NHMFL National High Magnetic Field Laboratory

1997 Annual Report

Volume 2 – Programs

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1997 Annual Report — Volume 2 – Programs

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1997 ANNUAL REPORT

Executive Summary

This year the National High Magnetic Field Laboratory (NHMFL) is publishing the annual report in two volumes because of the expanding number of research reports generated by users of the facility and in-house scientists. Volume 1 published early in the year contained user research reports and research-related sections and can be accessed on the Internet *(http://www.magnet.fsu.edu/publications/1997annualreport)* or by contacting the NHMFL. This publication, Volume 2, addresses the progress of the specific program areas of the laboratory and is published in late summer. Please note that during this transition year, Volume 2 covers an eighteen-month period for most program areas and will return to its one-year reporting format next year.

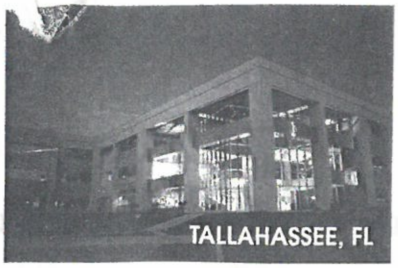
Program highlights are summarized in this section. More comprehensive reports are provided in the corresponding sections of this volume.

Users Program

The NHMFL user community continues to grow and flourish at all three of our sites, as evidenced by the record number of 2[illegible]5 research reports published in Volume 1 of the annual report. At the DC Field Facility in Tallahassee, researchers spent 1,188 magnet days on the resistive and superconducting magnets. At Los Alamos in the Pulsed Field Facility, users spent 515 magnet days on the pulsed magnets and superconducting magnet. User demand for the short pulse magnets continues to grow; the number of users increased to 118 during the past year, up from 86 in 1996. The High B/T Facility in Gainesville entertained its first users this year, and interest in the special capabilities of the system is high. The Center for Interdisciplinary Magnetic Resonance (CIMAR), with facilities in Tallahassee and Gainesville, hosted 77 user groups that worked on 125 different projects. Of these, NMR supported 34 groups and 52 projects; EMR, 20 groups and 30 projects; and ICR, 23 groups and 43 projects.

In Tallahassee, new instrumentation at the laboratory is offering users important new capabilities. For example, a new non-metallic high pressure cell allows both optical and electrical experiments at ultra low temperature with minimal eddy-current heating even in pulsed magnets. In addition, a new Oxford portable top loading dilution refrigerator is now available for the resistive magnets. The combination of high DC fields and low temperatures allowed one group of users to observe new properties of highly correlated electron systems and enabled several other groups to extend their research to higher fields.

The commissioning of the "Keck" magnet, a 25 T, 52 mm bore, high homogeneity resistive magnet, has opened up new opportunities for electron magnetic resonance spectroscopy. Among the first projects were studies of photosynthesis and motional dynamics. In photosynthesis, the increase in resolution allows for a precise determination of the electronic structure of the systems



involved—information not available otherwise. Measurements at frequencies up to 670 GHz, possible only with this magnet, opened new means for examining the motions of complex fluids, for instance nitroxide spin-labeled molecules in the study of the glass transition in hydrocarbons.

The Geochemistry group has been improving their analytical techniques with the inductively coupled plasma mass spectrometer. Presently available analytical routines allow fast analysis of minute concentrations of trace elements in environmentally significant materials. One group of researchers used these techniques to identify the sources and trace the routes of migration of mercury-containing compounds in air and water.

At the Pulsed Field Facility, testing of the 60 T Quasi-Continuous magnet is almost complete and performance has met all expectations. This important new research facility will be officially commissioned on August 28, 1998, by the Director of Los Alamos National Laboratory and the Chancellor of the State University System of Florida. In recognition of this significant engineering achievement, the design and commissioning team, representing three LANL divisions, will be presented with a LANL Distinguished Performance Award at the commissioning ceremony. Once online in the fall, this user facility will enable fixed field measurements at 60 T for as long as 100 ms and magnetic field pulse profiles tailored to fit the special requirements of a particular experiment.

Greg Boebinger of Lucent Technologies, a highly respected scientist in pulse field research, joined the NHMFL team in 1998 as the new director of the Pulse Field Facility. In another significant organizational development, Los Alamos National Laboratory consolidated the Pulsed Field Facility into a Center that will report to the Materials Science and Technology Division. The formation of the NHMFL Center at Los Alamos represents Los Alamos National Laboratory's commitment to the future development and advancement of the NHMFL program and the unique federal-state-academia partnership reflected by the NHMFL.

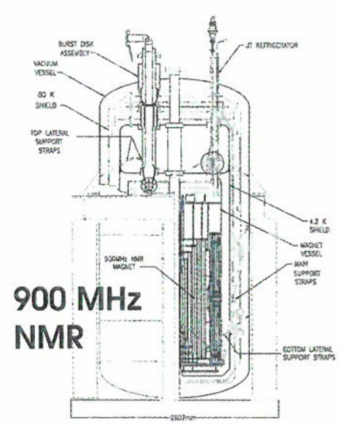
The High B/T Facility, a part of the NHMFL operated by the University of Florida, was commissioned in the fourth quarter of 1997 and is accommodating users. It is the only such facility worldwide. Early experiments show great potential for the demagnetization refrigerator and high field superconducting magnet system. Thus far, the system has achieved 39,000 teslas per kelvin, with a goal of 50,000 teslas per kelvin. User demand, coupled with the long times required for ultra low temperature experiments, is challenging operators to accommodate multiple experiments on each magnet run.

The Proposal Review Panel has been convened to review user proposals for large amounts of magnet time at the DC and Pulsed Field Facilities. Twenty-two major proposals from existing users who have reached a threshold of one percent consumed magnet time were reviewed and ranked in order of priority. These panel reviews apply for three years, subject to annual progress reviews by the panel. The panel of four reviewers will be expanded as needed and panel reviews will be conducted bi-annually, eventually covering all NHMFL facilities.

Magnet Science & Technology Programs

The Magnet Science & Technology (MS&T) programs continue to reach maturation with the completion of the ambitious cornerstone magnet systems initially requested by the NSF. The 45 T Hybrid superconducting outsert is approaching final assembly and will be tested in early fall, 1998. With the design reviews of the 900 MHz NMR wide bore completed and the procurement of $1.2 million of superconducting wire, a detailed manufacturing and assembly schedule has been established with our industrial partner, Intermagnetics General Corporation. The critical timing of the complex schedule to build this magnet requires an experienced project manager, and the NHMFL Director has asked Jim Ferner, Director of Facilities & Administration to lead the project. Denis Markiewicz will continue as the technical project manager. Mr. Ferner has an extensive career of managing large projects and working with industrial partners.

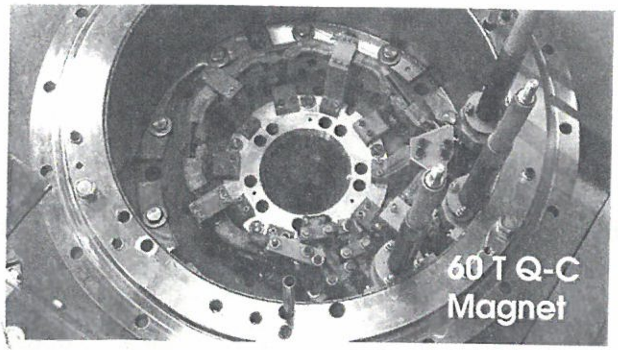
The innovative, high homogeneity magnetic resonance resistive magnet that was partially funded by a grant from the Keck Foundation was commissioned in February, 1998. Initial experiments on the Keck magnet have provided very interesting EMR and ICR data, and the MS&T staff are fine tuning the magnet to achieve greater homogeneity for 1 ppm NMR experiments. The 20 T wide bore, 200 mm magnet that was jointly developed with the High Magnetic Field Laboratory located in Grenoble, France, was also commissioned during the reporting period. This unique magnet system is attracting broad user requests. An improved version of the 33 T magnet is more efficient and may provide an additional two teslas of field in the future.


900 MHz NMR


IGC Team


Keck Magnet


20 T, 200 mm Magnet



The NHMFL Pulsed Field Facility successfully completed the world-record 60 T Quasi-Continuous pulsed magnet. This significant addition to the facility brings an exciting new dimension to pulse field research. While the generator that powers this magnet system roars like the "Godzilla of the Southwest," sophisticated data acquisition equipment is poised to capture new research data at these fields.

Capacitor driven pulse magnets continue to be developed. A 10 mm bore prototype for a new generation of pulse magnets with fields in the 70 T range was tested recently. It achieved a new world record of 77.8 T.

The NHMFL is also developing a 30 T, 25 mm bore, split-pair, repetitively pulsed magnet that will pulse at a rate of 2 Hz for the Los Alamos Neutron Science Experiment (LANSCE). This magnet is being funded by the Department of Energy and will be used in the LANSCE facility to provide a high magnetic field neutron beam scattering capability that will be unique in the world. Another joint development initiative with Los Alamos is the insert magnet for the 100 T magnet project. The insert will be a 15 mm bore capacitor powered magnet capable of producing a 52 T pulse in a 48 T background field generated by an outer coil set. These projects reflect the continued growth of the Florida-Los Alamos partnership and demonstrate the great potential of the human resource that has been developed by this model federal-state partnership.

In-House Research Program

The leadership of this program rotates among the three sites every two years, and in 1998, Prof. Zachary Fisk, member of the National Academy of Science, assumed the directorship. The In-House Research Program seeks to enhance collaborations among internal and external researchers and support bold and sometimes risky experiments that advance the facilities of the laboratory. The program is resulting in the development of a new user infrastructure and enhancement of the laboratory's capacity to serve the broad user community. In addition, the program is significantly enhancing collaborations among researchers at the three institutions and with the external user community.

Program activity during this reporting period has been very brisk. The second proposal solicitation (issued in January, 1997) resulted in receipt of 27 proposals and seven awards in September, 1997. The third solicitation for proposals was released in January, 1998. Forty proposals were received, 17 of which are undergoing a second review from external reviewers. Final awards will be made in September, 1998.

Outreach Activities: Education & Development

All of the NHMFL outreach programs and activities have been consolidated into a new organizational group under the leadership of Janet Patten, Director of Government and Public Relations. A new and needed dimension is being added with the anticipated hiring of a Development Officer who will foster giving opportunities for foundations and corporations. This individual will also work closely with senior management as the laboratory responds to economic development prospects for the region and the state.

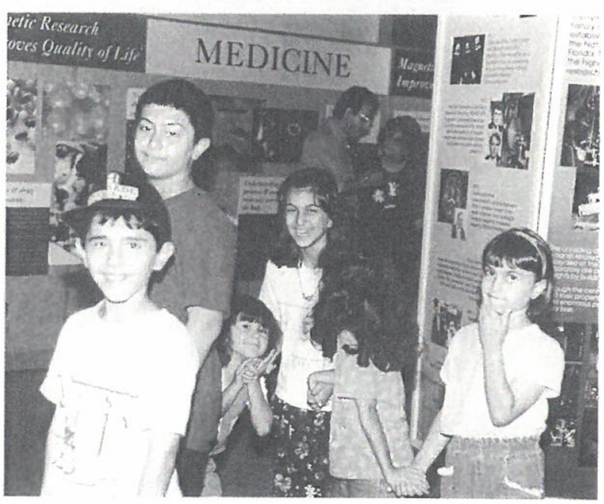
The educational outreach activities have mushroomed into a full-fledged program at the NHMFL. During the 1997 calendar year, NHMFL educators reached over 12,000 K-12 students with multifaceted, interdisciplinary programs presented in the schools. As one elementary school teacher wrote about the outreach program conducted at her school, *The manner in which you physically and mentally involved them (the students) in the process provided the perfect vehicle for increasing their comprehension.*

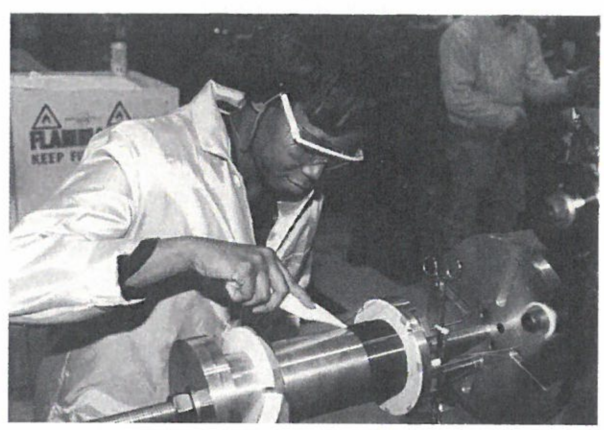
Another 4,000 students in grades 4-12 toured the laboratory and enjoyed lectures on science and magnetism tailored specifically to their classroom studies. As one teacher commented, *The NHMFL as an educational resource is the answer to students' questions about 'Why do we have to do this?' If I could bring just one class a year to this place, it would make a difference.*

All faculty and staff of the laboratory make a conscious effort to enhance science and technology awareness among the general public with guided tours, displays, talks, and hands-on activities. Approximately 6,000 visitors from the general public toured the facility, including over 3,500 who came to the annual open house. NHMFL researchers were featured on such national programs as the Discovery Channel's *World of Wonder*, CNN's *Future Watch*, ABC's *Good Morning America*, and also on Australia's science show, *Quantum*.

A new, valuable teacher education program was initiated this year to provide materials and activities to enhance science teaching. Over 550 teachers throughout Florida participated in programs and workshops using the new standards-based curriculum product developed at the NHMFL. Web-based resources are also available that extend the impact of these efforts. The laboratory's teacher education activities have been particularly well received by elementary school teachers. One participating teacher commented, *As a science education resource, the NHMFL seems to make a valuable contribution to research. It is evident that they lend themselves to all levels of scientists and scientific research.*

Needless to say, NHMFL educational programs and activities do not stop at the K-12 levels. The laboratory-related faculty at Florida State University and the University of Florida reported advising over 133 undergraduate students and teaching 60 undergraduate classes. They also served on over 267 graduate committees and taught 29 graduate classes. There were 19 NHMFL-affiliated graduate students who earned their Ph.D.'s in 1997. Forty postdoctoral fellows were affiliated with the laboratory during this period and most have now assumed new and exciting careers in industry and academia. The laboratory considers postdoctoral opportunities to be an invaluable resource in growing the next generation of users of the NHMFL.





Outreach Activities: Collaborations

The federal-state partnership that established the NHMFL and the laboratory's growing leadership role and recognized competence in science and magnet technology are nurturing a significant collaborative culture at the NHMFL. An ever-increasing number of private sector companies, as well as other national and international organizations, have contacted the laboratory for its expertise and partnering on proposals, as evidenced by the listing in Chapter 5 of this volume.

Two years ago, EURUS Technologies, Inc. moved to Innovation Park across the street from the laboratory. EURUS is dedicated to integrating superconducting technology into commercial products. The NHMFL-EURUS partnership has established an exciting public-private industry model of mutual cooperation. With the NHMFL providing cutting-edge research and facilities, EURUS has positioned itself to receive world-class insight into electric power systems and magnet-related technologies requiring commercialization. An early sign of success emerging from this partnership is the fact that EURUS and the NHMFL have already initiated two additional commercialization programs in the area of the next-generation conductor development.

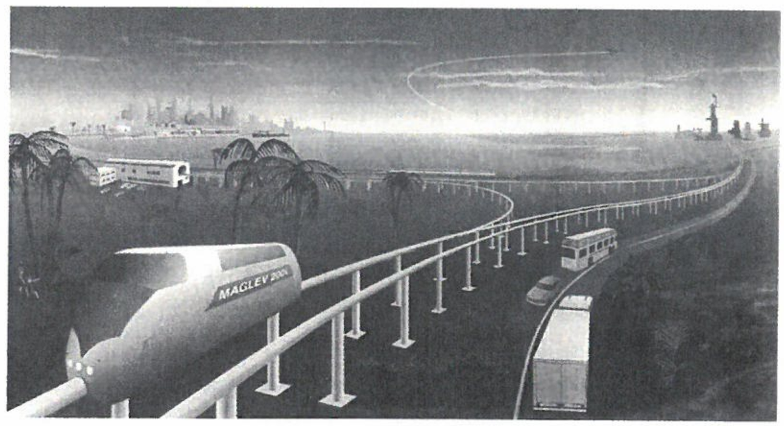
In the second year of the three-year CRADA between EURUS and the NHMFL, the primary focus has been on co-developing and testing ultra-high current, high temperature superconductor (HTS) leads. The program's intention is to develop the world's first commercially available 10,000-amp class, encapsulated HTS current lead suitable for high magnetic field applications. The aggressive pace of development has enhanced the program's target to produce current leads of the 100,000-amp class.

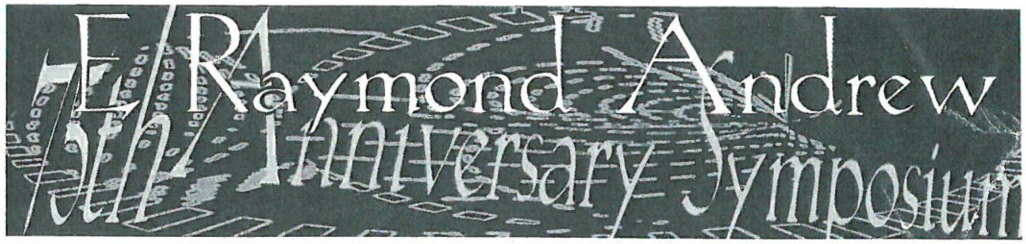
A technical team comprising DuPont Superconductivity, Carpco Inc. of Jacksonville, Florida, and the NHMFL has received funding from the U.S. Department of Energy to develop a prototype magnetic ore separator system. The three-year, $6 million project is one of six funded under the DOE Superconductivity Partnership Initiative program. The goal of the project is to develop a one-quarter commercial scale reciprocating magnetic separator based on high temperature superconductors. The separator cycles material into and out of the magnet bore collecting the waste in a fine mesh iron screen. Eventual replacement of conventional water-cooled, copper coils with HTS magnets would save the ore separation industry more than 90 percent of its energy costs.

The NHMFL and BWX Technologies (formerly Babcock and Wilcox) are developing a new design for a superconducting magnet energy storage (SMES) system for commercial delivery by mid-1999. SMES systems store large amounts of energy in a DC magnetic field with very little loss for later delivery as AC power. The main components in such systems are superconducting magnets and electronic power converters for the DC to AC and AC to DC conversion. The particular application planned by BWX Technologies is a system for stabilizing power transmission lines in such a way that voltage fluctuations are damped to an acceptable level. The NHMFL is also the official test site for the Navy's prototype SMES device. The Navy is interested in using the laboratory's unique testing facilities and engineering expertise to build large-scale magnet systems that utilize the cable-in-conduit technology developed for the 45 T Hybrid magnet system.

On the international front, the Japanese National Research Institute for Metals and the NHMFL signed a collaborative agreement to foster cooperative programs that will facilitate new scientific exchanges, advance user research facilities, and drive important new technologies. In addition, the two international laboratories will share personnel and conduct joint conferences. This agreement caps a series of productive exchanges between the two institutions over the last several years. A three-year partnership with the Grenoble High Magnetic Field Laboratory has resulted in the joint design, construction, and installation of magnets that are compatible with the different laboratories. A 20 T resistive, 200 mm wide-bore magnet was installed in Tallahassee in mid-1998, and it has already piqued new user interest. Discussions are underway with Grenoble for the next co-developed magnet systems. Other international collaborations include ones with the magnet laboratory in Toulouse, France, and the Bochvar Institute in Moscow, Russia.

The NHMFL is a contributing partner to the MAGLEV 2000 project, which is being driven by Florida industry and the Florida Department of Transportation. The State of Florida has a continuing interest in maglev as a next-generation alternative to high-speed rail that will link the metropolitan areas of Miami, Orlando, and Tampa. Construction of a demonstration project is underway on a 1,000-foot segment of a two-mile maglev guideway to be completed in late 1998. New interests in maglev have been expressed by the mining industry for mining applications—to climb steep grades at high speeds, to haul heavy loads, and to avoid noxious exhaust pollution. With no moving parts or contact with rail surfaces, maglev technology has the potential to be competitive and cost effective compared to traditional systems for both low and high speed transportation or special applications.





Conferences and workshops hosted by the NHMFL have been very productive in fostering new collaborations and associations beyond the scientific exchanges. The laboratory hosted numerous national and international meetings at the three sites, including the first Robert Schrieffer Tutorial Series at Los Alamos National Laboratory, the 75th Anniversary Symposium for Raymond Andrew, and the 29th Annual Southeastern Magnetic Resonance Conference at the University of Florida.

The First North American Fourier Transform Ion Cyclotron Resonance Mass Spectrometry Conference was convened at the NHMFL and attracted 110 registrants from the United States, United Kingdom, Germany, France, The Netherlands, and Japan. In addition, a workshop was held at the NHMFL to exchange information about the physical properties of Mn- and Ru-based metal oxides and to discuss science and technology opportunities in these areas. Informal meetings such as this one help to develop in-house science programs and promote collaborations among scientists and engineers.

The NHMFL also hosted the eighth workshop in a series between members of the Japanese and U.S. science communities that explores the latest innovations in high temperatu superconductor research. Over 75 invited participants discusse such topics as HTS coils for high field use; bulk synthesis, structur and applications; thin films; vortex structures, critical current and AC losses; new materials and characterization.

More and more frequently, the laboratory is participating in "of site" meetings. For example, the laboratory was invited to participat in a major technology conference sponsored by the State of Florid and the American Association for the Advancement of Scienc and organized by the University of Florida. The meeting attracte over 250 leaders from industry, government, and higher educatio and focused on issues critical to the state's economic growth in high-tech environment.

Early in the year the NHMFL's magnetic resonance grou coordinated a highly successful conference entitled *High Fiel NMR: A New Millennium Resource* in Washington, D.C. Th conference focused on scientific frontiers important to the nationa scientific agenda and addressable through the next generation o high field nuclear magnetic resonance spectrometers. The fou frontier areas discussed were Beyond the Genome, Neuroscience New Materials, and Gene Regulation. Participants also discusse how networking using Internet II could support collaborativ research through shared instrumentation that is regionally positione throughout the United States. A "virtual laboratory" on the Interne could provide important training opportunities for undergraduat and graduate students in magnetic resonance techniques and thei applications to emerging science and technology frontiers. In addition to the nation's leading NMR scientists who attende the conference, representatives from the National Scienc Foundation, the National Institutes of Health, and the Departmen of Energy participated in the workshop.

Users Programs

Chapter 1

Highlights

- The most exciting development at the Pulsed Field Facility during the past year has been the testing of the 60 T quasi-continuous magnet. Once online as a user facility in the autumn of 1998, the 60 T quasi-continuous magnet will enable fixed field measurements at 60 T for as long as 100 ms, as well as magnetic field pulse profiles tailored to fit the special requirements of a particular experiment.

- The High B/T Facility was commissioned at NHMFL facilities at the University of Florida in the fourth quarter of 1997 and is accommodating users. This facility is designed to provide users with the capability to reach very low temperatures (down to 0.4 mK) and high fields (20 T) simultaneously, and will be a valuable research tool for studies of materials and systems that require high spin polarizations. User demand and interest for this unique system are high.

- A new electrically nonconductive high pressure cell allows both optical and electrical transport experiments to be performed at millikelvin temperatures with minimal eddy current heating in the pulsed magnets. Transport measurements are currently limited to 15 kbar at low temperatures; optical work to 80 kbar.

- Two specialty resistive magnets were installed in Tallahassee. One has a 195 mm bore and provides 20 T fields for testing nuclear magnetic resonance (NMR) magnet coils and a variety of experiments not possible in the 32 mm bore standard magnets. The other magnet, a 25 T, 52 mm vertical bore system, has the highest homogeneity available to date in a resistive magnet and will be improved further by shimming and ripple cancellation to obtain 1 ppm spatial and temporal inhomogeneity. The magnet was funded in large part by a $600,000 grant from the W. M. Keck Foundation with additional funds from the NSF and the State of Florida.

- The EMR group, in collaboration with scientists from the University of Florida and Queen Mary and Westfield College, University of London, used the "Keck" magnet to perform very high frequency EPR spectroscopy (670 GHz, 24 T). They investigated a number of photosynthetic reaction centers, including *Rb. sphaeroides,* and *heliobacter*. The capacity to operate at very high field was instrumental in these studies and, for the first time, allowed for the complete resolution of the g-Lande tensor components. It also opened up new opportunities for determining the electronic structure of reaction centers, structures of paramount importance to understanding the processes involved in photosynthesis. Future work will continue the preliminary studies and investigate *Chlorobium* and *Viridis,* thus investigating a series of bacterial reaction centers with differing protein structures.

- The new Oxford portable top loading dilution refrigerator is now available. Visiting and NHMFL researchers observed exciting new phenomena in the first weeks of operation of the fridge in the laboratory's 33 T Florida-Bitter magnet. The combination of high DC fields and low temperatures now available at the NHMFL is unique in the world.

- During the past reporting period, significant new external peer-reviewed funding was generated for NMR and electron magnetic resonance (EMR) instrumentation (details provided later in this chapter). In addition, CIMAR was well represented in the NHMFL's In-House Research Program, for which several projects from all of the magnetic resonance areas received strong external peer review and are now underway.

- A large amount of time was spent last year on improving analytical techniques on the Geochemistry group's magnetic sector inductively coupled plasma mass spectrometer (ICP-MS) by experimenting with inlet systems. The vendor finished installation in June, 1997, and since that time different configurations of the instrument have been tested to optimiz analysis routines. Presently available analysi routines allow fast analysis of elementa concentrations in environmentally significan materials. In addition, improvements hav resulted in detection limits that are a factor o four to ten lower than when the instrumen was installed one year ago.

- Several magnet systems developed for testin components of large superconducting magnet have been consolidated into the Large Magne Component Test Facility. It provides greate convenience, improved safety, and additiona facilities. The development of this facility ha been driven by the increasing demand for larg conductor and component testing.

DC Field Facility—Tallahassee

The general purpose DC magnetic field facility at the NHMFL's headquarters in Tallahassee exists to provide to the user community the strongest, quietest, steady and slowly varying magnetic fields in the world, coupled with state-of-the-art instrumentation and experimental expertise. Several new systems dramatically expanded the magnetic field-temperature-pressure "phase space" available to researchers during the past year. Experiments in the new portable dilution refrigerator found phenomena at 40 mK in fields between 20 and 33 T that were entirely new, not extensions of lower field work. A very small diamond anvil high pressure cell with a plastic body fits into the restricted volume of the portable dilution refrigerator and has negligible eddy current heating, even in pulsed magnets. Two new water-cooled magnets were installed. One was built with Keck Foundation support and responded to the need for high homogeneity for magnetic resonance research, for example. Several groups rushed to use the 25 T, 52 mm bore, high homogeneity magnet for EMR experiments even as the resistive magnet design team and the solid state NMR group continued to test and improve the magnet toward their goal of solid state NMR at 25 T. The other new water-cooled magnet, which produces 20 T in a 195 mm room temperature bore, is much larger than the 50 mm previously available. It was designed and built in collaboration with the Grenoble High Field Magnet Laboratory.

Table 1. Magnet systems available to users at the DC Field Facility, Tallahassee, as of June, 1998.

SUPERCONDUCTING MAGNETS

FIELD (T), BORE (MM)	Temperature	Supported Research
20, 52	20 mK - 2 K	Magneto-optics (ultra-violet through far infrared), magnetization; specific heat, transport, high pressure, low to medium resolution NMR, dependence of optical and transport properties on field orientation, etc.
19.5, 52	0.4 - 300 K	
15, 45	10 mK - 1 K	
6, 100	1.8 K to 600 K	

RESISTIVE and HYBRID MAGNETS

FIELD (T), BORE (MM)	Power (MW)	Supported Research
20, 195	20	Magneto-optics (ultra-violet through far infrared), magnetization, specific heat, transport, high pressure, low to medium resolution NMR in highest fields, EMR, temperatures from 40 mK to 800 K, dependence of optical and transport properties on field orientation, etc.
30, 32	15	
33, 32	19	
24.5, 32[1]	15	
25, 52[1]	20	
45, 32[2]	~20	

1 Higher homogeneity magnet
2 Under development

Continuous Field General Purpose Magnets, Changes since August 1, 1997

- The first Bitter magnets installed at the NHMFL, two 20 T, 50 mm magnet coil sets built at the Grenoble High Field Magnet Laboratory, were retired after long, productive careers. The first was replaced with a higher homogeneity 24.6 T, 32 mm bore magnet. The second will be replaced with resistive magnets now in development. The hybrid insert design has been completed and procurement of components is underway.

- A 20 T, 195 mm magnet has been installed. It was designed and built in collaboration with the Grenoble High Field Magnet Laboratory. A 170 mm inner diameter, structurally reinforced cryostat will allow the large bore magnet to be used for superconducting coil testing. This magnet also can be used for FT-ICR, dual axis sample rotation experiments, optical measurements not possible with optical fibers, experiments at temperatures above 900 K, and other research exploiting the large bore.

- A 25 T, 52 mm, Bitter magnet, designed from the beginning for higher homogeneity, was completed with funds from the Keck Foundation and the NHMFL. It was immediately used very effectively for one Fourier Transform Ion Cyclotron Resonance (FT-ICR) mass spectroscopy experiment and several EMR experiments. The process of optimizing the homogeneity of the magnet to bring it within the design goal of 1 ppm over a 10 mm sphere is underway.

Magnet Power Supply & Cooling System Update

- Magnetic field ripple was reduced in all magnets through power supply improvements. It was further reduced to 2 ppm in a higher homogeneity magnet by using a ripple cancellation amplifier and coil. The NHMFL Electronic Instruments and NMR groups are collaborating on this continuing project.

- Major maintenance on the 10 MW magnet power supplies improved transistor current sharing and general reliability.

- Several steps taken to improve the reliability of the magnet power supply input transformers prevented a repeat of the three coil failures experienced in 1997. A transformer coil that failed in late May, 1998, was quickly replaced with a spare kept on hand, but the spare was defective. Operating and user services staff worked unusual hours, as did the scheduled users, to keep the research going while running only one magnet at a time. This failure will be analyzed to help prevent future problems. Two replacement coils have been ordered to be on hand in case of a future failure. Our ultimate goal is replacement of the existing transformers with more robust, higher capacity versions to allow steady state operation of 20 MW, two power supply magnets. This is particularly critical for high field magnetic resonance experiments and other research that requires only the highest fields.

Instrumentation for Users of the Continuous Fiel General Purpose Magnets

- The new Oxford portable, top loading dilutio refrigerator is now in use. Visiting and NHMF researchers observed exciting new phenomena in the firs weeks of operation of the fridge in the laboratory's 33 Florida-Bitter magnet, phenomena that required bot millikelvin temperatures and slowly varying magneti fields above 20 T. The combination of high DC field and low temperatures now available at the NHMFL i unique in the world.

- A new electrically nonconductive high pressure ce allows both optical and electrical transport experimen to be performed at millikelvin temperatures wit minimal eddy current heating, even in the pulse magnets. The plastic diamond anvil cell's small size allow it to fit into the small sample volumes available i dilution refrigerators. Transport measurements a currently limited to 15 kbar at low temperatures; optic work to 80 kbar.

- A two axis rotator has been developed for use in fiel to 20 T in the new 195 mm bore magnet. The samp space is roughly a right circular cylinder 25 mm i diameter and 40 mm high. More that 180 degrees rotation are available in both axes, and their motion independent.

- The Roots pumps on the two large capacity vacuu systems used to pump liquid helium in the resisti magnet cells have been replaced with new Edwar kinetic drive pumps. The change is expected to impro reliability and approximately double pumping speed about 700 SCFM per system at 1 mbar.

Magneto Optics

- A continuous wave dye laser was been purchased wi optics to allow it to be tuned from 570 nm to 710 n With the dye laser and the existing Ti:sapphire laser, can tune laser wavelength continuously from 570 n to 1000 nm.

- Optical filters (long pass, short pass, and band pass) ha been purchased to cover the wavelength range from 2 nm to 1200 nm.

- New software and a new, faster data acquisiti computer greatly improve data analysis duri experiments.

DC Field Facility

Magnetization

- We now offer users the ability to measure AC susceptibility in the resistive magnets. A new coil winder for extremely fine wire is being built and will make it possible to make smaller and other higher sensitivity coils.

NMR Spectrometers for High Field, Low to Medium Resolution Experiments

- A novel flow cryostat for NMR in the resistive magnets has been built and is being tested over its planned temperature range of 2.5 to 300 K. The new cryostat should give simpler and more stable temperature control, and increase the available probe space from 17 to 19 mm.

- A cryopump has been designed and constructed to reduce the pressure in the capacitor vacuum space of the NMR probes. The reduced pressure allows running considerably greater RF power at temperatures above 4.2 K.

- New wide band duplexers replace the quarter λ duplexers. This avoids having to change duplexers when changing frequencies.

DC Field Facility Operation and User Statistics

User activity is summarized below for the 11-month period August 1, 1997, through June 30, 1998. July, which is omitted, is one of our busiest months, so comparison of these data with previous years must be done carefully. A "magnet day" equals seven hours in a resistive magnet or up to 24 hours in a superconducting magnet.

Number of Projects	139
Number of Principal Investigators	101
Number of Users	374
Number of Students	83
Number of Postdocs	20

Magnet Day Statistics	**Magnets**		
	Resistive	**Superconducting**	**Percent**
Affiliations			
NHMFL, UF, FSU, FAMU, LANL	180	304	37%
U. S. University	194	196	30%
U. S. Govt. Lab.	3	9	1%
Industry	20	16	3%
Overseas	128	29	12%
Development, Calibration, & Maintenance	61	48	8%
Idle	9	105	9%
Total: 1302	595	707	100%

PULSED FIELD FACILITY—LOS ALAMOS

The Pulsed Field Facility provides experimental capabilities for a wide variety of measurements i pulsed magnetic fields. The 50 T and 60 T short pulse magnets (10 to 100 ms long pulses) are powere by a 1.2 MJ capacitor bank, while a newly constructed 60 T quasi-continuous magnet (100 to 100 ms) is driven by a motor generator set capable of delivering an energy pulse of 600 MJ. This past yea approximately 120 different user groups came to the Pulsed Field Facility to perform high fiel experiments. Additional information on magnets, instrumentation, and personnel, as well as a Researc Proposal Form can be found at the Pulsed Field Facility web site: *http://www.mst.lanl.gov/NHMFL/* o by e-mail to *lacerda@lanl.gov*.

Magnet, Instrumentation, and Services Update

The most exciting magnet development at the Pulsed Field Facility during the past year involves the 60 T quasi-continuous magnet, which is currently undergoing a period of engineering tests of both the magnet and power supply control systems. These test pulses are also being used by in-house researchers to develop experimental techniques and infrastructure necessary to support the future users program on this magnet. During this period, the laboratory will gain experience with operating the magnet, will develop a library of approved magnet pulse profiles, and will establish the safety envelope and operational procedures for the users program. Once online as a user facility in the fall of 1998, the 60 T quasi-continuous magnet will offer experimentalists the opportunity to make fixed field measurements at 60 T for as long as 100 ms, as well to tailor the magnetic field pulse profile to fit particular requirements of any given experiment. Initially, the 60 T quasi-continuous magnet is likely to be operated during evening hours with the magnet being available for alternating 4 to 6 week periods. (Some uncertainties regarding initiation of the users program on this magnet result from the radically different magnet and power supply; others are imposed by planned utilities shutdowns associated with the NHMFL move to a new building in 1999.)

Research proposals for 60 T quasi-continuous experiments are welcome anytime, and will be actively solicited beginning August, 1998.

The Pulsed Field Facility continues to offer the state-of-the-art DC and pulsed field magnets, as shown in Table 2. Some notable features of those magnets and highlights of recent research follow.

The 19.5 T superconducting magnet serves not only as a staging magnet for pulsed field experiments but also as an excellent tool for investigating magneto transport, magnetization, and thermodynamic properties of a wide variety of materials. An example of the exciting new resul coming from this system during the past year is the work o pinned vortex liquid above the critical point of the first ord melting transition in untwinned $YBa_2Cu_3O_{7-\delta}$ [D. Lope *et al.*, *Phys. Rev. Lett.* **80**, 1070 (1997)].

The short pulse magnets continue to be heavily subscribe by the user community; the number of users has increase to 118 during the past year, up from 86 in 1996. Ne stainless-steel-shelled magnets provide a greatly shorten magnet cool down time after every pulse. Only 25 minut are required between full-field pulses, a magnet desig improvement that has increased more than two-fold the puls repetition rate. The short pulse magnets are used extensivel for magneto transport and magnetization measurements, on example being the recent observation of quantum interferenc effects in metallic LaB_6 by Neil Harrison, *et al.*, which ca be found in *Phys. Rev. Lett.* **80**, 4498 (1998). Helium thre refrigerators are available for use in both the 50 T (24 mm and 60 T (15 mm) short pulse magnets, and an all-plasti dilution refrigerator is also available for use in a 50 T (2 mm) magnet.

A fast, high resolution optical spectroscopy system, based o a sensitive high speed CCD camera, was commissione recently for optics experiments in the 60 T quasi-continuou magnet. With this system, entire optical spectra can b acquired at rates up to 1 kHz, enabling continuou monitoring of the optical response throughout the entire tw second duration of a 0 to 60 T magnet pulse and permittin the acquisition of up to 200 spectra above 30 T during single magnet pulse. Present capabilities include optics an fibers for work from 350 to 1000 nm, at temperatures dow to 350 mK. Electrical leads to the sample facilitate concurren Hall resistance or photoconductivity measurements.

Instrumentation and user support continue to be hig priorities. Two technicians were hired in the past year (Marcu

Table 2. Magnet systems available to users at the Pulsed Field Facility, Los Alamos, as of June, 1998.

Field (T), Bore (mm)	First Use	Pulse Rise/Duration (ms)	Supported Research
PULSED			
50, 24	12/92	6/15	Magneto optics (ultra violet through far infrared), magnetization, transport. Temperatures from 40 mK to 300 K. Pressure from ambient to 3 GPa
60, 15	3/93	6/15	
40/24[1]	2/95	70/600	
60, 32[2]	5/98	1000/2000 (100 ms at 60 T)	
SUPERCONDUCTING			Same as pulsed fields, plus thermal expansion and specific heat. Temperatures from 20 mK to 600 K.
19.5, 52	12/92		
9, 32	11/95		Magneto optics (ultraviolet to near infrared)
FLUX COMPRESSION		100 T to 1,000 T available through LANL programs	

1 Developed in collaboration with Prof. S. Askenazy of the Toulouse, France National Pulse Field Laboratory (Service National des Champs Magnetiques Pulses)

2 Fully available to users in October, 1998

Bennett and Jon Betts) and a postdoctoral fellow (Scott Crooker from UC Santa Barbara) also recently joined the group, bringing extensive expertise in time resolved optical spectroscopy. A complete list of Pulsed Field Facility personnel is shown in the organization chart, Figure 1.

Related Developments

The Pulsed Field Facility is now organized as an independent Program Center within the Materials Science & Technology Division of the Los Alamos National Laboratory. Starting in July, 1998, the NHMFL Center Director will be Greg Boebinger, who brings from Bell Laboratories substantial experience in magneto transport measurements in pulsed magnetic fields, as well as design and construction of pulsed field magnets. The organization of the new Center is presented in Figure 1.

The capabilities of the Pulsed Field Facility will continue to grow in the near future: A non-destructive 100 T pulsed magnet is currently being designed by the NHMFL as a jointly funded effort of the U.S. Department of Energy and the National Science Foundation. Because this magnet pushes the limits for strengths of existing materials, it poses a considerable engineering challenge to the magnet designers at the NHMFL. Nonetheless, full operation of the non-destructive 100 T magnet is expected in a few years.

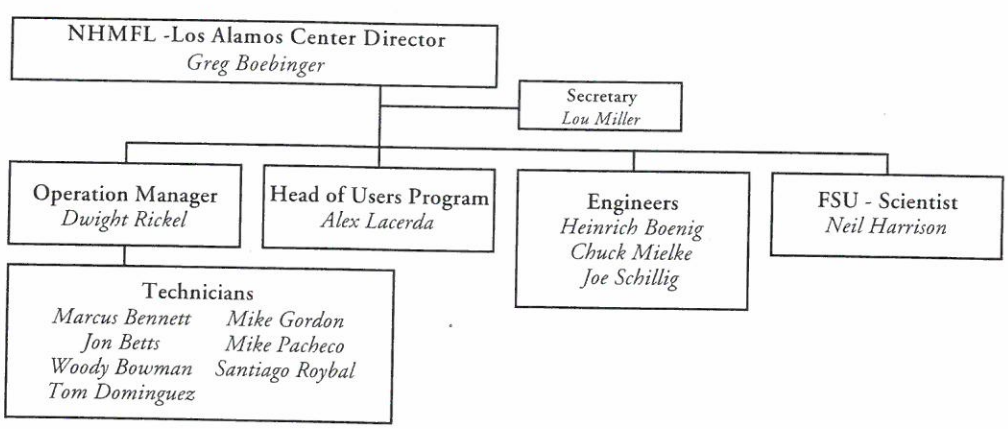


Figure 1. Organization and personnel of the Pulsed Field Facility/NHMFL Center at LANL.

PULSED FIELD FACILITY

Pulsed Field Facility Operation and User Statistics

The user activity is summarized below for the 11-month period from August 1, 1997, through June 30, 1998. Magn stations are assigned to users in units of days (24 hours).

Number of Projects	85
Number of Principal Investigators	115
Number of Students	46
Number of Postdocs	13

	Magnets					
Magnet Day Statistics	**20 T**	**50 T**	**60 T**	**60 T Long Pulse**	**Flux Compression**	**Total**
Affiliations						
NHMFL	29	16	22	16	3	86
LANL	2	34	9	0	0	45
U.S. Univ.	144	54	24	0	0	222
U.S. Govt. Labs.	4	0	0	0	0	4
U.S. Industry	0	0	0	0	0	0
Overseas	41	38	36	4	6	125
Development & Maintenance	12	15	15	N/A	N/A	42
Idle	5	5	5	N/A	N/A	15
Total	**237**	**162**	**111**	**20**	**9**	

The High B/T Facility operated for the NHMFL by the University of Florida provides users with the capability of carrying out studies that simultaneously reach very low temperatures (down to 0.4 mK) and high fields (20 T design). The facility was commissioned in the 4th quarter of 1997 though the magnetic field at the sample is limited to 15.3 T. This will be upgraded to 20 T when the magnet manufacturer finishes the replacement coil in 1999. Cooling is achieved with a $PrNi_5$ nuclear refrigerator that has a cooling capacity of 10 nW at 1 mK. The "20 T" magnet is persistent (<16 ppm/day) and sufficiently homogeneous (<18 ppm over 1 cm DSV) for solid state physics NMR experiments.

The facility is designed for studies of materials and systems that require high spin polarizations. This class of experiments includes transport on quantum heterostructures, quantum diffusion in highly polarized spin systems, and nuclear magnetism of various materials. The first user experiments have been studies of the fractional quantum hall effect plateaus for high quantum numbers and the phase diagram for nuclear spin ordering in solid helium three. Special features of the facility include an ultra-quiet environment with "tempest" quality shielding from electro-magnetic noise, and carefully designed vibration isolations for the cryostats. Instrumentation is available for high sensitivity pressure, magnetization, and transport measurements. Future enhancements include computer-interfaced pulsed and cw ultra-high frequency NMR capabilities.

Applications for the use of the facilities proceed in an identical fashion to the other NHMFL facilities. Given the specialized nature of the system and long turn around times of experiments, however, prospective users are advised to contact the facility manager, Dr. J. S. Xia, or members of the low temperature physics faculty for information.

High B/T Facility Operation and Users

One research team with principal investigators H.L. Störmer of Lucent Technologies/Bell Laboratories and D.C. Tsui of Princeton University and graduate student W. Pan of Princeton University is currently studying the Fractional Quantum Hall Effect. Two NHMFL/University of Florida researchers, Jian-sheng Xia and Vladimir Shvarts, have been supporting this research full time for seven months. Four $GaAs/Ga_{1-x}Al_xAs$ samples have been studied at ultra-low temperatures (below 1 mK) and high magnetic fields (15.0 T). The samples have been kept cold (below 30 mK) for 4600 hours, and around 8000 liters of liquid helium have been used. The second experiment, ^3He Melting Pressure Measurement at High Magnetic Fields, for University of Florida users E.D. Adams, V. Shvarts, and J.S. Xia, is in preparation.

Center for Interdisciplinary Magnetic Resonance (CIMAR)

A notable CIMAR milestone was the successful design, construction, and preliminary testing this pas year of a 25 T, 52 mm vertical bore resistive magnet. This fully interdisciplinary magnet system wa designed and built by the NHMFL Resistive Magnet Group, and field-mapped by NMR (for futur shimming to 1 ppm spatial and temporal inhomogeneity). It achieved ICR resolution of ~6 ppm (mor than ten times better than the best prior result with a 20 T Bitter magnet). EMR spectra extending t more than 600 GHz have already been obtained. The magnet was funded in large part by a $600,00 grant from the W. M. Keck Foundation with additional funds from the NSF and the State of Florida

During the past reporting period, significant new external peer-reviewed funding was generated fo NMR and EMR instrumentation (see NMR section that follows). In addition, CIMAR was we represented in NHMFL's In-House Research Program, for which several projects from all of the magneti resonance areas received strong external peer review and are now underway.

CIMAR's external user program, already well-developed for ICR, reached out significantly in 1997/9 to the EMR and NMR communities as well. In addition, the NHMFL's NMR Program organized "Millennium" NMR Conference in Washington, D.C., to showcase the potential of NMR for material and biotechnology research.

Ultimately, CIMAR's success as a user facility depends on developing new techniques and application of magnetic resonance, representative examples of which may be found in Volume 1 of this report. Fo

Table 3. CIMAR facilities in Tallahassee, as of June, 1998.

MAGNETIC RESONANCE SYSTEMS

Frequency	Field (T), Bore (mm)	Homeogeneity	Measurements
1066 MHz+	25, 52	1 ppm	Solid state NMR
830 MHz	19.6, 31	100 ppb	Solid state NMR
720 MHz	16.9, 50	1 ppb	Solution state NMR
600 MHz	14, 89	1 ppb	MRI and solid state NMR
500 MHz	11.75, 50	1 ppb	Solution state NMR
400 MHz	11.75, 89	1 ppb	Solid State NMR
400 MHz	9.3, 50	1 ppb	Solution state NMR with high T_c probe
300 MHz	7, 50	1 ppb	Solution state NMR
300 MHz	7, 89	1 ppb	Solid state NMR
Up to 7 THz	30, 32	100 ppm	ECR
700 GHz+	25, 52	1 ppm	Multifrequency EMR
470 GHz	17, 61	3 ppm	Multifrequency EMR
400 GHz+	14, 88	3 ppm	Transient EMR
9 GHz			X-band EPR
	25, 52+	1ppm	ICR
	20, 50	1000 ppm	ICR
	9.4, 210	1 ppm	ICR
	7, 150	10 ppm	ICR
	6, 150	10 ppm	ICR
	5.6, 90	10 ppm	ICR
	3, 150	10 ppm	ICR

+ Under development

Magnetic Resonance

example, collaborations spawned by those developments are now active between NHMFL and 16 external user groups worldwide in ICR. Moreover, NHMFL has provided pilot data to help junior faculty gain their first federal operating grants (e.g., Prof. Patrick Limbach at Louisiana State University), and to guide industry (e.g., Wyeth-Ayerst) and multi-user academic groups (e.g., University of California, Berkeley) in justifying, choosing, and properly specifying their own new instruments.

The CIMAR facilities are shown in Tables 3 and 4.

Table 4. CIMAR facilities at the University of Florida, as of June, 1998.

MAGNETIC RESONANCE SYSTEMS

Frequency	Field (T), Bore (mm)	Homeogeneity	Measurements
600 MHz	14, 50	1 ppb	Solution state NMR & MRI
500 MHz	11.75, 50	1 ppb	Solid and solid state NMR
200 MHz	4.7, 330	0.1 ppm	MRI & NMR of animals
125 MHz	3, 800	0.1 ppm	Whole body MRI & NMR

NMR Program

The program comprises four technological areas: Condensed Matter NMR; Solution NMR; Solid State NMR; and Diffusion NMR & MRI. Two major projects have been developed out of this program in the past 18 months: the Florida NMR Collaboratorium and the National Magnetic Resonance Collaboratorium. The former effort is designed to tie the Universities of Florida, Miami, and South Florida with Florida State University and the NHMFL in an internet-linked set of NMR resources to advance biological and chemical research throughout the State of Florida. The National Magnetic Resonance Collaboratorium is an initiative to develop very high field NMR resources throughout the United States. A planning group of internationally renowned NMR spectroscopists is spearheading this effort, which was kicked off with a conference in Washington, D.C. entitled "High Field NMR: A New Millennium Resource" in January, 1998.

New NMR Instrumentation and Services for Users

- Four scholar-scientist faculty members have been hired to further develop the NMR user program. Arneil Reyes pursues independent research and supports users in condensed matter NMR, Zhehong Gan and Riqiang Fu in solid state NMR, and Nagarajan Murali in solution NMR.

- The condensed matter NMR group continues to develop a thriving user program on both superconducting (16.5 T) and resistive magnets up to 33 T. (See "General Purpose DC Field Facilities" for complete report.)

- The NHMFL is a beta test site for a powerful new high temperature superconducting (HTS) probe for solution NMR from Varian Associates. This probe increases the sensitivity of the 400 MHz spectrometer by nearly 400 percent over state-of-the-art conventional probes at this field strength, and consequently signal averaging times are reduced by nearly a factor of 16.

- Triple axis pulsed field gradient capability was added to the 500 MHz system this past year, thereby increasing the research potential and improving performance for many existing experiments.

- The Keck resistive magnet has been energized (25 T, equivalent to 1066 MHz for protons). A shimset under development is required to achieve its goal of 1 ppm over a 1 cm dsv.

- GAMMA is a spectral simulation platform that continues to be developed at the NHMFL even as worldwide usage of this tool escalates. Its applications range from electron spin resonance to nuclear spin resonance, from solid state to solution NMR and to stray-field imaging. The platform has been exceptionally useful as a very sophisticated spin physics tool, and is now being developed as an educational tool that can be applied to very simple, and to very complex, experiments.

Funding Obtained for Future NMR and MRI Instrumentation

- The 720 MHz spectrometer will be upgraded with a fourth RF channel using $50,000 allocated from the NHMFL.
- A wide bore 750 MHz spectrometer at the University of Florida Brain Institute for solution NMR and MRI research will be purchased in addition to other instrumentation and instrumentation upgrades for several million dollars from the Department of Defense.
- $170,000 has been committed to the program from the NHMFL, the Keck Foundation, and NSF for new solid state NMR probes to perform triple resonance Multiple Angle Spinning (MAS) experiments on the 89 mm bore 600 MHz instrument; double resonance static experiments on the 600, 830 and resistive 1066 MHz magnets, as well as MAS on the 830 and 1066 MHz magnets. A slow spinning probe will also be purchased for the 600 MHz spectrometer. With these probes a wide variety of biological and chemical structural and dynamic characterization capabilities will be possible at unique field strengths.
- A new 830 MHz console has been funded by the National Science Foundation, along with a field mapping device for a total of $557,000.
- A contract for $2,400,000 provided by the Department of Defense has been signed for a unique 11.74 T, 40 cm horizontal bore magnet system for the University of Florida Brain Institute (UFBI). This magnet, along with the wide bore 750 MHz system mentioned above, form the core magnet technology for a new MRIS program that will be initiated in 1998-99 and run jointly by the UFBI and the NHMFL. Funding for a commercial MITI optical pumping source has been secured opening up numerous experiments from imaging to surface science through the ultra high sensitivity obtainable from polarized Xe or He.
- $80,000 from Florida State University and the NHMFL for a small animal holding facility at the NHMFL in Tallahassee has recently been granted.

NMR User Activity

Without specific funds for an NMR User Program the NHMFL NMR facilities are available to an external user community. Recent funding (see above) and recent hiring of Scholar Scientists is permitting the development of a much more extensive user program. During the past 18 months research conducted in the NMR program was supported by 9 different funding agencies, and involved scientists from 17 different universities and research laboratories in 52 research projects. 34 principal investigators and more than 49 graduate students and postdocs were involved in these research efforts.

EMR Program

The EMR program includes electron paramagnetic resonance (EPR), ferro and antiferro magnetic resonance (AFMR), and ferri magnetic resonance. The goals of the program are twofold: (1) to develop a strong in-house research program, and (2) to develop state of the art EMR instrumentation and methodologies and make them available to the user community of the NHMFL.

For slightly over two years a superconducting magnet (15/17 T) based spectrometer has been available. This is a multifrequency machine *not* dedicated to a specific application; it operates from 95 up to 550 GHz with solid state sources and can measure up to 3 THz with an optically pumped far infrared laser. A milestone was reached this year with the availability of the Keck magnet based spectrometer. This 25 T, 52 mm bore magnet is perfectly suited for EMR spectroscopy, and can be effectively used without shimming.

The scientific activity involves solid state physics, physical chemistry, biophysics, biochemistry, and material sciences. Thirty science projects from 20 principal investigators have been tackled. These projects involved 32 institutions: three from Florida, 15 from the United States outside Florida, 11 from Europe, and one each from Japan, Taiwan, and Brazil.

The activity with the Keck magnet during the period dealt with photosynthesis and motional dynamics. Outstanding results were obtained for photosynthesis-related projects. In particular, in a collaboration with Dr. Angerhofer (University of Florida) and Dr. Evans (University of London) that investigated a number of systems, the resolution of the three components of the g-Lande tensor were made possible for the first time. At Cornell, the group of Dr. Freed is interested in motional dynamics of complex fluids that he studies at 250 GHz. With the "Keck" magnet, Dr. Freed made measurements at frequencies up to 670 GHz, opening new avenues for the study of nitroxide spin-labels.

Currently our main instrumental activities are in the development of quasi-optical techniques, to increase the sensitivity of our machines, and in the setting up of a transient machine operating at 14 T in the subnano second time frame.

EMR User Statistics

Number of Projects	30
Number of Principal Investigators	20
Number of Students	8
Number of Postdocs	9
Affiliations	
NHMFL, UF, FSU	3
U.S. University	13
U.S. Govt. Lab.	2
Overseas	14
Total	32

Magnetic Resonance

Fourier Transform Ion Cyclotron Resonance Mass Spectroscopy

During the past year the ICR program continued instrument and technique development as well as outgrowth of 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. A full-time manager, machinist, technician, and three rotating postdocs are available to collaborate and/or assist with projects.

FT-ICR Magnet and Instrumentation Update

The 9.4 T system continues to be the highest performance FT-ICR mass spectrometer in the world. It offers unrivaled mass resolving power ($m/\Delta m$ = 10,000,000 at mass 9,000 Da) and dynamic range (>10,000:1), as well as high mass range, efficient tandem mass spectrometry (MS^n as high as MS^8), and long ion storage period.

Higher field spectrometers are under development. A dual MALDI/ESI system based on an 11 T, 220 mm bore superconducting magnet will be operational late in 1998. A 17 T, 110 mm bore superconducting magnet is due for delivery in mid-1999.

FT-ICR mass spectrometry was performed in the resistive 25 T Keck magnet. This system produced the world's highest field FT-ICR mass spectra and improved signal-to-noise ratio and resolving power by more than an order of magnitude over prior efforts in a low homogeneity 20 T resistive magnet at NHMFL.

ICR Operation and User Statistics

User activity is summarized below for the 11-month period August 1, 1997, through June 30, 1998.

Number of Experiments	43
Number of Principal Investigators	23
Number of Students	24
Number of Postdocs	9

Magnet Day Statistics	Magnet		
	9.4 T	6 T	7.4 T
Affiliations			
NHMFL, UF, FSU, FAMU, LANL	115	NA	NA
U.S. University	60	NA	NA
U.S. Govt. Lab	0	NA	NA
U.S. Industry	25	NA	NA
Overseas	30	NA	NA
Maintenance	15	NA	NA
Idle	79	NA	NA
Total	**324**	**324**	**324**

Magnetic Resonance

The majority of the funding for the Geochemistry program comes from the Earth Science Directorate at NSF. Presently there are three active research grants from either earth or ocean sciences to either Dr. Vincent Salters or Dr. Alan Zindler. NSF Ocean Sciences committed funds for a fourth research proposal that will start in August, 1998. The research funded through these programs concerns principally the chemical evolution of the Earth through trace element and isotope analysis and the lab has a major program on mid-ocean ridge basalt (MORB) genesis. A new direction was taken by the acceptance of a postdoc (Uddin) who is researching the orogenesis of the Himalayas as recorded in the sediments of the Bengal Basin. This project has received great interest from the oil industry.

The Geochemistry program continued its expansion of activities in environmental sciences this year. The program now includes one more faculty member (Cooper, also at the Chemistry department at FSU). In addition it now receives funding from both the South Florida Water Management District (Salters) and the Department of Energy (Wang) for its research. Salters has initiated the formation of a group of faculty that includes faculty from CIMAR as well as faculty from several FSU departments (Chemistry, Oceanography, Biology, and Geology) that is actively pursuing the application of high magnetic field analytical techniques to molecular ecology and environmental sciences.

Geochemistry Instrumentation, Technique, and Facility Developments

The instrumentation of the Geochemistry program comprises a mass spectrometry facility and a chemistry clean lab that approaches a Class 100 clean lab. This clean lab is used for the separation and purification of all elements that are analyzed by mass spectrometry. The facility has three mass spectrometers.

- The Lamont Isolab, a mass spectrometer with secondary ionization capability, is used mainly for difficult to ionize elements like Hf and Th and potentially Hg. The Lamont Isolab, outfitted with a Daly detection system and 5 faraday cups, has TIMS, SIMS capability.
- A fully automated 9 collector Finnegan mass spectrometer is equipped with an RPQ-system for increased abundance sensitivity and a 13 sample touret. This mass spectrometer will be used for Sr, Nd, Pb, and U isotope analyses by positive thermal ionization and Re and Os by negative ionization, as well most isotope dilution analyses.
- An ICP-MS Finnegan "Element," including all the peripheral equipment such as mineral picking stations and decay counting systems, is present for elemental analyses.

Instrumentation improvements are concentrated on developing analytical techniques for the High Resolution Inductive Plasma Mass Spectrometer. The experimentation was concentrated on developing highest signal to noise by varying the different inlet systems. We experimented and developed procedures for desolvation, direct insertion nebulization, and a guard electrode. Compared to the original installation a factor of ten to four improvement (dependent on element) in signal-to-noise ratio has been achieved. Significant improvements to one of the mass spectrometers, the Lamont Isolab were accomplished. The vacuum system on this instrument was significantly improved this year, which will result in less maintenance and downtime in the future. Technique developments also include a new technique for measuring mercury isotopes. The first results indicate significant variations in Hg-isotopes in the environment and the usefulness of Hg-isotopes for tracing sources. Lastly, facility development included the fabrication of separation lines for sample preparation for light stable isotope measurements.

Geochemistry Operation and User Statistics

User activity is summarized below for the 11-month period August 1, 1997, through June 30, 1998.

Number of Projects	22
Number of Principal Investigators	14
Number of Students	8
Number of Postdocs	2

Number of Magnet Days	Isolab	262/RPQ	ICP-MS	Total
NHMFL, UF, FSU, FAMU, LANL	120	220	60	400
U.S. University	10	40	0	50
Maintenance	80	20	40	140
Idle	40	20	0	60
Total	**240**	**300**	**100**	**640**

Large Magnet Component Test Laboratory

The Large Magnet Component Test Laboratory (LMCTL) is being established in Cell 16 of the DC Field Facility in Tallahassee. While it will fulfill the requirements of the laboratory's Magnet Science and Technology Group, it will primarily respond to magnet-technology development needs outside the laboratory, from both the government and commercial sectors.

LMCTL Magnet and Instrumentation Update

Presently, the facilities in the LMCTL are being upgraded for better performance as well as for more efficient and safer use. Upgrades include the following:

- A permanent user platform providing easier and safer access to the various test stations
- Rigid, water-cooled, high-current DC buswork with protected distribution to all test stations
- Simplified connections of the buswork either to one of the building power-supply modules or to the Hybrid outsert power supply
- Permanently installed, high-power load resistors that will allow the regulation specifications of the building power supply to be achieved during tests of low-resistance components.

LMCTL Magnets and Instrumentation Available, as of June, 1998

Several superconducting magnets are available with special capabilities for testing large conductors:

- The CWTX magnet is a nearly cryostable, NbTi magnet capable of providing 8 T on a conductor sample in its 380 mm cold bore. Sample configuration can be either a loop in the bore or a straight piece fit through the magnet's 67 mm radial-access port.
- The Navy SMES CTA magnet can apply up to 4 T to a 2 m diameter loop of test conductor and is also designed for operation as part of a 50 MJ SMES system. The sample volume of the SMES-CTA cryostat provides full thermal isolation from the magnet vessel and can be operated over a full range of temperatures from LHe to room temperature.
- The Oxford Split Solenoid is designed to produce 14 T in its 150 mm diameter high-field region, which accepts large, straight conductor samples through a 30 mm x 70 mm radial-access port. The inner wall of the Oxford cryostat is designed as a compression tube capable of safely transmitting 250 kN mechanical loads and is equipped with remotely actuated pin-and-clevis at the bottom for attaching samples for cold, mechanical testing.
- The TACL magnet is 1 m dipole designed to produce a highly uniform 7 T field over the full length of its 40 mm cold bore. The magnet is primarily used for testing AC losses of large conductor samples in linearly ramped fields with rates up to 1 T/s or exponentially discharged fields with initial rates of up to 45 T/s.

Materials Development & Characterization

The resources of the Materials Development and Characterization (MD&C) group are dedicated to the characterization of materials proposed for use in all kinds of high field magnets and in cryogenic applications. The group supports NHMFL magnet design teams while also providing testing and analysis services to industrial and academic researchers. The laboratory provides precise measurements of electrical resistivity, thermal expansion, and superconductor critical currents, as well as mechanical properties such as tensile, compressive, fatigue, and shear strength measurements. The group's work can be divided into three areas:

- Internal basic and applied research for the improvement of magnet materials
- Internal support for Magnet Science and Technology magnet design teams
- External contract research supported by funding from outside sources.

MD&C Magnet and Instrumentation Update

The characterization of single element superconductors or small scale superconductors that are tested at currents below 1 kA is done in support of superconductor materials research and development. To improve this capability a standardized sample holder has been adopted, upon mutual agreement with superconductor wire manufacturers. The sample holder is designed for critical current vs. field measurements in the 20 T, 50 mm bore superconducting magnet at temperatures of 4 K and 2.2 K and currents up to 1 kA.

MD&C Related Developments

R.P. Walsh and V. Toplosky participated in an international cooperative program (VAMAS) to standardize low temperature test methods and analyses. Interactions include participation in Round Robin Test Programs and participation in panel discussions of materials research topics.

Access to NHMFL Facilities

User access to NSF-funded NHMFL 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 six months, 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 one to two percent) within the previous twelve months are then required to submit a more detailed 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 percent of the annual total facility use. In addition, all users of the 45 T Hybrid magnet will be required to submit such a proposal for peer review.

Each accepted proposal is in force for three years. Each detailed proposal is reviewed by a panel of scientists chosen for their familiarity with the fields of research commonly done at the NHMFL. The panel also can seek input in the form of mail reviews. The Proposal Review Panel met in May, 1998, to review twenty-two major proposals. The grades ranged from "A" to "C" 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. The final decision for use of the High Field Facility rests with the Director of the NHMFL.

Most of the NMR spectrometers, EMR facilities, FT-ICR mass spectrometer facilities, isotope geochemistry facilities, and the magnetic resonance 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. General access is by the same process as for the general purpose resistive and pulsed magnets.

Magnet Science & Technology

Chapter 2

The Magnet Science and Technology (MS&T) Division has three main responsibilities within the NHMFL:

- Major magnet development projects
- Research and development programs
- Services to the community including external activities.

The first and largest of these activities is major magnet development projects, which includes both in-house magnet systems and those funded by external organizations. MS&T has developed this dual role in response to the laboratory's charge to help develop and support magnet technology in cooperation with the private sector and other agencies. These activities also help establish a diverse funding base and ensure the long term stability of the human resources developed under NSF support. In addition, this human resource is refocused on critical needs within the private sector and at other agencies.

Over the past year, MS&T has increased its efforts in attracting external programs and projects and collaborating with outside agencies. This is part of the natural evolution of the organization and exemplifies the high regard the NMHFL MS&T group has worldwide. A few examples of external major project initiatives are:

- DuPont Superconducting Partnership Initiative on ore separation
- Michigan State University sweeper magnet for the National Superconducting Cyclotron Laboratory
- Pulsed magnets for Sandia National Laboratory
- Muon accelerator magnets
- SMES design and testing with BWX Technologies
- Navy SMES and electronic building blocks tests.

A significant amount of work has been accomplished over the past year. Highlights of achievements are listed below.

Major Project Highlights

- The 198 mm bore, 19.8 T resistive magnet was completed and tested to full field in June, 1998. The insert cryostat and test probe are under construction and the entire system should be operational by the end of July, 1998.
- The Keck 25 T, 52 mm bore, high homogeneity magnet is complete and was tested to full field in February, 1998. The magnet is now undergoing field mapping and a shim set is being designed in order to achieve the desired 1 ppm over 10 mm DSV.
- The outsert for the 45 T Hybrid magnet is in the process of being assembled and will be installed in the cryostat in August, 1998. A test of the superconducting system is scheduled for early fall, 1998. The resistive insert design is complete and the complete magnet system should be available in spring, 1999.
- A detailed study has been performed on a new hybrid consisting of a series connection of a resistive insert and superconducting outsert magnet. The goal is production of 35 T with one 10 MW power supply.

- The 900 MHz project has undergone a recent reorganization critical to managing the fabrication phase of this project. Most materials and components are on order and coil winding is to begin in fall, 1998. The final shipment of Nb_3Sn wire is expected in August, 1998.

- The design of the cryostat for the 900 MHz is complete and will be sent out for bid in July. Selection of an industrial contractor will occur in fall 1998.

- The pulsed magnet group continues to deliver capacitively driven magnets for the LANL user facility. Recent advances have allowed the upgrade of the 15 mm bore magnet to 65 T.

- Developmental pulsed magnets using CuNb conductor and Zylon reinforcement were tested in June, 1998. A significant achievement of 77.8 T in a 10 mm bore should provide the basis for a 70 T user magnet and points to the possibility of even higher pulsed fields in the near future.

- The 60 T quasi-continuous magnet at LANL was tested to full field in April, 1998. The magnet is scheduled to be available to all users by October, 1998.

- The 100 T project achieved significant progress over the last year. A self consistent design exists for 100 T in a 15 mm bore. Insert test coils are being developed and tested.

- The NHMFL has begun the development of a 30 T split pulsed magnet for the Los Alamos Neutron Science Experiment (LANSCE). This magnet is scheduled for completion in June, 1999.

Research and Development Highlights

- The High Temperature Superconducting (HTS) Magnets and Materials group, building on the successful test of a 1.2 T, 50 mm OD coil in a background field of 17 T last year, is preparing tests of two 2.5/3 T insert coils in summer, 1998, in the 20 T/200 mm bore resistive magnet.

- The HTS Magnets and Materials group continues to develop collaborations with industry. A few examples include conductor development with EURUS and high field insert coil development with both IGC and Oxford Superconductor Technologies.

- The Cryogenics group completed a two-phase He II flow experiment in collaboration with DESY laboratory in Hamburg.

- The High Strength/Conductivity Materials group recently completed a comprehensive study of eutectic AgCu.

External Activities Highlights

- The Materials Development and Characterization group performed a variety of tests on a collaborative basis. A few examples carried out during the past year include characterization of a large aluminum stabilized conductor for Lawrence Livermore National Laboratory and critical current measurements for Supercon and IGC.

- MS&T staff have performed a number of scoping studies for different magnet systems. These include superconducting magnetic energy storage (SMES) magnets for BWX Technologies in Lynchburg, VA.

- The NHMFL MS&T Division is consolidating and augmenting the materials testing facilities to establish a new materials and component test capacity. This need is driven by the expanding role of the NHMFL in responding to the needs of other groups for testing large conductor assemblies and components.

Details on these and other MS&T projects are described herein.

Project Title: 45 T Hybrid Magnet
Report Date: May 31, 1998

Objective

The 45 T Hybrid has been designed as a versatile, reliable, user-friendly magnet system capable of producing 45 T in a 32 mm bore. This goal is to be accomplished using:

- a superconducting outsert magnet with a clear, warm bore of 616 mm and capable of 14 T on axis during normal operation,
- a resistive insert magnet contributing at least 31 T while immersed in the background field of the outsert, and
- technology that significantly advances the state of the art for large, high-field superconducting magnets.

The superconducting outsert has been designed for a minimum 10-year life and with capability of safely accepting upgraded, higher field resistive inserts, potentially extending the combined field to 50 T.

Status

The 45 T Hybrid Project includes five major components: (1) the superconducting outsert magnet, (2) the resistive insert magnet, (3) the outsert cryogenic system, (4) the outsert power/protection system, and (5) system integration.

(1) Superconducting Outsert Magnet

Coils A and B (the Nb_3Sn coils) and all the pancakes for Coil C (the NbTi coil) have been completed through the insulation stages and are in the process of assembly into the final outsert configuration.

Both current feeds and the current jumper between Coils B and C have been fabricated and heat treated (as appropriate)

A trial assembly to check alignment and axial compliance of the Coil-C stack has been made and the final assembly is in progress.

(2) Outsert Cryogenic System

Following minor repairs of the outsert cryostat, a final test has demonstrated that heat-load specifications could be met and that temperatures below 1.8 K could be maintained continuously, essentially with a single refrigerator (although a second was used for convenience during the test to cool the 20 K shields).

The cryostat has been warmed and opened to accept installation of the outsert magnet.

(3) Resistive Insert Magnet

(See the separate report, "Hybrid Insert," in the Resistive Magnet section.)

(4) Outsert Power/Protection System

Components for the outsert quench-detection system and computers for the data-acquisition/control system are being procured. A system with less stringent requirements for inductive-signal suppression than occurs in the combined insert/outsert operation will be assembled for the outsert-only test planned in September, 1998.

(5) System Integration and Test

Full system tests of the superconducting outsert systems are planned for September, 1998.

Tests of the combined insert/outsert system will follow completion of the resistive insert.

Budget Summary ($K)

	Cost to 5/31/98	Cost to Complete	Total Estimated Cost	Budget 7/31/96	Variance -(over) +(under)
Resistive Insert					
Labor	227	69	296	297	1
Equipment/Subcontracts	369	568	937	457	-480
Travel/Expense	23	1	24	22	-2
Subtotal	618	638	1256	776	-480
Superconducting Outsert/Nb_3Sn Coils					
Labor	1394	0	1394	1259	-135
Equipment/Subcontracts	3305	0	3305	3305	0
Travel/Expense	208	0	208	187	-21
Subtotal	4907	0	4907	4751	-156
Superconducting Outsert/NbTi Coil					
Labor	301	8	309	289	-20
Equipment/Subcontracts	371	0	371	296	-75
Travel/Expense	44	0	44	22	-22
Subtotal	716	8	724	607	-117
Superconducting Outsert/Assembly & Enclosure					
Labor	538	24	562	503	-59
Equipment/Subcontracts	81	0	81	60	-21
Travel/Expense	65	0	65	43	-22
Subtotal	684	24	708	606	-102
Cryogenic System					
Labor	561	0	561	518	-43
Equipment/Subcontracts	1857	0	1857	1857	0
Travel/Expense	57	0	57	54	-3
Subtotal	2475	0	2475	2429	-46
Outsert Power/Protection System					
Labor	225	36	261	242	-19
Equipment/Subcontracts	413	20	433	433	0
Travel/Expense	44	3	47	41	-6
Subtotal	682	59	741	716	-25
System Integration					
Labor	332	80	412	418	6
Equipment/Subcontracts	384	0	384	384	0
Travel/Expense	109	70	179	180	1
Subtotal	825	150	975	982	7
Project Totals					
Labor	3577	217	3794	3526	-268
Equipment/Subcontracts	6780	588	7368	6792	-576
Travel/Expense	550	74	624	549	-75
Subtotal	10907	879	11786	10867	-919
Overhead	1899	134	2031	1875	-157
Project Grand Total	**12805**	**1012**	**13817**	**12742**	**-1076**

Milestone Schedule Summary

	7/31/96 Schedule	Actual (A) or Current (C) Schedule
Coil A		
Heat Treatment Complete	11/7/96	2/17/97 (A)
Impregnation Complete	12/31/96	4/24/97 (A)
Manufacture Complete	2/25/97	11/1/97 (A)
Coil B		
Heat Treatment Complete	9/5/96	11/9/96 (A)
Impregnation Complete	11/4/96	5/15/97 (A)
Manufacture Complete	1/1/97	11/1/97 (A)
Coil C		
Complete Pancake Delivery	5/5/97	10/15/97 (A)
Coil C Assembly Complete	5/22/97	7/15/98 (C)
Outsert Magnet Assembled in Vessel	8/7/97	8/1/98 (C)
I&C System Ready for Operation	6/1/97	8/1/98 (C)
Outsert System Ready for Test	9/2/97	9/1/98 (C)
Superconducting Outsert Operational	10/21/97	10/1/98 (C)
Resistive Insert		
Insert Installed in Cryostat Warm Bore	7/15/97	5/31/99 (C)
Resistive Insert Tests Complete	7/30/97	6/31/99 (C)
45-T Hybrid System		
System Ready for Combined Tests	10/28/97	7/1/99 (C)
System Operational for Users	11/8/97	7/15/99 (C)

Project Title: 45 T Hybrid Insert
Report Date: June 26, 1998

Objective

The object of this project is to provide at least 45 T in a 32 mm bore given a 14 T, 616 mm bore superconducting outsert.

Status

The hybrid insert comprises five axially cooled Florida-Bitter coils. The two innermost coils are labeled A1 and A2 and are electrically in parallel. These two together make up the A coil. The other three are labeled B, C, and D from the inside out. Coils A through D are electrically in series. All coils are hydraulically in parallel. All coils utilize axial current grading to increase the field-to-power ratio for each coil as well as to reduce the sharpness of the transition from the low current density electrodes to the high current density active part of the coil.

The central part of the A coils is to be made of copper-silver alloy provided by Tanaka Kikinzoku of Japan. The central part of the B coil is to be made of copper-silver alloy provided by Toshiba of Japan. The C coil and the ends of the A and B coils are to be made of copper-beryllium alloy provided by Brush Wellman of Ohio. The central part of the D coil will be made from copper-zirconium alloy from Olin Brass of Illinois. The ends of the D coil will be made of high purity copper from Kabel-Metal Europa of Germany.

The insert housing was designed by the Francis Bitter National Magnet Laboratory and constructed by Oak Ridge Tool and Engineering of Tennessee. It is now being modified at RV Industries of Honeybrook, PA.

A layout design review was held January 13, 1998. During February, March, and April first drafts of the detailed drawings of the magnet parts were completed. Also during this time the copper alloy sheet for the Bitter disks was ordered as well as forged blanks for the electrodes and multilam plug-in connections. On May 12, 1998, a final design review was held. Corrections to the drawings have been made and parts are being quoted and purchased.

The copper-zirconium alloy for the D coil arrived in late April, 1998. The copper-silver alloy for the A coil is expected in late July. The copper for the D coil is expected in August. The copper-beryllium for the C coil is expected in September. The copper-silver for the B coil is expected in November. Stamping tooling for the B, C and D coils should be completed in June while that for the A coils should be completed in August. Stamping will then proceed from August through December, 1998. Silver plating of the disks will take place from September, 1998, through January, 1999. We expect to have all the parts completed by mid-February, 1999, and have the insert assembled and operational in mid-May, 1999. Unexpectedly long lead times of the different companies have lengthened the schedule.

The budget for the insert equipment and materials was set in 1996 at $456,700. In the 1997 progress report the estimated cost for equipment and materials had grown to $598,000. That cost change was the result of switching from Cu-Be in the B coil to Cu-Ag. At this point equipment and materials are expected to be $728,700. This change consists of four items. (1) The tooling for the B, C and D coils has been ordered and cost $41,000 more than expected. (2) It has been realized over the past year of magnet operation that silver plating of the conductors will improve the long-term performance of this magnet (estimated cost of $32,000). (3) The magnet housing built by the Francis Bitter National Magnet Laboratory requires modification with a cost of $29,500. (4) We have discovered that etching Cu-Ag Florida-Bitter disks is not cost effective in the long run. Consequently we have purchased stamping tooling for the A coil conductors at a cost of $75,100. This reduces the fabrication costs of these conductors by $46,900. Thus, this tooling will pay for itself when we make a spare set of coils for this magnet.

Budget Summary ($K)

	Cost to 6/24/98	Cost to Complete	Total Estimated Cost	7/31/96 Budget	Variance -(over) +(under)
Labor (incl. fringes)	226.8	69.1	295.9	297.0	1.1
Equipment/Materials	431.7	297.0	728.7	456.7	-272.0
Travel/Expense	23.0	2.0	25.0	22.0	-3.0
Subtotal	681.5	368.1	1049.6	775.7	-273.9
Overhead	114.9	32.7	147.6	146.7	-0.9
Total	796.4	400.8	1197.2	922.4	-274.8

Milestone Schedule Summary

	6/31/96 Schedule	7/31/97 Schedule	Actual (A) or Current (C) Schedule
Coil Design Complete	10/31/96	10/1/97	1/13/98 (A)
Mechanical Design Complete	2/15/97	12/31/97	5/12/98 (A)
Purchasing Complete			7/20/98 (C)
Sheet Metal Delivery Complete			10/13/98 (C)
Stamping Complete			11/30/98 (C)
Silver Plating Complete			12/31/98 (C)
Component Fabrication Complete	7/31/97	6/30/98	2/15/99 (C)
Assembly Complete	8/31/97	7/31/98	5/11/99 (C)
Testing Complete	9/15/97	8/30/98	6/11/99 (C)

Project Title: Series-Connected Hybrid Study
Report Date: June 30, 1998

The Series-Connected Hybrid (SCH) concept departs from traditional hybrid design in that the superconducting outsert is connected electrically in series with the resistive insert. Although this feature constrains the system to operate at higher currents, typical for resistive magnet designs, there are important advantages, for example:

- The SCH system being considered is ideally suited to using a single 10 MW power supply, leaving the other three available to serve other users.
- In comparison to all-resistive systems capable of fields attainable with the SCH approach, the inductance is typically higher and the resistance is significantly lower making the time constant of the combined SCH system significantly higher, which can be useful for reducing field ripple and noise.
- The power requirement at full field is significantly lower than a comparable all-resistive system (typically one-third to one-fifth).
- Some off-normal and fault scenarios that introduce complications and cost in the design of the superconducting outsert for a conventional hybrid are significantly ameliorated.

A detailed scoping study has been carried out on the SCH to assess critical design issues and to provide a basis for more precise cost estimates. That study indicates:

- Significant savings can result from a structural combination of the resistive insert housing and the bore tube of the outsert cryostat.
- A 35 T system using a single 10 MW power supply can be built for between $3 and $4M total cost, depending on uniformity requirements.
- When operating costs are included, the total cost of the SCH system after five years of operation; one four-hour shift per day; three days per week, is less than the cost of a comparable all-resistive system.
- A detailed analysis of the impact of the larger series inductance on the DC power supply remains to be completed.

The technologies assumed for the SCH scoping study will be demonstrated in the 45 T Hybrid, usually with higher performance requirements. An exception is the requirement in the SCH for HTS cryogenic current leads. A design code has been developed for such leads and the NHMFL is working closely with EURUS Technologies on their development and fabrication.

MAJOR PROJECTS:
High Field Magnetic Resonance Magnet System

Project Title: High Field Magnetic Resonance Magnet Systems
Report Date: June 15, 1998

Objective

The 900 MHz magnet is a major part of the long-term program to achieve high resolution NMR at 25 T, corresponding to a proton resonance frequency of 1.066 GHz. The future 25 T magnet will consist of a high temperature superconducting (HTS) inner coil operating in the field of a large low temperature superconducting (LTS) outer magnet. The requirements of this LTS magnet have been formulated as the wide bore 900 MHz program. Activities toward development of the HTS inner coil are carried out in the Delta B program.

The 900 MHz magnet is a very wide bore high resolution NMR magnet, with a central field of 21.1 T, a room temperature bore of 110 mm, and a temporal and spatial homogeneity objective of less than 1 part per billion in a 4 cm DSV. The magnet will operate in the persistent mode at a reduced temperature of 1.8 K. The magnet employs epoxy-impregnated coil technology, with coils fabricated from NbTi and Nb_3Sn metallic superconductors. The magnet system includes magnet, superconducting and room temperature shims, cryostat, JT refrigerator, and power supply.

The program is a collaboration between the NHMFL and the principal industrial partner Intermagnetics General Corporation (IGC). Additional industrial suppliers include Supercon and VAC.

Program Status

The activities on the 900 MHz magnet in the past year have spanned the full range from detailed analysis of the basic magnetic design of the coils to the production of component drawings for manufacture. Analytical activities continue in support of the detailed structural design. The preparation of manufacturing drawings for the magnet is well underway. There continue to be aspects of technology that require further development.

The full analytical design of the coils includes recognition of all dimensions and manufacturing tolerances for coil components such as bore tubes, conductors, and reinforcement. The design examines the magnetic performance, determines stress and strain in the windings, and guides the design on the coil protection circuit. A so-called even layers design was generated to set the final dimensions of the conductors in all coils. The compensation coil locations are critical for the achievement of field uniformity. The actual location of the compensation coils is subject to thermal and stress deflections of the support structure, and to manufacturing tolerances. A correlation between field uniformity, coil displacements, and shim strength has been accomplished.

The detailed dimensional information provided by the even layers design has been the basis for detailed coil assembly drawings defining the locations of all top flange features. These layout drawings in turn provide the information for the detailed manufacturing drawings of the coil forms, which are a major component of the magnet assembly. The coil form drawings have been prepared and the coil forms are in the process of procurement. The coil assembly layout drawings continue to be prepared for lead support structures, compensation coil components, and overall assembly structures. The detailed manufacturing design of the lead support structure of the Nb_3Sn coils is well along.

The detailed information given in the even layers design also provided the final information for conductor specification. The long lead and critical Nb_3Sn conductor has been fabricated and received except for a small outstanding quantity. Initial test results are above specification. The NbTi conductor has been completely fabricated as bare wire and is now entering insulation.

The protection analysis revealed, early in the design, a problem with potential thermal stress in the reinforcement in the case of a quench. The solution adopted, that of using the reinforcement as a coupled secondary, required the development of an appropriate copper/stainless steel wire. A significant development activity demonstrating the production of this wire in sufficient lengths has been completed. The reinforcement is presently in production.

Preparations are being made for Nb_3Sn coil fabrication at the NHMFL. A detailed plan for coil handling has defined fixtures for coil processing and handling. The basic equipment for winding, heat treatment and coil impregnation has been put in place. Special fixtures for coil handling and rotation, and for special processes such as persistent joints are being designed and fabricated.

Technology development activities have continued in the past year. The magnetic properties of the steel for the reinforcement have been studied in some detail to assure low permeability. The possibility of low permeability welds for the coil forms has been studied. Work on persistent joints continues. Joints have been developed and demonstrated for the NbTi-NbTi connections and the Nb_3Sn-Nb_3Sn connections. Additional development work is underway on the Nb_3Sn-NbTi connections. Small test coils and a major test coil are planned to gain experience in the technology and to evaluate the designs of components and processes.

Budget Summary ($K)

	Cost to 6/30/98	Cost to Complete	Total Estimated Cost	7/31/96 Budget Budget	Variance - (over) +(under)
900 MHz Research & Development					
Labor	1,611	200	1,811	1,234	-577
Materials/Subcontract	163	20	183	261	78
Travel/Expense	117	10	127	118	-9
Subtotal	**1,891**	**230**	**2,121**	**1,613**	**-508**
900 MHz Fabrication (NHMFL)					
Labor	126	500	626	644	18
Materials/Subcontract	432	250	682	2,110	1,428
Travel/Expense	234	200	434	67	-367
Subtotal	**792**	**950**	**1,742**	**2,821**	**1,079**
IGC Subcontract					
Labor	0	0	0	0	0
Materials/Subcontract	960	500	1,460	901	-559
Travel/Expense	0	0	0	0	0
Subtotal	**960**	**500**	**1,460**	**901**	**-559**
Facility Completion					
Labor	73	100	173	161	-12
Materials/Subcontract	142	400	542	900	358
Travel/Expense	169	120	289	15	-274
Subtotal	**384**	**620**	**1,004**	**1,076**	**72**
Project Totals					
Labor	1,809	800	2,609	2,039	-570
Materials/Subcontract	1,698	1,170	2,868	4,172	1,304
Travel/Expense	520	330	850	200	-650
Subtotal	4,027	2,300	6,327	6,411	84
Overhead			1,591	1,138	-453
Total	**4,027**	**2,300**	**7,918**	**7,549**	**-369**

Milestone Schedule Summary

	7/31/96 Schedule	Actual (A) or Current (C) Schedule
Issue Engineering Design (NHMFL)		
Engineering Design	8130196	9/12/98 (A)
Even/Integer Design		3/26/97 (A)
Conductor Procurement (NHMFL)		
Nb_3Sn Specification	8/30/96	8/30/97 (A)
Nb_3Sn Order	10/1/96	10/1/96 (A)
Nb_3Sn Delivery Complete		
Coils 1, 2, 3	10/1/97	3/30/98 (A)
Coils 5, 6		8/30/98 (C)
NbTi Specification		5/6/97 (A)
NbTi Order		6/97 (A)
NbTi Delivery		3/30/98 (A)
900 MHz Research and Development (NHMFL)		
Nb_3Sn J_c (B,T) Development	6/30/96	6/30/96 (A)
Nb_3Sn Mechanical Properties	11/30/96	11/30/96 (A)
Epoxy-Fiber Composites Development	1/31/97	1/31/97 (A)
Winding Composites	3/31/97	3/31/97 (A)
Persistent Joint Development	5/31/97	9/30/98 (C)
Persistent Switch Development	6/15/97	9/30/98 (C)
Model/Test Coils Fabrication		3/16/99 (C)
Mechanical Configuration and Structural Design (NHMFL)		
Initial Concepts Review		5/15/97 (A)
Design Initial Inputs Complete	8/15/97	9/15/97 (A)
Configuration Design Complete		TBD
IGC Design and Fabrication		
Prepare Manufacturing Drawings		
Start Manufacturing Design	12/16/96	9/22/97 (A)
Manufacturing Design Complete	11/15/97	2/28/99 (C)
Fabricate NbTi Coils		
Ti Coil Forms and Tooling Delivered	2/2/98	
Coils 6 & 7		7/31/98 (C)
Coils 8, 9, & 10		10/9/98 (C)
Start Winding of Ti Coils	2/2/98	10/2/98 (C)
Ship Ti Coil Set to NHMFL	9/30/98	8/1/99 (C)
Fabricate Shim Coils		
Shim Coil Tooling Received	1/10/98	11/1/98 (C)
Complete Winding of Shim Coils	2/15/98	2/28/99 (C)
Assemble Shim Coil Set	7/10/98	4/30/99 (C)
Ship Shim Coil Set to NHMFL	9/30/98	6/11/99 (C)
NHMFL Fabrication Program		
Fabricate Nb_3Sn Coils		
Sn Coil Forms and Tooling Delivered	11/20/97	9/25/98 (C)
Start Winding Sn Coils	11/21/97	9/25/98 (C)
Complete Sn Coil Assembly	9/30/98	8/1/99 (C)
Cryostat and Cryogenic System		
Start Cryogenic System Design	TBD	3/1/98 (A)
Receive Cryostat and Components	4/15/98	8/6/99 (C)
Power Supply and Protection Controls		
Start Electronic Components Design	TBD	10/1/98 (C)
Complete System Assembly and Test	8/30/98	6/30/99 (C)
Magnet Assembly and Test		
Start Final Assembly of Magnet	10/1/98	8/1/99 (C)
Installation of Magnet in Cryostat	12/23/98	11/30/99 (C)
Magnet Testing	12/26/98	12/31/99 (C)

Project Title: Delta B Program
Report Date: July 31, 1998

Objective

The ultimate goal of the Delta B program is the development of high temperature superconducting (HTS) magnets for the 25 T high resolution NMR system. In support of this goal, the immediate objectives of the program are:

- the development of key technologies necessary for high field insert coils
- the construction and testing of prototypical insert coils to identify the primary obstacles to the ultimate goal.

Status

The efforts of the past year in the Delta B program have built on last year's successful development and testing of a 1.2 T coil that operated in a 17 T background magnetic field. This year's focus has been directed along the same technological path but aimed at increased magnetic field, overall coil current density, and system size. Specifically, we have focused on further improvements in the performance of the sol-gel insulation process while increasing production speed, improvements in characterization capabilities to match the needs of the program, and the design and construction of a larger, higher-field, insert coil. Specific progress and current activities are listed below.

Insulation

- The NHMFL sol-gel insulation process was improved further, enabling us to coat HTS tape samples of kilometer lengths with high-temperature compatible ceramic insulation. The coating thickness is controllable and can be as thin as a few micrometers and as thick as tens of micrometers. The insulation materials now include ZrO_2, Al_2O_3, CeO_2, Y_2O_3, MgO, CeO_2, and Pb and Sn doped zirconia. Combinations of these oxides are under investigation to optimize the processing speed (which is strongly dependent upon adhesion characteristics), homogeneity of the coating layer, and interactions with the conductor.

- A wheel-to-wheel system with an in-line furnace and bath has been established for the continuous coating of long-lengths of conductor. We are improving the process by the addition of more baths and furnaces as well as running several conductors in parallel.

- More than a kilometer of HTS tape has been insulated and used in several HTS coil applications, including the 3 T HTS coil.

- Short sample tests have studied the application of the oxide sol-gel insulation to Nb_3Sn superconductor. No adverse effects were observed in J_c measurements. For small conductor diameter, this insulation improved the packing density of the superconducting winding. Furthermore, coil fabrication, heat treatment, and conductor handling become much less delicate than with existing insulation technologies.

- In collaboration with EURUS Technologies/Plastronics, the sol-gel insulation was applied to monocore HTS tapes that were subsequently stacked and reduced to multifilamentary form. The interlayer insulation reduced filament coupling and a three-fold reduction in AC losses was achieved.

Characterization

- To facilitate measurements on sizable coils in the cryostat of the 20 T large bore resistive magnet, a support structure was designed and is now being assembled. The support features a large load bearing capacity, multiple current lead sets, and ample instrumentation wiring.

- Last year we reported the successful testing of a 1.2 T coil (in a 17 T background). This year we have continued to test the behavior of this coil by repeatedly load cycling at 17 T and thermally cycling to study the effects on I_c.

- A double pancake coil was thermally cycled at different rates of temperature change, to study its effect on I_c.

Coil Development

- A set of two double-pancakes were wound using surface-coated Bi-2212 conductor (manufactured by Intermagnetics General Corporation). These were successfully tested in background magnetic fields up to 9 T and subsequently used as outsert coils with the 1.2 T coil as an insert. Thus, we demonstrated that React&Wind and Wind&React (W&R) technology can be used in tandem.

- A layer-wound W&R coil was tested to verify the integrity of the insulation at the edges of the conductor.

- A new initiative, in collaboration with Oxford Superconductor Technologies, began in January 1998 to construct a Bi-2212 insert coil that will generate 3 T in the 20 T Large Bore Resistive magnet. The design, based on the successful 1.2 T coil, entails three concentric stacks of double pancake coils. In total, fifty double-pancake coils will be wound, insulated, heat treated, stacked, and tested. Over 1 km of HTS conductor is required. Construction of the double pancakes units is underway and testing of the completed system is planned for 1998.

Collaborations

The Delta B program maintains important ongoing collaborations with EURUS Technologies, Hitachi, Intermagnetic General Corp., Oxford Superconductor Technologies, and Southwire Corporation that are reported in Chapter 5, Collaborations.

MAJOR PROJECTS: Resistive Magnets

Project Title: Large Bore Resistive Magnet
Report Date: June 4, 1998

Objective

The objective of the Large Bore Resistive Magnet is to provide 20 T in a 195 mm bore using 20 MW of power. This magnet is an international collaboration between the NHMFL and the Grenoble High Magnetic Field Laboratory of Grenoble, France. Two similar magnets have been constructed. The one in Grenoble will provide 34 T in a 34 mm bore using 24 MW of power.

Status

The Tallahassee magnet was tested to 19.8 T on-axis (20.5 T maximum in the bore) on June 3, 1998 using 19.4 MW of power. We plan to use it to characterize the superconducting wire for the 900 MHz magnet in the near future. There are also high temperature superconducting wire and coil development experiments planned. In addition, this magnet helps meet the needs of the user community where high fields and large volumes are required.

Budget Summary ($K)

	Cost to 6/4/98	Cost to Complete	Total Estimated Cost	7/31/96 Budget	Variance -(over) +(under)
Labor (incl. fringes)	229.6	0.0	229.6	209.4	-20.2
Equipment/Materials	541.9	5.0	546.9	800.0	253.1
Travel/Expense	4.3	0.0	4.3	0.0	-4.3
Subtotal	**775.8**	**5.0**	**780.8**	**1009.4**	**228.6**
Overhead	107.6	0.0	107.6	96.3	-11.3
Total	**883.4**	**5.0**	**888.4**	**1105.7**	**217.3**

Milestone Schedule Summary

	7/31/96 Schedule	Actual (A) or Current (C) Schedule
Complete Coil Design	7/15/95	7/15/95 (A)
Complete Mechanical Design	4/15/96	4/15/96 (A)
Component Fabrication Complete	3/15/97	8/18/97 (A)
Magnet Assembly Complete	3/15/97	5/21/98 (A)
Full Power Testing	5/30/97	6/3/98 (A)

Project Title: 33 T Magnet II (Prototype Test for Hybrid Insert)
Report Date: June 3, 1998

Objective

The objective of this system is to provide a second 33 T magnet to the user community and to provide a facility for testing new concepts in magnet design to determine the limits attainable in terms of operating stresses, heat fluxes, and power densities in view of the design of the hybrid magnet insert.

Status

The magnet was tested to full field on March 30, 1998. It consumes 10% less power at 33 T than does the old version.

Budget Summary ($K)

	Cost to 6/3/98	Cost to Complete	Total Estimated Cost	7/31/96 Budget	Variance -(over) +(under)
Labor (incl. fringes)	15.4	0.0	15.4	25.9	10.5
Equipment/Materials	109.5	0.0	109.5	110.0	0.5
Travel/Expense	0.0	0.0	0.0	0.0	0.0
Subtotal	**124.9**	**0.0**	**124.9**	**135.9**	**11.0**
Overhead	7.1	0.0	7.1	12.0	4.9
Total	**132.0**	**0.0**	**132.0**	**147.9**	**15.9**

Milestone Schedule Summary

	7/31/96 Schedule	Actual (A) or Current (C) Schedule
Coil Design Complete		10/31/96 (A)
Mechanical Design Complete	9/15/96	1/6/97 (A)
Component Fabrication Complete	5/31/97	2/27/98 (A)
Assembly Complete	7/15/97	3/30/98 (A)

Project Title: **Multipurpose Resistive Magnet**
Report Date: **June 3, 1998**

Objective

This magnet will provide high modulation, gradient and/or homogeneity in a 32 mm bore. It will consist of three Florida-Bitter coils and some small wire wound coils on the bore tube to provide the various field quality modifications. Preliminary calculations show that a DC Field of 30 T, a modulation amplitude of 0.1 T, a gradient of 0.05 T/cm, and a homogeneity of approximately 10 ppm over 10 mm DSV can be attained.

Status

Mechanical layout will begin in September, 1998. Parts will be ordered in November, 1998. The magnet should be operational in December, 1999.

Budget Summary ($K)

	Cost to 6/3/98	Cost to Complete	Total Estimated Cost	7/31/97 Budget	Variance -(over) +(under)
Labor (incl. fringes)	1.6	36.3	37.9	37.9	0.0
Equipment/Materials	0.0	130.0	130.0	130.0	0.0
Travel/Expense	0.0	0.5	0.5	0.5	0.0
Subtotal	**1.6**	**166.8**	**168.4**	**168.4**	**0.0**
Overhead	0.7	16.9	17.7	17.7	0.0
Total	**2.3**	**183.7**	**186.1**	**186.1**	**0.0**

Milestone Schedule Summary

	7/31/97 Schedule	Actual (A) or Current (C) Schedule
Coil design complete	9/6/97	9/6/98 (C)
Mechanical design complete	10/6/97	11/6/98 (C)
Component fabrication complete	10/4/98	6/15/99 (C)
Assembly complete	12/4/98	7/13/99 (C)

Project Title: Keck Magnet
(Funded by the Keck Foundation and the NHMFL)

Report Date: June 4, 1998

Objective

This magnet is intended to provide 25 T in a 52 mm bore with inhomogeneity less than 1 ppm over a 10 mm diameter spherical volume using less than 20 MW. It has been installed at the NHMFL and will be used primarily for magnetic resonance experiments.

Status

The magnet was tested to full field on February 17, 1998. It successfully attained 25 T and has been used extensively for NMR, ICR, and EMR experiments. Three-dimensional field maps have been performed, and we are in the process of shimming the magnet to 1ppm via a combination of passive ferrous shims and active wire wound coils.

Budget Summary ($K)

	Cost to 6/4/98	Cost to Complete	Total Estimated Cost	7/31/96 Budget	Variance -(over) +(under)
Labor (incl. fringes)	116.8	0.0	116.8	85.4	-31.4
Equipment/Materials	359.0	5.0	364.0	456.0	92.0
Travel/Expense	0.0	1.1	1.1	0.0	-1.1
Subtotal	475.8	6.1	481.9	541.4	59.5
Overhead	218.9	2.8	221.7	249.0	27.4
Total	694.7	8.9	703.6	790.4	86.9

Milestone Schedule Summary

	7/31/96 Schedule	Actual (A) or Current (C) Schedule
Coil Design Complete	9/30/96	10/31/96 (A)
Mechanical Design Complete	1/15/97	5/7/97 (A)
Component Fabrication Complete	9/30/97	2/9/98 (A)
Assembly Complete	11/30/97	2/17/98 (A)

Project Title: 52 mm Bore, High Field Magnet
Report Date: June 4, 1998

Objective

This magnet will provide a high field 52 mm bore site to replace our obsolete 20 T, 50 mm bore magnets. It will be used largely for wire characterization and other experiments that do not fit in the 32 mm standard bore of NHMFL magnets. Preliminary calculations show that a field of 29 T can be achieved.

Status

Mechanical layout will begin in July, 1998. Parts will be ordered in September, 1998. Magnet should be operational in July, 1999.

Budget Summary ($K)

	Cost to 6/4/98	Cost to Complete	Total Estimated Cost	7/31/98 Budget	Variance -(over) +(under)
Labor (incl. fringes)	0.0	40.0	40.0	40.0	0.0
Equipment/Materials	0.0	130.0	130.0	130.0	0.0
Travel/Expense	0.0	0.5	0.5	0.5	0.0
Subtotal	**0.0**	**170.5**	**170.5**	**170.5**	**0.0**
Overhead	0.0	18.6	18.6	18.6	0.0
Total	**0.0**	**189.1**	**189.1**	**189.1**	**0.0**

Milestone Schedule Summary

	Actual (A) or Current (C) Schedule
Coil Design Complete	7/15/98 (C)
Mechanical Design Complete	8/26/98 (C)
Component Fabrication Complete	3/31/99 (C)
Assembly Complete	7/6/99 (C)

Project Title: Pulsed Magnets for User Facility
Report Date: June 2, 1998

Objective

The objective of this activity is to provide the magnets necessary to sustain the NHMFL Pulsed Field Facility at LANL and upgrade magnet performance, as technology becomes available.

Status

- *User Facility Support.* 24 mm bore, 50 T magnets and 15 mm, 60 T magnets are provided on an as-needed basis for the user facility. The 15 mm bore, 60 T magnet has been upgraded to 65 T after the successful test of a Glidcop coil up to 72.7 T. Three such magnets with 15 mm bore and ten 50 T magnets were delivered to LANL users. These magnets have shown a faster cooling time when the thick stainless steel cylinder is used as external reinforcement.

- *Materials.* New conductor and reinforcing materials have been introduced in developing pulsed magnets to upgrade the user facilities. The tensile test and electrical property measurements of the CuNb wire from Supercon have shown both thermal and mechanical advantages. The comparison of the coils reinforced with the carbon shell and the zylon shell indicates that zylon fiber appears to be 12 percent more efficient.

- *Test Magnets.* To investigate the behavior and the limits of the magnets using the combination of CuNb and the Zylon fiber composite, three test magnets with the bore sizes of 10 mm, 15 mm, and 24 mm were developed and tested to destruction in June, 1998. The 10 mm bore magnet produced a record field of 77.8 T with a pulse duration about 20 ms. All the coils were stress-failed at the peak fields of 80.1 T, 74.2 T, and 65 T respectively. These test results show a promising future of the pulsed magnet construction. A 10 mm bore, 70 T pulsed magnet will be provided to our users in the near future.

- *Improvements.* A new coaxial assembly interface between the magnet and the bus bar connection was designed and constructed. This reduces the vibration and the acoustic noise during the high current pulses and the energy loss in the coil connection. The same assembly system is recommended to the user magnet setup to avoid the additional forces exerted on the magnet.

Project Title: 60 T Quasi-Continuous Magnet
Report Date: June 30, 1998

Objective

The objective of this project is to provide a generator-driven, controlled-power pulsed magnet capable of sustaining a constant field of 60 T in a cold bore of 32 mm for 100 ms. In addition, the magnet is to furnish a variety of pulsed shapes including steps, linear ramps, field reversals, and long decays, in response to user needs. This magnet will be upgradable, with the replacement of a portion of its inner cluster of coils, to 65 T and approximately double the pulse widths at lower fields. In addition, a crowbar decay from full field can be added to available user pulse shapes with suitable modifications to the power supply. The system design includes the following:

- Magnet: Nine mechanically independent coils designed to operate in the elastic strain region for 10,000 pulses
- Power supply
- Existing 1.4 GVA motor-generator to provide the primary energy from inertial storage.
- New 400 MVA pulsed power supply driven from the generator comprising five 80 MW power modules (rectifier-transformer units). Two additional 80 MW modules are installed to power the 100 T magnet and can be used to enhance the performance of the 60 T magnet.

Status

Commissioning tests of the magnet and power supply operating together began September, 1997. Difficulties were encountered with the measurement of current being supplied to the magnet and commissioning was suspended in October, 1997. Improved current measurement transformers were obtained, tested, and installed. Commissioning resumed in March, 1998. Design field and duration (60 T and 100 ms) was attained on April 20, 1998. A variable temperature cryostat was built at Los Alamos and was installed on the magnet for the final commissioning tests. Four users took advantage of these commissioning tests to conduct experiments in the magnet bore. Full field magnet operation was suspended May 1, 1998, to permit implementation and testing of automatic control of the power supply and magnet. Full field operation for system optimization and support of the restricted access user program is scheduled to resume June 15, 1998. Full field operation with restricted access users specifying field pulse profiles is scheduled to begin August 3, 1998. The magnet is scheduled to be available to all users October 17, 1998. A dilution refrigerator has been ordered and is expected to be ready no later than early 1999. No outstanding issues are identified at this time.

*Budget Summary ($K)**

	Cost to 7/31/98	Cost to Complete	Total Estimated Cost	7/31/96 Budget	Variance -(over) +(under)
Labor (incl. fringes)	1055.1	0	1055.1	110.0	-945.1
Equipment/Materials	123.1	0	123.1	225.0	101.9
Travel/Expense	57.8	0	57.8	0.0	-57.8
Subtotal	**1236.0**	**0**	**1236.0**	**335.0**	**-901.0**
Overhead	623.6	0	623.6	174.2	-449.4
Total	**1859.6**	**0**	**1859.6**	**509.2**	**-1350.4**

* Budgeted costs do not include power modules and associated power system components.

Pulsed Magnets

Milestone Schedule Summary

	7/31/97 Schedule	Actual (A) or Current (C) Schedule
60 T Magnet		
Design	Done	
Assembly & Installation	10/96	8/97 (A)
Commissioning	12/96	4/98 (A)
Dewar		
Design	Done	
Assembly & Installation	7/96	
Commissioning	9/96	8/97 (A)
Control System (power supplies)		
Design	10/96	
Assembly & Installation	11/96	
Commissioning	12/96	1/97 (A)
Power Modules (3)		
Design	Done	
Assembly & Installation	9/96	11/96 (A)
Commissioning	12/96	1/97 (A)
Power Modules (4)		
Design	Done	
Assembly & Installation	6/97	5/97 (A)
Commissioning	9/97	6/97 (A)
System Optimization	New Task	7/98 (C)

Project Title: 100 T Insert Magnet Project
Report Date: June 4, 1998

Objective

The objective of this activity is to design, construct, and test a 15 mm bore capacitor powered magnet coil capable of producing a 52 T pulse in a 48 T background field generated by an outer coil set, operated in a quasi-continuous mode.

Status

- Two different insert coil designs based on different conductors (CuAg and CuSS) have been developed. Coil geometry, required conductor properties and dimensions, and the reinforcing materials have been determined. Prototype coils of both designs will be made and tested. Currently available materials do not permit, with any reasonable certainty of success, the design of a 24 mm bore insert coil. It may be possible to extend the current insert coil designs to a 24 mm bore after gaining experience with the candidate materials and coil geometry.

- The CuAg conductor will be produced by IGC-AS and will be available by the end of 1998. The Bochvar Institute will produce the CuSS conductor. The internal reinforcement for both designs is the cobalt-based multiphase alloy MP35N.

- The magnetic field reduction due to eddy currents in the MP35N reinforcement has been modeled by computer simulation. Experimental verification of this field reduction will be obtained by testing model coils that contain MP35N reinforcement.

- Several model coils incorporating CuSS conductor and MP35N internal reinforcement will be made and tested to gain coil design, fabrication, and operation experience with these materials. The fabrication of the first prototype 100 T insert magnet coil incorporating CuAg conductor is scheduled in February, 1999. The insert coils will be of duplex construction and will be powered with two separate capacitor power supplies.

Project Title: LANSCE 30 T Split-Pair Repetitively Pulsed Magnet (30 T Water Cooled Neutron Scattering Magnet)

Report Date: June 30, 1998

Objective

The object of this project, which is funded by the Department of Energy, is to supply the Los Alamos Neutron Science Experiment (LANSCE) with two 25 mm bore, 30 T split-pair magnets that can provide repetitive pulsing at a rate of 2 Hz. These magnets will be used in the LANSCE facility to provide a unique high magnetic field and neutron beam scattering capability in the world.

Status

A $150,000 grant from Los Alamos funds the engineering design and manufacture of these magnets and was the logical follow on to the conceptual design also performed by the MS&T group. The preliminary engineering design phase is presently underway. Several engineering designs have been identified and are being investigated in detail. Prototypes are being built to determine the manufacturing feasibility and to provide feedback to the engineering designs. This project will take advantage of the conductor development already performed by the NHMFL 100 T project and thereby save much time and resources in expensive and lengthy conductor development activities.

This project is a continuing example of how the intellectual resources developed under NSF funding can be directed to magnet science opportunities at other institutions and represents another facet of inter-agency cooperation.

Project Title: Cryogenic Component Development
Report Date: June 1, 1998

Objective

The objectives of this program are to develop and better understand cryogenic systems in order to improve our ability to support magnet technology. To this end, the Cryogenic Component Development (CCD) program has three main objectives:

- To develop cryogenic technology in support of large scale superconducting magnet systems
- To provide support in the form of cryogenic services to NHMFL users
- To collaborate with industry and other laboratories in development of cryogenic technology.

Status

Over the last year, the CCD group has concentrated its efforts in three main projects, which are as follows:

- *Completion of the 45 T Hybrid cryostat in preparation for the installation of the superconducting outsert magnet.* This cryostat was tested several more times to increase experience with operation and reduce heat loading. Several thermal shorts were eliminated and a minimum temperature below 1.5 K was achieved.

- *Design of the cryostat for the 900 MHz NMR magnet.* The preliminary design of this system is complete, and we have initiated the process of vendor selection. Selection of vendor will take place late summer, 1998, which will be followed by detailed design. In addition to the design effort, we are developing sub-component testing to check the operation and reliability of the design.

- *Design and insert for 20 T, 200 mm Resistive Magnet.* The fabrication of this facility is nearing completion and will be installed at the NHMFL in the end of June. This facility will first operate for testing HTS coils.

In addition, the CCD group is pursuing several R&D activities, which are partially funded by outside grants as indicated:

- *Cooling of HTS current leads.* A model has been developed to optimize the design of binary high temperature superconducting current leads. This thermodynamic optimization procedure allows for minimum refrigeration power for the application of these leads.

- *He II two phase flow and heat transfer.* This grant-funded project is studying two phase He II as it is used to cool future accelerators. Both numerical modeling and experimental confirmation are included in the project.

- *Transient heat transfer in He II.* This grant-funded project studies the propagation of intense thermal shock and second sound attenuation.

Collaborations

The CCD program maintains important ongoing collaborations with DESY-Hamburg, CERN High Energy Physics Laboratory, and the University of Oregon, that are reported in Chapter 5, Collaborations.

Budget Summary

The CCD program is jointly funded by the Department of Energy, Division of High Energy Physics (40%); the National Science Foundation through the NHMFL (40%); and the National Science Foundation, Thermofluids Division (20%).

Project Title: Hydraulic Test Stand
Report Date: June 3, 1998

Objective

This facility will permit operation of individual coils by themselves to develop a better understanding of heat and momentum transfer in turbulent flow through the very rough channels of resistive magnets. This information is critical to the development of any future high power density magnets such as the Hybrid insert, a 35 T resistive magnet, a split pair, future hybrid inserts, etc. The device also will serve to benchmark theoretical calculations on turbulent flow in channels with periodic roughness structures.

Status

In the latter part of 1997 we moved the test stand to provide better crane access. The construction is complete. The first coil, an old B coil from a 33 T magnet, has been tested. This test provided the first measurement of the Nusselt number as a function of Reynolds number in resistive magnets at the NHMFL. We discovered that at low water speeds heat transfer is about 20% greater than previously believed. We also measured the hydraulic friction factor in a single coil and now believe the friction factor in the Hybrid Insert will be about one-half that previously expected. Furthermore, we verified that this coil is still usable despite it having accumulated over 2000 megawatt-hours of operation over its year and a half operational period. We presently plan to reinstall this coil in another 33 T magnet. The A coil from our first 33 T magnet is now being installed and will be tested in the near future. After that we plan to test prototype 80 kA plug-in joints for the Hybrid Insert and then continue with tests of four other coils of various designs.

Budget Summary ($K)

	Cost to 6/3/98	Cost to Complete	Total Estimated Cost	7/31/96 Budget	Variance -(over) +(under)
Labor (incl. fringes)	41.1	0.0	41.1	42.6	1.5
Equipment/Materials	31.6	10.0	41.6	46.1	4.5
Travel/Expense	0.0	0.0	0.0	0.0	0.0
Subtotal	**72.7**	**10.0**	**82.7**	**88.7**	**6.0**
Overhead	18.9	0.0	18.9	40.8	21.9
Total	**91.6**	**10.0**	**101.6**	**129.5**	**27.9**

Milestone Schedule Summary

	7/31/96 Schedule	Actual (A) or Current (C) Schedule
Complete Test Stand Mechanical Design	3/15/96	3/15/96 (A)
Fabrication of Components Complete	9/15/96	5/19/97 (A)
Assemble and Install Test Stand Complete	10/15/96	2/6/98 (A)
Test First Coil		4/15/98 (A)

Project Title: High Strength/High Conductivity Materials
Report Date: June 2, 1998

Objectives

The main objective of this project is to develop high strength conductor materials for pulse magnet applications. The study is focused on two alloys, Ag-Cu and Cu-8%Ag plus Cu-Nb/Ti composite, and the aim of the research program is divided into three closely related goals, namely:

- To find new ways of producing low cost conductor wires, which combine high mechanical strength with high electrical conductivity
- To provide a better understanding of the factors affecting the strength and conducting properties of the materials
- To correlate the microstructure with mechanical and electrical properties of the conductor materials.

Status

- *Optimization studies on eutectic Ag-Cu.* A comprehensive set of quantitative scanning and transmission electron microscopy data has been collected and used for the correlation of microstructure and properties. An optimization scheme has been developed and applied to determine the optimal eutectic lamellae thickness for a combination of ultimate tensile strength and electrical resistivity at room and cryogenic temperatures.

- *Modeling of properties.* The electrical and mechanical properties of the materials are being modeled through correlation with microstructure.

- *Comparison of properties and microstructure of swaged and drawn wires.* Wire specimens of Cu and Cu-8%Ag were prepared by solely swaging, solely drawing, and a combination of both. The mechanical and electrical properties, as well as the microstructure and texture characteristics, have been evaluated. The goal is to produce information on the influence of deformation mode on the performance of the material.

- *Fabrication of the composite material.* The Cu-Nb/Ti composite was processed into wire using different fabrication modes, such as swaging and drawing. The effect of heat treatment (prior to processing) on the properties of wire is under investigation. The wires are now being hexed in preparation for stacking and rebundling processing.

- *Comprehensive characterization of the processed Cu-Nb/Ti wires.* The evolution of microstructure and texture of the wire during processing has been completed. The tensile strength and electrical resistivity of the wires are been evaluated as a function of fabrication mode. It is expected that the microstructural parameters will be correlated with the mechanical properties of the material.

Project Title: **Superconductor Characterization**
Report Date: **June 30, 1998**

Objective

The objectives of this program are to provide and maintain a superconductor measurement service for researchers. The characterization of superconductors is necessary for two major reasons:

- To support the research and development of superconducting materials
- To provide engineering data for magnet design.

Status

The work is divided into large scale and small scale tests as described below.

- The large scale work involves characterization of superconducting cables requiring high currents (up to 13 kA) that are supplied by the laboratory's main DC power supply. This work provides engineering data on cables and components.

- The small scale work is generally related to materials development. The characterization of single wires is usually performed at currents below 1 kA.

Over the last year the facilities for both large and small scale tests have been improved.

The commissioning of a mechanical actuator for applying transverse loads to conductors in the 14 T split solenoid superconducting magnet has improved the already unique superconductor test facility. This year we have performed first time measurements on Rutherford Style Superconducting cables used in dipole magnets.

For small scale characterization, a standardized sample holder has been adopted, upon mutual agreement with superconductor wire manufacturers. The sample holder is designed for critical current vs. field measurements in the 20 T superconducting magnet at temperatures of 4 K and 2.2 K.

Collaborations

The Superconductor Characterization group maintains important ongoing collaborations with the BABAR Detector Magnet Program at Lawrence Livermore National Laboratory, the Superconducting Magnet Group at Lawrence Berkeley National Laboratory, Supercon, Inc., Oxford Superconductor Technologies, and Intermagnetics General Corp., that are reported in the Chapter 5, Collaborations.

BWX Technologies SMES

The Magnet Science and Technology Group was funded by BWX Technologies of Lynchburg, Virginia, to assist them in the conceptual design of a medium-sized superconducting magnetic energy storage (SMES) system. Basic requirements for the system were a stored energy of about 100 MJ (when operated at a maximum current of 4 kA) and a capability of riding through a variety of specified transients without quench. We provided conceptual, cost-optimized designs for the superconducting magnet and associated systems, as well as a detailed design of the cable-in-conduit conductor (CICC) derived from the study. In addition, we contracted with BWX Technologies to assist in developing part of the detailed engineering database that will be essential for progress toward a more complete design of the proposed SMES system. In particular, we provided BWX Technologies with AC-loss data both on wires and on CICCs with dimensions and composition similar to those required in their proposed system. Discussions are in progress regarding potential future requirements by BWX Technologies for similar design, development, and testing support.

Navy SMES

In collaboration with the Naval Surface Warfare Center (NSWC), a large facility capable of testing SMES-relevant components is being installed at the NHMFL. This facility, dubbed the SMES CTA (for SMES Conductor Test Apparatus), is based upon a superconducting magnet with 2 m clear bore and 4 T field in the test region. The system includes a cryostat that provides separate cryogenic volumes for the magnet and for a test article positioned in its bore as well as a PSI 1400 refrigerator for cooling the magnet volume. The test volume is equipped with 50 kA cryogenic current leads.

In addition to its value as a large Conductor Test Apparatus, the SMES CTA is a capable energy storage magnet in its own right. Maximum stored energy is 50 MJ at approximately 2 kA operating current. Maximum power is a few kW. Plans are being formulated for a SMES demonstration wherein the SMES CTA magnet will be coupled to a modular power conversion system capable of transferring energy between the magnet and the utility grid in both directions. Collaborators in this activity will be NWSC, NHMFL, and Virginia Polytechnic Institute and State University, which will provide the power conversion modules.

Lawrence Berkeley National Laboratory Transverse Load Testing

A special facility was created for testing the critical current of large cabled superconductors while exposing them simultaneously to high field and large transverse load. This facility is designed for operation with the NHMFL superconducting split solenoid, which is capable of 13 T transverse field in its 150 mm bore. Transverse load up to 250 kN can be applied by a 100 mm diameter steel ram actuated by helium gas pressure inside a leak-tight bladder. The ram rides inside a heavy-wall cylinder, which allows the load to be reacted entirely within the cold part of the apparatus. Both the split-solenoid structure and the transverse-load apparatus have 30 x 70 mm^2 radial access ports for passing test conductors or small coils into the high-field region of the magnet. Until now, the facility has been used to test samples of the conductors (Rutherford cables with Nb_3Sn/Cu composite strands) used in the 13 T Lawrence Berkeley National Laboratory (LBNL) D20 dipole magnet. These measurements will play an important role in LBNL's development program to achieve 15 T in an accelerator dipole.

Lawrence Livermore National Laboratory Conductor Characterization

Engineers from the LLNL/BABAR Detector Magnet Program collaborated with MS&T to investigate the current transport characteristics of aluminum-stabilized high current superconductors. Characterization of the large conductor requires the capabilities of the NHMFL's main DC power supply and the 14 T split-solenoid superconducting magnet.

IPR India

A contract with the Institute for Plasma Research (IPR)–India has been extended. In the earlier phases of the agreement, we provided consultation on design and performance analysis of cable-in-conduit conductors for both toroidal-field and poloidal-field coils of their proposed SST1 tokamak. In addition, we outlined for them the critical aspects of a development and test program that would give assurance of acceptable conductor and magnet performance during machine operation. Since then, IPR has requested that we be available to help with analysis of data from the test program, which is being carried out in collaboration with the Kurchatov Institute in Moscow, Russia.

In-House Research Program

Chapter 3

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

In 1996, the NHMFL established the In-House Research Program (IHRP) that seeks to achieve these objectives by funding research projects of normally one- to two-year durations 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
- Initial seed support for new faculty and research staff, targeted to magnet laboratory enhancements.

This annual report presents progress reports from the first solicitation in 1996, followed by abstracts from the second solicitation in 1997. External reviews are underway on 17 of the 40 proposals received in response to the 1998 solicitation.

1996 Solicitation

The first NHMFL In-House Research Program solicitation was released on May 10, 1996. 67 proposals were submitted, 38 went to external review, and 15 were funded.

The following brief summaries are the first six-month progress reports of the 1996 proposals that were funded from January 1, 1997, to December 31, 1998. Because of a longer-than-anticipated process in transferring funds from FSU to UF and LANL, actual start up of the projects did not occur until April, 1997. Consequently, the first six-month reports were not due until October, 1997, and the annual reports are due June, 30, 1998 (too late to publish with this annual report). The final project reports will be due December 31, 1998, unless a six-month, no-cost extension is requested and approved. In that case, the final reports will be due June 30, 1999. Two of the 15 proposals were one-year grants, and their final reports are due June 30, 1998.

Progress of 1996 Funded Projects
(Date of Information October 31, 1997)

Experimental and Theoretical Aspects of Quasi-Three Dimensional Quantum Hall Systems
PI: J. S. Brooks (FSU)
Funding: $86,185 over 2 years

The focus of this research is to determine how the physics of the quantum Hall effect in the strictly two dimensional electron gas evolves in a quasi-three dimensional system of many coupled two dimensional layers. To address this question experimentally, we have performed a systematic study of five different GaAs/GaAlAs 200 layer quantum well structures with different degrees of disorder and also different barrier widths. By a variation of the barrier width, Al concentration, and Si doping, the effective barrier height, carrier concentration, and degree of impurity scattering can be modified systematically. Measurements of Rxx (magnetoresistance) and Rxy (Hall resistance) were carried out over a three month period to dilution refrigerator temperatures and to 30 T. This included tilted field measurements. At present these results are being analyzed and two papers, one short communication and one longer paper are in preparation. The main, although still preliminary results of this work are:

- There is strong evidence for the presence of a warped cylindrical Fermi surface as a result of the finite interplane band width. This is observed for instance is beating of the quantum oscillations in Rxx as a function of angle. Above a tilted angle of about 30 degrees, the Rxx minima of the $\nu = 2$ quantum Hall step and the Rxy Hall plateau are fully developed for T->0.
- We find in the data evidence for an oscillation between metallic and insulating behavior with increasing magnetic field.
- The temperature dependence of, for instance, the Rxx minima do not follow a power law, but are linear in T for T->0. This is one of the more important preliminary results, since this is a clear departure from the results for a single 2D layer.

In parallel, theoretical work has been carried by Z. Wang, Boston College. Concerning Multi-layer Quantum Hall Structures, it is found that:

- Any finite inter layer tunneling will give rise to successive metallic and insulating phases.
- The Hall conductivity is not renormalized in the metallic phases, but is quantized in the insulating phases.

The next important stage of the work is to establish more directly the quasi-2D metallic nature of the multi-layer system, and to look for the edge state currents which are expected to be present. We are happy to report that our UNSW collaborators have selectively etched some structures with differing numbers of layers so that we can investigate the difference between vertical transport in 200 - N layers, where N varies from 0 to 180. The characterization of these new structures will be a main effort over the next several months.

Design of a High Frequency, Short Pulse Gyrotron for Pulsed EPR
PI: L.-C. Brunel (FSU)
Funding: $79,491 for 1 year

The program goal is to determine the feasibility of a 150-600 GHz gyrotron for an EPR system. This is being accomplished through the initial design of critical components and the experimental test of the modulator.

The gyrotron will be designed to operate in both a pulsed and CW mode. For pulsed operation there will be two ~3 ns - 10 ns pulses, separated by 5 ns - 20 ns, repeated at a 1 kHz rate. The pulses will be separated by optical splitting and an optical delay, and will thus be coherent.

The elements being considered in detail in this study are the modulator, electron gun, cavity and output coupling and transmission line. The collector and output window will be addressed briefly. The requirements for the superconducting magnet will be determined.

The modulator will be used to drive the modulating anode of the electron gun from ~100 V below to 5 kV above the cathode voltage. A rise time of >1 ns is sought. Three approaches are being considered.

(1) Optically triggered semiconductor switch. This approach is expected to produce the shortest rise time, but is the most complex and potentially the most expensive. The system is based on technology developed at Sandia National Laboratory. A test system is being assembled by Sandia. It will be tested there, then shipped to Physical Sciences, Inc. (PSI). This is being done by Sandia as a demonstration of the commercial potential of their technology, and at no cost to PSI. The Sandia demonstration will be completed within the next few weeks.
(2) Coaxial line with self triggered spark gap. This approach is the simplest, and will be low cost. A test system is being assembled at PSI, and will be tested in about two weeks.
(3) Miniature Marx-Blumlein. This is will be based on technology from the former Soviet Union.

The electron gun will be a triode MIG, as is often used in gyrotrons. Cavity calculations dictate that the beam after compression have a radius of 2.6 mm, with a width of less

1996 Solicitation

than 0.2 mm. To minimize the modulator problem, the voltage was minimized. The appropriate cathode voltage, based on efficiency and space charge considerations, was estimated to be -15 kV. The mod anode voltage, relative to the cathode was chosen to be 5 kV, based on analytic design calculations for the gun. To achieve > 10% efficiency in the second harmonic (for operation from 300 0Hz to 600 6Hz), a beam current of 3 A is required. An initial simulation of the gun has been performed, and the results found to be satisfactory.

Calculations of the cavity interaction, yielding the efficiency, power, and cavity Q's and ohmic loading are almost complete. Efficiencies are >10% for all modes. As anticipated. cavity ohmic loadings are too high to permit CW operation at the second harmonic. Therefore operation above 300 0Hz will be in the pulsed mode, only. If time permits, we will investigate the possibility of extending the fundamental operation to 600 0Hz through extension of the magnetic field to 20 T.

Study of Spin Gapped Quasi-1D Compounds with ESR Techniques and Numerical Simulations

PI: Elbio Dagotto (FSU)
Funding: $138,061 over 2 years

High-field electron spin resonance measurements were made on powder samples of $Cu_{(1-x)}Zn_{(x)}GeO_3$ (x-0.00, 0.01, 0.02, 0.03 and 0.05) at different frequencies (95, 110, 190, 220, 330 and 440 GHz) and low temperatures. The spectra of the doped samples show resonances whose positions are dependent on Zn concentration, frequency, and temperature. The analysis of intensity variation of these lines with temperature allows us to identify them as originating in transitions within states situated inside the Spin Peierls gap. A qualitative explanation of the details of the spectra is possible if we assume that these states in the gap are associated with "loose" spins created near the Zn impurities, as recently theoretically predicted.

Highlights. The work described above is the bulk of a Ph.D. dissertation to be presented December 1997 (A. Hassan). It is also the subject of a submitted paper (Ref. 1). It represents a collaboration between theorists and experimentalists as outlined in the original proposal.

The efforts on the theoretical front have been focused on the study of the collapse of the spin gap in gapped materials upon Zn doping. Numerical calculations as described in the original proposal led us to predict the existence of 5=1/2 states inside the gap, which have been addressed recently using a variety of experimental techniques. The results of this effort are documented in publications (Ref. 2, 3).

Recently the development of new techniques to handle the physics of correlated electrons was proposed in Ref. 4. The method involves two steps: first, an exact change of basis takes into account the short distance correlations in the problem, and second, a truncated Lanczos approach is carried out to obtain results using large enough clusters. The method will be applied to models for gapped materials, as described in the original proposal.

References:

1 Hassan, A.K.; Pardi, L.; Martins, G.; Cao, G. and Brunel, L.-C., *High Field Electron Spin Resonance of $Cu_{1-x}Zn_xGeO_3$*, Phys. Rev. Lett., **80**, 1984 (1998).

2 Martins, G.; Laukamp, M.; Riera, J. and Dagotto, E., *Local Enhancement of Antiferromagnetic Correlations by Nonmagnetic Impurities*, Phys. Rev. Lett., **78**, 3563 (1997).

3 Laukamp, M.; Martins, G.B.; Gazza, C.; Malvezzi, A.; Dagotto, E.; Hansen, P.; Lopez, A. and Riera, J., *Enhancement of Antiferromagnetic Correlations Induced by Nonmagnetic Impurities: Origin and Predictions for NMR Experiments*, Phys. Rev. B, 57 17, 10755 (1998).

4 Dagotto, E.; Martins, G.B.; Riera, J. and Malvezzi, A., *Diagonalization in Reduced Hilbert Spaces Using a Systematically Improved Basis: Application to Spin Dynamics in Lightly Doped Ladders*, Submitted to Phys. Rev. B.

High Resolution Solid State NMR Techniques and Applications to Materials Science

PI: N. Dalal (FSU)
Funding: $109,070 over 2 years

The overall goals of this project were the following: (1) To develop new r.f. pulse sequences and experimental techniques that will enhance the range of NMR Zeeman fields to higher values than those utilized in the currently available NMR spectrometers, and, (2) To demonstrate the application of the newly developed techniques to important problems in materials science, with a focus on quadupolar nuclei such as 0-17, K-39, Rb-85 and Rb-87, and the line-broadening effects of these nuclei when coupled to nuclei with spin-l/2, such as C-13 and P-31. It is expected that the proposed development of the instrumentation and the pulse-sequence techniques would enable us to better characterize ferroelectric and antiferroelectric phase transitions as well as enhance the NMR capability at NHMFL.

As proposed, we have initiated a three-prong approach:

(1) Development of a novel two-dimensional (2-D) NMR technique that will enable measurements of spin correlations between molecules in two different phases of a solid in the close vicinity of its phase transition temperature, T_c.
(2) Acquisition, modification, and installation of an NMR probe that will extend the capability of variable temperature high resolution solid state NMR (cross polarization magic angle spinning i.e., CP-MAS) measurements at NHMFL.

(3) Development of the CP-MAS technique utilizing single crystals which will help obviate the line broadening effects of anisotropic bulk magnet susceptibility (ABMS). This development is important because the ABMS broadening increases in proportion to the applied Zeeman field, and thus restricts the extension of NMR at ultrahigh fields.

We have developed a novel 2-D technique in which one of the dimensions is sample temperature with the second dimension as the chemical shift. We have thus named this technique as TOESY standing for "Temperature Jump Nuclear Overhauser Effect Spectroscopy." This technique has made it possible for the first time to carry out the detection of spin correlations between the spins clusters in the paraelectric and antiferroelectric phases of a lattice in the critical region. The technique has been demonstrated for detecting the slow (kHz range) H exchange in the region of the paraelectric-antiferroelectric phase transition in squaric acid ($H_2C_4O_4$) crystals around 373 K. The results were reported at the Experimental NMR Conference held in Orlando in March, 1997.

We have shown that the utilization of single crystals in a CP-MAS experiment significantly reduces the ABMS line broadening effects in NMR spectra. This constitutes the first application to materials science, a higher resolution characterization of solids undergoing phase transitions. The technique was applied to squaric acid: An enhancement in resolution of up to a factor of 450% was demonstrated for the spectra of natural abundance ^{13}C nuclei. A refereed publication based on this technique has been accepted for publication in the September (1997) issue of Zeitschrift Fur Physik.

As planned, we have ordered a new NMR probe that will extend the variable temperature range of our solid State NMR measurements from about 500 K down to 150 K. The probe delivery date is early October. The availability of this probe will enable us to embark on our new phase of experiments: to understand the mechanism of linebroadening observed for spin-1/2 nuclei coupled to quadrupolar nuclei. The availability of this probe will open up new avenues for the use of the current solid state NMR spectrometers to other users in general.

Publications:

Klymachyov, A.N. and Dalal, N.S., *Magic Angle Spinning on Single Crystals as a New Aid in Characterizing Phase Transitions: Application to Squaric Acid*, Zeitschrift Fur Physik B **104**, 651-656 (1997).

Klymachyov, A.N. and Dalal, N.S., *Spinning Crystals Leads to Significant Enhancement in 13-C Spectral Resolution in MAS Experiments on Organic Compounds: A New Aid in Studying Phase Transitions*, Solid St. Nuc. Magn. Reson. **9**, 85-89 (1997).

Klymachyov, A.N. and Dalal, N.S., *Discriminating Between The Displacive and Order-Disorder Character of a Phase Transition By Magic Angle Spinning NMR*, Ferroelectrics, **206**, 103-112 (1998).

Klymachyov, A.N. and Dalal, N.S., *On Quantitative Determination of the Displacive Versus Order-Disorder Character of a Phase Transition by High Resolution NMR Spectroscopy*, (Invited Paper), J. Korean Physical Society, Supplementary Issue, **32**, S629-S633 (1998).

Invited Talks:

Dalal, N.S., *High Resolution NMR As a Technique For Discriminating Between the Order-Disorder Vs. Displacive Behavior of Phase Transitions*, E. Majorana International School of Solid State Physic, Sicily, Italy, June 10-14, 1997.

Dalal, N.S., *Magic Angle Spinning with Single Crystal Significantly Enhances the Spectral Resolution in Solid State*, 9th International Meeting on Ferroelectricity, Seoul, Korea, August 24-29, 1997.

Dalal, N.S., *Magnetic Resonance at High Fields*, Colloquium at the University of Florida, May 12, 1997.

Dalal, N.S., *Magic with Crystals*, a colloquium at the Josef Stefan Institute, University of Ljubljana, Slovenia, June 9, 1997.

Dalal, N.S., *High Resolution NMR in Ferroelectrics*, Workshop on Fundamental Experiments in Ferroelectricity, Williamsburg, VA, February 5, 1997.

Contributed Talks:

Dalal, N.S., Experimental NMR Conference in Orlando, FL, March, 1997.

Materials Processing in Magnetic Fields: High Strength Polymers

PI: E. P. Douglas (UF)
Funding: $112,819 over 2 years

Magnetic fields hold great promise for materials processing, leading to new materials that can not be obtained by any other technique. In particular, orientation of liquid crystalline polymers using high magnetic fields holds tremendous potential for creating high strength materials without the use of fillers or complex composite fabrication techniques. Our goal for this project is to develop new techniques for using magnetic fields to orient liquid crystalline thermosets in order to control the level of orientation, and ultimately the mechanical properties of these materials. Specifically, the research is intended to develop new methods for inducing biaxial orientation through the combined use of magnetic and shear fields. The resin system investigated is a liquid crystalline epoxy formulated with a diamine hardener This resin system forms a smectic liquid crystalline phase upon curing. Over the first months of the project we focused on the specific effects of magnetic fields. The results described below will provide a basis for more complex processing protocols in our future work.

- We have designed a statistical design experiment in order to investigate the combined effects of magnetic field strength, processing time, and B-staging (pre-processing) on the orientation and mechanical properties of the liquid crystalline thermosets. Samples have been prepared based on these protocols and testing is currently underway.

We have created a fractional factorial design to study the main and combined effects of the magnetic field strength, processing time in the field, and amount of B-staging on the physical properties of the liquid crystalline thermoset system. The design studies the effects over a wide range of each of the factors in order to determine the variation in properties that result from the different processing parameters. The study also concentrates on obtaining an economically achievable final product. The focus here is to keep the processing time, magnetic field strength and amount of B-staging as low as possible but still obtain the desired properties. Preliminary testing is underway to screen each of the factors to determine the main and combined effects of each factor, and successive tests will optimize the factor level s for a give n response. The project is currently in the preliminary screening of the main and combined effects of the factors. The major responses being measured are the degree of orientation and the mechanical properties in the processed sample. The degree of orientation or orientation parameter is being measured using x-ray diffraction techniques, while the mechanical properties are being measured using standard tensile specimens.

- Measurements of orientation as a function of magnetic field strength for two levels of B-staging show significant differences in the threshold field strength required to obtain orientation.

The measurements were conducted on samples with no B-staging and samples with some degree of B-staging. The B-staging is conducted at 1200C for a time determined by the statistical design, The B-staging is conducted on the material to increase the molecular weight, and hence, the viscosity of the melt, which will affect the orientation process in the magnetic field. Preliminary results indicate the presence of a threshold magnetic field strength required to orient the B-staged samples as compared to the non-B-staged samples. Typically this threshold occurs at about 3.0 to 4.5 T. However, preliminary results also indicate that at high magnetic field strengths orientations are higher for the B-staged material than for the non-B-staged material. This indicates a complex relationship among the viscosity, the ease of orientation, and the preservation of the final level of orientation. This relationship will be studied more closely as described later in the future work section. Preliminary screening will, however, identify the main effects of B-staging on orientation and its interaction with processing time and magnetic field strength.

- We have investigated a number of different curing agents in order to identify a system that gives a nematic phase for comparison to the smectic phase formed by our current system.

The nematic phase, we believe, will yield higher orientations at lower magnetic field strengths than the smectic phase. This is due in part to the presence of a layer structure in the smectic phase, which results in greater cooperativity for orientation of the molecular structure compared to a nematic phase. We are currently screening a number of different hardeners for the epoxy thermoset in order to identify a system which gives a nematic phase. Precautions are being taken to ensure similar reaction kinetics between the two systems for a better comparison in modeling of the orientation process. Once a suitable nematic system is obtained, experimentation will continue to determine the differences in the physical properties that each structure yields.

Work will continue on the statistical design approach to determining the optimal level of each of the factors for obtaining the desired properties from the current resin system. Preliminary screening will be completed as well as the optimization portion of the design. Once a suitable nematic resin system is found, we also will investigate the effects of the levels of the three factors with the statistical design approach for the nematic phase. From there we will go on to compare the two resin systems and the properties that each yields. Specifically, the magnitude of orientation for each system and mechanical properties for each system will be compared.

While characterization of the magnetic alignment process is well underway, the next six months will also include characterization of the mechanical alignment process. The liquid crystalline thermoset will be studied from a rheological standpoint to determine the material's stress rate response and viscosity as a function of time. This information will help not only in determining optimal amounts of B-staging for mechanical orientation but also for the magnetic orientation process as well. Gel point information obtained will also aid in determining ideal processing times for both processes. Detailing of the magnetic orientation and mechanical orientation processes will lead eventually to combining the two to obtain high strength, biaxially oriented structures.

Novel Syntheses and Fourier Transform Mass Spectrometric Analysis of Combinatorial Libraries
PI: J. R. Eyler (UF)
Funding: $148,897 over 2 years

The two graduate students working on this project, Maria Wigger and Joe Nawrocki, have been studying different aspects of mass spectral analysis of combinatorial libraries (mainly amino acid based). Nawrocki has focused his attention on the analytical issues such as looking at various parameters such as response factors, detection limits, and system linearity. These studies have involved using "real" libraries, real libraries "doped" with an excess of a peptide, and synthetic mixtures (where we know the concentration of each components). Nawrocki has started a related combinatorial project with Dr. Alan Katritzky using a variety of alkyl-substituted pyridinium systems. The purpose of this work is to establish a correlation between the "chemical" nature of the components in the library and their relative mass spectral response factors.

Wigger has worked more with the biological/chemical end of things. Her work includes: looking at various peptide/receptor interactions; actual screening experiments where a receptor "grabs" hold (interactions are mainly due to non-covalent interaction) of a few library components (those with the highest binding constants) and has demonstrated that MS (and MS/MS) has sufficient specificity to screen for such interactions. She also has been busy developing other strategic uses of combinatorial chemistry, such as determining the activity of certain enzymes.

Both of these students have used the high-field 9.4 T FT-ICR instrument at the NHMFL to clarify problems which they have encountered in their work at UF and which could not be resolved at the lower resolutions and sensitivities provided on the 4.7 T system at UF.

In addition, Dr. Clifford Watson has written several computer applications for mass spectral simulation and data analysis of combinatorial libraries. These program are freely available on the Internet and can be downloaded from Dr. Watson's entry on the Eyler group home page, accessible from *www.chem.ufl.edu.*

This work has produced two published papers to date, with several more in various stages of completion.

Publications:

Wigger, M.; Nawrocki, J.P.; Watson, C.H.; Eyler, J.R. and Benner, S.A., (1997*): Assessing Enzyme Substrate Specificity Using Combinatorial Libraries and Electrospray Ionization- Fourier Transform Ion Cyclotron Resonance Mass Spectrometry*, Rapid Comm. Mass Spectrom, **11**, 1749-1752 (1997).

Nawrocki, J.P.; Wigger, M.; Watson, C.H.; Hayes, T.W.; Senko, M.W.; Benner S.A. and Eyler, J.R., *Analysis of Combinatorial Libraries Using Electrospray Fourier Transform Ion Cyclotron Resonance Mass Spectrometry*, Rapid Comm. Mass Spectrom., **10**, 1860 (1996).

Doped Hole Physics in Single-Layer Perovskites
PI: Z. Fisk (FSU)
Funding: $138,194 over 2 years

In crystal growth, the main progress to date has been successful growth of single crystals of La_2NiO_4 and $La_{1.67}Sr_{0.33}NiO_4$ using the optical floating zone furnace. The Sr-doped material is in the regime of reported charge ordering in the planes, and part of our interest to determine whether the Sr atoms show local ordering as well. Our interest here is also to determine whether the doped holes can he considered to reside on Ni^{+3} species.

A study has been completed of lightly Li-doped La_2CuO_4, in which the Li is an in-plane substitution. The data clearly show that in-plane holes introduced via Li and out-of-plane holes introduced via Sr have very similar effects on the properties of La_2CuO_4. In particular, NQR measurements are almost identical between the two types of sample, including the surprising finding that the sublattice magnetization climbs to the undoped value at low temperatures for both. In the case of Sr-doping where the holes are believed to be mobile, the explanation for this involved the holes becoming static. Now with the similar effect seen with the static holes introduced via Li, this explanation no longer seems correct. A paper has been submitted for publication of this work.

Resistance and susceptibility has been measured on $La_2Cu_{1-x}Ni_xO_4$ across the entire range of x. These studies have been made on sintered powder samples. We have followed the evolution of the magnetic ordering temperature across the series. This study is preliminary to our planned study using mixed Sr/Ni substitutions.

In the next six months, January 1 to June 30, 1998, we will study the Sr-doped La_2NiO_4 single crystal that has been prepared. Single crystal growths will be attempted with mixed Sr/Ni substitutions in La_2CuO_4. The growths involving La_2CuO_4 are difficult, and we are still learning how to do them. EPR studies will be carried out in the mixed doping systems. This can be done in sintered powders as well as single crystals.

Applications of Magnetic Resonance Imaging Velocimitry for Flow in Porous Media and Fiber/Composite Manufacturing
PI: S. J. Gibbs (FSU)
Funding: $141,543 over 2 years

Protocols for model porous media fabrication have been established:

- Preliminary images of model porous media were aquired: Magnetic susceptibility nonuniformities in model systems are manageable at 600 MHz.

- Ten micron resolution velocimetry was performed on capillary flow at 600 MHz: Velocimetry protocols were established and data analysis software was prototyped.

A postdoctoral research associate (Dr. Galina Pavlovskaya) was hired on October 9, 1997. Dr. Pavlovskaya will adopt the porous media fabrication procedures developed by co-PI Dr. Kerang Han and perform MRI velocimetry for Newtonian fluids in these systems. Dr. Pavlovskaya also will streamline the data analysis software written by the PI in order to analyze apparent slip behavior at interfaces. Progress on this project is expected to move rapidly now with the addition of Dr. Pavlovskaya to the research team.

Very High Magnetic Field Studies of the Cuprate Spin Gap
PI: P. C. Hammel (LANL)
Funding: $143,759 over 2 years

We have purchased and received a new spectrometer specifically designed for high field measurements in high T_c cuprates. This equipment will augment NHMFL capabilities.

A postdoc, Oleg Vyaselev, who will carry out the bulk of the experimental measurements in this research program, was hired and has arrived at Ohio State University where he is being supervised by Prof. Charles Pennington.

A series of measurements of the 17O Knight shift in $YBCO_{(6+x)}$ for x=O.63 and x=O.94 have been made at fields sufficiently high that T_c is significantly suppressed relative to the zero field value. We find a significant sensitivity of the detailed temperature dependence of the magnetic susceptibility to applied fields of 24 T in the normal state of both materials of particular interest is the observed field dependence of the suppression of the spin susceptibility above T_c. We find that the opening of the spin gap in the normal state (i.e., above the zero field T_c) for x=O.94 is significantly influenced by the application of high fields. We expect that these experiments will provide important insight into the nature of the normal state spin gap in the cuprates.

High Field, High Frequency RF Coils for NMR Spectroscopy and Microscopy of Small Samples
PI: T. H. Mareci (UF)
Funding: $51,487 over 1 year

No report received.

NMR Studies of Superconducting and Magnetic Cuprates and Low Dimensional Electron Systems at High Magnetic Fields
PI: W. G. Moulton (FSU)
Funding: $73,045 over 2 years

The work has concentrated on two problems: (a) The use of ^{17}O, $^{63,65}Cu$, and ^{159}Tb NMR to study the effect of Tb substitution in $YBa_2Cu_3O_7$ on the vortex phase diagram along with studies of the role of Th on changes in the magnetic couplings and why T_c is unchanged with Th doping and (b) detailed studies of the field and temperature dependence of metallic, spin density wave (SDW), and charge density wave (CDW) phases and phase boundaries in one-dimensional organic conductors.

The first step in the studies of the Tb doped $YBa_2Cu_3O_7$ was to complete the studies of the undoped $YBa_2Cu_3O_7$ vortex phase diagram. This has been done and a paper has been submitted to Physical Review Letters. The work was a collaboration with W. P. Halperin, A. P. Reyes, and H. N. Bachman. Recent work on high temperature superconductors has focused on understanding the dynamics of vortices. One of the most dramatic results is the demonstration of a thermodynamic first order melting of the vortex lattice or glass at a temperature T_p just below T_c using an unconventional NMR technique. At lower fields, up to about 10 T, T_p decreases smoothly with increasing field, similar to the upper critical field. In contrast, this work has found that at high fields, above 10 T, the melting temperature becomes essentially field independent, qualitatively similar to theoretical predictions. In addition the NMR technique has identified an intermediate phase indicative of a 2-D vortex melting in which vortex fluctuations are limited to directions perpendicular to the field. This plane is characterized by a coexistence of a solid and liquid phase defined by the presence of random pinning centers throughout the sample. The upper phase boundary agrees well with other measurements showing a first order vortex melting transition. There is no confirming data at the higher fields. The NMR technique in these studies utilizes the fact that in the liquid vortex state the rapid vortex fluctuations motionally average the local fields so the line shape does not change from the normal state, while in the immobile vortex region the line has a long low frequency tail and a distinct shift relative to the liquid vortices. The spectrum just below the pinning transition has both Gaussian and exponential components, clearly indicating a coexistence region, observed here for the first time. It should be pointed out that these samples were aligned powders and probably have a large concentration of defects (pinning centers) in contrast to the previous work on very clean untwinned single crystals.

The striking features are the independence of T_p on field above 10 T, and the presence of a coexistence region with both solid and melted components. Future work, which is in progress, is to extend these studies to the Tb and Nd doped $YBa_2Cu_3O_7$, Neither of these dopants affects T_c, but should introduce additional pinning sites, and dramatically modify the vortex phase diagram.

The preparation of high quality $Tb_xY_{1-x}Ba_2Cu_3O_7$ proved to be a more challenging task than originally anticipated. Only single crystals have the quality needed for these experiments, and the yield of single crystals is quite low, Û 5%, so a large number of batches had to be made to acquire the 150 mg or so required for the NMR experiments. We now have adequate sample size for 0.10, 0.20, and 0.30 which show high quality from T_c, EDS, and x-ray analysis. The crystal growth was carried out by Gang Cao of Jack Crow's group. The system for 70 exchange has been designed, fabricated, completed, and leak checked. Considerable time has been spent developing our techniques for aligning the powders, made from grinding crystals, in epoxy using Y123 for the tests. Due to skin depth and penetration depth limitations in the high frequency NMR single crystals cannot be used. This has all been accomplished and the ^{17}O exchange will be done shortly. Since the 170 costs $5000/liter STP, we are being very careful to insure good samples the first time. In addition to the 170 experiments, A. P. Reyes, who joined our group the middle of September to replace Alfred Kleinhammes, is planning $^{63,65}Cu$ experiments in these samples to study the bonding and magnetic coupling changes introduced by the Tb.

Another system currently being studied is α-(BEDT-TTF)$_2$KHg(SCN)$_4$. This is a quasi 1D metal in the high temperature phase, and an insulator in the low temperature phase. There is considerable controversy over the insulating phase, with some claiming a spin-density wave, and some a charge density wave state. Muon rotation data show a moment of 0.003 BM.

The region from about 8 K to 60 K show typical Korringa (metallic) behavior, and the shortening of T_1 above 60 K is ascribed increased relaxation due to the onset of rotation of the methyl groups. At about 8 K, there is clear indication of entering the insulating phase by the dramatic increase of T_1. The very surprising aspect of these data is that the onset of the insulating phase is identical to that found by Miyagawa *et al.* taken at 8 T. From the current phase diagram the transition should have moved down by about 1 K. Preliminary data at 21 T also indicate no movement of the phase boundary with field, which at present is a puzzling result. The ^{13}C NMR spectrum shows little or no change in going from the metallic to insulating phase. In the usual spin-density wave case a dramatic broadening occurs below the transition. In this case, since the moment is so small (0.003 BMW if it exists, of the order of the proton moment) a spin-density wave cannot be completely ruled out, although we believe we would see a broadening of even this small magnitude. Careful T_2 measurements need to be made to try to sort this out. In an orientation where the dipolar splitting would be expected to be maximum at least six resolved lines are observed, while in the orientation perpendicular to this the lines are not resolved. The spectra are due to the differences in nuclear dipole interaction, Knight, and chemical shifts at the inequivalent C sites. The spectra and the interaction are being sorted out by rotation and temperature dependent studies. This is a system of considerable current interest, and work is continuing to elucidate the insulating phase. Resistive magnet to carry out further work up to 24 T is scheduled for the week starting October 20, 1997.

The plans are to continue the work in Tb doped 123 and the over the next six months, January 1 to June 30, 1998, which are in the spirit of the proposal.

On the facilities instrumentation side, a new flow VT insert and probe for the 24 T resistive magnets have been designed and the components recently completed in the shop. This probe is to overcome some of the limitations of the current most commonly used probe, namely that it does not control well below the "bubble" field and the frequency range is limited to below 250 MHz. A number of other improvements to the resistive magnet facility are planned including adding sample rotation capability. This development work has been nearly stopped for several months due to the loss of Alfred Kleinhammes in November, 1996. His replacement by Arneil Reyes September 15, 1997, already has allowed progress in this area. The 16 T superconducting magnet was delivered in June, a VT insert and probe designed and constructed, and the system is now in operation. The Tecmag spectrometer ordered for this system through the in-house science program with Chris Hammel as PI was delivered September 1, 1997, and is in operation. While this magnet is primarily for in-house research (most of the data on α-(BEDT-TTF)$_2$KHg(SCN) was taken in this magnet), it is available to outside users/collaborators on a limited basis, and two have been scheduled so far.

Heat Capacity Measurements in NHMFL 60 Tesla Quasi-Continuous Magnet

PI: R. Movshovich (LANL)

Funding: $127,860 over 2 years

During the period from the beginning of the project to date the following progress has been made:

- Designed the heat capacity cell. Fabricated unique single crystal Silicon stages.
- Fabricated test versions of the thick-film Ruthenium Oxide thermometers tuned to operate in the few degrees to few tens of degrees Kelvin; tested several of these thermometers in both 60 T short pulse magnet at Los Alamos NHMFL Pulsed Field Facility and 30 T resistive magnet at FSU NHMFL. Thermometers appear to

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behave appropriately, with good temperature sensitivity and low magnetoresistance. Eddy current heating of thermometer was not detected during the short 60 T pulse, and therefore it is not expected to present a challenge in the long pulse magnet.

- Heaters were tested for compatibility with high magnetic fields and appear suitable for incorporation into the heat capacity cells.
- Submitted request for a price quote for fabrication of the vacuum insert to go directly into ^{4}He bath of the main dewar. This arrangement will allow us to have a maximum volume for experimental region. Design suggested by Oxford at the moment does not appear to be optimized for the largest possible experimental volume. The other options (such as building the probe in UF) are under consideration. We are designing the probe with the goal of maximizing the available experimental volume.

A postdoctoral member of technical staff was hired on this project. Dr. Marcelo Jaime has experience with measurements in high magnetic field at cryogenic temperatures, and visited NHMFL at Los Alamos during his postdoctoral tenure with Prof. Myron Salamon of the University of Illinois at Urbana. He has experience with both transport and thermodynamic measurements and will add greatly to the success of the project. Dr. Jaime began to work at Los Alamos on August 11, 1997.

During the next six months, January 1 to June 30, 1998, we will build the cryostat insert that will provide a adequate experimental volume under vacuum that is necessary for specific heat measurements. We will build the heat capacity cell using the components that have been already tested. The 60 Tesla magnet appears to be coming on line within the next few months. We will participate in commissioning this magnet and will tune characteristics and design of our cell to its performance parameters (field profile, rise time, and the duration of the flat top). We will test operation of the heat capacity cell in 0 field. We will calibrate our thermometers for the field of up to 60 T either in the long or short pulse magnets. We will initiate heat capacity measurements (empty cell and standards) to test the cell's operation in a pulsed field.

Time Resolved Photoluminescense Studies of Semiconductor Heterostructures in High Magnetic Fields
PI: D. G. Rickel (LANL)
Funding: $128,390 over 2 years

During the first period, we identified and hired a postdoctoral Research Associate (Scott Crooker; Ph.D. UC Santa Barbara with Prof. D. Awshalom). Dr. Crooker has an impressive resume and direct experience in time-resolved spectroscopy and in quantum well structures doped with magnetic ions. Dr. Crooker received a LANL Director's funded position for three years; this will allow the PIs to reassign some of the funds to equipment purchases and technical assistance. A Northeastern University graduate student (Florin Muneanu) has been assigned to the project (funded through the NU sub-contract) and has been at NHMFL-LANL since the middle of August, 1997. Dr. Crooker will not be able to start at LANL until January, 1998. Consequently, there will be some delay in the installation of the optical setup and we do not anticipate that this will be completed until after his arrival.

The PI, co-PI, the Research Associate, and the graduate student have been in constant contact (e-mail, phone, FAX) during the period, and the instrumentation has been finalized following the list outlined in the addendum to the proposal. The process of ordering the necessary equipment for the project is in the implementation stage. Purchase requests for this equipment were put on hold awaiting the commitment of Magnet Lab funds. We recently received permission to proceed and the necessary documentation has been forwarded to the Purchasing Department at FSU. As this is a prototype project, we expect that additional items (other optical and electronic components) will be required as the program evolves.

The time resolved optics and electronics will be set up and tested initially in the 20 T superconducting magnet prior to its installation in the long-pulse magnet system. Preliminary measurements on specific semiconductor quantum well materials will be carried out as outlined in the original proposal.

The NU graduate student (Florin Monteanu) is currently involved in measuring the magneto-photoluminescence spectra of GaAs/AlGaAs quantum well devices under the direction of Dr. Yongmin Kim at NHMFL-LANL. He is receiving direct training in all the spectroscopic and electronic instrumentation and in the stringent safety requirements for their operation at LANL. In addition, this is enabling him to become acquainted with the "physics" involved, so that he will be in a strong position to participate in the installation, testing, and the implementation of the research proposal with the PI, co-PI, and Dr. Crooker in the new year.

Comparing Magnetic Langmuir-Blodgett Films to Their Isostructural Solid-State Analogs Using Antiferromagnetic Resonance

PI: D. R. Talham, (UF)
Funding: $116,136 over 2 years

The high-field EPR spectrometer located at the NHMFL was used to characterize the ordered state of a series of canted antiferromagnets. As far as we are aware, this is the first time that antiferromagnetic resonance (AFMR) has been used to probe differences in an isostructural series of compounds.

Magnetic interactions in layered materials are of high interest because of their relationship to layered Superconductors. Manganese organophosponates are mixed organic-inorganic layered materials that can be characterized as two-dimensional Heisenberg antiferromagnets that undergo a transition to a canted antiferromagnetic state below 18 K. The ordered states of powdered samples of $KMnPO_4{\cdot}H_20$, of a series of manganese alkylphosphonates $Mn(O_3PC_nH_{2n+1}){\cdot}H_2O$ n = 3-6, and of manganese phenylphosphonate, $Mn(O_3PC_6H_5){\cdot}H_2O$ have been characterized by antiferromagnetic resonance (AGMR). The high-field election paramagnetic resonance facility at the NHMFL was used to acquire AFMR spectra at 5 K. The unique capabilities offered by this facility, namely variable temperature, frequency sources from 24 to 380 GHz, and magnetic fields ranging from 0 to 17 T, made this an ideal place to perform these experiments.

Analysis of the frequency and field dependence of the AFMR signals, has led to determination of the vanous mean molecular field exchange parameters and the related components of the intraplanar coupling tensor, J. These results show that Ising-type anisotropy is present in these systems (which is a requisite for a two-dimensional lattice to undergo a transition to long-range order), and the magnitude of this deviation from the Heisenberg limit has been determined. The canting angle, defined as the angle that the sublattice magnetization vectors make with respect to the magnetic easy-axis, was determined to be 0-7-0 90°± 0.2° for all samples, and this value is on average three to four times larger than the canting angles determined from SQUID magnetization measurements. This analysis shows that the magnetic structures of the mixed organic/inorganic phosphonate materials are similar to that of the purely inorganic phosphate analog.

This work has been accepted for publication and is now in press:

Fanucci, G.E.; Krzystek, J.; Meisel, M.W.; Brunel, L.-C. and Talham, D.R., *Antiferromagnetic Resonance as a Tool for Investigating Magnetostructural Correlations: The Canted Antiferromagnetic State of* $KMnPO_4{\cdot}H_2O$ *and a Series of Manganese Phosphonates,* J. Am. Chem. Soc., 1998, in press.

The next stage of the project is to extend the technique to studies on Langmuir-Blodgett films. Details are described in the original proposal.

High Field Optical Studies of Highly Correlated Metals

PI: D. B. Tanner (UF)
Funding: $141,634 over 2 years

Infrared measurements on a variety of highly correlated metals are being carried out at the NHMFL. The materials studied include cuprate superconductors and antiferromagnetic insulators, with planned work on organic conductors as well.

In addition, an improved detector cryostat is being constructed, allowing transmission and reflection studies in fields up to 30 T and at temperatures between 4 and 300 K. Construction of the parts for this apparatus is about 75% complete and assembly will begin soon.

The far-infrared reflectance and transmittance of superconducting ab-plane-oriented YBCO films has been measured in magnetic fields up to 30 T. The application of magnetic field at low temperatures produces no discernible effects in these spectra. This observation differs from other previous far-infrared measurements in this temperature range. Only at fields and temperatures where the DC resistance is not zero—on account of dissipative flux motion—is a field-induced effect observed.

Infrared measurements and linear-spin-wave calculations for single-crystal insulating cuprates, including YBCO and SCOC in magnetic fields up to ~30 T show that absorption features which have been ascribed to magnon excitations are very insensitive to the applied field. The substitution of pr^{3+} for y^{3+} in YBCO leads to an additional absorption feature, which does have strong field dependence. This excitation is assigned to an intermultiplet transition in the Pr^{3+} ion. The zero-field temperature dependence of this absorption shows clear evidence of an interaction between Cu and Pr spins.

An undergraduate student, Jonathon Wrubel, has contributed strongly to the design and construction of the detector cryostat. He has done the drawings of the locally-made parts, interacted with the machine shop on their construction, worked with the vendor for the cryostat, and will be involved closely with assembly, commissioning, and measurements with this apparatus.

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The second NHMFL In-House Research Program solicitation was released in January, 1997; 27 proposals were submitted, 15 were sent out for external review, and 7 were funded.

The following abstracts are from the seven successful project proposals that are to be funded from January 1, 1998, to December 31, 1999. Their first six-month reports are due June 30, 1998.

Microwave Spectroscopy of High Magnetic Field Insulators in One and Two Layer Heterostructures

PI: Lloyd Engel (FSU)
Funding: $128,207 over 2 years

Insulating phases (IP's) in $GaAs/Al_xGa_{1-x}As$ heterostructures in high magnetic field *(B)* are probably forms of impurity-pinned Wigner crystals (WC's). Resonant microwave response in such IP's was reported some time ago and attributed to a pinning mode, in which WC domains oscillate in the impurity potential. More recently, the same collaboration brought together in this proposal measured the spectra of the IP quantitatively, as $Re(\sigma_{xx})$ vs. frequency (f), in the low wavevector limit. Preliminary results, for example a linear increase of resonance Q vs. *B* and a surprisingly high oscillator strength, are described in part E. These results show that such quantitative measurements can significantly advance the understanding of these important insulators. M. Shayegan's group recently obtained DC transport evidence for a bilayer WC with interlayer correlation(BiWC). Microwave spectroscopy of BiWC's will yield information on the structure and dynamics of these fundamental two-component systems. The proposal will result in:

- Measurements of microwave resonances observed in the IP of single-layer two-dimensional electron or hole Systems (2DES or 2DHS), for many samples, and approaching the high *B* limit. The experiments will examine a low Landau filling, low *T* regime that is inaccessible by other methods. This comparatively simple limit is of fundamental importance, and systematic, quantitative measurements of a number of samples in this regime should clarify the dynamics and structure of the monolayer IP's.
- Observation of pinning and "optical" modes in *bilayer* systems that apparently are interlayer-correlated BiWC's. Bilayer optical modes entail opposite motion in the electrons of each layer should be relatively insensitive to disorder, though affected by interlayer tunneling and by the lattice type.
- Extensive use and enhancement of NHMFL facilities, equipping dilution refrigerators (available to users*)* with high quality microwave coaxial lines of general usefulness in measuring surface resistance, spin resonance, and susceptibilities.
- Acceleration of startup for new in-house researcher (Engel).
- External collaborations, substantial and reflected in budget, with D. C. Tsui and M. Shayegan.

Collaborators: D.C. Tsui and M. Shayegan (Princeton); N. Bonesteel (NHMFL/FSU).

Three-Dimensional Low-Density Metals in Ultra Quantum Magnetic Fields: Search for Instabilities

PI: Art Hebard (UF)
Funding: $141,881 over 2 years

Three-dimensional (3D) conductors placed in strong magnetic fields are expected to exhibit a number of instabilities toward non-trivial correlated states. The most widely discussed types of these states include the Celli-Mermin spin-density-wave state, the charge-density wave state in a fully spin-polarized conductor, re-entrant high-field superconducting state, marginal Fermi-liquid state, and the excitonic insulator in compensated semimetals and semiconductors. The origin for all of these instabilities is the effectively one-dimensional (1D) nature of charge carrier motion along the field lines. The trajectory of a carrier in a strong field can be viewed as a tube of radius $\ell_B = \sqrt{\hbar c / eB}$ separated from the other tubes by a distance of order 'B. Electron-electron interactions between the carriers in the same tube cause strong fluctuations either of the density-wave or superconducting type, depending on the sign of interaction and degree of polarization. Interaction between tubes may lead to the development of 3D order. The 1D nature of motion also facilitates the formation of bound pairs between carriers of opposite sign.

Despite the vigorous theoretical activity in this field spanning over three decades, there is only limited experimental evidence suggesting the existence of high-magnetic-field-induced correlated states. An obvious reason for this situation is the stringent criteria on both the experimental conditions and on the choice of candidate materials.

The goal of the proposed research is to search for density wave, re-entrant super-conductivity, marginal Fermi-liquid,

and excitonic insulator states in semi-metals (e.g., Bi, graphite, and divalent hexaborides) and in degenerately-doped ^{70}Ge:Ga. The experimental search for these instabilities requires fields of 15 T to 60 T+, to be performed at the lowest possible temperatures. Measurements will include electronic transport, tunneling, and optical reflection and transmission, thereby providing direct information upon field-driven changes in the electronic structure. The theoretical part of the proposed research includes a description of the behavior of metals and semi-metals in certain experimentally relevant regimes not considered in previous theories, as well as the analysis and interpretation of experimental results.
Collaborators: D. Maslov, J. Graybeal (UF); Y. Liu (Penn State); Z. Fisk (NHMFL/FSU); E. Haller (Berkeley LBL).

Development of Quasi-Optical Methods for High-Field EPR Spectroscopy
PI: Jurek Krzystek (FSU)
Funding: $119,682 over 2 years

This proposal is generally targeted toward the stated IHRP goal of advancing "the NHMFL facilities and their scientific and technical capabilities by initiating small, seeded collaborations between internal and/or external investigators that utilize their complementary expertise." Specifically, it is aimed at establishing short-wavelength designs for the existing high-field electron paramagnetic resonance (EPR) spectrometer at the NHMFL that achieve the full functionality and sensitivity of conventional EPR bridges. The challenge is to extend narrow-band quasioptical methods recently implemented at wavelengths above 1 millimeter in order to develop novel broadband (multifrequency) applications in the submillimeter range. Quasioptical analogs to conventional high-quality sample cavities, low-loss waveguides, and circulator-based bridge designs will be developed and implemented over the entire useful frequency range of the existing EPR facility (140 to 400 0Hz). These developments will increase the sensitivity of the instrument by two orders of magnitude for small or lossy samples, and allow discrimination between absorption and dispersion phases of the EM spectra. The specific scientific goals of these enhancements will be to develop applications to (a) samples of biological importance, which in most cases contain low concentrations of paramagnetic species dissolved in loose solvents such as water, and (b) radical ion salts, for which it is necessary to establish precisely such parameters as linewidth and lineshape.

The proposed work involves a collaboration with a group at Northeastern University that has established a quasioptical EPR design at a wavelength of 1.4 mm, and with a group at Stuttgart University with expertise in EPR of radical ion salts. The new bridge will utilize existing elements of the NHMFL spectrometer (sources and magnet) and rely intensively on the Millimeter Wave Vector Network Analyzer (MVNA) resource that is already operational at the NHMFL. When implemented, the redesign will afford the existing high-field NHMFL spectrometer an unparalleled combination of sensitivity, flexibility, and broadband operation at the highest available magnetic field with good homogeneity (17.1 T). These improvements are essential for the NHMFL to maintain a premier user facility in addition to enhancing capabilities for in-house research.

Co-PIs: D. Budil (Northeastern U.), L.-C. Brunel (NHMFL/FSU)
Collaborators: J. U. von Schutz (Stuttgart U. Germany).

ODMR of Mass-Selected Gas-Phase Ions
PI: Alan Marshall (FSU)
Funding: $112,463 over 2 years

We seek to develop a methodology for carrying out electron paramagnetic resonance (EPR) measurements on gas-phase ions of a selected mass and isotopic composition. Current EPR techniques are limited to the detection of very small and selected classes of paramagnetic species, essentially the stable di-and triatomic radicals such as NO, OH, O(2) and NCS radicals. The methodology proposed herein is, in principle, far more general and powerful in that it will not be limited to stable ions and will be mass-selective.

The proposed undertaking is interdisciplinary, involving the coupling of the techniques of FT-ICR (Fourier Transform Ion Cyclotron Resonance) and ODMR (Optically-Detected Magnetic Resonance). The proposed work will benefit from the synergism of the facilities and personnel at NHMFL.

The core of the instrumentation is an FT-ICR mass spectrometer specially designed for the detection of UV/visible laser-induced fluorescence of trapped, mass-selected, gas-phase ions. Azimuthal quadrupolar excitation in the presence of ion/neutral collisions cools, axializes, and mass-selects ions as they fill the trap. A pulsed dye laser pumped by an Nd:YAG laser provides electronic excitation. Laser-induced fluorescence is collected from mirrors and lenses in the FT-ICR cell. The fluorescence is then directed through a quartz window and fiber optic bundle to a photomultiplier. This system has been tested by measuring the excitation spectrum of atomic Ba^+ ions. The results are consistent with data available in the literature.

The FT-ICR cell and vacuum chamber are designed to allow irradiation of the mass-selected, fluorescent ions with microwave power at frequencies corresponding to the expected EPR transitions of the trapped ions. The microwave radiation will be supplied by a frequency tunable Gunn diode. The radiation will be transmitted by specially designed waveguides, coaxial cables, and microwave horns to the FT-

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ICR cell. ODMR signals will be detected by monitoring the change in the intensity of the laser-induced fluorescence as the Gunn diode is swept in frequency through the hyperfine and/or the zero-field splitting.

The two-year plan is as follows. First, assemble the W-band microwave sources, modulators, frequency and power meters, waveguides with the appropriate bends. and coaxial cables. Second, incorporate these components into the vacuum chamber and the FT-ICR cell. Third, examine the ODMR of Ba^+ ions and compare the results with values published in the literature to demonstrate that the instrument is functioning correctly. Fourth, extend the measurements to Ca^+, which will open up a new avenue for investigating its reactions with biological ligands in the absence of solvent. Fifth, extend the measurements to organic ions. The first organic ion we will investigate is hexafluorobenzene cation, which has a high quantum yield. These measurements will be extended to heavier and more complex (e.g., distonic) ions selected for their strong fluorescence. We believe that the successful completion of this proposal will add a fundamentally new dimension to FT-ICR: a methodology for measuring the spin density distribution on various parts of a gas phase ion and, thereby, a tool for discriminating between the theoretical models of the compound's structure-reactivity relationship.

Co-PI: Naresh Dalal (NHMFL/FSU).

A Diffusion-Based Process for Metal-Clad (Hg,X) $Ba_2Ca_2Cu_3O_{8+x}$ Superconducting Wires

PI: Justin Schwartz (FSU)
Funding: $140,435 over 2 years

The goal of the proposed research is a method for processing superconducting (Hg,X)$Ba_2Ca_2Cu_3O_{8+x}$ wires resulting in high critical current density (J_c) in high magnetic field. The proposed approach will leap-frog other methods for synthesizing high temperature superconducting wire by employing a diffusion process that takes advantage of the high solubility of Hg in Ag. The resulting wire will facilitate superconducting magnets generating higher magnetic fields at higher operating temperature than presently achievable.

Superconductors of the $HgBa_2Cu_{u-1}Cu_nO_{2n+2+x}$ system are of special interest because they offer many attractive features for implementation in engineering systems, including the highest critical temperatures (T_c) of presently known superconductors (129 K for $HgBa_2CaCu_2O_{6+x}$ (Hgl212) and 135 K for $HgB_2Ca_2Cu_3O_{8+x}$ (Hgl223)).[1] Recent reports of high irreversibility fields and J_c above 77 K demonstrate the potential of the $HgBa_2Ca_{n-1}Cu_nO_{2n+2+x}$ superconductors for technical applications.[2] Even more recently it has been shown that tapes with highly-oriented microstructures can be synthesized.[3]

An early concern with the $HgBa_2Ca_{n-1}Cu_nO_{2n+2+x}$ family was chemical stability; however, this issue has been resolved by doping small quantities of rhenium, bismuth, or lead into the starting powder. (Hg,X)l212 and (Hg,X)1223 form over a drastically broadened stable region in p(Hg) temperature space and are far less sensitive to chemical impurities. By expanding the stable phase field, the options for substrates and sheath materials is greatly expanded. Furthermore, the magnetic irreversibility line and J_c are also enhanced by doping, especially at high temperatures.

The production of technical superconductors requires not only the synthesis of chemically stable material with high J_c, but also the ability to do so in a form that satisfies the engineering requirements of applications including mechanical strength, strain resistance, and a high normal-state electrical conductivity. For all technical superconductors this is accomplished by Co processing with a metallic matrix. Due to the high chemical reactivity and toxicity of Hg, the choice of matrix material takes on even greater significance for the (Hg,X)$HgBa_2Ca_{n-1}Cu_nO_{2n+2+x}$ compounds. Early results with powder-in-tube $HgBa_2CuO_x$, wires indicate that Ag, which has been used successfully with the Bi-Sr-Ca-Cu-O and T1-Ba-Ca-Cu-O superconductors, may also be a useful sheath for (Hg,X)$HgBa_2Ca_{n-1}Cu_nO_{2n+2+x}$ compounds. The $HgBa_2CuO_x$ phase, however, is not attractive for wires due to its block-like grain growth and relatively low T_c. Furthermore, the conventional powder-in-tube process with (Hg,X)$HgBa_2Ca_{n-1}Cu_nO_{2n+2+x}$ superconductors still requires at least one heat-treatment in a Hg-containing atmosphere.

This proposal will investigate a variation on the powder-in-tube process that facilitates the synthesis of (Hg,X)1223 within metallic sheaths by using Hg diffusion from the sheath into the oxide core. Specific objectives include the identification of barrier materials that prevent Hg leakage, the synthesis of (Hg,X)1223 within metallic sheaths, and investigations of processing parameters resulting in high transport J_c in high magnetic field at 4.2 K and 77 K.

Field-Induced Relaxation of Spin Currents in Dilute Fermi Liquids

PI: N S. Sullivan (UF)
Funding: $141,581 over 2 years

An important effect predicted by Fermi-liquid theory is the field-induced relaxation of transverse spin currents. Unlike all other transport coefficients, the transverse spin diffusion should tend to a finite limit at low temperatures in high magnetic fields. Experiments on weakly interacting dilute systems are needed to test the theory, but studies of very dilute ^3He-^4He mixtures in 9 T did not show this field-induced relaxation. Recent quantitative many-body calculations by Jeon and Mullin predict that much higher polarizations are needed, and that the fields (>15 T) and temperatures (T< 0.5 mK) available in the NHMFL High B/T Facility should show a strong effect. The study will use NMR spin echoes to measure the transverse diffusion in dilute ^3He-^4He mixtures to test for the predicted field dependence. This experiment will provide a stringent test of the understanding of quasiparticle scattering in Fermi liquids, and will quantitatively probe the fundamental theory of transport in polarized Fermi systems.

Co-PI: E. Dwight Adams (UF)
Collaborators: D. Candela, W. J. Mullin, (U. of MA); J. S. Xia (NHMFL/UF); W. G. Moulton, P. Kuhns (NHMFL/ FSU).

Development of Relaxation Calorimeter for Simultaneous Measurements of Heat Capacity and Nuclear Spin-Lattice Relaxation Time at Millikelvin Temperatures in High Magnetic Field
PI: Yasumasa Takano (UF)
Funding: $137,775 over two years

The primary objective of this proposal is the development of calorimeters for simultaneous study of electronic and nuclear heat capacity, and nuclear spin-lattice relaxation time T_1, at low temperatures and high DC magnetic fields. The proposed calorimeters are based on a new relaxation method of Andraka and Takano, two of the PIs.

Heat capacity, which is essentially the derivative of entropy with respect to temperature, is one of the most powerful tools to probe the nature of thermal excitations and to study phase transitions. Nuclear spin-lattice relaxation time T_1 is a dynamic probe for fluctuating internal fields. The calorimetric determination of T_1 the proposed technique allows is a powerful alternative to NMR, particularly in very high magnetic fields and for bulk metallic samples. The calorimeters will make these capabilities available at millikelvin temperatures in DC magnetic fields up to 33 T for the users of the Millikelvin Facility in Tallahassee and for in-house research in Gainesville and Tallahassee.

The second objective of the project it to demonstrate the usefulness of the calorimeters in the investigation of several exemplary physical systems representing a wide range of low temperature behaviors of paramount current interest. These systems will include: $PrInAg_2$, a candidate for a quadrupolar Kondo effect; UNi_4B, a frustrated magnet; and one-dimensional Heisenberg antiferromagnets. The electronic and nuclear heat capacities, as well as T_1, will be measured as a function of temperature and field.

The team assembled for the project comprises two PIs and a postdoctoral associate from the Physics Department in Gainesville, and one PI and a collaborator from the Millikelvin Facility, with a combined expertise in low-temperature high-field calorimetry, cryogenics, nuclear magnetism, thermodynamics, and sample preparation. Samples to be studied will be synthesized in-house or supplied by external collaborators.

Co-PIs: B. Andraka, (UF), E. Palm, (NHMFL/FSU).

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The 1998 IHRP solicitation was released in January, 1998. Forty proposals were submitted and 17 are in the external review process. We hope to have all reviews completed and funding decisions made by the end of summer, 1998.

Education Programs

Chapter 4

The NHMFL continued to expand its many education programs and engaged more students in integrated research and learning experiences than ever before. All of these programs—whether designed for K-12, technical, undergraduate, graduate, or postdoctoral—are developed through close consultation and guidance from the scientists, engineers, and technicians who develop and conduct research at the laboratory, including members of the visiting science community.

When examined as a whole, the various programs depict a learning center where research and learning are united. Consequently, the education programs have been organized into the ***Center for Integrating Research and Learning at the National High Magnetic Field Laboratory***, which has seven major thrusts:

- Student Education
- Teacher Education
- General Public Awareness
- Curriculum Materials Development
- Educational Research
- Educational Resource Laboratory
- Partnerships.

Through these efforts, we strive to provide the resources and connections necessary to enhance the learning and understanding of science, research, and technology in both formal settings (e.g., schools) and informal settings (e.g., at home or at our Open House), and particular care is taken to incorporate strategies that encourage and involve underrepresented student populations. This vision is consistent with the one promoted by the National Science Foundation, state agencies, and other reform advocates.

The National Science Education Standards present a vision of science education that requires all members of the "extended system" to work toward science and mathematics classroom reform. Although education is often perceived by the public as being done in schools exclusively, "it also extends to those outside the system who have an influence on science education including students, parents, scientists, engineers, business people, taxpayers, legislators, and other public officials" (National Research Council, 1996, p. 9).

We outline in this report our efforts toward these goals. While programs are listed under one of the seven Center focus areas, it should be noted that all of the programs influence—and are influenced by—the other areas. For example, our work with the Florida State University School is listed under "Partnerships," but this partnership has spawned several programs, such as the "Integrated A.R.T.S." project.

Integrated A.R.T.S. (Arts, Research, Technology, and Science) is a summer institute for gifted and high-achieving students. The seven-week program for rising high school freshman through seniors is funded by the Florida Department of Education and co-sponsored by the NHMFL. Participants work and learn with scientists at the laboratory, as they integrate A.R.T.S. into resource materials for use by learners worldwide via the Internet. This program, listed under "Partnerships," has led to a student mentorship program and a curriculum materials development program.

The education programs of the NHMFL have been extremely busy during the reporting period (January 1, 1997 through June 30, 1998). Highlights are presented below, followed by more detailed descriptions about each program.

Student Education Highlights

- The outreach program sends NHMFL educators directly to the schools with presentations and workshops on science. These multifaceted and interdisciplinary programs reached **12,334** Florida students during the period.
- The NHMFL provides mentorship and internship experiences for students from the middle grades level (grades 6-8) through graduate level. This year we hosted over **125** middle or high school students and more than **40** undergraduate students, including students in our Minority/Women Research Internship Program (see *http://k12.magnet.fsu.edu/intern/index.html*).
- The lab created and maintains an extensive website including education programs and resources (*http://k12.magnet.fsu.edu*), such as:
  - a Spanish version of the K-12 site (*http://k12.magnet.fsu.edu/indice.html*), and
  - a virtual microscope developed in conjunction with the Optical Microscopy group at the NHMFL (*http://micro.magnet.fsu.edu/virtual/translate/index.html*).
- Approximately **4,000** grades 4-12 students toured the NHMFL during the reporting period.
- NHMFL faculty reported advising over **133** undergraduate students and serving on over **267** graduate committees during the reporting period, with **19** NHMFL-affiliated graduate students earning Ph.D.s in 1997.

Teacher Education Highlights

- NHMFL educators modeled effective strategies for teaching science to over **410** K-12 classroom teachers through outreach programs at schools throughout Florida.
- We provided statewide and regional workshops for elementary, middle grades, high school, and community college teachers that reached over **190** teachers during the period.
- Our STAR TREE (Science Teachers and Researchers Translating Research Experiences into Educational materials) program continued to provide mentorship and curriculum development opportunities for teachers from north Florida.
- NHMFL educators offered undergraduate and graduate level courses for prospective teachers through the Florida State University College of Education.

General Public Awareness Highlights

- Approximately **2,500** members of the general public experienced guided tours of the lab in 1997. In addition, the 4th Annual NHMFL Open House held in October, 1997, attracted over **3,500** visitors.

Curriculum Materials Development Highlights

- We completed development of a resource package called "MagLab: Alpha," an integrated science, standards-based curriculum package designed to enhance the teaching and learning of magnet-related science in middle grades (grades 6-8). We distributed versions of this product to over **200** Florida classrooms and anticipate national marketing of it in late 1998.

Educational Research Highlights

- This effort is currently evaluating NHMFL education programs overall, as well as specific features of the program. For example, the teacher education component is the subject of ongoing research to determine how best to provide professional development locally, statewide, and nationally.
- MagLab: Alpha, the curriculum product that was developed by the NHMFL, is the subject of ongoing research, as is the connection between a science research facility and education reform.
- Papers written by Center faculty were presented at **four** national/international conferences.

Education Resource Laboratory Highlights

- This state-of-the-art laboratory houses multimedia development equipment, manipulative development equipment, curriculum materials, and instructional resources, and was used extensively during the period by teachers, students, and NHMFL personnel.

Partnerships & Community Support Highlights

- The NHMFL continues to work closely with Florida Agricultural and Mechanical University and the Alliance for Minority Participation to promote the laboratory's Minority/Women Summer Research Internship Program. We also co-developed with FAMU and Clark Atlanta University a proposal for distance learning courses and research mentorships, and submitted it to NSF for funding through the CIRE program.
- Sempco, Inc., a private business in Nashua, New Hampshire, and the laboratory continue to develop and produce NHMFL curriculum materials. We expect our negotiations with publishers to result in national marketing of these products in 1998.

Student Education

NHMFL student education efforts seek to provide resources and experiences for learners throughout their formal education, and we have specific programs for kindergarten (K) through high school, undergraduate, graduate, and postdoctoral students. Each program is designed to enhance the students' understanding of science, while encouraging them to become scientifically-literate citizens and consider careers in science or science-related fields. We are continuing to develop this comprehensive program, which affords opportunities for students at all levels and abilities to engage in science and to experience the excitement of learning. These experiences are engaging, fun, and promote high standards. As one elementary school teacher wrote about a program recently conducted at her school, "the manner in which you physically and mentally involved them [the students] in the process provided the perfect vehicle for increasing their comprehension" (J. Taylor, Kate Sullivan Elementary School, Florida, 1998).

K-12 Student Education. At the K-12 level, our student education programs comprise "in-house" programs that bring the students to the NHMFL and "outreach" programs that send NHMFL educators or resources to the students. The in-house efforts include programs such as tours of the facility, mentorship and internship experiences, and classes taught in our resource lab or seminar rooms. The outreach efforts engage students through presentations and classes taught at schools across Florida and through our website resources. Some highlights from these programs follow.

- *Outreach.* Our outreach program sends NHMFL educators directly to the schools with presentations and workshops on science. These multifaceted and interdisciplinary programs reached approximately **12,334** Florida students between January 1997 and June 1998. In all of these programs, we encourage students from all backgrounds to see themselves as potential scientists, engineers, and/or end-users of science and technology.
- *Mentorships and Internships.* The NHMFL provides mentorship and internship experiences for students from the middle grades level (grades 6-8) through graduate level. Each year we host over **75** middle or high school students. The research projects this year spanned topics ranging from studying the engineering design of structures, to educational materials development, to the development of magnet stress measurement software, to correlational studies of El Nino and stream flow.
- *Summer Internships.* The Optical Microscopy lab hosted students during the summer to engage in learning about scientific enterprises through technology. Students who participated in this program were provided the resources to build their own computer, which they were able to take home at the end of the project.
- *Young Scholars Program.* The NHMFL supported the Young Scholars Program by providing mentorships and speakers for the summer program.
- *Website.* The lab created, maintains, and continues to develop an extensive website (*http://k12.magnet.fsu.edu*) that includes educational programs and resources, such as:
  - an "Ask an Expert" component that allows students of all ages to ask questions of the scientists and experts at the NHMFL (*http://k12.magnet.fsu.edu/tr/ask.html*),
  - a Spanish version of the K-12 site (*http://k12.magnet.fsu.edu/indice.html*),
  - an area for students to try discovery activities, experiments, or get some ideas for research projects, and
  - a virtual microscope developed in conjunction with the Optical Microscopy group at the NHMFL (*http://k12.magnet.fsu.edu/virtual/index.html*).
- *Tours.* Approximately **4,000** grades 4-12 students toured the NHMFL during the reporting period.

Future plans include seminars and courses available through distance learning strategies (such as telecasts and web-based resources), activity books for intermediate grade students, a "women in science" day at the laboratory, and science fair workshops for students and parents.

Undergraduate Student Education. The NHMFL provides a variety of opportunities for undergraduate students. NHMFL faculty reported advising 133 undergraduates and teaching over 60 undergraduate courses. At the University of Florida, over 60 percent of all graduating students enroll in at least one physics course. In addition to advising and

Undergraduate Students Advised	133
Undergraduate Classes Taught	60

coursework, undergraduates also have opportunities for internship, research, and work experiences throughout the laboratory.

In 1997 we hosted the fifth NHMFL Minority/Women Summer Internship Program. Over 100 applications were received for the 18 positions. The selected undergraduate students were placed for two-month-long research experiences with mentors in Tallahassee, Gainesville, and Los Alamos. Table 1 provides details about the "NHMFL Internship Class of '97."

Graduate Student Education. The graduate student education program at the NHMFL continues to provide strong learning experiences for students both in formal class settings and through productive "workplace" and research-based learning. NHMFL faculty taught graduate courses and advised students through the site universities (Florida State University and University of Florida) and Florida Agricultural and Mechanical University. Our faculty reported teaching **29** graduate courses and serving on over **267** graduate committees during the reporting period, as illustrated below.

Graduate Students Advised	118
Graduate Classes Taught	29
Master's Committees	42
Doctoral Committees	225
Total Graduate Committees	267

Through these efforts, NHMFL graduate students continue to learn while contributing to the work and educational efforts of others at the laboratory. Nineteen NHMFL-affiliated graduate students from five disciplines (see Table 2) earned their Ph.D.s in 1997 and have gone on to new positions in academia and industry.

Postdoctoral Fellows at the NHMFL. Postdoctoral opportunities for independent research provide scientists with skills and expertise that enhance their already considerable talents. Additionally, postdocs provide the laboratory with a base of energetic "new thinkers" who provide different insights and facilitate the development of new programs and the enhancement of existing programs. By incorporating postdocs into our research and development activities, we are developing our future users and the next generation of significant drivers of science and technology in high magnetic fields. Even a cursory review of their activities reveals the remarkable breadth of their contributions and educational experiences, and the bright future ahead for magnet-related science and technology. **Forty** postdoctoral fellows were affiliated with the laboratory during the reporting period, and a few of their wide-ranging research activities are listed below.

- Pancake coil fabrication from surface-coated high critical temperature $Bi_2Sr_2CaCu_2O_x$ (Bi2212) superconductor
- The study of superfluid helium flow at high Reynolds number in the Liquid Helium Flow Facility
- Photodissociation studies of proposed interstellar polycyclic aromatic hydrocarbon cations; fluorescence detection of ions trapped in an ICR
- Development of user instrumentation in the field of magnetometry; and electrospray ionization of biological molecules
- Project exploration of the brain activation detected by functional magnetic resonance imaging (fMRI) during auditory stimulation
- Development of new techniques in the field of liquid-state and solid-state NMR spectroscopy, and their applications to physics and chemistry
- High magnetic field measurements of optical and electronic properties of semiconductors.

Following their postdoctoral fellowships these talented individuals move on to new and exciting careers in industry and academia. In their new positions they have been establishing themselves while further promoting the NHMFL. We look forward to learning of their new accomplishments and welcoming them back to the laboratory as part of the user community.

Vocational Coop Programs at the NHMFL. The NHMFL cooperative programs with two regional vocational and technical schools have continued during the period, with students from Lively Technical Center and Thomas Technical Institute continuing to work closely with senior staff members in our Facilities and Electronics Instrumentation programs. Both "Lively" and "Thomas Tech" are undergoing shifts in administration, so we have renewed conversations with the institutions and expect to reinvigorate these programs in the coming years.

Table 1. NHMFL Minority/Women Summer Internship Program, 1997.

Intern, *Home Institution*	NHMFL Advisor	Research Experience
Rachel Andre, *University of Central Florida*	Dwight Rickel and Heinrich Boenig, *LANL*	Analyzed circuit containing a magnetic core using SPICE software. Measured for distributed capacitance in an inductive circuit
Ian Dean Bacchus, *University of California at Berkeley*	Yusuf Hascicek, *FSU*	Investigated and characterized points between tape samples of powder-in-tube $Bi_2Sr_2CaCuO_x$ high temperature superconductors
Emily Clark, *Clark University*	Alex Lacerda, *LANL*	Studied low temperature, low noise transport measurements
Elizabeth Cranston, *University of Florida*	Tom Mareci, *UF*	Conducted studies in fluorine spectroscopy in mice with the use of a 4.7 T magnet
Awanna Ferguson, *Bethune Cookman College*	Timothy Logan, *FSU*	FKBP insertion
Kendall D. Haynes, *Florida A&M University*	Herman Gill, *FSU*	Studied electrical design and operation in high field magnet systems
Miranda Hicks, *Southern University, Shreveport/Bossier*	Piotr Fajer, *FSU*	Studied areas of biochemistry and structural analysis of muscles
Veta Johnson, *Claflin College*	Yusuf Hascicek, *FSU*	Examined sol-gel insulation with oxides
Cindy Le Huong, *FSU*	Louis-Claude Brunel, *FSU*	Developed a bibliographic database
Heather Joan Lynch, *Princeton University*	Denis Markiewicz, *FSU*	Studied the morphology of fracture surfaces and fracture toughness of epoxy
Rachel Long, *University of Florida*	Tom Mareci, *UF*	NMR microscopy and spectroscopy
Maleika Matthews, *Bowie State University*	James Brooks, *FSU*	Examined molecular conductors
Smitha Pabbathi, *FSU*	Piotr Fajer, *FSU*	Investigated enzyme kinetics
Naseem Sowti, *Valencia Community College*	Bill Moulton, *FSU*	Studied organic superconductors
Chana Toran, *Morgan State University*	Justin Schwartz, *FSU*	Investigated HTS superconductors
Courtney Van Sciver, *Duke University*	Mike Davidson, *FSU*	Microscopy of paleontological samples
Tiffany Wong, *University of California*	Louis-Claude Brunel, *FSU*	EMR on systems of biological systems
Connie Wadeyua, *Jackson State University*	Mike Davidson, *FSU*	Microscopy of paleontological samples

Table 2. NHMFL-affiliated graduate students earning Ph.D.s in 1997.

Graduate Student, *Institution and Department*	Dissertation Title
Kathleen Amm, *FSU Physics*	*Synthesis and Properties of Mercury Cuprate Superconductors with Metallic Interfaces*
Juan A. Caballero, *UF Materials Science and Engineering*	*Growth and Characterization of Thin Films of the Heusler Alloy NiMnSb and its Application to Magnetoresistive Multilayer Structures*
Daniel Q. Duffy, *FSU Physics*	*Numerical Studies of Strongly Correlated Electronic Systems*
Franz Freibert, *FSU Physics*	*Critical Phenomena of Selectively Doped* $YBa_2Cu_2O_7$
Edgar B. Genio, *UF Physics*	*Low Temperature Nuclear Quadrupole Resonance Studies of Antimony and Application to Thermometry*
Alia Hassan, *FSU Physics*	*High-Field ESR Studies of the Doped Spin-Peierls System* $CuGeO_3$
Patrick Henning, *FSU Physics*	*Thermal Conductivity as a Function of the Critical Temperature in High Temperature Superconductors*
Krishna Iyengar, *FAMU-FSU Mechanical Engineering*	*Heat Interception for Construction Structural Support and Current Lead for Cryogenic Equipment*
George S. Jackson, *FSU Chemistry*	*Tailoring and Analysis of Excitation and Trapping Potentials in FT-ICR/MS. Applications and Animations of Common FT-ICR/MS Experiments*
Kiho Kim, *UF Physics*	*NMR Studies of the Orientational Behavior of Quantum Solid Hydrogen Films Absorbed on Boron Nitride*
Jewon Lee, *UF Materials Science Engineering:*	*Comparison of High Density Electron Cyclotron Resonance and Inductively Coupled Plasma Sources for Etching of Electronic Materials: New Plasma Etch Regimes for Electronic Materials*
Hsiang-Lin Liu, *UF Physics*	*Effects of High Magnetic Field and Substitutional Doping on Optical Properties of Cuprate Superconductors*
Thomas Meersmann, *Université de Lausanne, Switzerland, Chemistry*	*Relaxation and Coherent Evolution as Competing Mechanisms for Coherence Transfer in Nuclear Magnetic Resonance Spectroscopy*
K. Eric Milgram, *UF Chemistry*	*Abatement of Spectral Interferences in Elemental Mass Spectrometry: Design and Construction of Inductively Coupled Plasma Ion Sources for Fourier Transform Ion Cyclotron Resonance Instrumentation*
Joseph P. Nawrocki, *UF Chemistry*	*Characterization of Combinatorial Libraries Using Fourier Transform Ion Cyclotron Resonance Mass Spectrometry*
Wenhua Xu Ni, *UF Physics*	*Designs of Novel RF Coils for Signal-to-Noise Ratio Improvement in NMR*
Samuel A. Spiegel, *FSU Science Education*	*Understanding Teacher Enhancement Programs: Essential Components and a Model*
Forest M. White, *FSU Chemistry*	*External Ion Injection Techniques and Biological Applications of Fourier Transform Ion Cyclotron Resonance Mass Spectrometry*
Feng Xu, *FSU Chemistry*	*Solvent Roles in Polypeptide Structure and Stability*

Teacher Education

In collaboration with the FSU College of Education, science education centers and museums, and local school districts, the NHMFL has initiated a rich teacher education program that involves educators from K-12 through the university level. The teacher education program comprises a wide array of activities, which are summarized briefly below.

- *Outreach programs* conducted at schools across Florida have provided us the opportunity to model effective strategies for teaching science to over **410** K-12 classroom teachers. In most instances, this modeling entails an NHMFL educator teaching a lesson to the teacher's class. The teachers are provided with follow-up materials and activities. Many of the teachers discussed strategies that they could implement to enhance their science teaching. Other teacher education programs such as the workshops and web-based resources further enhance the impact of this effort. This effort has been particularly well received by elementary school teachers, who are often concerned about teaching science.

- *Statewide and regional workshops* for elementary, middle level, high school, and community college teachers are offered to translate the practice and excitement of science into classrooms. Over **150** teachers attended workshops ranging in subject from the use of the new standards-based curriculum product developed at the NHMFL to integrating science and mathematics in the primary classroom using literature and hands-on activities.

- *Statewide training* was conducted for **50** representatives of the Area Centers for Educational Enhancement in conjunction with the State of Florida Department of Education. Participants attended a three-day training session on conducting teacher workshops in their home counties. Representatives from all six regions in the State shared their plans to distribute statewide integrated science materials created at the NHMFL. Educators from the Lab shared their expertise in assisting the trainers in working through a number of activities, developing strategies for connecting the NHMFL with students and classroom teachers, and promoting the study of magnets and magnet-related areas in Florida middle school classrooms.

  Comments at the end of the training indicated that the sessions accomplished far more than their original goals. For example: "These products will allow students to explore the Magnet Laboratory and its resources, investigate a variety of related scientific concepts and careers, and develop and enhanced understanding of theory." Region I. "As a science education resource, the NHMFL seems to make a valuable contribution to research. It is evident that they lend themselves to all levels of scientists and scientific research." Region II. "The NHMFL as an educational resource is the answer to students' questions about 'Why do we have to do this?' If I could bring just one class a year to this place, it would make a difference!" Region II.

  Requests for more teacher workshops from central and south Florida have come to the attention of the Center, resulting in summer 1998 and fall 1998 teacher education sessions.

- *Teacher mentorships* taking the form of Teacher Quest scholarships (competitive awards to teachers in Florida) are designed to provide educational and research experiences to classroom teachers from north Florida. The teachers that participate translate the excitement of working in a national laboratory with research scientists to the classroom through activities they design based on science done at the NHMFL. We are hosting **five** teachers in 1998.

- *STAR TREE* (Science Teachers and Researchers Translating Research Experiences into Educational materials) provided teachers with the opportunity to work with scientists and researchers to develop materials that would translate the excitement of science to classrooms around north Florida. Hands-on, collaborative activities were developed based on magnets and magnet-related content areas for use with middle level and high school students that would lead students to further scientific exploration.

- *The NHMFL Ambassador Program* involves teachers and community organizations from elementary, middle, and high schools in the three counties surrounding the NHMFL in Tallahassee. Teachers work to improve science and mathematics teaching and learning by becoming actively engaged in determining needs for and applications of curriculum products and teacher workshops. Ambassadors serve as conduits through which communication is maintained with all science and mathematics teachers in the three-county area. Input is provided to NHMFL educators from this network of **105** teachers, community members, and school board personnel that influences the development and modification of our education programs.

- *Conference presentations* by NHMFL educators serve to inform teachers nationwide about the laboratory's scientific and educational activities and opportunities and also to introduce them to new strategies for implementing national and local standards in the science classroom. Papers were presented at the annual conferences of the following groups: American Educational Research Association (AERA), National Association for Research in Science Teaching (NARST), and the Association for the Education of Teachers in Science (AETS); and at regional meetings of the National Science Teachers Association, and Southeastern AETS.

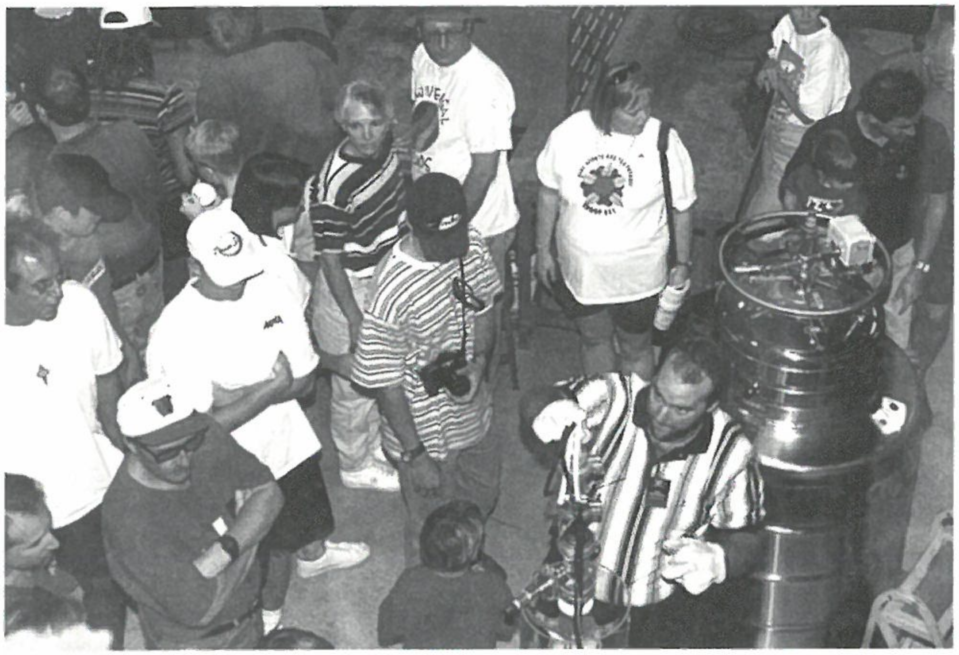
- The NHMFL conducted a ***Chautauqua Short Course*** for College Teachers in June, 1997. It was taught by members of the laboratory faculty and staff and focused on magnetism in science and technology. The program began with an overview of why we all need magnetic fields, followed by an in-depth tour of the research facilities. Participants were then divided into groups to focus on one of three subtopics: Physics & Materials Science, Environmental Science & Geochemistry, and Biology & Chemistry. Participants had an opportunity to discuss and examine new teaching strategies, while developing resource materials at the laboratory to be used in courses at their home institutions.

- *Graduate level courses* were offered through the FSU College of Education. Conceptual Learning in Elementary School Science was formatted to allow Master's level students a chance to develop materials, reconceptualize and articulate their ideas about science and science teaching and learning, and reflect on the role of science in education today. Instructional Technology in Teaching and Learning Mathematics was held at the NHMFL's Educational Resource Laboratory and allowed Master's students to create their own multimedia presentations that could then be transferred directly to classrooms.

- *An undergraduate level course* was offered to preservice teachers from all disciplines as part of the Educational Foundations and Policy Studies Department at FSU. Schooling in American Society, with an emphasis on science education, provided preservice teachers at all levels with an overview of issues in education today.

- *Web-based resources* have been established to serve several purposes:
  - A teacher discussion room allows teachers to share lesson plans, discuss questions related to current issues in science teaching and learning, share successes and failures of classroom activities, and offer ideas for discussions.
  - Activities appropriate for classroom, home, and individual use are provided to enhance classroom teaching and learning. Teachers are encouraged to add to the repertoire of activities on the web and provide comments about the activities that they try.
  - Ask An Expert allows entire classes of students to address issues of interest or ask specific questions about science. Students send their questions via e-mail and receive an answer from a scientist, researcher, or educator at the NHMFL either by e-mail or regular mail. Sometimes phone calls are made to desperate students awaiting an answer in order to complete a Science Fair project. For example, one question that was handled by educators from a young boy in a rural area resulted in a 4' x 8' MagLev train model that took "all of the magnets that any local Radio Shack stores had" and "plenty of duct tape." The result, however, was a working model that was created collaboratively.

Future teacher education plans include technology workshops for teachers, seminars and courses offered through distance learning strategies, telecasts to teacher conferences, development of a video modeling classroom science teaching and learning practices, more web-based resources for teachers to use in classrooms, and collaborations on teacher enrichment workshops with local science centers.



3,500 visitors of all ages attended the 4th Annual NHMFL Open House on October 9, 1997.

General Public Awareness

In addition to our efforts to educate students and teachers through formal settings, we also strive to educate the general public about the NHMFL and to be contributing members of the community and region. Our general public awareness program seeks to promote general scientific literacy, to inform the public about the research at the laboratory, and to communicate the importance of research facilities—to regional economic development, to national competitiveness, and to the advancement of our quality of life. These activities mirror the other educational programs of the laboratory and include special events, such as our annual Open House.

- *Tours.* In 1997 approximately **2,500** members of the general public toured the lab. Each tour consists of a general overview of the laboratory, as well as a walking tour of the main research areas of the Tallahassee facility.

- *Open House.* Every October, in recognition of the laboratory's dedication in 1994, the NHMFL hosts an Open House. The 4th Annual NHMFL Open House on October 11, 1997, shattered previous records for the day by attracting over **3,500** visitors. Kicking off the event—and prior to the opening of the laboratory for the day—we held a "fun run" with over 80 registered participants, including NHMFL Director Jack Crow. The official Open House included a greeting by senior faculty and staff, an orientation video, and self-guided tours of the facility. Throughout the laboratory, guests experienced a wide range of demonstrations, hands-on activities, and informational videos. For example, visitors could see magnetic levitation demonstrations, learn about the latest research efforts in our various laboratories, make ice cream with liquid nitrogen in the Cryogenic Laboratory, and learn how contaminants get into well water as they dissipate through the soil. Additionally, one of the local radio stations joined the laboratory as a sponsor of the event. The station provided us with air-time to promote the Open House and had celebrity hosts at the lab conducting live broadcasts and interviews throughout the day. We have a variety of new activities and partners planned for our 1998 Open House, slated for October 3. Some of the new events include an interpretive dance with original music by the FSU Dance Theater designed to portray research at the Magnet Lab, displays by community education groups and schools, and new hands-on activities for learners of all ages.

- *Community Service.* The laboratory and its staff contribute to the community in a myriad of ways, and in doing so, educate the community about the laboratory. Through community service events and personal involvement in civic organizations and activities, the NHMFL faculty and staff work to overcome commonly-held misconceptions about scientists and science and demonstrate that science facilities are very beneficial to their host communities. For example, numerous members of the laboratory volunteer at annual "fix-up" days where they help build or repair homes; others promote the lab through their efforts in groups such as the Rotary Club; many judge science fairs and/or mentor students; while others teach community information courses, such as safety training.

- *Science Shows.* In addition to the outreach programs listed under student education, we also perform science shows for community events, such as local fairs. In 1999, we will be conducting shows in Atlanta in conjunction with the APS Centennial celebration.

Sam Spiegel, Director of the Center for Integrating Research and Learning at the NHMFL, announces the field testing of MagLab: Alpha at a press conference in October, 1997. With Dr. Spiegel (left to right) are NHMFL Director Jack Crow, Superintendent of Leon County Schools Bill Montford, and Florida Commissioner of Education Frank Brogan.

- *Media Coverage.* Much of our general public awareness is further emphasized by local and national media coverage. For example, this past year the NHMFL was featured on national programs such as a Discovery Channel special, CNN's World of Wonder, Australia's Quantum, and Good Morning America. Local coverage is through numerous television, radio, and printed news stories on the research and educational efforts of the laboratory. A local radio station has "adopted" the NHMFL as its official science facility, thereby providing us with regular promotion of the laboratory. In addition, we have begun conversations with a local television station to include a regular science segment from the laboratory as part of its regional "kids club" series on the Fox network.

- *Website.* Through our website we provide information and numerous resources to educate the general public. One of the popular features is our "Ask an Expert" site (*http://k12.magnet.fsu.edu/tr/ask.html*) that receives numerous requests from the general public, in addition to those we receive from students. Many of the general public questions focus on inventions or medical applications of magnets. We try to respond to all queries in an informative manner.

Curriculum Materials Development

The NHMFL's K-12 Curriculum Development program has grown to include a curriculum package already in classrooms, materials to enhance outreach programs and tours, and web-based resources for the general public. These product development efforts, like all NHMFL education activities, are guided by the well-established premise that a research facility can—and should—influence reform in the teaching and learning of science.

The first NHMFL-sponsored curriculum materials based on magnets, magnetism, and related concepts (MagLab: Alpha) were produced in response to the need for such products in middle school classrooms. K-12 Educational Programs expanded its curriculum development mission to include other products and, based on the success of MagLab: Alpha, is planning another package targeted for elementary schools. Combining the curriculum materials development program with teacher education and educational research has proven to be a successful blending that enhances all three programs. The overwhelmingly positive feedback from MagLab: Alpha supports further development of it, and similar, products.

- *MagLab: Alpha* was developed for use in middle grades classrooms and already has been distributed in over 200 classrooms in Florida. An integrated, standards-based curricular resource package, MagLab: Alpha was designed to promote hands-on, collaborative, interdisciplinary learning based on science concepts. We anticipate national marketing of this program in 1998. MagLab: Alpha, which has three components—The Alpha Guide, The Alpha Pack, and The Alpha Interface—takes students in grades 5-8 on a journey toward discovering magnets, magnetism, and related concepts. A series of "Excursions" and "Explorations" goes beyond the original 20 hands-on collaborative activities and leads students to additional study that incorporates mathematics, history, geography, language arts, literature, art, and music.

  The **Alpha Guidebook** contains (1) instructions on how to use the materials presented and (2) discussions of issues that enhance teaching and learning in the science classroom, such as cooperative learning, interdisciplinary approaches, assessment, learning styles, Florida's Sunshine State Standards, National Science Education Standards, accurate and insightful record keeping in the form of a science notebook, and management techniques in the science classroom. Posters provided with the guidebook emphasize the team metaphor used to create a collaborative classroom atmosphere.

  The **Alpha Pack** contains all the equipment ("gear") necessary for a class of 36 students in groups of 4 to complete all activities. Materials in the Alpha Pack are nonconsumable and can be used year after year without refurbishing. For example, rechargeable batteries and battery chargers are included to eliminate the recurring need to buy batteries.

  The **Alpha Interface** is a CD-ROM and web-based resource closely aligned with the Alpha Guidebook to provide support for both teachers and students. Teachers and students can use the interface resources to directly support learning in the expeditions and explorations of MagLab: Alpha, or they can use the CD to launch deeper probes into areas of interest. The Alpha Team, a group of characters that guide students beyond the scope of the Alpha Guidebook, provides the link between the Guidebook and the Interface. Features include graphics and animations of complex concepts, an interactive interpreter that helps students choose the correct path, and in-depth information that both informs and leads students to further study.

- *Pre/Post Tour Packages* are sent to every student group that tours the NHMFL. Prior to their arriving, teachers are encouraged to engage students in a variety of activities that will enhance their visit to the Lab. Activities are also provided to be used *after* their tour to further extend their experience. Resources are suggested for teachers to expand the experience to classroom research and exploration.

- *Activity Books* were created for elementary age students for those students who are engaged in outreach programs but are too young to tour the NHMFL. Activities are presented to engage students in investigations on their own, discover how scientists think and work, learn about the history of magnets and magnetism, as well as practical applications of magnet research. Teachers are using the books in their classrooms to extend the outreach experience. An activity book for intermediate students has been created and will be available to students in the 1998-99 school year.

- *Web-Based Resources (http://k12.magnet.fsu.edu)* mirror the commitment that K-12 has made to offer materials to teachers and students in a variety of media. Web-based activities for teachers to use in classrooms and for students to use at home are designed to act as jumping off points for future research. A discussion room for teachers using curriculum materials created at the NHMFL provides a forum through which teachers can share ideas and concerns about curriculum and implementation of a standards-based classroom. The virtual microscope web site provides another curriculum alternative for teachers and students while focusing on photomicroscopy, a technique used at the NHMFL.

- ***A curriculum package for intermediate elementary teachers and students*** (grades 4-6) is being developed. As with MagLab: Alpha, the new product will combine print media with CD-ROM and web-based technology while providing manipulatives for collaborative learning activities. The new curriculum package is being developed using the theme of optics, observation, and interpretation. In the same spirit, all activities will be collaborative in nature and fully supported by the CD-ROM, web resources, and print resources. Interdisciplinary in nature, the package will include reading books for students and strategies for teachers to assist them in integrating reading and writing with the science material.

Future curriculum development efforts will be directed toward primary and pre-school students and teachers. Possible items for development include a "big book" to accompany the curriculum packages for elementary classes, another activity book to expand upon concepts from the first book, additional activities on the web site, and a "girls in science" curriculum package for middle schools.

Educational Research

An important aspect of the concept behind the Center for Integrating Research and Learning is research, not only science research but science education research. With this in mind, we have been developing a research agenda that examines the teaching and learning of science, mathematics, and technology at all levels. Research is currently being conducted to evaluate our education programs overall, as well as specific features of the program. For example, the teacher education component is a subject of ongoing research to determine how best to provide professional development locally, statewide, and nationally. The fully-developed, nationally-available curriculum product that the NHMFL developed is the subject of ongoing research as is the connection between a science research facility and educational reform.

The results of these research activities will provide valuable information for Center educators and drive the development of new curriculum projects. The curriculum development process has become an area of intense interest for the program (with the successful fielding of one curriculum product and another project underway) making the NHMFL's affect on science teaching and learning fertile ground for the research effort that was started this year. Requests for papers presented at international and national conferences, which are listed below, validate the interest in a science research facility as an agent of educational reform.

Additional papers and presentations are anticipated on subjects ranging from the MagLab: Alpha curriculum package to "Reinventing the Science Teacher for the New Millennium." Research is presently being outlined to investigate teacher education program design and implementation.

Conference Papers and Presentations

National Science Teachers' Association (NSTA), 1997, Workshop Presentation: *Presenting MagLab: Alpha — Implementing an Integrated Magnetism-based Curriculum Product.* Samuel A. Spiegel, NHMFL/FSU and Patricia J. Dixon, NHMFL/FSU

Southeastern Association for the Education of Teachers in Science (SAETS), 1997: *STAR TREE: Science Teachers and Researchers Translating Research Experiences into Educational materials.* Samuel Spiegel, NHMFL/FSU and Patricia Dixon, NHMFL/FSU

American Educational Research Association (AERA), 1998, Paper, Roundtable: *The Science Research Institution: A New Model of Educational Reform through Community Involvement.* Patricia J. Dixon, NHMFL/FSU, Samuel A. Spiegel, NHMFL/FSU, and George J. Papagiannis, FSU

Association for the Education of Teachers in Science (AETS), 1998, Paper(s): *Creating an Effective Teacher Enhancement Program.* Samuel A. Spiegel, NHMFL/FSU and Angelo Collins, Vanderbilt University; *STAR TREE: Science Teachers and Researchers Translating Research Experiences into Educational materials.* Patricia J. Dixon, NHMFL/FSU and Samuel A. Spiegel, NHMFL/FSU

National Association for Research in Science Teaching (NARST), 1998, Paper: *A Successful Science Teacher Enhancement Program: The Essential Components.* Angelo Collins, Vanderbilt University and Samuel A. Spiegel, NHMFL/FSU

National Association for Research in Science Teaching (NARST), 1998, Poster Presentation: *The Science Research Institution: A New Model for Reforming Science.* Patricia J. Dixon, NHMFL/FSU, Samuel A. Spiegel, NHMFL/FSU and George J. Papagiannis, FSU

National Association for Research in Science Teaching (NARST), 1998, Paper Set: *Teachers Developing Curriculum Products: Bridging Vision and Practice.* Elizabeth A. Viggiano, NHMFL/FSU and Patricia J. Dixon, NHMFL/FSU; *P.L.U.N.G.E. into Collaborative Learning.* Karl Hook, Florida State University School, Debi Barrett-Hayes, FSUS, Marleni Young, FSUS, and David Young, FSUS; *Standards, Reform and Learning: Perspectives from a National Research Facility.* Jack E. Crow, NHMFL/FSU and Samuel A. Spiegel, NHMFL/FSU

Educational Resource Laboratory

In support of our vision to create a unique learning center for students of all ages (including K-12 students, teachers, undergraduates, and so forth), the NHMFL maintains an Educational Resource Laboratory that was developed in conjunction with the State of Florida. The state-of-the-art laboratory houses multimedia development equipment, manipulative development equipment, curriculum materials, and instructional resources. It is intended for use by educators, students, and NHMFL personnel, and it is a popular instructional and development resource for regional schools. As one teacher wrote, "It was great—would like to come again. The lab is great. Very effective as it is." Susan Walters, Elementary Teacher, Leon County.

Students and teachers make good use of the Educational Resource Laboratory at the NHMFL.

During open hours, teachers and students can come to the Resource Laboratory to develop a new interactive multimedia program; to desktop publish student materials; to create quicktime movies and video clips; to preview a variety of curriculum products such as those produced by other classroom teachers. Additionally, teachers can schedule classes for small groups of teachers or students to learn about the development or integration of multimedia into their classrooms. This laboratory is also used as an instructional technology classroom for our teacher education efforts.

Partnerships & Community Support

The Center has been actively developing partnerships to pursue new ways to promote science learning, develop new opportunities for our various target groups (e.g., students, teachers, parents, etc.), and extend the resources of the NHMFL. Partnerships with the private sector have helped to support new curriculum products, promote the mission of the Center, and generate some revenue for future programs. The partnerships with schools and other learning agencies extend our resources and tap into a pool of expertise on various education issues. Some of our recent partnerships include:

- ***Florida Agricultural and Mechanical University, Alliance for Minority Participation (FAMU/AMP) Programs.*** The NHMFL has been working closely with FAMU/AMP in the development and promotion of our Minority/Women Summer Research Internship Program. This year we also co-developed a program submitted for NSF funding through the CIRE program. This new program would develop distance learning courses and research mentorships dealing with advanced materials science and chemical NMR techniques. These courses and experiences will be offered initially to students at FAMU, Clark Atlanta University, and FSU. The project also will enhance faculty ties between the institutions and encourage collaborative research projects supported through the NHMFL In-House Research Program.

- ***Sempco, Incorporated.*** This private business located in Nashua, NH, has been working with us to develop and mass produce our curriculum materials projects. Together with Sempco we have been negotiating with publishers and marketing companies to market these products nationally. Sempco has assisted by providing sample materials to test new activities and in the creation and production of new equipment, specifically designed to meet the needs of our programs.

- *Schools and Oher Student Groups* (e.g. home school groups). Through our Ambassador Program and various other efforts, we have developed close relationships with most of the regional schools, as well as some in other regions (i.e., schools in Alabama and Georgia). These partnerships facilitate the development of our education programs and engage a variety of stakeholders in education (students, parents, teachers, etc.) by providing links that allow them to take ownership and see that what is accomplished in a science research institution is "do-able."

- *Research Schools.* In collaboration with local research schools such as the Florida State University School, we have developed programs such as the "Integrated A.R.T.S." project. Integrated A.R.T.S. is a summer institute for ten gifted and high-achieving students. The unique, seven-week, non-residential summer program for rising high school freshman through seniors, is funded by the Florida Department of Education and co-sponsored by the NHMFL. Participants in the Integrated A.R.T.S. program will work and learn with scientists at the lab while integrating the visual "Arts, Research, Technology, and Science" as they translate the research conducted at the laboratory into resource materials posted on the Internet for use by learners worldwide.

- *College of Education.* Our collaborations with the Florida State University College of Education has resulted in Center educators working with preservice teachers through formal courses and by providing internship and work experiences. We are continuing to promote links between the College of Education and the NHMFL.

- *Science Museums.* The NHMFL has partnerships with the ODYSSEY Science Center of Tallahassee, and the Orlando Science Center to design and develop interactive web-based exhibits and resources, as well as, traveling and permanent exhibits for science museums and centers. We are exploring new programs to extend the impact of our outreach programs across Florida, and possibly nationally.

- *Community Classroom Consortium (CCC).* The CCC is an ideal partnership joining the north Florida/south Georgia community with cultural, natural, and educational resources. The purpose of this liaison as described in the CCC mission statement is "to inspire a sense of community; to provide educational enrichment by offering authentic experiences through collaborative projects, programs, and publications; and to support and strengthen the educational missions of the members of the community." This year the CCC will be assisting us in proving hands-on activities and displays for our annual Open House.

COLLABORATIONS

CHAPTER 5

The NHMFL continued to pursue new partnership and development opportunities with the private sector, with other institutions and agencies, and with international laboratories and organizations. Collaborations, particularly those with the private sector and U.S. agencies and institutions, offer the laboratory critical avenues through which we enhance the facilities, expand user support, and drive new high field magnet research and development activities. They are also essential to regional and state economic development. This chapter presents the more significant partnerships of the NHMFL during 1997 and midway through 1998.

PRIVATE SECTOR ACTIVITIES

Brush Wellman Inc., Cleveland, OH. The development of high strength/high conductivity, commercial conductors requires the evaluation of the strength and conductivity properties performed by the NHMFL. By evaluating these properties, the NHMFL has helped to assess the variables in the manufacturing process, thermal or mechanical, and their respective influences on the properties. This program responds to critical needs within the NHMFL for high strength, high conductivity materials important to both the resistive and pulsed magnet programs.

BWX Technologies, Lynchburg, VA. The NHMFL and BWX Technologies (formerly Babcock and Wilcox) are joining forces to develop a new Superconducting Magnetic Energy Storage (SMES) system by mid-1999. The particular application planned by BWXT is a system for stabilizing power transmission lines. This collaboration came to light primarily because of the laboratory's experience and knowledge gained through the design, development, and manufacture of the 45 T Hybrid magnet system. In particular, they view the experience and human resources at the NHMFL in cable-in-conduit conductor technology as crucial to their system design. The NHMFL also has a variety of magnet component testing facilities.

DuPont Central Research & Development Experimental Station, Wilmington, DE. DuPont scientists collaborated with the NHMFL's ICR group in the first successful mass analysis of all five possible copolymer families formed from glycidyl methacrylate (GMA) and butyl methacrylate (BMA). The ultra-high mass resolving power of the FT-ICR mass spectrometry made it possible to distinguish GMA and BMA units having the same "nominal" mass (142 Dalton), but differing in exact mass by 0.036 Dalton (CH_4 vs. O), for polymers up to 7,000 Dalton in size. Analysis of the asymmetrical isobaric distribution for copolymer oiligomers proved that GMA is less reactive than BMA in the polymerization process. Their results, recently accepted for publication in *Analytical Chemistry*, provide a complete and unequivocal component analysis of GMA/BMA copolymers of the size used for high solid content automobile coatings.

DuPont Superconductivity, Wilmington, DE, and Carpco, Jacksonville, FL. A team comprising DuPont Superconductivity, Carpco, and the NHMFL have initiated a collaboration to develop a high temperature superconducting magnetic ore separation system. The goal of this three-year project will be to build a quarter-scale working ore separator system using a conductively-cooled, high temperature superconducting magnet. The working prototype system will be assembled and tested at the NHMFL and then shipped to DuPont for processing. This $6M project is one of six being funded under the Department of Energy's Superconductivity Partnership Initiative (SPI) program.

EURUS Technologies, Inc., Tallahassee, FL. The close proximity between the NHMFL and EURUS helps to foster many collaborative projects, such as the following.

- The design and development of the SX Series power lead, the world's first bipolar YBCO current lead engineered to power superconductive and hybrid magnet systems while minimizing the influence of heat load from room temperature into the cryogen system.

- The enhancement of the SL Series YBCO current leads, where redesign has reduced joint resistance by an order of magnitude while significantly enhancing the reliability, ruggedness and cost effectiveness of these state-of-the-art power leads.
- The improvement of Power Plus BSCCO 2223 Ag tape, where technical consulting has enabled EURUS to commence development of insulation and coating techniques essential to providing this commodity for HTS coil windings.
- The development of a long-length HTS power transmission cable as a mutual venture to illustrate the cost effectiveness and problem- solving capacity of HTS materials.
- The commencement of development of second generation YBCO tape that will reshape the cost of HTS materials while offering significant HTS coil design and fabrication advantages. The improvements achieved in AC losses of the HTS conductors in power applications (by using the NHMFL's proprietary sol-gel insulation) show the AC loss reduction is improved by three-fold. This particular activity was supported by a Phase I SBIR proposal and the Phase II proposal is pending reviews.

General Atomics Inc., San Diego, CA. Engineers at General Atomics and the NHMFL are using the laboratory's unique materials testing facilities to help determine low temperature physical properties data on large support struts for the company's Superconducting Mine Countermeasure Systems. This collaborative work is providing designers with the data necessary to develop a superconducting magnet system for the U.S. Naval Surface Warfare Center.

Haldor Topsoe A/S, Denmark. The NHMFL ICR program recently completed a successful collaboration with this Danish company that produces catalysts for processing petroleum fuels. The ICR group was able to resolve, identify, and monitor the removal by hydrotreating the various sulfur-containing organic compounds in diesel fuel. The results were consistent with a desulfurization catalysis mechanism proposed by the Danish collaborators, and the results of the tests have been submitted for publication.

Hitachi, Ltd., Hitachi, Ibaraki, Japan. The NHMFL developer of the proprietary sol-gel high temperature insulation is evaluating its use in high field HTS insert coils with Hitachi. The coils were tested at the NHMFL and the improvement achieved with the sol-gel approach in packing density of the HTS pancake coils is about 30 percent better than the alternative spray insulation.

Intermagnetics General Corporation (IGC), Latham, NY. Researchers at IGC in collaboration with the NHMFL are developing an HTS insert coil as a prototype for the 1.1 GHz NMR application. IGC will build the coil and the NHMFL's HTS group will test its performance in a background field of 20 T and evaluate integration into future NMR applications.

The IGC and NHMFL collaboration on the ambitious 900 MHz NMR magnet system continues at an active pace. Weekly conferences calls are held between the two partners to discuss and coordinate the complex fabrication schedules and other technical issues. The senior management of the two organizations have bi-weekly conference calls to review the entire project. The magnet system is designed in a manner that allows it to be upgraded to 1 GHz and beyond with insert coils. IGC has honored the technology transfer potential of this collaboration with a $1 million contribution to the project.

Maxdem Inc., San Dimas, CA. A collaboration between engineers at Maxdem (an advanced polymer research company) and the NHMFL has resulted in the verification of the performance of two high strength unreinforced polymers at ambient and cryogenic temperatures. Initial applications of the polymers in magnet instrumentation probes that require the strength and the insulating characteristics of the polymers show promise for other low temperature and magnet applications.

Oxford Superconductor Technologies (OST), Carteret, NJ. The HTS Magnets and Materials group at the NHMFL is collaborating with OST on the development of a 3 T insert coil to be tested in the large bore 20 T resistive magnet. This insert coil, requiring approximately 1.5 km of HTS conductor, is an important development on the path toward a 1 GHz NMR magnet system. OST is providing all of the powder-in-tube BSCCO 2212 conductor for the program. After OST fabricates the unreacted conductor, the NHMFL insulates it using an internally developed sol-gel approach and subsequently winds the double pancake coils. Approximately half of the coils are then treated by the NHMFL, the other half by OST. After epoxy impregnation, the reacted coils are stacked at the NHMFL and electrically joined. Testing is planned for August, 1998.

Oxford Superconductor Technologies (OST), Carteret, NJ. An additional collaboration between the NHMFL and OST involves the development of high strength copper-niobium conductors for pulsed magnet applications. OST is providing samples of CuNb rod with different volume fractions for final processing and testing at the NHMFL.

Sempco Incorporated, Nashua, NH. In conjunction with the NHMFL's K-12 educational programs, Sempco has been collaborating with laboratory educators to develop curriculum products. These products are designed to promote the teaching and learning of science by building on both the underlying concepts of research conducted at the laboratory and the potential implications and applications of this research. Sempco has aided in the development of the physical materials for the curriculum packages of equipment. Sempco is now serving as the production company for these packages, which will be marketed nationwide.

Southwire Corporation, Carrollton, GA. Researchers at the NHMFL are working with Southwire on the characterization of bend strain and thermal cycling effects of BSCCO 2223 powder-in-tube conductors in support of their ongoing HTS Cable Project.

Supercon Inc., Shrewsbury, MA. The NHMFL is evaluating the strength and conductivity properties of Supercon's high strength/high conductivity, composite conductors. This evaluation helps to determine which manufacturing process, thermal or mechanical, has the best influence on these properties. This cooperative program, like others, is focused on helping to address the laboratory's critical needs for better materials within the resistive and pulsed magnet efforts.

Supercon Inc., Shrewsbury, MA
Intermagnetics General Corp., Latham, NY. Members of the NHMFL MS&T Superconductor Characterization group and researchers at Supercon and IGC are collaborating to conduct critical current measurements of strands on barrel samples in a 20 T, 50 mm bore superconducting magnet at 2.2 K and 4.2 K. There has been ongoing work to test various developmental superconductor wires. Critical temperature and upper critical field are also characterized on the strand conductors.

Varian Associates, Palo Alto, CA. The NMR program in the NHMFL is a beta test site for a new HTS probe for NMR spectrometers. The prototype HTS probe is on loan to the laboratory and is the result of a joint venture between Varian Associates and Conductus Inc. HTS probes will dramatically enhance NMR sensitivity, the primary limitation in NMR since its inception more than five decades ago. This HTS probe utilizes radio frequency coils made from the high temperature superconductor, YBCO.

Inter-Agency & Inter-Institutional Activities

Department of the Navy. The NHMFL infrastructure renovations for testing the Navy's Superconducting Magnetic Energy Storage (SMES) system have been completed. All components of the large-scale SMES system are on-site at the NHMFL, and we are awaiting the final contract authority from the Navy. Discussions are also being pursued to use this SMES prototype to support testing of some of the Navy's power electronic building blocks being developed for the electrification of ship drives and related systems.

Lawrence Berkeley National Laboratory (LBNL), Berkeley, CA. The Superconducting Magnet Group at LBNL collaborated with the NHMFL's Magnet Science & Technology group to measure the current transport characteristics of Rutherford Style Superconducting cables for dipole magnet development. The Large Superconductor Test Facility at the NHMFL was then modified to enable transverse compressive loading of conductors.

Lawrence Livermore National Laboratory (LLNL), Livermore, CA. Engineers working on the BABAR Detector Magnet Program at LLNL collaborated with the Magnet Science & Technology group of the NHMFL to investigate the current transport characteristics of aluminum stabilized high current superconductors. Characterization of the large conductor requires the unique capabilities of the NHMFL's Large Superconductor Test Facility. The test results and analyses will be presented at the 1998 Applied Superconductivity Conference.

Los Alamos National Laboratory (LANL), Los Alamos, NM. The object of the LANSCE 30 T split-pair repetitively pulsed magnet, which is funded by the Department of Energy, is to supply the Los Alamos Neutron Science Experiment (LANSCE) with two 25 mm bore, 30 T split-pair magnets that can provide repetitive pulsing at a rate of 2 Hz. These magnets will be used in the LANSCE facility to provide a unique high magnetic field and neutron beam scattering capability in the world. The 30 T pulsed magnet for neutron scattering at LANL requires the fatigue life characterization of high strength/high conductivity candidate materials for the proposed magnet design. This magnet is being designed and fabricated by the NHMFL's Magnet Science & Technology group.

MAGLEV 2000, Brevard County, FL. The NHMFL is a contributing partner to this project in east-central Florida. MAGLEV 2000 is supported by Florida industry, academia, and the state Department of Transportation. For several years, the State of Florida has had a continuing interest in maglev as the next-generation alternative to high-speed rail in congested central and south Florida. A 1,000-foot demonstration track will be completed later this year.

Pacific Northwest National Laboratory (PNNL), Richland, WA. Researchers from both national laboratories have been collaborating on the analysis of radionuclides, which require ultra-high mass resolving power. NHMFL scientists have been developing the elemental analysis technique of Inductively Coupled Plasma FT-ICR that provides a definite advantage in the analysis of these elements. This can be a beneficial technique for PNNL's problems associated with the clean-up of radioactive wastes at the Hanford site.

University of Oregon, Eugene, OR. The Magnet Science & Technology group at the NHMFL is working with the Physics Department on a Liquid Helium Wind Tunnel project. The NHMFL's task has involved the measurement of drag on a spherical body.

International Activities

A.A. Bochvar Institute, Moscow, Russia. The long-term collaborations with the Bochvar Institute continue to remain productive and driven primarily by researchers at the NHMFL's Pulsed Field Facility at Los Alamos. A major activity is underway devoted to the further development of stainless steel clad copper wire in especially large cross sections and with different stainless steel alloys. This is an important component for the 100 T magnet and other high field user magnets with long decay times.

CEA, Saclay, France. A collaboration between magnet designers at the French Atomic Energy Commission and the NHMFL has successfully detailed the thermal and mechanical behavior of an aluminum stabilized composite superconductor. These characterization tests also resulted in the publication of a research report.

CERN High Energy Physics Laboratory, Switzerland. NHMFL researchers have completed tests of a liquid helium pump for the CERN Laboratory. These tests confirm the required performance and demonstrate the suitability for the ATLAS detector system of the LHC.

CNRS/MPIF High Field Magnet Laboratory, Grenoble, France. After a three-year design and development partnership, the two laboratories successfully commissioned the two large-bore, 200 mm, 20 T resistive magnets using 24 MW power supplies. This collaborative project saved considerable development costs for each laboratory. The NHMFL is exploring new possibilities for further cooperation in the field of split-coil magnets and other high field inserts.

Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany. The NHMFL is collaborating with the DESY laboratory on cryogenic problems relating to the future of the TESLA electron accelerator. DESY is developing the Tesla Test Facility for He II cooling of RF cavities. The NHMFL will provide components to study the flow characteristics of two-phase He II for the test facility and modeling to assist with the design of the accelerator.

Forschungszentrum Rossendorf, Dresden, Germany. Five German institutes and laboratories are proposing to establish a 100 T pulsed field laboratory. The NHMFL is participating in the design and definition of the magnet systems. A staff member of the Forschungszentrum Rossendorf worked at the NHMFL for three months and participated in the evaluation of the different options for the design and construction of magnets.

High Magnetic Field Laboratory, Institute of Plasmaphysics, Hefei, China. The Chinese laboratory is working on securing funding for the 45 T long pulsed magnet that will be developed jointly with the NHMFL and installed at Hefei. There is also a proposal to work on the design and construction of a high gradient magnet for magnetic levitation of diamagnetic matter.

International Forum on High Magnetic Fields. This international group has been officially sanctioned and will meet next at the NHMFL during two back-to-back conferences being hosted by the laboratory in late October, 1998. At the first meeting, the forum by-laws will be discussed, amended, and passed, thus officially launching this international forum. It will provide a forum for establishing cooperation in magnet and magnet materials research, help promote scientific exchange, and promote great governmental and public awareness of the impact of magnet related research. Leadership of the forum will rotate among representatives from Europe, Japan, and the United States. The current chair is N. Miura, Institute for Solid State Physics, University of Tokyo.

Institute of Low Temperature Physics, University of Sao Paulo, Brazil. The Los Alamos Pulsed Field facility has an ongoing collaboration with the group at the University of Sao Paulo to investigate colossal magnetoresistance materials at very high magnetic fields.

Institute of Materials Research, Charles University, Prague, Czech Republic. Researchers at Charles University and the Pulsed Field group at Los Alamos are collaborating on the investigation of correlated metals at the facility's sophisticated low temperature and very high pressure instrumentation.

National Pulse Magnet Laboratory, University of New South Wales, Sidney, Australia. The NHMFL has benefited from long-term collaborations with the University of New South Wales and their lithographed transmission line method for pulsed field experiments. This technology essentially eliminates the dB/dt pick-up that normally plagues pulsed field transport measurements.

National Research Institute for Metals (NRIM), Tsukuba, Japan. The NHMFL and NRIM signed an international collaborative agreement on December 8, 1997, to enter into a cooperative program to facilitate new scientific exchanges, to advance user research facilities, to drive important new technologies, and to conduct joint conferences. On November 10, 1997, the 30 T magnet for NRIM was successfully tested and accepted at the Tsukuba Magnet Laboratory. This magnet is very similar in construction to the 30 T magnets at the NHMFL but uses Cu-Ag alloy in the innermost coil instead of Cu-Be in order to be compatible with NRIM's power and cooling water supplies. The two laboratories are exploring further possibilities to increase cooperation and share expertise in personnel and programs.

In other long-term collaborations with NRIM, the NHMFL has moved to a Cu-Be and phosphor bronze cantilever magnetometer used at NRIM. The new design has superior resilience to breakage over the silicon devices and is easy to construct on site. Its cost is minimal compared to the $1,500 commercial silicon devices.

Physikalisches Institut of Johann-Wolfgang-Goethe University, Frankfurt, Germany. The Institute acquired an NHMFL pulsed magnet for EPR studies. The magnet generates 50 T in a 24 mm bore. Further collaborations are anticipated to include other models of magnets. If successful, this effort will provide input for possible development of high field pulsed EPR facilities at the NHMFL.

Service National des Champs Magnetiques Pulses of the CNRS, Toulouse, France. The NHMFL is working in close cooperation with Toulouse on the development of pulsed field magnets. This includes the fabrication and testing of high strength conductors that are especially designed to achieve the highest fields possible. The wire is fabricated at the laboratory in Toulouse, and the NHMFL will design and build magnets with the conductor and then test the magnets to destruction. It is hoped that this strong conductor with high conductivity, coupled with the new design features developed at the NHMFL, will advance pulsed magnet technology and lead to enhanced performance of the pulsed magnets being provided to the user community at the NHMFL pulsed facilities at Los Alamos National Laboratory.

University of Nijmegen, The Netherlands. Researchers from the NHMFL and Nijmegen developed a probe for uniaxial stress. The probe was constructed at Nijmegen with Jos Perenboom and is currently being used at the NHMFL in high field resistive magnets at temperatures down to 0.5 K. It is unique because the stress may be changed at room temperature while the sample is cold and the field is on. A second probe for two-angle rotations was developed by the same group. It is also being used at the NHMFL at temperatures down to 0.5 K and is unique in that the motion of each angle is independent.

University of Nottingham, England. Scientists at the University of Nottingham are collaborating with NHMFL scientists at the University of Florida to design and construct novel gradient coils for high field magnetic resonance microimaging. The new coils will enable much stronger and faster switching gradient fields to be employed, which will be particularly important for increasing the sensitivity limits in diffusion measurements. Applications to microimaging of single cells and brain slices will be investigated, followed by collaborations with the NHMFL pulsed field gradient spectroscopy.

Versaille Project on Advanced Materials and Standards (VAMAS). VAMAS is an international collaboration of laboratories that is organized into Technical Working Areas. The NHMFL is working with one technical subgroup on pre-standards measurements research to help foster the development of internationally acceptable standards for advanced materials. Specific research has focused this year on low temperature test methods for the compression and shear properties of fiber-reinforced composite laminates.

University of Tokyo for Agriculture and Technology, Japan. Researchers from Tokyo have been collaborating with NHMFL's NMR program to develop the use of solid-state NMR orientation constraints for the structural characterization of synthetic and biosynthetic polymers. In the past year, extensive work has been performed on *Bombyx mori* silk fibroin achieving the first significant improvement in this structure since the 1950's.

Uppsala University, Sweden. The NHMFL's ICR program is collaborating with researchers at Uppsala University in a project jointly funded by the Swedish Foundation for International Cooperation in Research and Higher Education and the laboratory. The groups are cooperatively investigating the detection, identification, and quantification of neuropeptides in biological tissues, to elucidate the effects of drugs on neurotransmission pathways in the brain. A special emphasis of this project is the study of the role of neuropeptides in movement disorders such as Parkinson's disease and Tardive diskinesia.

Workshops & Conferences

Chapter 6

Hosting workshops and conferences in Tallahassee, Gainesville, Los Alamos, and elsewhere has proven to be a very effective way for the NHMFL to establish new partnerships, expand its user community, and drive the interdisciplinary dialogue that will open new opportunities for science and engineering in the 21st century. For example:

- The pioneering Dirac Series of experiments—conducted at Los Alamos in 1996 and 1997 at some of the highest magnetic fields ever achieved by man—grew out of a U.S.-Russian workshop at LANL in mid-1994
- The relocation of EURUS Technologies, Inc., to Innovation Park in Tallahassee across from the NHMFL resulted from the High Magnetic Fields: Industry, Materials, and Technology conference held at the laboratory in the first quarter of 1996.

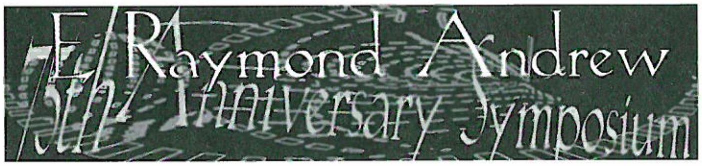
The NHMFL hosted or co-hosted a variety of major meetings during the reporting period, which are briefly described in this section. The hectic pace of these activities is expected to continue, as the NHMFL will host the VIIIth International Conference on Megagauss Magnetic Field Generation and Related Topics (Megagauss VIII) and Physical Phenomena at High Magnetic Fields-III (PPHMF-III) in October, 1998.

In addition to hosting major functions, the NHMFL frequently participates at meetings sponsored by others as part of its corporate development and user outreach activities. This participation takes many forms—from exhibits and displays to keynote presentations by the laboratory's directors to session chairmanships. A few examples of these activities include the following.

- High-Tech Florida Means Business—The Future of Science and Technology in Florida: Trends and Indicators, sponsored by the State of Florida and the American Association for the Advancement of Science and organized by the University of Florida
- Gulf Coast Alliance for Technology Transfer meetings and programs
- Enterprise Florida bio-technology workshop
- Department of Energy Wire Development Workshop
- European Science Foundation's Case Studies on Large Research Facilities: Meeting on 100 T Science EuroLab
- Knowledge Networking Processes Workshop
- International Conference on Magnetism and International Conference on Research in High Magnetic Fields, Cairnes, Australia
- Centers of Excellence Project: Materials with Atomic Scale Structures at NRIM
- Department of Energy Basic Energy Sciences Advisory Committee
- Office of Naval Research University & Business Technology Conference
- Trade shows at the 1997 and 1998 March Meetings of the American Physical Society and the 1998 Materials Research Society meeting.

Another important vehicle for fostering discussions and initiatives is the sponsorship of seminars and talks by NHMFL faculty, distinguished guests, and visiting users. Because of their great number, these seminars are reported in Appendix B.

The significant workshops and conferences hosted by the NHMFL from January 1997 through June 1998 are summarized on the following pages.



January 5, 1997
75th Anniversary Symposium for E. Raymond Andrew
Gainesville

The University of Florida honored E. Raymond Andrew on the occasion of his 75th anniversary in recognition of his many far-reaching contributions to magnetic resonance, solid state physics, and magnetic resonance imaging. The international celebration was sponsored by UF, the NHMFL, Elsevier Science B.V., Nolarac, Corp., Magnex Scientific, Oxford Instruments, Varian Associates, and John Wiley & Sons, Ltd.

Invited speakers at the symposium included Nicolaas Bloembergen, Paul Bottomley, James Carolan, Stan Clough, Erwin Hahn, Laurie Hall, Jacek Hannel, Sir Peter Mansfield, Vincent McBrierty, Alex Pines, Robert Pound, Hans Schneider-Muntau, Charles Slichter, and Sir Martin Wood. A special publication, SOLMAG Edition of *Solid State Nuclear Magnetic Resonance*, Vol 9, pp 1-97 (1997), ed. N. Sullivan with 16 authors, Elsevier Science, Amsterdam, 1997, was dedicated to the series.

Dr. Andrews was instrumental in establishing the NHMFL in Florida in 1990 and remains an active member of the magnetic resonance group at UF. In recognition of his exceptional contributions to science, medicine, and the State of Florida, Dr. Andrews was presented a formal "Resolution" of appreciation approved by the Florida Cabinet and signed by Governor Lawton Chiles.

March 13-15, 1997
First North American Fourier Transform Ion Cyclotron Resonance (FT-ICR) Mass Spectrometry (MS) Conference
Tallahassee

This first-ever conference attracted 110 registrants from leading FT-ICR research groups from the United States, United Kingdom, Germany, France, The Netherlands, and Japan. It comprised two intensive days of 24 oral and 52 presentations; all sessions were plenary and well attended.

The meeting was sponsored by the NSF National High-Field FT-ICR MS Facility, with additional support from Finnigan and Bruker. The scientific program featured four symposia—Instrumentation; Polymers/Electrospray; Laser Applications (MALDI, Photodissociation, Ion Spectroscopy); and Ion Chemistry and Ion-Molecule Reactions—plus several invited posters on industrial applications, and a closing guest lecture on ion mobility mass spectrometry by Michael Bowers (University of California, Santa Barbara).

It was decided not to publish the proceedings, in order to encourage presentation of new and controversial results. In response to strong encouragement from the ICR community, the organizers will be sponsoring a second FT-ICR Conference in March, 1999 in San Diego, California.

October 4-14, 1997
Robert Schrieffer Tutorial Series
Los Alamos

The NHMFL and LANL are co-sponsoring an annual tutorial series called the *Robert Schrieffer Tutorial Series on High Magnetic Field Phenomena*. The first series was held in October, 1997, and entitled Extreme Games: Type-II Superconductivity in a Magnetic Field. It included four talks given by former Los Alamos postdoctoral fellow, Zlatko Tesanovic of Johns Hopkins University.

The series is being overseen by NHMFL Chief Scientist Robert Schrieffer, who is a LANL External Fellow. It features prominent scientists presenting lectures on significant developments in high magnetic field research. The tutorial mode was chosen in order to be accessible to a wider audience than are technical seminars.

October 30-November 1, 1997
29th Annual Southeastern Magnetic Resonance Conference (SEMRC)
Gainesville

SEMRC featured invited and contributed papers and posters in NMR, MRI, EPR, and ICR, including time-resolved and multidimensional spectroscopies; high magnetic fields; and applications in material sciences, physics, chemistry, biology, and the medical fields. Invited keynote speakers were Michael Mehring (University of Stuttgart), Hans Thomann (Exxon Corp.), and Warren Warren (Princeton University).

November 9-11, 1997
Physics of Manganites, Ruthenates, and Related Materials
Tallahassee

The NHMFL hosted a small workshop to share information about the physical properties of Mn- and Ru-based transition metal oxides and to discuss science and technology opportunities in this area. Thirty-five participants attended, representing government and university institutions, as well as industry. Informal meetings such as this one are consistent with the NHMFL's mission to develop an in-house science program and to promote collaboration among scientists and engineers working in areas related to magnetism and magnet development.

December 8-10, 1997
8th U.S.-Japan Workshop on High T_c Superconductors
Tallahassee

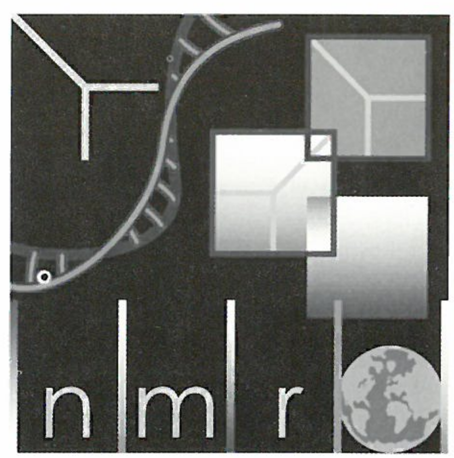
The NHMFL hosted the eighth workshop in this series between members of the Japanese and U.S. science communities that explores the latest innovations in high temperature superconductor research. The series is co-sponsored by the Japanese, and this year's co-chair was Professor K. Tachikawa from Tokai University. In addition to discussing a range of topics—including HTS coils for high field use; bulk synthesis, structures and applications; thin films; vortex structures, critical currents, and AC losses; new materials and characterization—participants enjoyed dinner and a glass-bottom boat ride at nearby Wakulla Springs.

During a break in conference activities, the NHMFL and the National Research Institute for Metals' (NRIM) held a press conference to announce the signing of a new cooperative agreement to facilitate scientific exchanges, to advance user research facilities, and to drive important new technologies. The accord is an important step in enhancing the partnership between these two international laboratories.

January 15-16, 1998
High Field NMR: A New Millennium Resource
Washington, D.C.

The NHMFL helped to organize this important conference on the frontiers of biology and chemistry in high magnetic fields. Many of the nation's leading NMR scientists attended, along with representatives from NSF, the Department of Energy, and the National Institutes of Health. The meetings focused on the science drivers for the next generation of high field NMR, which have the potential to address critical national science opportunities in the fields of chemistry and biology. Four frontier areas were discussed: Beyond the Genome, Gene Regulation, Neuroscience, and New Materials.

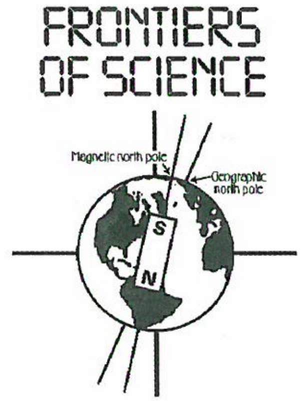
Participants at the conference also discussed how networking, using Internet II, could support collaborative research through shared instrumentation that is regionally positioned throughout the United States. This concept of a "virtual laboratory" or "center without walls" on the Internet could provide important training opportunities for undergraduate and graduate students in magnetic resonance techniques and their applications to emerging science and technology frontiers.



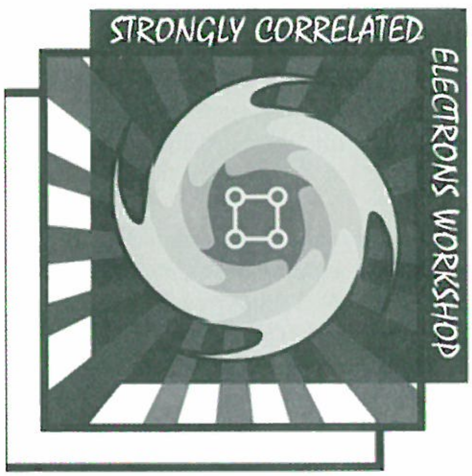
Winter, 1998
Imaging Science Visiting Lecture Series
Gainesville

The UF Imaging Science and Technology Center and the MRI/S component of the NHMFL sponsored a series of lectures by distinguished guests of the university, including James S. Duncan (Yale School of Medicine); Robert N. Beck (University of Chicago); Robert F. Wagner (Food & Drug Administration); Michael W. Burns (University of California, Irvine); Philip G. Haydon (Iowa State University) and Phi Beta Kappa Visiting Scholar Robert G. Schulman (Yale University). The dates and titles of their talks are provided in Appendix B.

Spring, 1998
Frontiers of Science Lecture Series
Gainesville



This annual lecture series at the University of Florida focused in 1998 on the "magic of magnetism," as a celebration of the occupation of the new UF Physics Department building, the ongoing enhancement of NHMFL activities on the UF campus, and the myriad of revolutionary technological applications growing out of magnetism. By coincidence, it was noted that 1998 is the centennial of the first patent on the magnetic recording of information. The talks, held in January through April and listed in Appendix B, addressed the history, present status, and future contributions of magnetism to medical imaging, information storage, and other new devices.



March 12-14, 1998
Strongly Correlated Electrons Workshop
Tallahassee

This workshop was the latest in a series of workshops that have taken place in recent years in Switzerland and Japan. It was held for the first time this year in the United States. The goal of these workshops is to bring leaders in the field of strongly correlated electrons together in a pleasant atmosphere for discussions. A core list of about 50 participants for this conference has remained constant over time, with a group of new speakers every year.

March 13-15, 1998
Fifth Institute for Fundamental Theory Workshop—Axions
Gainesville

This international workshop brought together physicists from several groups around the world who are working on experiments or the theory of detecting axions. Axions were originally proposed to solve the strong CP problem of particle physics and have become one of the leading candidates for the origin of the mysterious dark matter that we now know makes up approximately 90 percent of our universe. University of Florida and NHMFL colleagues built the first prototype detector, which looks for the decay of galactic halo axions in a large laboratory magnetic field.

The large U.S. contingency included the University of Florida, the NHMFL, Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, Fermi National Laboratory, the University of Chicago, among others. Other laboratories and universities represented at the workshop included Moscow State University, Kyoto University, Max Planck Institute (Munich), Moscow Eng. Physics Institute, University of Sussex, Seoul University, Cambridge University, University of Rochester, and University of British Columbia.

1999 Budget

Chapter 7

Budget Background

The NSF Grant funding is fixed at $17.5 million per year for the five-year period of the cooperative agreement. The annual budget process is one of allocating the available resources among the various functions of the laboratory. The renewal proposal set forth a five-year spending plan that established the proposed allocation of resources. That spending plan allocation is summarized in Table 1 on the basis of total cost allocations (including indirect costs). The plan clearly shows that the first two years were to be dedicated to completing the major facilities and magnet systems. The out years would emphasize the Users Programs and the Science Program.

Table 1. NHMFL Five-Year Budget Plan. (Total Cost Allocation)

Function	1996	1997	1998	1999	2000
Administration & Facilities	5.9%	7.2%	8.2%	8.1%	8.1%
User Operations, DC Fields & NMR	25.0%	25.7%	29.5%	29.0%	28.6%
Magnet Science & Technology	34.2%	23.2%	22.0%	21.3%	21.2%
Science Program	6.9%	9.9%	12.2%	13.0%	12.8%
Los Alamos Pulsed Field Facility	26.5%	32.8%	26.1%	26.2%	26.8%
University of Florida High B/T and MRI	1.5%	1.2%	2.0%	2.5%	2.6%

1996 and 1997 Actual New Commitments

Since many commitments are for long-lead items, such as major equipment, actual costs may not show up until the following year. For this reason, we have elected to show actual resource allocations based on new commitments each year. Table 2 compares the actual new commitments for 1996 and 1997 to the five-year plan allocations.

The first year of the renewal—1996—was funded at the full $17.5 million rate for a period of 10 months that provided capital funds to cover needs in the magnet program. The funding allocation budget for 1997 reflected a reduction in magnet programs and the fact that the Los Alamos power supply commitments were spread over two years. The actual commitment allocations for 1996 and 1997 are related to specific programs. The activities are as follows.

Table 2. 1996 and 1997 Actual New Commitments. (Total Cost Allocation)

Function	1996 Budget	1996 Actual	1997 Budget	1997 Actual
Administration & Facilities	5.9%	7.5%	7.2%	10.5%
User Operations DC Fields & NMR	25.0%	24.6%	25.7%	30.4%
Magnet Science & Technology	34.2%	30.6%	23.2%	32.3%
Science Program	6.9%	0.9%	9.9%	4.2%
Los Alamos Pulsed Field Facility	26.5%	36.4%	32.8%	20.6%
University of Florida High B/T and MRI	1.5%	0.0%	1.2%	2.0%

- *Administration & Facilities.* The growth of Administration and Facilities cost share reflects the cost of personnel responsible for maintaining the magnet power supplies, cooling systems, and related systems that have not been included in this category in previous budget scenarios.

- *User Operations.* Commitments for instrumentation that were made in 1996 and 1997 will be delivered in 1997 and 1998. In addition, electric power costs have increased in the past two years, due in large part to increased user demand and changed use patterns. The development of capabilities for solid state NMR in resistive magnets has resulted in longer runs at high power with corresponding increases in power costs.

- *Magnet Science and Technology.* Major commitments related to the 900 MHz and Hybrid Resistive Insert were not made in 1996 as originally planned. Those commitments have been made in 1997 and 1998.

- *Science Program.* Initial In-House Research Program awards were not made until 1997. Many of the programs are over two years so commitments will build up over 1997 and 1998 and beyond.

- *Los Alamos Pulsed Field Program.* Funds for three additional Los Alamos pulsed power supply modules needed for the 100 T program were committed in 1996 rather than being spread over two years. Commissioning and actual payments occurred in 1997 and 1998. The full planned funding for the Pulsed Field Program at Los Alamos was committed in 1996 and 1997 and the funds transferred to Los Alamos. The equivalent of approximately two months direct cost funding remained unused at Los Alamos from the original five-year program. Those funds are being held for use in improving the user facilities when the LANL facilities are moved in early 1999.

- *High B/T Program.* The 1996 funds were not committed because the magnet system was not completed and delivered by the vendor. The magnet was delivered in 1997 and is now in operation. Funds set aside for 1996 and 1997 were transferred to UF in 1997.

1998 Projected New Commitments

Projected new commitments for 1998 based on five months of actual data (through May, 1998) are presented in Table 3. The 1998 budget is the original five-year plan allocation. The projected new commitments reflect current spending against funds available. Magnet Science & Technology costs have been adjusted to reflect credits received from work for others contracts.

Table 3. 1998 Projected New Commitments. (Total Cost Allocation)

Function	1998 Five-Year Plan	1998 Projected Actual
Administration & Facilities	8.2%	7.9%
User Operations DC Fields & NMR	29.5%	28.4%
Magnet Science & Technology	22.0%	31.2%
Science Program	12.2%	9.2%
Los Alamos Pulsed Field Facility	26.1%	21.4%
University of Florida High B/T and MRI	2.0%	1.9%

The primary reasons for the expenditure variations are listed below.

- *Administration and Facilities.* Director's reserve funds have been used to cover costs of personnel responsible for maintaining the magnet power supplies, cooling systems, and related systems. These expenditures had not been previously budgeted to this category.

- *User Operations.* Indicated lower share reflects the higher proportion allocated to Magnet Science & Technology.

- *Magnet Science and Technology.* Higher share reflects additional expenditures for the 900 MHz and Hybrid Insert that are being committed in 1998. The allocation also reflects credits received for work for others.

- *Science Program.* Awards still will trail the availability of funds by about six months.

- *Pulsed Field Program (LANL).* Commitment of funds proceeds on budget.

- *High B/T and MRI (UF).* Commitment of funds proceeds on budget.

Staffing Analysis

A summary of the staffing situation at the NHMFL is given in Table 4.

Table 4. Staffing Summary.

Function	1996 Actual	1997 Actual	1998 Actual (July)	1999 Five-Year Plan	2000 Five-Year Plan
Administration & Facilities	10	18	20*	10	10
Instrumentation & Operations	34	31	37	37	37
Magnet Science & Technology	36	35	44	35	35
Science Program	2	2	8	2	2
Pulsed Field Program (Los Alamos)	13.5	12.5	12.5	12.5	12.5
High B/T and MRI (University of Florida)	0	0	2	4	4
Total*	**95.5**	**98.5**	**123.5****	**100.5**	**100.5**

* Includes education program summer staff and graduate students.

** Total comprises 97 permanent staff and 36.5 temporary employees, which includes graduate students and postdocs. 1998 actual staffing is staff on board as of July 1, 1998.

Staffing is somewhat above the five-year renewal plan. The 1998 increases in Facilities and Administration correspond to the actual levels resulting from rebudgeting of Facilities staff against the Administrative and Facilities account, and two temporary summer personnel on educational program activities. The increases in Magnet Science & Technology are primarily temporary staff to support the major magnet programs.

1999 Proposed Budget

The proposed new commitment allocation for 1999 is given in Table 5, based on projections of 1998 actuals adjusted for known changes.

Table 5. 1999 Projected New Commitments. (Total Cost Allocation)

Function	1999 Five-Year Plan	1999 Projected Budget
Administration & Facilities	8.1%	9.9%
User Operations DC Fields & NMR	29.0%	28.1%
Magnet Science & Technology	21.3%	28.8%
Science Program	13.0%	10.3%
Los Alamos Pulsed Field Facility	26.2%	21.3%
University of Florida High B/T and MRI	2.5%	1.6%

- *Administration and Facilities.* Allocation reflects increased facilities maintenance staff costs.

- *User Operations.* There are no significant changes in User Operations. The electric power budget has been increased to reflect increased magnet usage in magnetic resonance applications. Two-magnet operation coupled with an increased demand for use of the magnets for NMR will increase both demand and energy charges.

- *Magnet Science & Technology.* The proposed budget reflects completion of funding for the Hybrid and 60 T Quasi-Continuous magnet programs. Capital costs for these programs have essentially been committed out of funds through 1998. Additional capital allowances are provided in 1999 to support completion of the 900 MHz magnet and continued replacement coil activities for the resistive magnets and the small pulsed magnets. In addition, a small capital allowance has been provided to support initial studies of a series-connected hybrid magnet that could have several objectives: prototype for a 1.5 GHz NMR magnet or an energy-saving general research magnet. Credit has been taken for expected work for others, which helps to carry a significant portion of the MS&T group salaries.

- *Science Program.* The Science Program budget reflects the planned In-house Research Program awards and the cost of managing the solicitations, reviews, and awards.

Budget Details

Detailed information on actual costs and proposed budgets are available upon request.

USERS & PROJECTS

APPENDIX A

NHMFL - DC HIGH FIELD FACILITY

USERS	INSTITUTION	FUNDING	PROJECT
Agosta, Charles Coffey, Tom* Bayindir, Zeynel*	Clark U. Clark U. Clark U.	NSF	TDO Experiment. Transport Measurement
Allen, Mark Lagorce, Laure	Georgia Tech. Georgia Tech.	NSF	Micromachined Polymer Magnets
Anderson, James Gorska, Malgorzata Jen, Jen+ Story, Tomek Wolters, Christian+	U. of Maryland Polish Academy of Sciences U. of Maryland Polish Academy of Sciences NHMFL	NSF	Magnetization and Exchange Interactions in Diluted Magnetic Semiconductors
Aronson, Meigan	U. of Michigan	NSF	High Pressure Fermi Surface of SmB_6
Awipi, Mebenin Photimat, Phomma	Tennessee State U., Nashville Tennessee State U., Nashville	NSF	Focused Electromagnetic Field as Replacement for Ionizing Radiation in Single Event Upset Testing
Benicewicz, Brian Smith, Mark Whitney, Erin*	LANL LANL LANL	NSF	Processing of Polymers in Magnetic Field
Bernier, Gerald Luongo, John	Sanders Inc.-Lockheed Martin Sanders Inc.-Lockheed Martin	SPAWAR	Magnetization of Sonar Drive Rods
Bowers, C. Russell Vitkalov, Sergey+ Kuhns, Phil Engel, Lloyd Moulton, Bill Schmeidel, Thomas+	U. of Florida U. of Florida NHMFL NHMFL FSU NHMFL	NSF	Manifestations of Nuclear Spin in the Integer and Fractional Quantum Hall Effect
Bowers, C. Russ Vitkalov, Sergey+	U. of Florida U. of Florida		Electrical Detection of ESR in the Quantum Hall Effect
Brandt, Bruce Rubin, Larry Liu, Dawei*	NHMFL MIT NHMFL	NHMFL	Magnetoresistance of CERNOX Temperature Sensors

+POSTDOC **STUDENT*

USERS	INSTITUTION	FUNDING	PROJECT
Brooks, James Hill, Steven+ Qualls, Jeremy*	FSU NHMFL FSU	NSF	Applications of Uniaxial Stress to Induce the Metallic State in a SDW Material
Brooks, James Matthews, Malieka Stalcup, Tom*	FSU Bowie State U. FSU	NSF	Magnetic Susceptibility Measurements of $NbSe_2$ with Tunnel Diode Oscillator
Brooks, James Qualls, Jeremy*	FSU FSU	NSF	Temperature Sweeps on Organic Materials to Determine the Metal-to-Density Wave Transition Line in α-$ET_2KHg(SCN)_4$
Brooks, James Matthews, Maleika* Stalcup, Tom*	FSU Bowie State U. FSU	NSF	Tunnel Diode Oscillator Measurements to Measure Critical Fields in Low-D Superconductors
Brooks, James Cothem, John Qualls, Jeremy*	FSU Guilford College FSU	NSF	Studies of Quantum Jumps in the Magnetization of Nano-Magnet Clusters by Optical Methods
Brooks, James Stalcup, Thomas*	FSU, NHMFL FSU	NSF	Transport Measurements in κ-ET_2X Based Materials. Determination of Cooling Effects and Search for Quantum Oscillations
Brown, Stuart Clark, Gilbert Hall, Donavan Zheng, Guo-qing Tanaka, Kenji* Moulton, Bill Kuhns, Phil	UCLA UCLA NHMFL Osaka U. UCLA FSU NHMFL	NSF	Cantilever Magnetization Studies of the Spin Peierls Phase of $(TMTSF)_2PF_6$
Brunel, L.-C. Hassan, Alia+ van Tol, Hans	NHMFL FSU Grenoble	NSF	Determination of the Resolution of the Keck Magnet at 24 T
Butler, Les Mrse, Anthony* Bryant, Pam* Kuhns, Phil	Louisiana State U. Louisiana State U. Louisiana State U. NHMFL	NSF	Field Swept NMR Testing for Al-27 and N-14 Diamagnetic Molecules

+*POSTDOC* **STUDENT*

Users	Institution	Funding	Project
Chaikin, Paul M. Naughton, Mike Hannahs, Scott Tozer, Stan Lee, Injae* Chashechkina, Katya* Scheven, Ulrich+ Dancer, Guy	Princeton U. SUNY, Buffalo NHMFL NHMFL SUNY, Buffalo Princeton U. Princeton U. Princeton U.	NSF	Heat Capacity, Transport and Critical Field of $(TMTSF)_2PF_6$
Charles, Renauld Yu, Dingen	Supercon Inc. Supercon Inc.	Supercon Inc.	J_c and H_c in NbTi Wire Samples
Chen, Ching Pai, Vinay* Haik, Yousef*	FAMU/FSU College of Eng. FAMU/FSU College of Eng. FAMU/FSU College of Eng.	NSF	Effects of Magnetic Fields on Biological Fluids
Choyke, Wolfgang Rutsch, Gerald+ Devaty, Robert Rowland, Larry	U. of Pittsburgh U. of Pittsburgh U. of Pittsburgh Northrup Grumman	NSF	Measurement of the Hall Scattering Coefficient in Different SiC Polytypes
Clark, Gil Brown, Stuart Zheng, Guo-qing Tanaka, Kenji* Moulton, Bill Kuhns, Phil	UCLA UCLA Osaka U. UCLA FSU NHMFL	NSF	NMR Measurements of Spin Density Wave Fluctuation in $(TMTSF)_2PF_6$
Clark, Gil Brown, Stuart Moulton, Bill Kuhns, Phil Wudi, Fred+ Menon, Reghu	UCLA UCLA FSU NHMFL UCLA UCLA	NSF	NMR Studies of Conduction Electron Dynamics in the Doped Polymer Polypyrrole (PF_6)
Coey, Michael von Molnár, Steve Renyoust, Bertraund Wirth, Steffen	Trinity College, Dublin FSU FSU/MARTECH FSU/MARTECH	ONR	Magnetotransport of Noise on Manganites
Cross, Tim Soghomonian, Victoria+ Rosanske, Richard	FSU NHMFL FSU	NHMFL	Development of Higher Homogeneity Resistive Magnet Capabilities
Cross, Tim Soghomonian, Victoria+	FSU NHMFL	NHMFL	Biological NMR D Spectroscopy of Oriented gA in Lipid Bilayers
Crow, Jack Shepard, Michele* Wolters, Christian+ Guertin, Bob Cao, Gang Hall, Donavan Felner, Israel Maeno, Yoshiteru	NHMFL FSU NHMFL Tufts U. NHMFL NHMFL U. of Israel Kyoto U.	NSF	Magnetic and Transport Studies of Collective Behavior in 4d- and 5d-Oxide Systems

+Postdoc **Student*

DC Field Facility Users

Users	Institution	Funding	Project
Crow, Jack Gao, Gang Shepard, Michele*	NHMFL NHMFL Florida State U.	NSF	Righi-Leduc Effect in YBCO and $SrRuO_3$
Crow, Jack Painter, Tom	NHMFL NHMFL	NSF	Magnetoresistance of Solder Wires; Testing for the Hybrid
Dalal, Naresh Achey, Randall	FSU-NHMFL FSU		Magnetic Field Dependence of the FIR Spectrum of the Nanomagnet Mn-Acetate
Davis, Bruce Grama, George	F. W. Bell F. W. Bell	F. W. Bell	Hall Effect Generator Linearity
Dietderich, Dan Scaulan, Ron Walsh, Robert Miller, John Miller, George	Lawrence Berkeley Natl. Lab Lawrence Berkeley Natl. Lab NHMFL NHMFL NHMFL	NHMFL	Critical Current Measurements of Large Cables for High Energy Physics Applications
Douglas, Elliot Lincoln, Derek* Setz, Stefan	U. of Florida U. of Florida U. of Florida	NSF	Magnetic Field Processing of Liquid Crystalline Thermosets
Du, Rui Zudov, Michael+ Simmons, Jerry	U. of Utah U. of Utah Sandia Natl. Labs.	Sloan Foundation	Quantum Hall Activation Energy vs. Angle Around ν=3/2
Eichler, Markus Shillig, Joseph	ABB-Turgi Switzerland NHMFL-LANL	ABB	Test of Foeldi Current Transductors for LANL/NHMFL Power Supplies
Fisk, Zachary Sarrao, John+ Lacerda, Alex Immer, Chris*	FSU NHMFL NHMFL/LANL FSU	NHMFL	Magnetic Field and Pressure Studies of Pure and Doped $YbInCu_4$
Folan, Lorcan	Polytechnic U.	NHMFL	Electron Capture Beta-Decay Rates at Low Temperatures in Large Magnetic Fields
Fortune, Nathanael Anzai, H. Eblin, Melissa* Uji, Shinja Aoki, H.	Smith College Heniji Institute Smith College NRIM - Tsukuba NRIM - Tsukuba	Petroleum Research Fund	Quasi-Low-Dimensional Collective Phenomena in Molecular Conductors
Freed, Jack Brunel, L.-C. Earle, Keith Hassan, Alia vanTol, Hans	Cornell U. NHMFL Cornell U. FSU Grenoble	NSF	Study of Motional Dynamics in Complex Fluids by FIR-ESR

+*Postdoc* **Student*

Users	Institution	Funding	Project
Furdyna, Jack Wei, Xing Pareek,* Yin, A.* Dobrowolska, M.	U. of Notre Dame NHMFL U. of Notre Dame U. of Notre Dame U. of Notre Dame	NSF	Magnetoluminescence on ZnMnSe Interrupted Epilayers
Gatteschi, Dante Pardi, Luca Dei, Andrea Brunel, L.-C. van Tol, Hans Hassan, Alia+	U. of Florence U. of Pisa U. of Florance NHMFL Grenoble FSU	CNR Italy	Zero Field Splittings Measurements of Ni Dioxolene Adducts
Geerts, Wim+ Schmeidel, Thomas+ Pearton, Steve Childers, Jeff	NHMFL NHMFL U. of Florida U. of Florida	NHMFL	Magneto-Optical Kerr Experiments at Low Temperatures and High Fields
Giacometti, Giouanni Maniero, Anna Lisa Carbonera, Donatella Brunel, L.-C. Hassan, Alia+ van Tol, Hans	U. of Padova U. of Padova U. of Padova NHMFL FSU Grenoble	CNR Italy	Bacterioclorophyll C Oligotiers in Chlorosoties of Chlorobium
Goodrich, Roy G. Hall, Donavan* Palm, Eric Murphy, Tim	Louisiana State U. NHMFL NHMFL NHMFL	NSF	Magnetoresistance Measurements on Bismuth-Ruthenate Thick Film Chip Resistors
Goodrich, R. G. Fisk, Zachary Hall, Donavan Teklu, Alem Harrison, Neil Young, David*	LSU FSU NHMFL LSU NHMFL-LANL NHMFL	NSF	dHvA Measurements on Metallic Hexaborides
Goodrich, Roy G. Smith, James L. Hall, Donavan	Louisiana State U. Superconductivity Tech. Center NHMFL	NSF	Fermi Surface in Highly Correlated Systems
Gottstein, Guenter Schnieder-Muntau, Hans Heringhaus, Frank*	RWTH Technical U. NHMFL RWTH Technical U.	NHMFL	Electromagnetic and Thermomagnetic Properties of Eutectic Ag-Cu. Part II: Thermomagnetic Properties
Gottstein, Guenter Molodov, Dmitry Herringhaus, Frank* Czubayco, U.	RWTH Technical U. RWTH Technical U. RWTH Technical U. RWTH Technical U.	NHMFL	Measurement of Grain Boundary Mobility in Bi-Bi Crystals

+*Postdoc* *Student

Users	Institution	Funding	Project
Graf, Michael J. Hannahs, Scott	Boston College NHMFL		Superconductivity, Magnetism and Their Interplay in $U(Pt_{1-x}Pd_x)_3$: Exploring the Phase Diagram for 0.004<X<0.01
Guertin, Robert McCall, Scott* Crow, Jack	Tufts U. FSU NHMFL	NHMFL	Magnetization to 30 T to Seek Saturation of Ru Moment
Gwinn, Elisabeth Druist, Dave Maranowski, Kevin* Gossart, Art Yoo, K.	UC, Santa Barbara UC, Santa Barbara UC, Santa Barbara UC, Santa Barbara UC, Santa Barbara	NSF	Mesocopic Fluctuations of Chiral Surface Sheaths in the Integer Quantum Hall Effect
Halperin, William Reyes, Arneil Bachman, H. Nathan* Moulton, Bill Kuhns, Phil	Northwestern U. Northwestern U. Northwestern U. FSU NHMFL	NSF	Flux Melting Phase Transition by NMR
Hammel, P. Chris Moulton, Bill Pennington, Charles Smith, James L. Hults, William Kuhns, Phil Kleinhammes, Alfred+ Nandor, Valerie*	LANL FSU Ohio State U. LANL LANL NHMFL NHMFL Ohio State U.	DoE	NMR Study of Magnetic Properties of $YBa_2Cu_3O_7$
Harrison, Neil+ Mielke, Chuck+ Honold, Markus* Nam, Moon-sun*	LANL LANL U. of Oxford U. of Oxford	NHMFL	Investigations of Angle-Dependent Magnetoresistance Oscillations, the SdH Effect and the dHvA Effect in Quasi-Two Dimensional Organic Metals
Hascicek, Yusuf Dur, Osman* Cubukcu, Ilkay	NHMFL NHMFL NHMFL	NSF	I_c as a Function of Magnetic Field *in-situ* Lorentz Force Stressing of HTS Conductors
Hascicek, Yusuf Tachikawa, K. Cubusku, Ilkay	NHMFL Tokai U. NHMFL	NSF	Critical Current as a Function of Magnetic Field of Nb_3Sn Produced by a Novel Method
Hascicek, Yusuf Kuhns, Phil	NHMFL NHMFL	NSF	Field Homogeneity Characterization for an HTS Shim Coil in the 20 T LTS Magnet

+*Postdoc* **Student*

Users	Institution	Funding	Project
Hascicek, Yusuf Dur, Osman *	NHMFL NHMFL	NSF	Magnetoresistance of Silver and Silver Alloys as Sheathing to HTS Conductors
Hentges, Rob Zhang, Youzhu Marken, Ken McKinnell, Jim Hong, Seung Dai, Weiming Neff, Dan, Tatum, Julie Ting, Steven Cowey, Lisa	Oxford Superconducting Technology Oxford SC Tech. Oxford SC Tech. Oxford SC Tech. Oxford SC Tech. Oxford SC Tech. Oxford SC Tech. Oxford SC Tech. Oxford SC Tech. Oxford SC Tech.	Oxford Superconducting Technology	Critical Current as a Function of Temperature, Magnetic Field, and Strain in High Field Superconducting Materials
Hettinger, Jeffery Gray, Kenneth Veal, Kenneth Paulikas, A. Paul Lee, J. Hinks, D. Wasniewski, Chris*	Rowan U. Argonne Natl. Lab. Argonne Natl. Lab. Argonne Natl. Lab. Argonne Natl. Lab. Argonne Natl. Lab. Rowan U.	NSF	Josephson Interlayer Coupling in High-Temperature Superconductors at High Magnetic Fields
Hill, Steven+ Brooks, James Perenboom, Jos	FSU FSU U. of Nijmegen	NSF	Microwave Conductivity of Organic Conductors in High Magnetic Fields
Hill, Steve Brooks, James Stallcup, Tom* Sandhu, Pravindrajit S.*	Montana State U. FSU FSU NHMFL	NSF	Millimeter-Wave Spectroscopy of Novel Electronic Systems in High Magnetic Fields
Ihas, Gary G. Kim, Jungsoo Frederick, Larry	U. of Florida U. of Florida U. of Florida	NSF	Magnetoresistance of Various Samples and Sensors
Jones, Eric D. McCombe, Bruce D. Wang, Yong-Jie	Sandia Natl. Labs. SUNY, Buffalo NHMFL	Sandia Natl. Labs.	High Field Cyclotron Resonance, Electron Optical Phonon Interaction and Many Electron Effects in Quantum Well Structures
Kang, Woowon Young, Joe+ Cho, Hyung*	U. of Chicago U. of Chicago U. of Chicago	Packard Foundation	Sonoluminescence at High Magnetic Fields
Kang, Woowon Gossard, Art Young, Joe+	U. of Chicago UC, Santa Barbra U. of Chicago	NSF	Study of Spin Effects in Quantum Hall Effect

+*Postdoc* **Student*

USERS	INSTITUTION	FUNDING	PROJECT
Kim, Yongmin Schmiedel, Thomas+	LANL NHMFL	NHMFL	Studies of Non-Linear Energy Transitions of Semiconductor Heterostructures in Strong Magnetic Fields
Lacerda, Alex Korolyov, Alexander	NHMFL-LANL IMP, Ekateringurg	NHMFL	Magnetic and Magnetoelastic Properties of Intermetallic Compounds $Sm(Fe_{1-x}Co_x)_2$
Lacerda, Alex Beyermann, Ward P. Mielke, Chuck* Yatskar, Alex* Canfield, Paul Wolters, Christian+	NHMFL-LANL UC, Riverside Clark U. UC, Riverside Ames Lab. NHMFL	NHMFL	Magnetization Measurements at Low Temperatures
Landee, Christopher Turnbull, Mark Albrecht, Andy Woodward, Matt	Clark U. Clark U. Clark U. Clark U.	NHMFL	Magnetization of Low Exchange Strength Heisenberg Antiferromagnets in 2D
Larbalestier, David Cai, Xueyu	U. of Wisconsin U. of Wisconsin		Calibration of Hall Sensor
Marchenkov, V.V. Brooks, James Qualls, Jeremy* Terashima, Taichi Han, So Young* Biskup, Neven+	Institute of Metal Physics FSU FSU NRIM Tsukuba FSU FSU	NSF	Interface Scattering in Ultra Pure Single Metal Crystals in High Magnetic Fields
Markiewicz, Denis Pickard, Kenneth Dixon, Iain Dougherty, Jerry Bruce, Robert	NHMFL NHMFL NHMFL NHMFL NHMFL	NSF	Critical Current Measurements of Wire for 900 MHz NMR Magnet
Markiewicz, Denis Swenson, Chuck Hall, Donavan	NHMFL NHMFL NHMFL	NHMFL	Magnetization (VSM) Measurement of Permeability of Stainless Steel for the 900 MHz Magnet
Marshall, Alan Hendrickson, Chris Drader, Jared*	NHMFL NHMFL U of Texas - Austin	NSF	FT-ICR Mass Spectrometry Using a High-Field Resistive Magnet
McCombe, Bruce Wang, Yong-Jie Singh, Shailesh	SUNY, Buffalo NHMFL SUNY, Buffalo	NSF	Resonant Polaron Studies Study of 'X' Line at Higher Field

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Users	Institution	Funding	Project
Miller, John Miller, George Haslow, Mike	NHMFL NHMFL NHMFL	NSF	Multi-Element High-Temperature Superconductor Current Lead Heat-Load Test
Miller, John Walsh, Robert	NHMFL NHMFL	NSF	Critical Current and Field Tests on Hybrid Conductor Samples
Missell, Frank Romero, Sergio de Campos, Marcos* Landgraf, Fernando	IFUSP- Brazil IFUSP-Brazil IPT-Brazil IPT-Brazil	FAPESP	Anisotropy Field of $SmCo_5$ Magnets
Moulton, Bill Brooks, James Kuhns, Phil Uji, Shinya Reyes, Arniel	FSU FSU NHMFL NRIM NHMFL	NHMFL	^{77}Se NMR in the Spin Density State of $(TMTSF)_2PF_6$
Moulton, Bill Habiger, Trent* Abdelrack, Margie*	FSU Lutheran College FSU	NHMFL	Orientation of $Tb_{0.2}Y_{0.8}Ba_2Cu_3O_7$ Powder Samples for NMR
Murphy, Tim Palm, Eric	NHMFL NHMFL	NHMFL	Low Field Behavior of RuO_2 Resistors and Nuclear Orientation Thermometry
Musfeldt, Janice L. Wang, Yong-Jie Li, Guo Feng* Lee, Janice Long, Virginia* Wei, Xing Dong, Jian*	SUNY, Binghamton NHMFL SUNY, Binghamton SUNY, Binghamton SUNY, Binghamton NHMFL SUNY, Binghamton	SUNY Binghamton	Studies of the Inorganic Spin-Peierls System, $GeCuO_3$, as a Function of Magnetic Field and Temperature
Musfeldt, Janice L. Wang, Yong-Jie Schmeidel, Thomas Long, Virginia Zhu, Zheng Tao* Lee, Janice Wei, Xing Dong, Jian*	SUNY, Binghamton NHMFL NHMFL SUNY, Binghamton SUNY, Binghamton SUNY, Binghamton NHMFL SUNY, Binghamton	SUNY Binghamton	Spectroscopic Investigations of Magnetically Driven Phase Transitions in Organic and Inorganic Solids
Naughton, Mike Petrou, Athos Leone, Michael* Salib, Mike Na, Myung He* Luo, Hong	SUNY, Buffalo SUNY, Buffalo SUNY, Buffalo SUNY, Buffalo SUNY, Buffalo SUNY, Buffalo	NSF	Magnetization of GaAs Quantum Wells
Naughton, Mike Sushko, Yuri+	SUNY, Buffalo SUNY, Buffalo		Accurately Aligned Critical Fields in Superconductors

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DC Field Facility Users

USERS	INSTITUTION	FUNDING	PROJECT
Ng, Hon Kie Wang, Yong-Jie Samarth, Nitin Starr, Kevin* Fisk, Zachary Sarrao, John+	FSU NHMFL Penn State U. FSU FSU NHMFL	NSF	Magnetoresistance of Disordered Heavy Fermion Systems
Ng, Hon Kie LaSalle, Alex Wang, Yong-Jie	FSU LANL NHMFL	NSF	Magneto-Reflectance Measurements of FeSi That Resulted in No Field Dependence of the Conductivity with Field
Ng, Hon Kie Samarth, Nitin Wang, Yong-Jie	FSU Penn State U. NHMFL	NSF	Cyclotron Resonance in Modulation-doped $ZnSe/Zn_{1-x}Cd_xSe$ and $Zn_{1-x-4}Cd_xNa_3Se$ Heterostructures; Modifications of Effective Mass by Spins in the Quantum Well
Nurmikko, Arto V. Song, Yoon Kyu* Zhou, Hailong	Brown U. Brown U. Brown U.	NSF	Spectroscopy of Blue Green Semiconductor Light Emitting Heterostructures
Park, Yung Woo Hannahs, Scott Kim, Guy Tae* Choi, Eun Sang*	Seoul Natl. U. NHMFL Seoul Natl. U. Seoul Natl. U.	KOSEF	Magneto-Thermoelectric Power of Doped Polyacetylene and High T_c Superconductor
Pearton, Steve Geerts, Wilhelmus J. Schmiedel, Thomas	U. of Florida U. of Florida NHMFL	NHMFL	Test of the Kerr Effect Probe in the 20 T Magnet
Perenboom, Jos Brooks, James Hill, Steven Qualls, Jeremy* Sandhu, Pavi* Stalcup, Tom*	U. of Nijmegen NHMFL Montana State U. FSU Boston U. FSU	NSF	Angular Dependence Magnetoresistance of Ansiotropic Materials
Perenboom, Jos Brooks, James	U. of Nijmegen NHMFL	NSF	Angular Dependence Two DEG Quantum Hall Effect
Perenboom, Jos Qualls, Jeremy* Lyobouski, Ruslem Yagubskii, E. B.	U. of Nijmegen NHMFL CP Chernogolouka IPP Chernogolouka	NSF	Dependence of SdH Oscillations on Temperature and Sample-Field Angle

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USERS	INSTITUTION	FUNDING	PROJECT
Perenboom, Jos Brooks, James Dicapua, Paul* Stalcup, Tom* Nelson, Jane*	U. of Nijmegen FSU Miami High School FSU Orlando U. High School	NSF	Levitation of Non-Ferromagnetic Materials in Magnetic Fields
Perenboom, Jos Brooks, James Dalal, Naresh	U. of Nijmegen FSU FSU	NSF	Studies of Quantum Jumps in the Magnetization of Nano-Magnet Clusters by Cantilever Methods
Petrou, Athos Salib, Mike* Chang, Hui-Cheng* Kioseoglou, George* Luo, Hong Furdyna, Jack Haetty, Jens* Dutta, Mitra	SUNY, Buffalo SUNY, Buffalo SUNY, Buffalo SUNY, Buffalo SUNY, Buffalo U. of Notre Dame SUNY, Buffalo Army Research Lab.	NHMFL	Magneto Absorption of N-Type ZnSe/ZnCdMnSe Based Quantum Wells
Popovic, R.S. Schott, Christian* Bird, Mark Waser, Jean-Marc*	Swiss Federal Institute of Technology Swiss Federal Institute of Technology NHMFL Swiss Federal Institute of Technology	Switzerland	Characterization of New Hall Sensor Design
Rao, K.V. Ortega, Ricardo* Nicolaides, George Madurga, V. Inoue, Akihisa	Royal Institute of Technology U. Publica de Navarra Tech. Ed. Inst. of Piraeus U. Publica de Navarra Tohoku U.	NUTEK	High Field Properties of Bulk Amorphous Magnets
Reich, Shymon Schwartz, Justin Tsabba, Isaac Nakamae, Saco*	Weitzmann Institute of Science NHMFL Weitzmann Institute of Science FSU	NHMFL	Revealing the Cryogenic Temperature Normal State in Mercury Containing Superconductors
Reich, Shymon Schwartz, Justin Nakamae, Saco*	Weizmann Inst. of Technology FAMU/FSU College of Eng. FSU	NHMFL	Magnetoresistance of Hg-1223 Thin Films
Sarma, Bimal Ketterson, John Feller, Jeff+ Debashis, Dasgupta* Huanlin, Zhang*	U. of Wisconsin, Milwaukee Northwestern U. U. of Wisconsin, Milwaukee U. of Wisconsin, Milwaukee U. of Wisconsin, Milwaukee	NSF	High Field Ultrasonic Studies in the Heavy Fermion Systems
Sato, Akio Iijima, Yasuo Kosuge, Michio Yuyama, Michinari Matsumoto, Fumiaki	NRIM NRIM NRIM NRIM NRIM	Science & Tech. Agency, Japan	Development of Nb_3Al Wire for High Field Application

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Users	Institution	Funding	Project
Schmiedeshoff, George M. Stewart, Greg.	Occidental College U. of Florida	NHMFL	Development of a Magnetvolume Cell for Measurements at Very Low Temperatures for Both DC and Pulsed Magnets
Schmiedeshoff, George M. Smith, James L. Canfield, Paul Beyermann, Ward P. Lacerda, Alex	Occidental College Superconductivity Tech. Center Ames Lab. U. of California, Riverside NHMFL-LANL	NHMFL	Upper Critical Field Magnetoresistance Measurements
Schwartz, Justin Peterson, Simone Knoll, David* Amm, Kathleen Wolters, Christian+ Pamidi, Sastry Chen, Shelley*	FAMU/FSU College of Eng. FAMU/FSU College of Eng. FAMU/FSU College of Eng. FAMU/FSU College of Eng. NHMFL FSU FAMU/FSU College of Eng.	NSF	Microstructure and Superconducting Properties of Bulk Hg-Ba-Ca-Cu on Metallic Surfaces (VSM Measurement of Magnetization)
Schwartz, Justin Wei, Wangshui* Trociewitz, Ulf*	FAMU/FSU College of Eng. FAMU/FSU College of Eng. Aachen U.	Argonne & NHMFL	Development of High Temperature Superconductors for High Field Magnets
Schwartz, Justin Nakamae, Saco* Burkhardt, Earle*	FAMU/FSU College of Eng. FSU U. of Illinois	Naval Research. Lab.	Magnetothermal Conductivity of High Temperature Superconductors
Shaheen, Shahid Mendoza, Bill Coey, J. M.	FSU FSU FSU	NSF	High Field Crystallization of Magnet Materials
Shaheen, Shahid Coey, Michael Ozair, Arifa Mendoza, William* Neu, Volker	MARTECH Trinity College, Dublin MARTECH FSU MARTECH	ONR	Processing of Magnetic Materials in High Magnetic Fields for Inducing Texture and Anisotropy
Shivaram, Bellave S. Vernon, Ulrich*	U. of Virginia U. of Virginia		Unconventional Superconductivity and Magnetism in Heavy Electron Metals
Singleton, John Harrison, Neil Tam, Moon Sun* Honnold, Markus*	U. of Oxford LANL U. of Oxford U. of Oxford	Eng. & Phy. Sci. Res. Council	Transverse Magnetotransport of Alpha Phase ET Salts in High Field State
Smet, Jurgen Von Klitzing, Klaus Weiss, Deiter Coleridge, Peter Wegscheider, Werner	Max-Planck Institut, Stuttgart Max Planck Institute, Stuttgart Max-Planck Institut, Stuttgart Natl. Research Council TU-Munchen	Max-Planck Institut	Quasi-Classical Dynamics of Composite Fermions

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USERS	INSTITUTION	FUNDING	PROJECT
Stewart, Greg	U. of Florida	NSF	Specific Heat and Magnetization of Non-Fermi Liquid Systems to 33 T
Andraka, Bohdan	U. of Florida		
Thomas, Steve	U. of Florida		
Lumpe, Hetre*	U. of Augsburg		
Kim, Jung Soo	U. of Florida		
Hall, Donavan*	Louisiana State U.		
Shepard, Michele*	NHMFL		
Heuser, Karstan*	U. of Augsburg		
Tanner, David	U. of Florida	NSF	Infrared Studies of Correlated Systems: Cuprates, Manganites and Organics
Wang, Yong-Jie	NHMFL		
Ugawa, Akito	U. of Florida		
Hong, Sunkwang*	U. of Florida		
Gasaparov, Lev	U. of Florida		
Wrubel, Jonathan*	U. of Florida		
Taylor, Craig	U. of Utah	NSF	MR (High Magnetic Field) Studies of Chalcogenide Glasses
Parameswar, Hari	Texas A&M U.		
Moulton, Bill	FSU		
Su, Tining*	U. of Utah		
Kuhns, Phil	NHMFL		
Reyes, Arneil	NHMFL		
Tennant, Alan	Oak Ridge Natl. Lab.	ORNL	High Field Susceptibility/ Magnetization Measurements on the One-Dimensional Antiferromagnet
McMorrow, Desmond	Risoe Natl. Lab.		
Coldea, Radu*	Oxford U.-UK		
Cowley, Roger	Oxford U.-UK		
Terashima, Taichi	NRIM Tsukuba	NRIM	Quantum Oscillations and Field Induced Transitions in CeP in Very High Magnetic Fields
Brooks, James	FSU		
Hill, Steven*	FSU		
Perenboom, Jos	Nijmegen, HMFL		
Sandhu, Pavi*	Boston U.		
Stallcup, Tom*	FSU		
Han, So Young*	FSU		
Qualls, Jeremy*	FSU		
Terashima, Taichi	NRIM Tsukuba	NRIM	Experimental Transport and Magnetization Studies of Novel Materials and Superconductors
Brooks, James	FSU		
Qualls, Jeremy*	FSU		
Stallcup, Tom	FSU		
Han, So Young*	FSU		
Tessema, G.X.	Clemson U.	NHMFL	The Effect of High Magnetic Fields on the Ground State Properties of $Tl_2Mo_6Se_6$, an Unconventional Quasi-One-Dimensional Superconductor

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Users	Institution	Funding	Project
Thurnauer, Marion Angerhofer, Alex Scheer, Hugo Bubenzer, Clandion Hassan, Alia+ Brunel, L.-C. Bratt, Peter von Tol, Hans	Argonne Natl. Lab. U. of Florida Munchen U. Munchen U. FSU NHMFL U. of Florida Grenoble	DoE	High Field EPR Studies of the Photosynthetic Reaction Center
Tozer, Stan Wei, Xing	NHMFL NHMFL	NSF	Optical Measurements of Gallium Nitride
Tsui, Daniel C. Störmer, Horst L. Du, Rui R. West, Ken Pfeiffer, L. Yeh, Andrew*	Princeton U. Lucent Technologies U. of Utah Lucent Technologies Lucent Technologies Princeton U.	NSF	Fractional Quantum Hall Measurements as a Function of Angle
Uji, Shinya Brooks, James Sandhu, Pravindrajit S.* Hill, Steve	NRIM - Tsukuba FSU Boston College Montana State U.	NSF	Precision Magnetization Studies of Low-Dimensional Fermi Surfaces
Van Sciver, Steve Fisher, Verilyn Weijers, Huub Cochran, Vince Baudouy, Bertrand Hazelton, Drew Dur, Osman *	NHMFL NHMFL NHMFL NHMFL NHMFL Intermagnetics General Corp. NHMFL	NHMFL	Bi HTS Superconductivity for 1M Straight Sample I_c vs. B
von Molnár, Steve Wirth, Steffan Muller, Karl-Hartaiut Coey, Michael	FSU/MARTECH MARTECH IFW Dresden Trinity College, Dublin	ONR	Magnetization Measurements at Elevated Temperature to Investigate Field and Orientation Dependence of Spontaneous Polarization
von Molnár, Steve Coey, Michael Renyoust, Bertraund Wirth, Steffan Yu, Xaing	FSU/MARTECH Trinity College, Dublin MARTECH MARTECH MARTECH	ONR	MR, Hall, and Noise Measurements on $LaMnO_3$ and CrO_2 Films
Vuillemin, Joseph J. Goodrich, Roy G. Wolters, Christian+ Hall, Donavan*	U. of Arizona Louisiana State U. NHMFL Louisiana State U.	NHMFL	Fermi Surface Parameters in Highly Correlated Systems
Wang, Ziqiang Zhang, Biao* Qualls, Jeremy* Perenboom, Jos Young, So Brooks, James Simmons, Jerry	Boston College Boston College FSU U. of Nijmegen FSU FSU Sandia Natl. Labs.	NSF	Experimental and Theoretical Aspects of Quasi-Three-Dimensional Quantum Hall Systems

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USERS	INSTITUTION	FUNDING	PROJECT
Wang, Kang Wang, Yong-Jie	UCLA NHMFL	Army (SSDF)	Magnetotransport Study of Two-Dimensional Electron Gas in AlGaN/GaN Heterostructures
Weinstein, Roy Ren, Y. Liu, Jianxiong Parks, Drew	U. of Houston U. of Houston U. of Houston U. of Houston	NASA & NSF	Characterization for High Temperature Superconductor Trapped Field Magnets with New Types of Pinning Centers
Woo, Jong-Chun Kim, Daisik Ko, H. S.* Kim, Woo Sik, Kim, Do Hyum, Woo, D. H. Kim, Dae Wook Leem, Youngahn Kim, Y.M.* Kim, Yong Soo Rhee, S. J.* Schmiedel, Thomas	Seoul Natl. U. Seoul Natl. U. Seoul Natl. U. Seoul Natl. U. Seoul Natl. U. Korean Inst. of Sci. & Ind. Sun Moon U. Seoul Natl. U. Seoul Natl. U. Seoul Natl. U. Seoul Natl. U. NHMFL	KOSEF	Magnetoluminescence Studies of Excitonic State of Quasi-One-Dimensional Quantum Wire Super Lattice
Wosnitza, Jochen Brooks, James Qualls, Jeremy* Han, So Young Stalcup, Tom*	U. of Karlsruhe FSU FSU NHMFL FSU	NSF	Precision SdH & dHvA Studies of Low-Dimensional Fermi Surfaces
Yuen, Tan	Temple U.	NSF	Magnetic Properties of the 2D Magnetic System $CsFe_xAg_{x-1}Te_2$
Zheng, Guo-Qing Clark, Gil Moulton, Bill Reyes, Arneil Kuhns, Phil	Osaka U. UCLA NHMFL NHMFL NHMFL	Ministry of Ed - Japan	High Field NMR Studies of the Pseudogap in $YBa_2Cu_4O_8$

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NHMFL - Pulsed Field Facility

Users	Institution	Funding	Project
Arko, A. Cornelius,A.+ Harrison,N.+	LANL LANL NHMFL-LANL	DoE	De Haas van Alphen Measurements on U_2Zn_{17} and UGa_3
Baranov, N. Nakotte, H. Lacerda, A. H.	Ural State U., Russia NMSU NHMFL-LANL	University	Magnetization as a Function of High Magnetic Fields on Tb_3Co
Beyerman, W. P. Lacerda, A. H. Canfield, P. C.	UC, Riverside NHMFL-LANL Ames Labs.	NSF	Magnetoresistance of $RENi_2B_2C$
Beyermann, W. P. Lacerda, A. H. Canfield, P. C.	UC, Riverside NHMFL-LANL Ames Labs.	NSF	Heat Capacity Experiments in High Magnetic Fields of RENiBC
Beyermann, W. P. Yatskar, A.* Movschovich, R. Canfield, P. C. Lacerda, A. H.	UC, Riverside UC-Riverside LANL Ames Labs. NHMFL-LANL	NSF	Magnetotransport Measurements on PrAgCu
Boebinger, G. Mielke, C. H. Lacerda, A. H.	Lucent Technologies NHMFL-LANL NHMFL-LANL	Lucent Technologies	Magnetotransport Measurements on FeSi
Brooks, J. Mielke, C. H.	NHMFL-FSU NHMFL-LANL	NSF	Hall Effect Measurements on GaAs Quantum Wells
Brooks, J. Harrison, N.+ Mielke, C. H.	NHMFL-FSU NHMFL-LANL NHMFL-LANL	NSF	High Field Magnetotransport Measurements on $\kappa-ET_2I_3$
Brown, S. Klemme, B.* Clark, G. W.	UCLA UCLA UCLA	NSF, DoE	NMR Measurements on $(TMTTP)_2PF_6$
Clark, R. G. Dzurak, A. S. Kane, B. E. Lumpkin, N. E. O'Brien, J. Facer, G. R. Starrett, R. P. Skougarevsky, A.	HFNML, Australia HFNML, Australia HFNML, Australia HFNML, Australia HFNML, Australia HFNML, Australia HFNML, Australia HFNML, Australia	University	Magnetoresistance Measurements on High T_c Superconductors to 800 T
Clark, R. G. Starrett, R. P. Rickel, D. Arko, A. Harrison, N.+ Mielke, C. H.	HFNML, Australia HFNML, Australia NHMFL-LANL LANL NHMFL-LANL NHMFL-LANL	University	Test of a Nanofabricated Magnetometer to Use in Pulse Fields

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Users	Institution	Funding	Project
Cooley, J.+ Smith, J. L. Mielke, C. H.	LANL LANL NHMFL-LANL	DoE	Magnetotransport Measurements on SmB_2
Cornelius, A.+ Arko, A. Harrison, N.+	LANL LANL NHMFL-LANL	DoE	Magnetotransport Measurements on U_2Zn_{17}, and UCd_{11}
Crooker, S. A.+ Awschalom, D.	NHMFL-LANL UC, Santa Barbara	DoE	High-Speed Optical Spectroscopy in Single ZnMnSe Quantum Wells
Furdyna, J. Kim, Y.+	U. of Notre Dame NHMFL-LANL	NSF	High-Field Magneto-Photoluminescence and Magnetization in Magnetic Semiconductors
Goodrich, R. Harrison, N.+ Fisk, Z.	Louisiana State U. NHMFL-LANL NHMFL-FSU	NSF	De Haas van Alphen Measurements on $La_xCe_{1-x}B_6$ Intermetallics
Guertin, R. McCall, S.* Cao, G. Crow, J. Shepard, M.* Mielke, C. H. Harrison, N.+ Lacerda, A. H.	Tufts U. FSU NHMFL-FSU NHMFL-FSU FSU NHMFL-LANL NHMFL-LANL NHMFL-LANL	NSF	Magnetization Measurements of Ruthenates
Hill, S. Mielke, C. H.	Montana State U. NHMFL-LANL	NSF	High Sensitivity Microwave Spectroscopy of Molecular Conductors in Pulsed Fields
Jardim, R. Sandim, M.+ Torikachvili, M. S. Lacerda, A. H. Cohenca, P.*	USP, Brazil USP, Brazil San Diego State U. NHMFL-LANL USP, Brazil	University	Magnetization Measurements on CMR Materials
Jiang, H.-W. Lee, X.* Kim, Y.+	UC, Los Angeles UC, Los Angeles NHMFL-LANL	NSF	Magneto-Photoluminescence and Quantum Hall Effect Measurements of Semiconductors
Jiang, H.-W Dultz, S. C.*	UC, Los Angeles UC, Los Angeles	NSF and University	Metal-Insulator Transition Around the Half-Filled Landau Level in a Two-Dimensional Hole Gas

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Users	Institution	Funding	Project
Jones, Eric Kim, Y.+	Sandia Natl. Labs. NHMFL-LANL	NSF, DoE	Quantum Hall Effect of CdTe / CdMnTe
Jonston, D. C. Torikachvili, M. S. Harrison, N.+ Lacerda, A. H.	Ames Labs. San Diego State U. NHMFL-LANL NHMFL-LANL	DoE	High Field Magnetization Measurements on LiV_2O_4
Kwok, W.-K. Safar, H. Crabtree, G. W.	Argonne Natl. Lab UC, Irvine Argonne Natl. Lab	DoE	Magnetotransport Measurements and Vortex Studies of Irradiated YBCO
Labouriau, A. Earl, W.	LANL LANL	DoE	High Field Magnetization Measurements on Zeolite NaY
Lacerda, A. H. Betts, J.	NHMFL-LANL NHMFL-LANL	NSF	Dil Fridge Test
Lacerda, A. H. Jardim, R.	NHMFL-LANL USP, Brazil	NSF, DoE	Magnetotransport Measurements of CMR Materials
Lacerda, A. H. Canfield, P. C. Mielke, C. H. Bud'ko, S. L.	NHMFL-LANL Ames Labs. NHMFL-LANL CBPF, Brazil	NSF, DoE	Magnetotransport Measurements on $RESb_2$
Lacerda, A. H. Beyerman, W. P. Canfield, P. C.	NHMFL-LANL UC, Riverside Ames Labs.	NSF, DoE	Magnetotransport Measurements on $YbNi_2B_2C$
Lawrence, J. Figeroa, E.+ Mielke, C. H. Lacerda, A. H. Booth, C.+	UC, Irvine UC, Irvine NHMFL-LANL NHMFL-LANL LANL	NSF, DoE	High Field Magnetotransport Measurements on $BaVS_3$
Li, L. Rickel, D.	NHMFL-FSU NHMFL-LANL	NHMFL	Pulse Field Magnet Test
Mandrus, D. Sales, B. C. Keppens, V. Lacerda, A. H.	Oak Ridge Natl. Lab. Oak Ridge Natl. Lab. Oak Ridge Natl. Lab. NHMFL-LANL	DoE	High Field Magnetotransport Measurements on Skutterudites
Maple, B. M. Dickey, R. P.* de Andrade, M. C.+ Freeman, E. J.#	UC, San Diego UC, San Diego UC, San Diego UC, San Diego	DoE, NSF	Low Temperature, High Field Magnetotransport Measurements on (U, Th)Pd_2Al_3

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Users	Institution	Funding	Project
Mielke, C. H. Cooley, J.+ Smith, J. L. Rickel, D. Lacerda, A. H.	NHMFL-LANL LANL LANL NHMFL-LANL NHMFL-LANL	NSF, DoE	Magnetoresistance Measurements to 140 T on SmB_6
Mielke, C. H. Montgomery, R.	NHMFL-LANL U. of Indiana	NSF, DoE	Magnetotransport Measurements on α - $(BEDT\text{-}TTF)_2$ $TlHg(SCN)_4$, λ - $(BEDT\text{-}TSF)_2GaCl_4$ and κ - $(BEDT\text{-}TSF)_2GaCl_4$ to 140 T
Montenegro, F. C. Torikachvili, M. S. Lacerda, A. H.	UFPE, Brazil San Diego State U. NHMFL-LANL	University	High Field Magnetization and Relaxation Measurements of Spin Glass Systems: $(Fe, Zn)F_2$
Moshovich, R. Jaime, M.+ Mielke, C. H.	LANL LANL NHMFL-LANL	DoE	Magnetoresistance Measurements on RuO_2 Sensors
Nakotte, H. de Boer, F. R. Prokes, K.+ Torikachvili, M. S. Lacerda, A. H.	New Mexico State U. U. of Amsterdam Charles U., Prague San Diego State U. NHMFL-LANL	University	High Field Magnetotransport Measurements on UNiGa
Naughton, M. Leone, M.*	SUNY SUNY	NSF	Pulse Fields Cantilever Magnetometer Measurements on Organic Conductors
Neumeier, J. Torikachvili, M. S. Lacerda, A. H.	FAU San Diego State U. NHMFL-LANL	University	Magnetotransport Measurements on CMR Materials
Perry, Clive Kim, Y.+	Northeastern U. NHMFL-LANL	NSF	Magneto-Photoluminescence Measurements on AlGaAs/GaAs, with Low Carrier Concentration
Perry, Clive Munteau, F.* Kim, Y.+	Northeastern U. Northeastern U. NHMFL-LANL	NSF, DoE	Magnetoresistance and Spin Polarized Magneto-Photoluminescence Measurements of CdTe / CdMnTe
Phillips, N. Fisher, R. Schiling, A. Hundley, M. F.	UC, Berkeley U. of Zurich UC, Berkeley U. of Zurich LANL	DoE	High Temperature Heat Capacity Measurements on YBCO

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PULSED FIELD FACILITY USERS

USERS	INSTITUTION	FUNDING	PROJECT
Rickel, D. Schillig, J. Mielke, C. H. Boenig, H. Sims, J.	NHMFL-LANL NHMFL-LANL NHMFL-LANL NHMFL-LANL LANL	NSF	60 T QC Magnet Testing and Development
Safar, H. Maley, M. Krusin-Elbaum, L.	UC, Irvine LANL IBM	NSF	Magnetotransport Measurements on Cuprates and In-Plane Magnetoresistance and Magnetotransport Measurements on Bi:2212
Safar, H. Lopez, D.+ Kwok, W.-K.	UC, Irvine Argonne Natl. Lab. Argonne Natl. Lab.	NSF, DoE, University	Vortex Line Formation Investigations on Cuprates (Cuprat), C-Axis Magneto-resistance on Cuprates and I vs. V Measurements on Cuprates
Salamon, M. B. Jaime, M.+ Lin, P.* Chun, S.-H.+ Eckstein, J.	U. of Chicago, Urbana LANL U. of Chicago, Urbana U. of Chicago, Urbana Varian	NSF, University	Hall Effect Measurements on CMR Materials
Schmiedeshoff, G. M. Detwiler, J.* Lacerda, A. H. Canfield, P. C.	Occidental College Occidental College NHMFL-LANL Ames Labs.	NSF	Hc_2 Studies of $LuBNi_2C_2$
Schmiedeshoff, G. M. Canfield, P. C. Beyermann, A. P. Lacerda, A. H. Smith, J. L.	Occidental College Ames Labs. UC, Riverside NHMFL-LANL LANL	NSF	Magnetotransport Measurements on $(Lu, Y)Ni_2B_2C_2$, $(U, Th)Be_{13}$, UBe_{13} and YNi_2B_2C
Schmiedshoff, G. M. Lacerda, A. H.	Occidental College NHMFL-LANL	NSF, Other	Thermal Expansion Cell Test
Sechovisky, V. Arnold, Z. Lacerda, A. H. Syshenko, A.* Beyermann, A. P.	Charles U., Prague Prague Academy of Science NHMFL-LANL Charles U., Prague UC, Riverside	NSF	Magnetotransport Under Pressure on UNiGa
Sims, J.	LANL	DoE	Material for Pulse Magnet
Singleton, J Honold, M.*	Oxford U., UK Oxford U., UK	University	Angular Dependence Magnetoresistance Measurements on α-$(ET)_2khg(SCN)_4$

+POSTDOC **GRADUATE STUDENT* *#UNDERGRADUATE STUDENT*

Users	Institution	Funding	Project
Singleton, J. Honold, M.* Harrison, N.+	Oxford U., UK Oxford U., UK NHMFL-LANL	University	Hall Measurements on α-(ET)$_2$khg(SCN)$_4$ and κ-(BEDT-TTF)$_{13}$
Singleton, J. Honold, M.* Nam, M.-S.* Harrison, N.+ Mielke, C. H.	Oxford U., UK Oxford U., UK Oxford U., UK NHMFL-LANL NHMFL-LANL	University	Magnetotransport and Magnetization Measurements on α-(ET)$_2$khg(SCN)$_4$
Singleton, J. Harrison, Neil+	Oxford U., UK NHMFL-LANL	DoE, DOD	Magnetotransport Measurements on κ-(BEDT-TTF)$_2$ Cu[N(CN)$_2$]Br
Srdanov, V. Kim, Y.+	UC, Santa Barbara NHMFL-LANL	NSF	C60 Transmittance Optical Limiting Studies
Tessema, G. Gamble, B.* Lacerda, A. H.	Clemson U. Clemson U. NHMFL-LANL	NSF	Density Wave Studies on $PrSb_2$
Tessema, G. Gamble, B.* Lacerda, A. H.	Clemson U. Clemson U. NHMFL-LANL	NSF, DoE, University	Hall Measurements on $NbSe_3$ and $PrSb_2$
Tessema, G. Gamble, B.* Mielke, C. H. Lacerda, A. H.	Clemson U. Clemson U. NHMFL-LANL NHMFL-LANL	NSF, DoE	Magnetotransport Measurements on $Tl_2Mo_6Se_6$
Tessema, G. Pirskusky, E.* Lacerda, A. H.	Clemson U. INSA, France NHMFL - LANL	NSF, DoE	Superconductivity Beyond Hc_2
Tessema, G. Gamble, B.* Mielke, C. H. Lacerda, A. H.	Clemson U. Clemson U. NHMFL-LANL NHMFL-LANL	NSF	Upper Critical Field Studies in $Tl_2Mo_6Se_6$
Thompson, J. D. Sarrao, J. L. Lacerda, A. H. Modler, R.+	LANL LANL NHMFL-LANL LANL	DoE	High Field Magnetization Measurements of $CeRh_2Si_2$, Heavy Fermions ($CeRu_2Si_2$) and of Kondo Insulators ($Ce_3Bi_4Pt_3$)
Thompson, J. D. Modler, R.+ Sarrao, J. L.	LANL LANL LANL	DoE	Magnetic Field Response of SmB_6 via High Field Magnetization Measurements

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Pulsed Field Facility Users

Users	Institution	Funding	Project
Torikachvili, M. S. Nakotte, H.	San Diego State U. New Mexico State U.	University	Low Temperature Magnetization Measurements on UPSn
Tozer, S. Hannahs, S. Mielke, C. H.	NHMFL-FSU NHMFL-FSU NHMFL-LANL	NHMFL	High Pressure Electrical Measurements on $(TMTSF)_2PF_6$ and $(TMTTF)_2PF_6$
Tozer, S. Kim, Y.+	NHMFL-FSU NHMFL-LANL	NHMFL	High Pressure Optical Measurements of GaN
Wosnitza, J. Mielke, C. H. Harrison, N.+	U. of Karlsruhe NHMFL-LANL NHMFL-LANL	University	Magnetization and Magnetotransport Measurements on κ-ET_2I_3
Yokoi, H. Tozer, S. Kim, Y.+ Crooker, S. A.+	ISSP-Japan NHMFL-FSU NHMFL-LANL NHMFL-LANL	ISSP	High-Pressure, High-Field Photoluminescence Measurements on Semiconductors

+*Postdoc* *Graduate Student #Undergraduate Student

NHMFL - NMR Facility

Users	Institution	Funding	Project
WB 300, WB 400, WB 600 MHz (NHMFL/FSU)			
Degarmo, H.* Achey, R.* Dalal, N. Fu, R. Bodenhausen, G.	FSU FSU NHMFL/FSU NHMFL Ecole Normale Superieure	NHMFL	High Resolution Solid State NMR Techniques and Applications to Materials Science
Glazier, J. Prause, B.	U. of Notre Dame	NSF	Foam Dynamics
Locke, B Moerland, T. Caban, J.* Penke, B. Vanderlinde, O. Shelly, D. Carbone, F.	FSU/FAMU NHMFL/FSU FSU FSU FSU FSU FSU	Whitaker Foundation	Analysis of Transdermal Drug Delivery by Iontophoresis and Electroporation Using Pulsed Field Gradient NMR
Bowers, R. Fanucci, G.E. Talham, D.R.	NHMFL/UF UF UF	NSF NHMFL	Structural Characterization of Layered Metal Organophosphate Langmuir Blodgett Films by Phosphorous-31 MAS NMR
Bowers, R. Vitkalov, S. Schmiedel, T. Moulton, W. Kuhns, P.	NHMFL/UF UF NHMFL NHMFL/FSU NHMFL	NSF	Field and Wavelength Dependence of the Optical Overhauser Effect in Indium Phosphide
Chopin, L.* Gullion, T. Stiegman, A.	FSU FSU FSU	NSF NHMFL	^{51}V Solid State NMR
Samoson, A. Anupold, T. Reinhold, A.	Inst. Chem. Phys. & Biophysics, Tallinn, Estonia	NATO NHMFL	DOR and DAS Probes
Fu, R. Randall, E.W.	NHMFL Queen Mary & Westfield Coll. England	NHMFL	^{14}N NMR in Solid State
Tian, F.* Fu, R. Cross, T.A.	FSU NHMFL NHMFL/FSU	NSF	^{13}C CPMAS NMR of Gramicidin A in Lipid Bilayers
Zhang, L.* Song, Z.+ Cross, T.A.	FSU NHMFL NHMFL/FSU	NHMFL	^{15}N CPMAS NMR of M2 TMP in Lipid Bilayers

+*Postdoc* *Graduate Student* #*Undergraduate Student*

Users	Institution	Funding	Project
Pelupessy, P.* Bodenhausen, G.	NHMFL Ecole Normale Superieure	NHMFL	Solid State NMR
Bull, L.	UC, Santa Barbara	NSF	^{17}O DOR Studies of Zeolites
Mahieu, N.* Randall, E.W.	Queen Mary & Wesfield Coll. England	NHMFL	^{13}C and ^{15}N Solid State NMR of Soils
Smith, M. Yang, Q.* Briggs, R.	Penn State U. Penn State U. NHMFL/UF		Removal of Magnetic Susceptibility Distortions in High-Field Magnetic Resonance Imaging
Butler, L. Bryant, P.L.*	Louisiana State U. Louisiana State U		Multiple Quantum Cross Polarization MAS
Randall, E.W. Samoilenko, A.A.	Queen Mary & Westfield Coll. England Inst. of Chem. Physics, Russia	NHMFL	Stray Field NMR Imaging
Lindblom, G. Strandberg, E.*	U. Umea, Sweden U. Umea, Sweden	NSF Sweden Science Foundation	Characterization of the Pgs E Polypeptide in Oriented Lipid Bilayers
Shelly, D.	U. Cincinnati	NSF	Microimaging
Blackband, S. Webb, A. Grant, S. Mareci, T.	NHMFL/UF UIUC UF NHMFL/UF	NHMFL	Microcolenoid Development for Ultra High Resolution Microscopy
Cotten, M.* Fu, R. Cross, T.A.	FSU NHMFL NHMFL/FSU	NIH	^{2}H NMR of Oriented Lipid Bilayers Containing Gramicidin A
Fu, R.	NHMFL	NHMFL	Solid State MAS NMR
Park, J.K.* Gibbs, S.	FSU/FAMU NHMFL/FSU	NHMFL	PFG NMR Studies of Flow and Dispersion in Chromatography
Pavlovskaya, G.+ Gibbs, S.	NHMFL NHMFL/FSU	NHMFL	MRI of Fluid Dynamics at Interfaces
Tian, F. Wang, J.* Cross, T.A.	FSU FSU NHMFL/FSU	NIH	Cation Binding to the Ion Channel Gramicidin A in Lipid Bilayers by Solid State NMR

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Users	Institution	Funding	Project
Kovacs, F. Song, Z.+ Wang, J.* Fu, R. Cross, T.A.	FSU NHMFL FSU NHMFL NHMFL/FSU	NSF	Development of ^{15}N and ^{2}H Structural Constraints for the M2 Protein of Influenza A Virus by Solid State NMR
833 MHz (NHMFL/FSU)			
Soghomonian, V.+ Cotten, M.* Cross, T.A.	NHMFL FSU NHMFL/FSU	NSF	^{2}H NMR Spectroscopy Development at High Fields
Randall, E.W. Samoilenko, A.A.	Queen Mary & Westfield Coll. England Inst. of Chem. Physics, Russia	NHMFL	Stray Field NMR Imaging
500 MHz (NHMFL/UF)			
Bharatam, J. Bowers, C.R. Storhaug, V.J. Gaffney, B.	UF NHMFL/UF UF NHMFL/FSU	NIH NHMFL	Xenon Adsorption and Exchange in Lyophilized Soybean Lipoxygenase: Optically Pumped NMR at Variable Temperature
600 MHz (NHMFL/UF)			
Espinoza, E.* Edison, A.	UF NHMFL/UF	Howard Hughes MIRR Program	Structural Studies of Small Neuropeptides
Zachariah, C.* Edison, A.	UF NHMFL/UF	American Heart Association	Structure of FMRFamide Bound to the FMRFamide-Gated Sodium Channel
Cain, B.* Sorgen, P.* Edison, A.	UF UF NHMFL/UF		Characterization of the b Subunit of F1-ATPase
Nikolau, B.* Edison, A.	Iowa State U. NHMFL/UF		Effects of Mutation on the Structure of a Biotin Binding Domain Protein

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Users	Institution	Funding	Project
400 MHz w/HTS Probe (NHMFL/FSU)			
Murali, N.	NHMFL	NHMFL	RF Transmit and Receive Properties of a High Resolution NMR Probehead Made with HTS Ceramics
Logan, T. Greenbaum, N. Newby, M.*	NHMFL/FSU NHMFL/FSU FSU	NIH	Enhanced Detection of Long-Range NOEs Using QUIET-NOESY Experiments and the HTS Probe
Logan, T. Wang, G. Murali, N. Jolivet, C. Holton, R.	NHMFL/FSU FSU NHMFL FSU FSU		Enhanced Detection of Weak ^1H-^1H NOEs in Natural Product Structure Determination Using an HTS Probe
720, 500 & 300 MHz (NHMFL/FSU)			
Boulat, B.	NHMFL	NHMFL	Spin Nutation and Relaxation at High Fields
Meersman, T.+ Bodenhausen, G.	NHMFL Ecole Normale Superieure	NHMFL	Quadrupolar Splitting in Xe-131 at High Magnetic Fields
Cutting, B.* Bodenhausen, G.	NHMFL Ecole Normale Superieure	NHMFL	Solution NMR
Xu, F. Cross, T.A.	FSU NHMFL/FSU	NIH	Catalytic Role of Solvent on Protein Structural Rearrangements
Newby, M.* Greenbaum, N.	FSU NHMFL/FSU	NIH	Structural Features of the U2 snRNA-intron Interaction
Greenbaum, N. Eschgafaller, B.* Benner, S.*	FSU UF UF		Structural Features of Dimethylene Sulfone-Bridged DNA Analogs
Callihan, D.* Logan, T.	FSU NHMFL/FSU	NIH	Characterization of Peptide Fragments to Mimic Early Stages of Protein Folding

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NMR Facility Users

Users	Institution	Funding	Project
Callihan, D.* Logan, T.	FSU NHMFL/FSU	NIH	Measuring Distances in Unfolded Proteins Through Paramagnetic-Enhanced Nuclear Relaxation
Wylie, G. Murphy, J.R. Logan, T.	FSU Boston Univ. NHMFL/FSU	NIH NHMFL	Structure Determination of Diptheria Toxin Repressor C-Terminal Domain
Murali, N. Logan, T.	NHMFL NHMFL/FSU	Petroleum Res. Fund	Enhancing Dipolar Cross-Relaxation by Suppressing Competing Relaxation Pathways
Rao, B.D.N. Lin, Y.*	IUPUI	NIH	Transfer-NOE Measurements of Bound Nucleotide Conformations
Murali, N.	NHMFL	NHMFL	Relaxation in Coupled Spin-1 to Spin-1/2 Systems
Resistive Magnets (NHMFL/FSU)			
Bowers, R. Vitkalov, S. Reno, J. Simmons, J.	NHMFL/UF UF Sandia Natl. Labs. Sandia Natl. Labs.	NSF	Electrical Transport Detection of Nuclear and Electron Spin Resonance in the Quantum Hall Effect
Bowers, R. Vitkalov, S. Schmiedel, T. Moulton, W. Kuhns, P.	NHMFL/UF UF NHMFL NHMFL/FSU NHMFL	NSF	Field and Wavelength Dependence of the Optical Overhauser Effect in Indium Phosphide
Soghomonian, V.+ Cotten, M.* Cross, T.A.	NHMFL FSU NHMFL/FSU	NSF	^{2}H NMR Spectroscopy Development at High Fields
Soghomonian, V.+ Bird, M. Cross, T.A.	NHMFL FSU NHMFL/FSU	NSF	Development of Improved Homogeneity on the Keck Magnet

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Users	Institution	Funding	Project
15/17 T Superconducting Magnet			
Angerhofer, A. Bratt, P.+ Smith, P.+ Evans, M.	U. of Florida U. of Florida U. of London U. of London	NHMFL	Photosynthesis
Blinc, R. Arcon, D.+ Maniero, A.L. Brunel, L.-C.	U. of Ljubliana U. of Ljubliana U. of Padua NHMFL	NHMFL	C60 Based Systems
Brunel, L.-C. Dagotto, E. Hassan, A.+ Martins, G.+ Cao, G.	NHMFL NHMFL NHMFL NHMFL NHMFL	NSF	Zn Doped $CuGeO_3$
Brunel, L.-C. Rohrer, M. Krzystek, J.	NHMFL NHMFL NHMFL	NHMFL	Fabry-Perot Cavities
Brustolon, M. Maniero, A.L. Segre, U. Bonora, M.* Brunel, L.-C.	U. of Padua U. of Padua U. of Modena U. of Padua NHMFL	CNR (Italy)	γ Irradiated Urea Inclusion Compounds
Krzystek, J. Budil, D. Smith, G.+ Wylde, R.^ Earle, K.+ vanTol, H. Brunel, L.-C.	NHMFL Northeastern U. St Andrew Thomas Keating, Inc. Cornell U. NHMFL NHMFL	NHMFL	Quasi Optical Designs
Dalal, N. Cage, B.* Brunel, L.-C.	FSU FSU NHMFL	NHMFL	Low Dimensional Magnetic Systems
Eaton, G. Krzystek, J. Brunel, L.-C.	U. of Denver NHMFL NHMFL	NSF	Ultramarine Blue
Furdyna, J. Brunel, L.-C. McCarty, A.*	U. of Notre Dame NHMFL NHMFL	NSF	Magnetic Semiconductors

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EMR Facility Users

USERS	INSTITUTION	FUNDING	PROJECT
Hendrickson, D. Aubin, S. Temple, W. Christou, G. Dilley, N.R. Maple, M.B. Krzystek, J. Pardi, L. Brunel, L.-C.	UC, San Diego UC, San Diego Indiana U. Indiana U. UC, San Diego UC, San Diego NHMFL NHMFL NHMFL	NSF NHMFL	Mn_4 Clusters
Hendrickson, D. Ruiz, D.+ Hassan, A.+ Maniero, A.L.	UC, San Diego UC, San Diego NHMFL U. of Padua	NSF/NIH	Single Molecule Magnets
Hendrickson, D. Knapp, M.* Krzystek, J.	UC, San Diego UC, San Diego NHMFL	NSF	Oxygen Activation in Ribonucleotide Reductase
Hoffman, B. Goldberg, D.+ Krzystek, J.	Northwestern U. Northwestern U. NHMFL	NSF	Metalloporphyrazins
Pardi, L. Reedijk, J. Hassan, A.K.+	U. of Pisa U. of Leiden NHMFL	CNR (Italy)	1D Antiferromagnetism
Makinen, M. Mustafi, E.+ Krzystek, J.	U. of Chicago U. of Chicago NHMFL	NIH	Vanadyl Ions
Maniero, A.L. Pasimeni, L. Pardi, L. Brunel, L.-C. Cao, G. Guertin, R.	U. of Padua U. of Padua U. of Pisa NHMFL NHMFL Tufts U.	CNR (Italy)	C60-TDAE
Meisel, M. Granroth, G.* Maegawa, S. Fanucci, G.* Talham, D.R. Bell, N.S. Adair, J.H. Chou, L.K.^ Krzystek, J. Brunel, L.-C.	U. of Florida U. of Florida U. of Kyoto U. of Florida U. of Florida U. of Florida U. of Florida Taiwan NHMFL NHMFL	NSF	Haldane Spin Systems
Rutherford, W. MacMillan, F. Rohrer, M. Brunel, L.-C.	CEA Saclay CEA Saclay U. of Freiburg NHMFL	CNRS	Membrane Proteins

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USERS	INSTITUTION	FUNDING	PROJECT
Oseroff, S. Rettori, C. Sarrao, J. Hassan, A. Martins, G. Brunel, L.-C.	San Diego State U. Campinas LANL NHMFL NHMFL NHMFL	NHMFL	Li Doped La_2NiO_4
Robinson, B. Krzystek, J. Brunel, L.-C.	U. of Washington NHMFL NHMFL	NSF NHMFL	Spin-Label Dynamics
Sienkiewicz, A. Krzystek, J. Pardi, L. Brunel, L.-C.	SUNY, Albany NHMFL NHMFL NHMFL	NHMFL	DPPH
Talham, D. Fanucci, G.* Krzystek, J. Brunel, L.-C.	U. of Florida U. of Florida NHMFL NHMFL	NSF	AFMR in Landmuir-Blodgett Films
Tesler, J. Pardi, L. Krzystek, J. Brunel, L.-C.	Roosevelt U. U. of Pisa NHMFL NHMFL	NHMFL	Chromium (II) Systems
Krzystek, J. von Schutz, J. Brunel, L.-C.	NHMFL U. of Stuttgart NHMFL	NHMFL	Low-D Conductors
Yuen, T. Hassan, A. Brunel, L.-C.	Temple U. NHMFL NHMFL	NHMFL	CsFeAgTe Magnetic Layers
20 T, 52 mm Bore Resistive Magnet (Keck)			
Angerhofer, A. Bratt, P.+ Evans, M. Hassan, A.+	U. of Florida U. of Florida U. of London NHMFL	NHMFL	Photosynthesis
Brunel, L.-C. Hassan, A.+ Maniero, A.L. vanTol, H.+	NHMFL NHMFL NHMFL NHMFL	NHMFL	Instrument Development
Freed, J. Earle, K.+ Hassan, A.+	Cornell U. Cornell U. NHMFL	NSF	Motional Dynamics
Giacometti, G. Maniero, A.L.	U. of Padua U. of Padua	CNR (Italy)	Photosynthesis
Thurnauer, M. Angerhofer, A. Bratt, P.+ Hassan, A.+ vanTol, H.	Argonne Natl. Labs. U. of Florida U. of Florida NHMFL NHMFL	DoE	Photosynthesis

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EMR FACILITY USERS

NHMFL - ICR Facility

Users	Institution	Funding	Project
Andrén, P. E. Bondesson, U. Emmett, M. R. Marshall, A. G.	U. Uppsala U. Uppsala NHMFL NHMFL/FSU	STINT and NSF ICR Facility	Analyze Conjugated Drug Metabolites by Micro-Electrospray Mass Spectrometry
Drader, J. J.+ Hendrickson, C. L. Shi, S. D.-H.* Marshall, A. G. Blakney, G.* Laude, D. A.*	NHMFL NHMFL FSU NHMFL/FSU U. Texas, Austin U. Texas, Austin	NSF ICR Facility	Digital Quadrature Heterodyne ICR Detection
Ekern, S. P.+ Szczepanski, J.+ Vala, M. Marshall, A. G.	NHMFL UF UF NHMFL/FSU	NSF ICR Facility	Photostability of Gaseous Polycyclic Aromatic Hydrocarbons
Emmett, M. R. White, F. M.* Bonneau, R.# Hendrickson, C. L. Marshall, A. G. Conrad, C. A.	NHMFL FSU NHMFL NHMFL NHMFL Trinity Lutheran Kansas City, MO	NSF ICR Facility	Identification of Endogenous TGFα Growth Factors
Hendrickson, C. L. Emmett, M. R. Marshall, A. G. Boehlein, S. K.+ Richards, N. G. J. Schuster, S. M.*	NHMFL NHMFL NHMFL/FSU UF UF UF	NSF ICR Facility	*E. coli* Asparagine Synthetase-B
Leary, J. A. König, S.+ Freitas, M. A.+ Marshall, A. G.+	UC, Berkeley UC, Berkeley NHMFL NHMFL/FSU	NSF and NSF ICR Facility	Metal Clusters; Dendrimer Polymers; Bioinorg. Complexes
Li, G.-Z. Jarrell, J. A. Marshall, A. G.	Waters Corp. Waters Corp. NHMFL/FSU	Waters Corp. and NSF ICR Facility	Combined Ion Trap Theory
Marçalo, J. Carretas, J. M.* Pires de Matos, A. Marshall, A. G.	ITEN, Lisbon ITEN, Lisbon ITEN, Lisbon NHMFL/FSU	NATO	Gas Phase Reactions of Thorium and and Uranium with Alcohols
Naito, Y.+ Gaskell, S. J. Hendrickson, C. L. Marshall, A. G.	U. MIST, England U. MIST, England NHMFL NHMFL/FSU	NSF ICR Facility	Isomerization of Protonated Gas-Phase Peptides
Pope, R. M.+ Rivera, M. White, F. M.* Marshall, A.G.	Brigham Young U. Oklahoma State U. FSU NHMFL/FSU	NSF ICR Facility	Heme Stability of Cytochrome *b5* Mutants

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Users	Institution	Funding	Project
Reinhold, B. E.+ Marshall, A. G.	Boston U. Med Sch. NHMFL/FSU	NSF ICR Facility	Cooling of Penning-Trapped Ions
Rodgers, R. P.* Andersen, K. Marshall, A. G.	FSU Haldor-Topsoe NHMFL/FSU	NSF ICR Facility and Haldor-Topsoe	Mechanism of Catalytic Hydro-Treatment of Diesel Fuels
Shi, S. D.-H.* Hendrickson, C. L. Marshall, A. G. Siegel, M. M. Kong, F. Carter, G. T.	FSU NHMFL NHMFL/FSU Wyeth-Ayerst Wyeth-Ayerst Wyeth-Ayerst	NSF ICR Facility	Oligosaccharide Analysis
Simonsick, W. J. Aaserud, D. J.+ Shi, S. D.-H.* Hendrickson, C. L. Marshall, A. G.	DuPont DuPont FSU NHMFL NHMFL/FSU	DuPont and NSF ICR Facility	Copolymer Analysis
Wang, F.+ Emmett, M. R. Hendrickson, C. L. Li, W.* Marshall, A. G. Zhang, Z.-Y. Wu, L.+	NHMFL NHMFL NHMFL FSU NHMFL/FSU Einstein Coll. Medicine Einstein Coll. Medicine	NIH and NSF ICR Facility	Effects of Inhibitors and Mutations on Protein Tyrosine Phosphatase
Wigger, M. Watson, C. H. Eyler, J. R. Benner, S. Li, W. Marshall, A. G.	UF UF UF UF FSU NHMFL/FSU	NHMFL In-House Grant NIH, NSF ICR Facility	Screening of Combinatorial Libraries by Electrospray FT-ICR MS

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SEMINARS

APPENDIX B

Seminars sponsored by the NHMFL from January 1, 1997, through June 30, 1998, are listed below. Entries noted by asterisks were held at the University of Florida, and further information about them is provided at the end of the listing.

January 6, 1997
L.D. Hall
Herchel Smith
Laboratory for Medicinal Chemistry, University of Cambridge
Can Quantitative MRI Be Used to Measure the Status of Human Articular Joints?

January 9, 1997
Ross McKenzie
University of New South Wales
Magnetoresistance and Phase Diagram of Low-Dimensional Organic Conductors in High Magnetic Fields

January 13, 1997
Thomas Schmiedel
NHMFL
Anomalous Photoluminescence Intensity and Giant Red Shift in Diluted Magnetic Semiconductors at High Magnetic Fields

January 14, 1997
Ross McKenzie
University of New South Wales
Quantum Phase Transitions in Random Spin Chains

January 16, 1997
Judy Chen
Lawrence Livermore National Laboratory
A Comprehensive Electromagnetic Analysis of AC Losses in Large Scale Superconducting Magnets

January 17, 1997
Marvin Cohen
University of California at Berkeley
Predicting New Materials: Alchemy with Computers

January 23, 1997
Lawrence R. Lawson
Northwestern University
Strength vs. Conductivity and Another Inverse Curve

January 24, 1997
Christie Enke
University of New Mexico
Flights of Fancy: A Novel GC/MS System Based on Time-of-Flight

January 24, 1997
Myriam Sarachik
The City University of New York
The Metal-Insulator Transition in Doped Semiconductors

January 27, 1997
Earle Burkhardt
NHMFL
Three-Dimensional Numerical Analysis of the Stability of Bi-2223/Ag Tape Conductors

January 31, 1997
Steven White
University of California at Irvine
Ground State Phases of Doped t-J Ladders

January 31, 1997
Joseph D. Seymour
Massey University
Pulsed Gradient Spin Echo (PGSE) Nuclear Magnetic Resonance (NMR) Studies of Flow and Dispersion in Porous Media and Hydrodynamic Instabilities

February 3, 1997
Liselotte Schioler
National Science Foundation
Materials Research at the National Science Foundation

February 5, 1997
Yoshihiro Asai
Electrotechnical Laboratory, Tsukuba
The Superconducting Ground State in the 2D t-t' Hubbard Model

February 6, 1997 ***
Robert G. Schulman
Yale University
Magnetic Resonance Images of Brain Function

February 7, 1997
Saul Oseroff
San Diego State University
Evidence of Spin Dynamics on $R_{1-x} B_xMnO_3$ (R=La, Pr, Sm; B=Ca, Ba)

February 10, 1997
Iain Dixon
NHMFL
External Reinforcement of the 900 MHz NMR Magnet

February 11, 1997
John D. Dow
Arizona State University
Experiment and Theory: The Case for Superconductivity Associated with Charge-Reservoirs, Not Cuprate-Planes

February 13, 1997
Chris Grovner
Oxford University
Bi-2212 and TL-1223 Tapes and Coils; Fabrication and Testing Studies at Oxford

February 14, 1997
Ravin Bhatt
Princeton University
Phase Transitions of Two-Dimensional Electron Gases in Magnetic Field

February 17, 1997
Arnaud Devred
CEA/Saclay
LHC Quadrupole Magnet Development Activities at Saclay

February 17, 1997
A.M. Niraimathi
Max Planck Institute
Magnetic Ordering and Superconductivity in HTSC-Ga Substituted Nd123 and Sm214 as Model Systems

February 17, 1997
Gordon Thomas
Lucent Technologies/Bell Laboratories Innovations
Invisible Metals

February 20, 1997
Frank P. Missell
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Institute of Metal Physics, Ekaterinburg, Russia; Atomic Institute of the Austrian Universities; NHMFL; International Laboratory of High Magnetic Fields and Low Temperatures, Wroclaw, Poland
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Optimal Use of Magnetic Energy in a Magnet

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Superconductivity of $(RE)_{2-z}Ce_zCuO_4$ *and* $(RE)_{2-z}Ce_zSr_2Cu_2MO_x$*, Where RE is a Rare Earth, x~10, and M=Nb, Ta, Ti, or Ru: More Evidence for the Charge-Reservoir Oxygen Model of High-Temperature Superconductivity*

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Yasuhide Shindo
Tohoku University
Cryomechanics of Structural Alloys and Insulators

* Seminar held at UF, as part of the 26th Annual Lecture Series "Frontiers of Science"
** Seminar held at UF
*** Seminar held at UF, as part of the Imaging Science Visiting Lecture Series

Key Personnel & Committees

Appendix C

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NHMFL Committees

External Advisory Committee

Members of the External Advisory Committee are appointed by the Chancellor of the State University System and meet twice a year. The committee reviews and evaluates the overall performance of the laboratory and provides recommendations to the Chancellor.

George W. Crabtree, Chair
Argonne National Laboratory

Gilbert Clark
University of California at Los Angeles
Chair, NHMFL Users Committee

Donald U. Gubser
Naval Research Laboratory

Eric Jones
Sandia National Laboratories

Brian Maple
University of California at San Diego

Eric Oldfield
University of Illinois at Urbana-Champaign

Raymond Orbach
University of California at Riverside

Chancellor Charles B. Reed
California State University

Peter Roemer
Advanced Mammography Systems

Carl H. Rosner
Intermagnetics General Corporation

Ray Shaw
Varian Associates, Inc.

Theoren P. Smith, Chair Elect
IBM-Watson Research Center

Peter Wyder
High Field Magnet Laboratory, Grenoble, France

Representative of
Southeastern University Research Association (SURA)

Users' Committee

Members of the Users' Committee are nominated and elected by the user community. The committee provides guidance on the equipment and policies needed for the development and utilization of the laboratory's facilities.

Charles Agosta
Clark University

Meigan Aronson
University of Michigan

Greg Boebinger
Bell Laboratories and Lucent Technologies

Gilbert Clark, Chair
University of California at Los Angeles

Jack Furdyna
University of Notre Dame

Larry Kevan
University of Houston

Martin Maley
Los Alamos National Laboratory

Janice Musfeldt
State University of New York at Binghamton

Mike Naughton
State University of New York at Buffalo

Clive Perry
Northeastern University

Regitze Vold
University of California at San Diego

Research Program Committee

The NHMFL Research Program Committee (RPC) is charged with promoting the In-House Research Program (IHRP) and with encouraging the highest quality research among the laboratory's research communities. The committee evaluates research opportunities available to the NHMFL and recommends programs for the use of NHMFL facilities and resources. It oversees the IHRP, encourages the formation of collaborative research efforts, establishes worldwide channels for communication, and identifies cutting-edge high magnetic field research programs. The committee, through its chair, administers the funding of the IHRP. Members of the RPC also participate in the Users' Program proposal review and evaluation.

NHMFL/FSU

James Brooks
Zachary Fisk, Chair
Lev Gor'kov
Alan Marshall
Stan Tozer
Stephan von Molnar

NHMFL/UF

John Graybeal
Kevin Ingersent
Thomas Mareci

NHMFL/LANL

Alan Bishop
Chris Hammel
Joe Thompson

Executive Committee

The NHMFL Executive Committee reviews and advises management on a broad range of issues including organization, staffing, resource allocation, and budgeting. Members take into account the objectives and mission of the laboratory, external reviews, and internal evaluations of the overall program. The committee is chaired by the director of the laboratory.

Jack E. Crow
Director and Co-Principal Investigator, FSU

Don Parkin
Co-Principal Investigator, LANL

Neil Sullivan
Co-Principal Investigator, UF

J. Robert Schrieffer
Chief Scientist

Hans Schneider-Muntau
Deputy Director

Steven Van Sciver
Director, Magnet Science and Technology

Bruce Brandt
Director, Continuous Fields Facility

Greg Boebinger
Director of Pulsed Fields Facility

Louis-Claude Brunel
Center for Interdisciplinary Magnetic Resonance (CIMAR) Representative

Zachary Fisk
Chair, Research Program Committee

Arthur Edison
University of Florida Representative

Jim Ferner
Chief Administrative Officer

Janet Patten
Director, Public and Governmental Relations

Addendum to *Volume I - Research*

Appendix D

The following information was inadvertently omitted from *1997 NHMFL Annual Report, Volume 1-Research,* Chapter 4: Publications, Presentations & Related Activities.

Peer-Reviewed Publications

Cao, G.; Freibert, F. and Crow, J.E., *Itinerant-to-Localized Electron Transition Perovskite* $CaRu_{1-x}Rh_xO_3$, J. Appl. Phys., **81**, 3884 (1997).

Cao, G.; McCall, S. and Crow, J.E., *Observation of Itinerant Ferromagnetism and Metamagnetism in* $Sr_3Ru_2O_7$ *Single Crystals*, Phys. Rev. B, **55**, **R**672 (1997).

Cao, G.; McCall, S.; Crow, J.E. and Guertin, R.P., *Multiple Magnetic Phase Transitions in Single Crystal* $(Sr_{1-x}Ca_x)_3Ru_2O_7$ $(0 \le x \le 1.0)$, Phys. Rev. B., **56**, 5387 (1997).

Cao, G.; McCall, S.; Crow, J.E. and Guertin, R.P., *Observation of a Metallic Antiferromagnetic Phase and Meta-Nonmetal Transition in* $Ca_3Ru_2O_7$, Phys. Rev. Lett., **78**, 1751 (1997).

Cao, G.; McCall, S.; Shepard, M.; Crow, J.E. and Guertin, R.P., *Magnetic and Transport Properties of Single Crystal* $Ca_3Ru_2O_4$*: Relationship to Superconducting* Sr_2RuO_4, Phys. Rev. B, **56R**, 2916 (1997).

Cao, G.; McCall, S.; Shepard, M.; Crow, J.E. and Guertin, R.P., *Thermal, Magnetic and Transport Properties of Single Crystal* $Sr_{1-x}Ca_xRuO_3$ $(0 \le x \le 1.0)$, Phys. Rev. B., **56**, 321 (1997).

Cao, G.; McCall, S.K.; Crow, J.E. and Guertin, R.P., *Ferromagnetism in* $Sr_4Ru_3O_{10}$*: Relationship to Other Layered Metallic Oxides*, Phys. Rev. B, **56R**5740 (1997).

Skanthakumar, S.; Lynn, J.W.; Rosov, N.; Cao, G. and Crow, J.E., *Observation of Pr Magnetic Order in* $PrBa_2Cu_3O_7$, Phys. Rev. B, **55R**, 3406 (1997).

Presentations and Posters

Dunford, R.B.; Popovic, D.; Pollak, F.H.; Noble, T.F.; Wojtowicz, M. and Streit, D.C., *Magnetotransport Investigation of High Density AlGaAs/InGaAs and InAlAs/InGaAs Quantum Wells*, APS Meeting, Kansas City, MO, March 17-21, 1997.

Li, K.P.; Popovic, D. and Washburn, S., *Conductance Fluctuations Near the Two-Dimensional Metal-Insulator Transition,* 12th International Conference on Electronic Properties of Two-Dimensional Systems, Tokyo, September, 1997.

Li, K.P.; Popovic, D. and Washburn, S., *Statistical Analysis of Magnetoconductance in a Mesoscopic 2DEG*, APS Meeting, Kansas City, MO, March 17-21, 1997.

Popovic, D. and Washburn, S., *Mesoscopic Behavior Near a Two-Dimensional Metal-Insulator Transition*, APS Meeting, Kansas City, MO, March 17-21, 1997.

Popovic, D., *Metal-Insulator Transition in Two Dimensions*, physics colloquium, University of North Carolina at Chapel Hill, October, 1997.

Popovic, D., *Two-Dimensional Metal-Insulator Transition in Si-Based Devices*, Workshop on Quantum Phase Transitions in Disordered Systems, Aspen Center for Physics, July, 1997.

Popovic, D.; Fowler, A.B. and Washburn, S., *Metal-Insulator Transition in a Low-Mobility Two-Dimensional Electron System*, 12th International Conference on Electronic Properties of Two-Dimensional Systems, Tokyo, September 1997.

Related Activities

Continuing Grants

PI: D. Popovic, S. Washburn
Grant Title: Experimental Studies of Correlation Effects in Quantum Insulators
Agency: NSF
Dates of Grant: 7/1/95-2/28/98
Award Amount: $225,000