geochemistry Facility	Sen, G	Evidence for a depleted component in Hawaiian volcanism from hafnium-neodymium isotope systematics of garnet pyroxenites
Geochemistry Facility	Wang, Y.	A 25 m.y. isotopic record of paleodiet and environmental change from fossil mammals and paleosols from the NE margin of the Tibetan Plateau
Geochemistry Facility	Wang, Y.	Distribution and turnover of DOC in natural and constructed wetlands in the Florida Everglades
Geochemistry Facility	Wozab, S T	Orthopyroxene/Clinopyroxene Trace Element Partitioning Systematics in the Natural Sample

Instrumentation - 15 Reports

Facility	PI Name	Report Title
DC Field Facility	Biswas, A	Point contact spectroscopy measurements on the electron-doped cuprate Pr2-xCexCuO4 in fields of up to 32 tesla
DC Field Facility	Fortune, N.A.	Flexible Temperature Sensors For Use In High Magnetic Fields
DC Field Facility	Miller, J.	In-field Ic of Nb3Sn Wires Under Strain
DC Field Facility	Molodov, D.A.	In Situ Measurements of Grain Boundary Migration with a High Magnetic Field Polarization Microscopy Probe
DC Field Facility	Souslov, A.	Angle-dependent magnetoacoustic phenomena in Sr2RuO4
DC Field Facility	Tozer, S.W.	Nuclear magnetic resonance using a tunnel diode oscillator
Pulsed Field Facility	Correa, V.F.	Magnetostriction experiments in YbInCu4 using a dilatometer for pulsed-fields
Pulsed Field Facility	Rickel, D	HfV2 Pulsed Ultrasound
Pulsed Field Facility	Rickel, D	PES in AuZn to observe Phase Transitions as a Function of Magnetic Field
Pulsed Field Facility	Singleton/ Mielke, J/CH	Instrumentation for the single-turn magnet project part 2: Faraday rotation measurements of TGG as a means of field calibration.
ICR Facility	Marshall, A. G.	Construction of a Hybrid Quadrupole/Fourier Transform Ion Cyclotron Resonance Mass Spectrometer for Versatile MS/MS Above 10 kDa
ICR Facility	Marshall, A. G.	Time Resolved Laser-Induced Fluorescence of Electrosprayed Ions Confined in a Linear Quadrupole Trap
MBI-UF AMRIS	Fitzsimmons, JR	The effect of load geometry on B1 inhomogeneities on a human body rf coil at 3 Tesla
MBI-UF AMRIS	Fitzsimmons, JR	Evalutaion of microstrips and surface coils for use as phased array surface coils at 11.1T
MBI-UF AMRIS	Fitzsimmons, JR	Development of a hardware interface for rapid prototyping of RF coils to facilitate translational research on a clinical MR scanner

Kondo/Heavy Fermion Systems - 19 Reports

Facility	PI Name	Report Title
DC Field Facility	Andraka, B.	Magnetic Field Study the "Hidden Transition" in UCd11
DC Field Facility	Andraka, B.	Magnetoresistance of PrOs4Sb12: Search for an Evidence of Heavy Fermion Behavior
DC Field Facility	Balicas, L	Magnetic field-tuned quantum critical point in CeAuSb2
DC Field Facility	Bernal, O O	Possible connection between hidden order and 29Si NMR line-intensity drop in UrU2Si2
DC Field Facility	Brooks, JSB	Shubnikov-de Haas oscillations of dense kondo lattice, CeAgSb2
DC Field Facility	Capan, C.	Metamagnetism and Fermi surface change in CeIrIn5: a high field transport and dHvA study
DC Field Facility	Curro, N. J.	Nuclear Magnetic Resonance Studies of URu2Si2 in High Fields
DC Field Facility	Ebihara, T	High field phase diagram of cubic CeIn3
DC Field Facility	Mydosh, J.A.	Anomalous irreversibility in cp(t) and MCE near a quantum critical point in U(Ru,Rh)2Si2
DC Field Facility	Stewart, G.R.	Specific Heat of Non-Fermi Liquid and Heavy Fermion Superconducting Systems
Pulsed Field Facility	Ardavan, A	Suppression of the gamma-alpha structural phase transition in Ce0.8La0.1Th0.1 by large magnetic fields
Pulsed Field Facility	Correa, V F	High magnetic field thermal-expansion and elastic properties of CeRhIn5
Pulsed Field Facility	Ebihara, T	High magnetic field magnetization of CeIn3
Pulsed Field Facility	Ebihara, T	High field physical properties in La, Lu and Sn doped CeIn3
Pulsed Field Facility	Mielke, C. H.	Contactless conductivity of cerium in high magnetic field
Pulsed Field Facility	Movshovich, R	Resistivity of a Quantum Critical Point in CeCoIn5
CM/T	Crow, J.E.	Angle-resolved de Haas-van Alphen study of SrRuO3
UF Physics	Ingersent, K.	Numerical Renormalization Group Study of the Bose-Fermi Kondo Model
UF Physics	Ingersent, Kevin	Absence of Lattice Coherence Effects in Ce0.6La0.4Pb3: A Magnetic Field Study

Magnet Technology - 10 Reports

Facility	PI Name	Report Title
DC Field Facility	Crow, J. E.	The First Repetitively Pulsed Magnet Prototype
Pulsed Field Facility	Swenson, C.A.	Training Performance of 75T Prototype Pulsed Magnet
Pulsed Field Facility	Swenson, C.A.	Design Development of a Rapid Cycling "Quick Cool" 55-T Pulsed Maqnet
MS & T	Markiewicz, W.D.	Analysis of the strain dependence of the critical temperature of Nb3Sn
MS & T	Miller, J. R.	Feasibility of a Nb3Sn Undulator for the Advanced Photon Source at Argonne National Laboratory
MS & T	Painter, T. A.	Conceptual Design of an All-Superconducting 30 T Solenoid Using Wire-in-Conduit Conductors
MS & T	Swenson, C. A.	Inspection of 65 T Prototype After Long Term Operation
MS & T	Swenson, C. A.	Design Enhancements to the New NHMFL Pulsed Magnets for Improved Performance and Manufacturability
MS & T	Swenson, C. A.	Coil Fabrication Technology Development for Copper Niobium Pulsed Magnet Conductors
MS & T	Swenson, C. A.	Evaluation of High VOltage Breakdown Properties of Zylon Serverd Kapton Insulation System Under Cyclic Compression

Magnetic Resonance Techniques - 37 Reports

Facility	PI Name	Report Title
Pulsed Field Facility	Harrison, N	Electron spin resonance measurements of NiCl2-thiourea.
Pulsed Field Facility	Singleton/Mielke, J/CH	Instrumentation for the Single turn magnet project part 1: GHz-frequency measurements of quantum oscillations.
ICR Facility	Marshall, A. G.	Broadband Phase Correction of FT-ICR Mass Spectra via Simultaneous Excitation and Dectection
ICR Facility	Marshall, A. G.	Ion 'Threshing': Collisionally-Activated Dissociation in an External Octopole Ion Trap by Oscillation of an Axial Electric Potential Gradient
ICR Facility	Marshall, A. G.	Continuous Flow Sample Introduction for Field Desorption/Ionization Mass Spectrometry
ICR Facility	Marshall, A. G.	Wavelength Resolved Laser-Induced Fluorescence Emission of C6F3H3+ Trapped in an Ion Cyclotron Resonance Cell
EMR Facility	Ardavan, A	Dynamic nuclear polarization of 15N@C60 for quantum computing

EMR Facility	Merbach, A. E.	High-Frequency Electron Paramagnetic Resonance Study of Gadolinium(III) Complexes in Aqueous Solutions
EMR Facility	Smirnov, A. I.	Investigation of the electronic and spin properties of potassium hexaboride, Kb6, by multifrequency EPR
NMR Facility	Brey, W.S.	Fluorine-19 And Carbon-13 Spectroscopy Of Fluorinated Organic Molecules
NMR Facility	Brey, W.W.	Efficient Coaxial Traps For NMR Probes
NMR Facility	Brey, W.W.	Test Of Current Injection Drift Compensation In A 900 MHZ NMR Magnet
NMR Facility	Brey, WW	Balanced transmission line probe for high field magnets
NMR Facility	Cross, T.A.	15N and 31P solid-state NMR study of transmembrane domain alignment of m2 protein of influenza a virus in hydrated cylindrical lipid bilayers confined to anodic aluminum oxide nanopores
NMR Facility	Cross, T.A.	Development of a joint solution and solid-state nmr based methodology for the backbone structural characterization of helical integral membrane proteins
NMR Facility	Cross, TA	Faraday shielding of solid state NMR samples
NMR Facility	Frydman, L	2D single scan NMR spectroscopy on a 25T Keck magnet.
NMR Facility	Fu, R.	Sensitivity enhancement by indirect detection in solid state 15N NMR
NMR Facility	Fu, R.	Dipolar Recoupling NMR Spectroscopy at 900 MHz
NMR Facility	Lin, Y	Spin turbulence at ultra-high magnetic fields
NMR Facility	Long, J.R.	Solid state CPMAS and homonuclear dipolar recoupling nmr experiments at 900 MHz
NMR Facility	Quine, J. R.	Random and rotary resonance
MBI-UF AMRIS	Blackband, SJ	Planar coil design for high-temperature-superconducting NMR probe
MBI-UF AMRIS	Edison, A.S.	Effect Of Conductor Geometry On SNR Of Micro-Coils
MBI-UF AMRIS	Fitzsimmons, JR	Reduction of wave effects at high field using serial excitation
MBI-UF AMRIS	Grant, SC	Enhancement of Native T1 Contrast at 4.7, 11 and 17.6 T for Animal Imaging
MBI-UF AMRIS	Grant, SC	Susceptibility-based Imaging of an Iron Oxide Labelled Construct
MBI-UF AMRIS	Mareci, T. H.	Implanted Magnetic Resonance Coil System for In Vivo Imaging and Spectroscopy of a Bioartificial Pancreas
MBI-UF AMRIS	Mareci, T. H.	Generalized Diffusion Tensor and Scalar Measures Using Trace, Variance and Entropy for High Angular Resolution Diffusion Weighted Imaging
MBI-UF AMRIS	Mareci, T. H.	Using Magnetic Resonance Imaging to Monitor Tumor Formation and Progression in a Mouse Model of Neurofibromatosis Type I Plexiform Neurofibroma
MBI-UF AMRIS	Mareci, T. H.	Use of Magnetic Resonance Imaging for the Study of Neuroprotection with Agmatine Following Excitotoxic Spinal Cord Injury
MBI-UF AMRIS	Sadleir, RJ	Magnetic Resonance Electrical Impedance Tomography at 11 and 17 T
MBI-UF AMRIS	Saylor, CA	Electromagnetic simulation of head and coil model at 7.1 T
MBI-UF AMRIS	Smith, MB	Human Head Imaging at 11 Tesla
MBI-UF AMRIS	White, K.D.	Techniques Enabling Longitudinal fMRI Studies of Age-Related Memory Changes
CM/T	Ardavan, A	Hyperfine structure of Sc@C82: ESR and DFT studies
UF Physics	Bowers, CR	Development of a New Field-Stopped Magnetoresistively Detected ENDOR Technique for Studies of Quadrupole Interactions and NMR Overtone Transitions in the Vicinity of a 2DES

Magnetism and Magnetic Materials - 44 Reports

Facility	PI Name	Report Title
DC Field Facility	Cao , G	Orbitally-driven Behavior: Mott Transition, Quantum Oscillations and Colossal Magnetoresistance in Bilayered Ca3Ru2O7
DC Field Facility	Crow, J.E.	Magnetization Study on Detwinned EuBaCo2O5.5 Single Crystals
DC Field Facility	Doerr, M.	Magnetoelastic investigation of rare earth based materials
DC Field Facility	Fisher, I. R.	= 2/3 BEC scaling close to Quantum Critical Point in \nu BaCuSi2O6
DC Field Facility	Guillot, M	Magnetic properties of Sc-substituted ytterbium iron garnet
DC Field Facility	Hayden, SM	De Haas-Van Alphen Study of Large Fermi Surface Sheets in ZrZn2

DC Field Facility	Jin, R.	On the Magnetoresistance of Na0.75CoO2
DC Field Facility	Kim, K. H.	Dielectric constant and ferroelectric polarization studies of multiferroic TbMn2O5 up to 33 tesla
DC Field Facility	Kirk, M. L.	Low-symmetry effects in metallacryptate single-molecule magnets
DC Field Facility	Krzystek, J.	High-Frequency and -Field EPR of Exchange-Coupled Lanthanide Centered [GdNi6] and [LnNi6] Clusters
DC Field Facility	Mackenzie, A	High Field Magnetotransport And Torque Magnetometry Of Ruthenate Metals
DC Field Facility	Reiff, W. M.	Unprecedented Long Range Magnetic Ordering and Metamagnetism of an S=2 Ferrous Dimer: Sub-THz Spectroscopy of [dmpipzH2][Fe2Cl4(H2O)6]Cl2
DC Field Facility	Reiff, W. M.	On the Use of Tunable-Frequency ESR in the Study of the H vs T Phase Diagrams of Multiple Metamagnetic Phase Transition 1D Magnets: Studies of 1D Chains Based on Exo-Bidentate Ligands in M(1,4-Pyrazine)CL2 Complexes (M = Divalent Fe, Co, Ni).
DC Field Facility	Stern, R.	High Field 11B NMR Study of 1/3 Magnetization Plateau of2D Quantum Spin System SrCu2(BO3)2
DC Field Facility	Takano, Y	Magnetic-phase diagram of Cu(C5H12N)2Br4: a s=1/2 spin ladder
DC Field Facility	Takano, Y	Low-temperature specific heat of copper benzoate in high magnetic fields
DC Field Facility	Turnbull, M.M.	High-field electron spin resonance studies of a new haldane spin system NeNb
Pulsed Field Facility	Balicas, L	Search for quantum oscillations and metamagnetism in Sr3Ru2O7 in pulsed fields
Pulsed Field Facility	Canfield, P. C.	Magnetoresistance in YbNi2B2C single crystals tuned by annealing
Pulsed Field Facility	Crooker, S. A	Measuring Random Spin Fluctuations for Perturbation-Free Probes of Spin Dynamics and Magnetic Resonance
Pulsed Field Facility	Fisher, I. R.	Effect of anisotropy and chemical pressure on high magnetic field ordering in the spin gap material Sr2Cu(BO3)2
Pulsed Field Facility	Fisher, R. A.	Specific Heat of GeCo2O4 and GeNi2O4: Frustrated Spinels in Magnetic Fields to 14 T
Pulsed Field Facility	Gaulin, B.	Thermal-expansion in the Shastry-Sutherland compound SrCu2(BO3)2
Pulsed Field Facility	Keppens, V	A field dependent study of the elastic behavior of Pr2CuO4
Pulsed Field Facility	Kim, K.H.	Dielectric constant and ferroelectric polarization studies of DyMn2O5 in pulsed magnetic fields up to 45 T
Pulsed Field Facility	Kimura, T.	Complex Conductivity of a Spin-dimer System
Pulsed Field Facility	Kimura, TK	Magnetoelectric coupling in TbMnO3
Pulsed Field Facility	Kirk, M. L.	Magnetic studies of a large dysprosium-manganese single-molecule magnet
Pulsed Field Facility	Lashley, J	Studies of the martensitic transition using magnetic fields
Pulsed Field Facility	Morosan, E.	Magnetic Energy Scales and Metamagnetic Transitions in TmAgGe
Pulsed Field Facility	Paduan-Filho, A	Specific heat and magnetocaloric effect of NiCl2-4Sc(Nh2)2
Pulsed Field Facility	Paduan-Filho, A.	Low temperature thermal conductivity of NiCl2-4Sc(Nh2)2 up to 14 T
Pulsed Field Facility	Stern, R	High field magnetic properties of spin tetramer compound Na5RbCu4(AsO4)4Cl2
EMR Facility	Nojiri, H	Characterization of twin ferromagnetic clusters: high frequency ESR investigation
NMR Facility	Mitrovic, V. F.	NMR investigation of Cs2CuCl4, 2d frustrated heisenberg antiferromagnet
NMR Facility	Reyes, A. P.	NMR studies of incommensurate quantum antiferromagnetic state of LiCuVo4
CM/T	Crow, J.E.	Magnetization and magnetotransport of LnBaCo2O5.5 (Ln=Gd,Eu) single crystals
CM/T	Dobrosavljević, V.	Absence of conventional quantum phase transitions in itinerant systems with disorder
CM/T	Schlottmann, P.	Evolution from insulator (x=0.003) to metal (x=1) of the Eu2+ local environment in Ca1-xEuxB6
CM/T	Schlottmann, P.	Magnetic polaron and Fermi surface effects in the spin-flip scattering of EuB6
CM/T	Schlottmann, P.	From itinerant ferromagnetism to insulating antiferromagnetism: A magnetic and transport study of single crystal SrRu1-xMnxO3 (0<X<0.60)< TD>
CM/T	Yang, K.	Theory of Ferromagnetic Transition in One-Dimensional Itinerant Electron Systems
UF Physics	Hill, S	Origin of the fast magnetization tunneling in the single-molecule magnet [Ni(hmp)(tBuEtOH)Cl]4
UF Physics	Hill, S	A spectroscopic comparison between several high-symmetry S = 10 Mn12 single-molecule magnets

Metal-Insulator Transitions - 7 Reports

Facility	PI Name	Report Title
DC Field Facility	Balicas, L.	Magnetic-field-induced fermi surface reconstruction in Na0.5CoO2
DC Field Facility	Brooks, J.B.	Dielectric Response in NiFe Nanowire - Nanoporous Silicon Structures
DC Field Facility	Hebard, A. F.	In-band Conductivity of Oriented Graphite in the High Field Ultra-quantum Regime
DC Field Facility	Musfeldt, J.L.	Directionally dependent magneto-optical response of Pr-Substituted LaSrMnO: Understanding the high field ferromagnetic state
DC Field Facility	Noh, T. W.	Relaxation behavior of the reflectance spectra of Nd0.65Ca0.35MnO3
Pulsed Field Facility	Migliori, A	3 Omega Thermal Conductivity Measurement of Nd0.5Sr0.5MnO3 in Pulsed Magnet
CM/T	Popovic, D	Time-dependent conductance fluctuations in the metallic phase of a two-dimensional electron system in silicon

Molecular Conductors - 15 Reports

Facility	PI Name	Report Title
DC Field Facility	Agosta, C. C.	Penetration Depth Studies of k-(ET)2Cu(NCS)2 at Low Temperatures
DC Field Facility	Ardavan, A	Angle-dependent-magneto-resistance-oscillations (AMRO) in kappa–(BEDT-TTF)2Cu(NCS)2 under high hydrostatic pressure
DC Field Facility	Ardavan, A	High field transport studies of beta" – (BEDT-TTF)4 [H3O Ga (C2O4)3] CH2Cl
DC Field Facility	Brooks, J. S.	Angular Dependence of the Magnetoresistance of (Per)2Pt(mnt)2 Under Hydrostatic Pressure
DC Field Facility	Brooks, J. S.	Simultaneous EMR and Resistance Measurements of Field-Induced Superconductors lambda - (BETS)2Fe0.4Ga0.6Cl4
DC Field Facility	Brooks, J. S.	Investigation of temperature-pressure phase diagram and magnetoresistance of beta-(BDA-TTP)2MBr4 (M=Fe, Ga)
DC Field Facility	Brooks, J. S.	High-Field Density Wave State of (Per)2Pt(mnt)2 Under Hydrostatic Pressure
DC Field Facility	Brooks, J.S.	Nernst effect at magic angles in (TMTSF)2ClO4
DC Field Facility	Hill, S	Cyclotron resonance in the quasi-1D organic superconductor (TMTSF)2ClO4
DC Field Facility	Kang, W	Study of pressure effect on the field-induced organic superconductor \kappa-(BETS)2FeBr4 using ultraminiature pressure cells
DC Field Facility	Musfeldt, J.L.	Understanding the totally symmetric intramolecular vibrations in K-phase organic supercondcutors
DC Field Facility	Park, Y. W.	Hopping conduction in polydiacetylene single crystals
Pulsed Field Facility	Harrison, N	Landau quantization within the CDW gap of Per2M(mnt)2 where M = Au, Pt.
Pulsed Field Facility	Singleton/Ardavan, J/A	The magnetic field dependence of narrow band noise in the charge density wave material Per2Pt(mnt)2
UF Physics	Hill, S	Angle-Resolved Mapping of the Fermi Velocity in Quasi-Two-Dimensional Conductors and Superconductors: Probing Quasiparticles in Nodal Superconductors

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Facility	PI Name	Report Title
DC Field Facility	Suslov, A	Elastic properties of Gd5(Si2Ge2) studied by ultrasonic technique
DC Field Facility	Suslov, A.	Ultrasonic quantum oscillations in AuZn single crystal
DC Field Facility	Wu, Y	NMR study of correlated electron behavior in single-walled carbon nanotubes
Pulsed Field Facility	Goddard, P.A.	Fermi surface reconstruction in the shape-memory alloy AuZn
Pulsed Field Facility	Kimura, T	Anisotropy of the optical transmission spectrum in BaCuSi2O6
Pulsed Field Facility	Kouprine, A.	Pulsed Magnetic Field Measurements of NaxCoO2
Pulsed Field Facility	McDonald, R. D.	GHz Conductivity Measurements of the f-electron Element Cerium
CM/T	Brooks, JS	Field-effect transistor made of derivative pentacene
CM/T	Cao, J	Femtosecond electron diffraction: probe and control ultrafast structural dynamics
CM/T	Schrieffer, J.R.	Gauge theory of pairing and spin fluctuations near a quantum critical point

Quantum Fluids and Solids - 6 Reports

Facility	PI Name	Report Title
DC Field Facility	Zvyagin, S.A.	Solitary waves in quantum spin chains
Pulsed Field Facility	Hussey, NE	The search for a 1D metallic state in PrBa2Cu4O8
High B/T Facility at UF	Lee, Y	Observation of a High Field Phase in Superfluid 3He in 98% Porosity Silica Aerogel
High B/T Facility at UF	Lee, Y	The A-B Transition of Superfluid Helium-3 in Aerogel and the Effect of Anisotropic Scattering
UF Physics	Sullivan, N	NMR line shapes for quadrupolar glass states of solid hydrogen
UF Physics	Sullivan, N. S.	Thermodynamic properties of hydrogen-helium and methane -helium dispersions: NMR studies.

Semiconductors - 27 Reports

Facility	PI Name	Report Title
DC Field Facility	Bowers, CR	High Frequency Microwave Induced Magnetoresistance Oscillations of a 2DES
DC Field Facility	Crooker, S. A.	Probing Excitonic Spin States in Nanocrystal Quantum Dots by Resonant Spin-Polarized Photoluminescence Spectroscopy
DC Field Facility	Drichko, I.L	Acoustoelectric Effects in Ge/Si Nanosystems with Ge Quantum Dots
DC Field Facility	Du, R. R.	Magnetotransport in (001) GaAs-AlGaAs High-Mobility 2D Hole Systems
DC Field Facility	Engel, L.W.	Pinning mode dispersion of 2D Wigner solid phases in high magnetic field
DC Field Facility	Engel, L.W.	RF spectra of bubble phases of 2D electron systems in tilted magnetic fields
DC Field Facility	Iyer, N	Photoluminescence and Magnetospectroscopy Studies of GaAsSbN/GaAs Single Quantum Wells
DC Field Facility	Khodaparast, G. K.	Cyclotron Resonance in InMnSb III-V Magnetic Semiconductors
DC Field Facility	Kono, J.	Interband magneto-optical studies of single-walled carbon nanotubes in high dc magnetic fields up to 45 t
DC Field Facility	Leotin, J.	Photoresponse of Si:B blocked-impurity-band structure in a magnetic field
DC Field Facility	Lewis, A	Far-infrared spectroscopy of electronic materials
DC Field Facility	Murphy, S.Q.	Quantum Hall Ferromagnetism in InSb Heterostructures
DC Field Facility	Reitze, D. H.	Magneto-Plasmonic Photoluminescence In Strong Magnetic Fields: Evidence For Stimulated Emission Processes
DC Field Facility	Santos, M.B.	Spin-mediated subband landau-level coupling in a two-dimensional electron gas
DC Field Facility	Shayegan, M.S.	Observation of spin-dependent longitudinal resistivity in the integer quantum Hall regime
DC Field Facility	Smirnov, D.	Intersubband lifetime magnetophonon oscillations in MIR GaAs quantum cascade lasers
DC Field Facility	Stormer, H. L.	Impurity Mediated Splitting of CR in Two-Dimensional Electron Systems
Pulsed Field Facility	Christianen, P.C.M	Triplet and Singlet States in GaAs/AlGaAs Quantum Wells in High Magnetic Fields
Pulsed Field Facility	Crooker, S. A.	Imaging and Manipulating Electron Spin Flows in Semiconductors
Pulsed Field Facility	Kim, YM	Magnetoluminescence of Asymmetric GaAs/AlGaAs Coupled Double Well Structures
Pulsed Field Facility	Kono, J.	Interband magneto-optical studies of single-walled carbon nanotubes in pusled high magnetic fields up to 65 t
Pulsed Field Facility	Petusky, W.	Hall Effect in a Wide Bandgap Semiconductor
High B/T Facility at UF	Tsui, D. C.	Tilt Induced Localization and Delocalization in the Second Landau Level
CM/T	Lu, J.	Current-induced dynamic nuclear polarization in GaAs and InSb
CM/T	Stormer , HL	Evidence for Skyrmion Crystallization from NMR Relaxation Experiments
UF Physics	Bowers, CR	ENDOR and DNP Phenomena in a 2DES
UF Physics	Dorsey, A. T.	Novel Phases of Two Dimensional Electron Systems in High Magnetic Fields

Superconductivity - Applied - 8 Reports

Facility	PI Name	Report Title
DC Field Facility	Buta, F	Flux pinning in RHQT-processed Nb3Al after various transformation heat treatments
DC Field Facility	Hong, S.	High field characterization of strands for superconducting magnets over 21 T
DC Field Facility	Larbalestier, D.C.	The Effect on Upper Critical Field of Ternary and Quaternary Additions to Superconducting Nb3Sn
DC Field Facility	Pyon, T.	High Performance Nb3Sn Superconducting Wire for Fusion Application
DC Field Facility	Schwartz, J.	In-field Transport Characterization of State-of-the-Art HTS-conductors up to 45 T
DC Field Facility	Sumption, MD	Upper Critical Field And Irreversibility Field In MgB2 Wires With Sic Additions
DC Field Facility	Thieme, C.L.H	Small Coils Made with Second Generation HTS Wire Tested in High Magnetic Fields
Pulsed Field Facility	Larbalestier, D. C.	Improved Hc2 in Bulk-Form Magnesium Diboride by Mechanical Alloying With Carbon

Superconductivity - Basic - 27 Reports

Facility	PI Name	Report Title
DC Field Facility	Biswas, A	Origin of the anomalous low temperature upturn in resistivity in the electron-doped cuprates
DC Field Facility	Boebinger , G.S.	Low temperature electronic-mass enhancement in the normal state of La1.78Sr0.22CuO4
DC Field Facility	Canfield, P.C.	Effects of Carbon Doping and Neutron Irradiation on the Upper Critical Field of MgB2
DC Field Facility	Carrington, A	De Haas-van Alphen Effect in Aluminium and Carbon Doped Magnesium Diboride
DC Field Facility	Cooper, JR	High field studies of single crystals of cuprate superconductors by cantilever magnetometry
DC Field Facility	Crow, J.	Growth of high quality Sr2RuO4 and Sr3Ru2O7 single crystals.
DC Field Facility	Dagan, Y	Magnetoresistance as a function of doping and dissorder in pcco
DC Field Facility	Hussey, NE	Angular Magnetoresistance Oscillations in Tl2Ba2CuO6 (Tc = 45K)
DC Field Facility	Krusin-Elbaum, L.	Zeeman-scaled Pseudogap in Superconducting Electron-doped Cuprates
DC Field Facility	Li, Q.	Magnetoresistance and Upper critical field in clean and doped MgB2 thin films
DC Field Facility	Maple, M. B.	Vortex-matter states in Y1-xPrxBa2Cu3O7-d films in magnetic fields up to 45 T
DC Field Facility	Maple, M. B.	Electrical Transport Properties of Underdoped Sm2-xCexCuO4-y Thin Films at Low Temperatures
DC Field Facility	Ong, N. P.	Doping dependence of the high-field nernst effect in La2-xSrxCuO4
DC Field Facility	Welp, U.	Field dependence of the local density of states in MgB2
DC Field Facility	Wosnitza, J	Magnetic quantum oscillations in the normal state of YNi2B2C
DC Field Facility	Yeh, N.-C.	Quantum criticality and high field phase diagram of HgBa2Ca3Cu4Ox
Pulsed Field Facility	Balakirev, FF	Normal-State Hall Effect in High-Tc La2-xSrxCuO4 at Low Temperatures
Pulsed Field Facility	Moschopoulou, E	Upper critical field in LiTi2O4
Pulsed Field Facility	Ronning, F	Resonant Ultrasound Spectroscopy of Sr2RuO4
Pulsed Field Facility	Rullier-Albenque, F.	Transport properties in irradiated cuprates
Pulsed Field Facility	Sarrao, J. L.	Probing the Superconducting State in PuCoGa5
Pulsed Field Facility	Torikachvili, M. S.	Upper critical field measurements in Ru1-xRhxSr2GdCu2O8 magnetic superconductors
Pulsed Field Facility	Torikachvili, M. S.	Double superconducting transition in Bi-2212 compounds in high magnetic fields
Pulsed Field Facility	Zapf, V. S.	High-field phase diagram and pinning phenomena in the infinite layer cuprate superconductor Sr0.9La0.1CuO2
CM/T	Gor`kov, L P	Pseudogap regime in high tc-cuprates as a manifestation of a dynamical phase separation
UF Physics	Hirschfeld, P.J.	Electronic structure of d-wave superconducting quantum wires
UF Physics	Hirschfeld, P.J.	Forward Scattering by Out-of-plane Defects in the Cuprate Superconducting State

Appendix B
PUBLICATIONS INDEX BY AUTHORS

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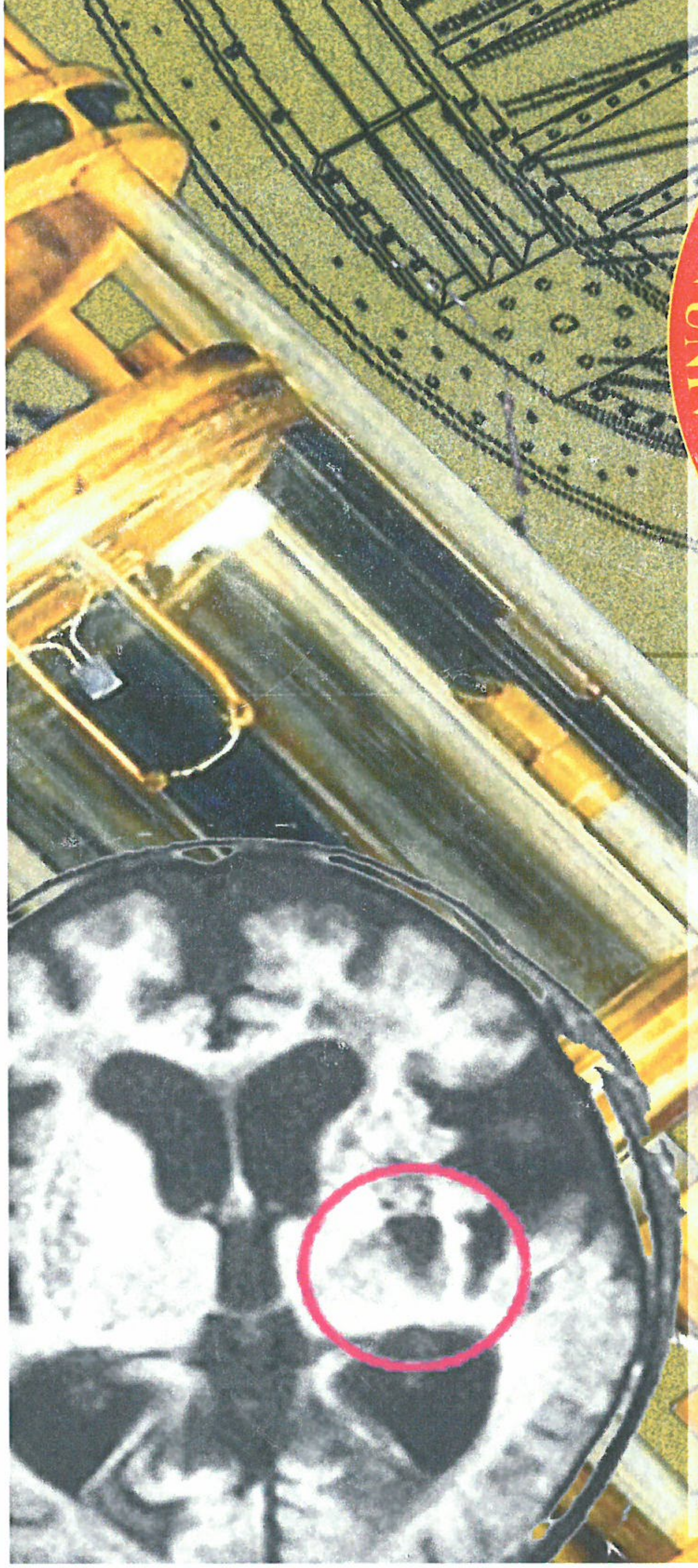

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