NHMFL

National High Magnetic Field Laboratory

1998 Annual Report

Volume 2 – Programs

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NHMFL National High Magnetic Field Laboratory

1998 Annual Report Volume 2 – Programs

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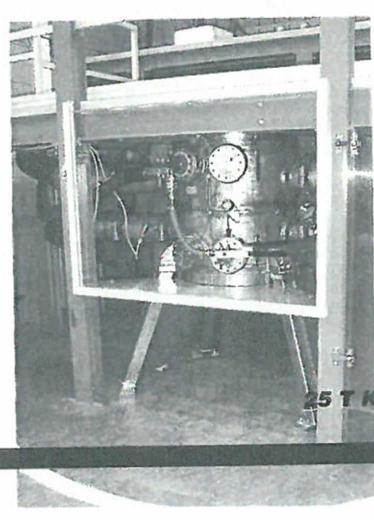
INTRODUCTION

This year's reporting brings closure to another highly active and productive year for the National High Magnetic Field Laboratory (NHMFL) and also coincides with a major strategic planning initiative for the laboratory as it approaches the end of its first decade and looks toward the future. The last nine-year period has seen many rapid and bold changes for this young national facility.

A number of significant achievements have been made that were not fully envisioned or proposed in the initial National Science Foundation (NSF) charge to the laboratory, but have evolved out of advances in magnet design capabilities and new science frontiers at all three consortium sites. For example:

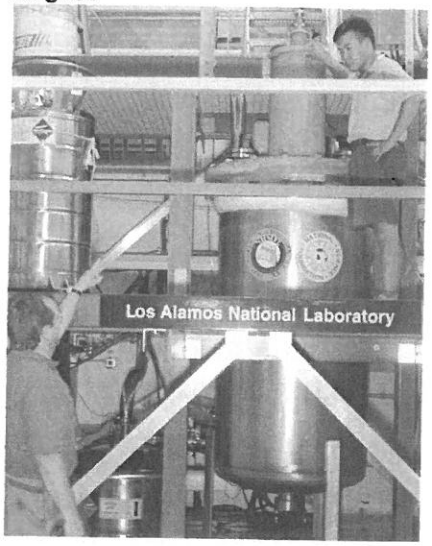
- *Today, researchers routinely and simultaneously conduct experiments in two different 33 tesla (T) resistive magnets that are so acoustically quiet that the researchers cannot even tell if the power and cooling systems are activated. This was not thought possible nine years ago.*
- *The fact that NMR research is being done in resistive magnets at fields of 25 T and 30 T was not thought conceivable a decade ago. This unique high field NMR capability has opened a totally new avenue for research in condensed matter physics.*
  The one-of-a-kind "Keck" 25 T magnetic resonance magnet with the demonstrated stability of the magnetic field better than 1 part per million (ppm) and the homogeneities approaching 1 ppm is opening exciting new research opportunities in chemistry and biology.
- *During the last year, the laboratory has built on our cooperation with sister laboratories around the world by signing a cooperative agreement with Catholic University at Nijmegen. As many may be aware, the Netherlands has decided to modernize the very successful Nijmegen magnet laboratory and has funded a new 20 megawatt (or more) power supply, cooling system, and pulsed field facility, all to be housed in a new facility. The NHMFL looks forward to working with our Nijmegen colleagues as they develop their new laboratory, and we would like to acknowledge the fine spirit of international cooperation that has been characteristic of our relationship with the French-German magnet laboratory in Grenoble, France, and the Japanese magnet laboratory in Tsukuba, Japan.*

Portable dilution refrigerator in 33 T magnet



25 T Keck magnet

60 T Long – Pulse magnet

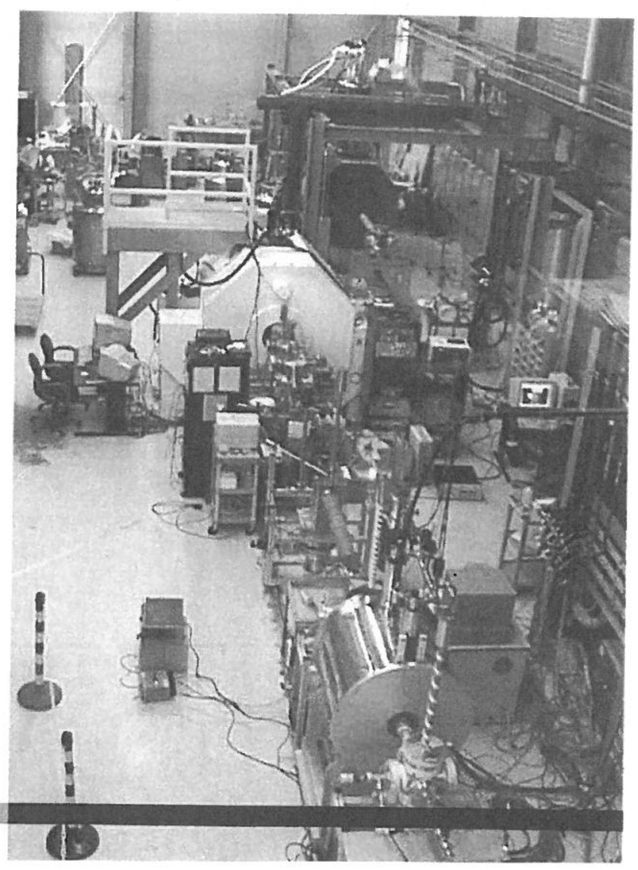


At the nation's first-ever national pulsed magnetic field user facility, users can routinely access fields of 60 T+ with impressively rapid cool down times.

The NHMFL has been dedicated to pushing pulsed fields higher by developing non-destructive pulsed magnets that approach 80 T in a 10 millimeter (mm) bore. Certainly, the most notable achievement of the NHMFL this past year has been the commissioning of the 60 T Long-Pulse magnet. The world's only 60 T long-pulse magnet powered by Los Alamos' unique power generation capabilities is driving exciting science opportunities. Researchers are still exploring the unique features of this new magnet system. With its unique capacity to tailor the pulse shape to the needs of the researcher, the 60 T Long-Pulse already has demonstrated capabilities previously thought impossible in pulsed magnet systems. For example, by programming the 60 T Long-Pulse with a series of short regions with constant magnetic field, researchers have been able to demonstrate the ability to measure specific heat at low temperatures and high magnetic fields to 60 T. This early demonstration of the new magnet capabilities represents the first measurement of specific heat at 60 T. It is clear that this is only the start and many more surprising applications of this system will be pursued through the inventiveness of the users and the staff of the NHMFL Pulsed Field Facility at Los Alamos National Laboratory.

Ion Cyclotron Resonance (ICR) Mass Spectroscopy was not even recognized in the original NHMFL proposal, however, today the highest precision mass spectrometers in the world are housed in the NHMFL ICR facility. This facility is funded by the Chemistry Division of NSF. Collaborators from all over the world work with the ICR group on such diverse science areas as examining neuropeptide metabolism in diseased versus healthy animals to identification and verification of desulfurization of crude oil. Another new capacity at the NHMFL is the opening of the magnetic resonance imaging (MRI) facility. NHMFL's MRI high field facility is housed in the state-of-the-art Brain Institute at the University of Florida that pushes the frontiers of neuroscience and instrumentation techniques. NHMFL researchers have recently achieved resolutions to study the internal structure of single living cells for the first time.

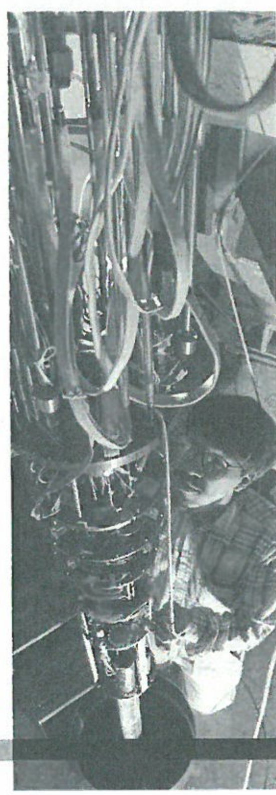
NHMFL FT-ICR Facility



An unprecedented and model federal and state partnership created the NHMFL facilities and infrastructure to support users pursuing multidisciplinary science opportunities at the highest fields available in the world. The NHMFL user community represents a very board cross-section of American universities, colleges, and research institutions and includes an ever-expanding list of international users from every part of the globe. At the DC Field Facilities, there is a constant demand for the 30 and 33 T resistive magnets, along with a significant wait for magnet time. The top loading dilution refrigerator available on the 33 T powered magnet provides an unprecedented 25 millikelvin (mK) to users, in addition to other innovative instrumentation constantly being added to the NHMFL inventory. Magnet use at the Pulsed Field Facility increases each year at an impressive rate–especially considering that the United States never had pulse field capabilities open to the general user community a decade ago.

There have been many accomplishments at the NHMFL during the past year, and only a few highlights are presented here. More detailed reporting may be found in the corresponding chapters of this annual report.

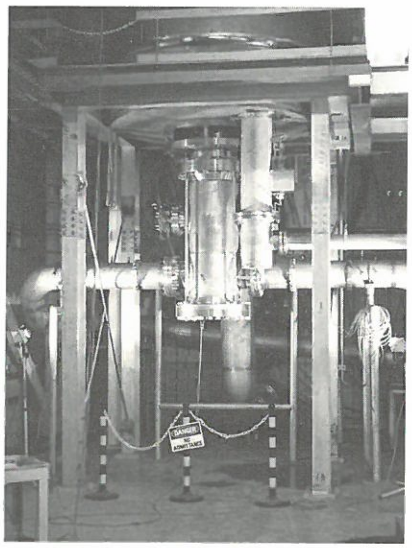
The world's only 60 T Long-Pulse magnet was commissioned at the NHMFL's Pulsed Field Facility at Los Alamos in late August, 1998. Dignitaries from the National Science Foundation, the U.S. Department of Energy, Florida State University System, and University of California System were on hand to celebrate this significant engineering achievement and the scientifically important partnership. This unique user magnet represents a 50 percent increase in peak-field capability over existing magnets of its class. One of the key features of the 60 T Long-Pulse is the incredible flexibility offered to experimentalists to tailor the magnetic-field pulse shape in response to the demands of the experiment. The magnet can be pulsed every hour and the magnetic-field pulse shape can be changed from pulse to pulse at the wishes of the user. Smooth magnetic field sweeps from 60 T down to 0 T have been demonstrated to last more than two seconds. Stair-step pulse shapes have been effectively used for specific heat measurements up to 60 T.



Utilizing the existing Microkelvin Laboratory at the University of Florida, the NHMFL has developed an ultra low temperature, high field capability that opened to users during this last year. The NHMFL High B/T Facility at the University of Florida provides experimental capabilities for studies that require temperatures down to 0.4 mK and fields up to 20 T. Users completed an important nine-month-long series of experiments on the fractional quantum Hall effect this year, and new experiments on high field magnetization of solid helium three are being installed. There is great interest in this facility and a small

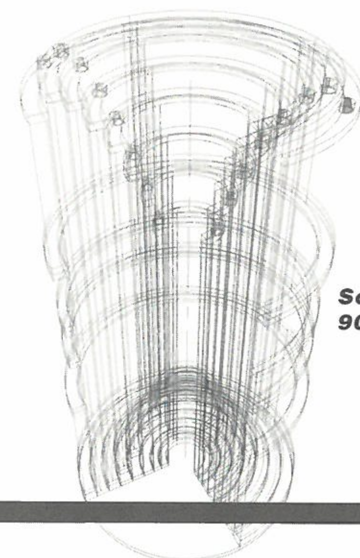
High B/T Facility

international workshop was held to review new and prospective experiments and to explore ways that the facility might be reconfigured to accommodate more users and reduce the long wait times.



45 T Hybrid

At the DC Field Facilities in Tallahassee, the 45 T Hybrid magnet was completed and installed. The resistive insert coil reached 32.4 T and the 14-ton superconducting coil is being cooled down to 1.8 K at an intentionally slow rate. Testing of the magnet will proceed throughout the summer of 1999 in order to prepare the very large magnet system for users. The 900 MHz wide bore NMR magnet is progressing well both at the NHMFL and with our industrial partner, Intermagnetics General Corporation. Two of the ten superconducting coils have been fabricated. An external technical review of the magnet was conducted this year, and the magnet's challenging design was deemed to be technically sound.



Schematic of 900 MHz magnet

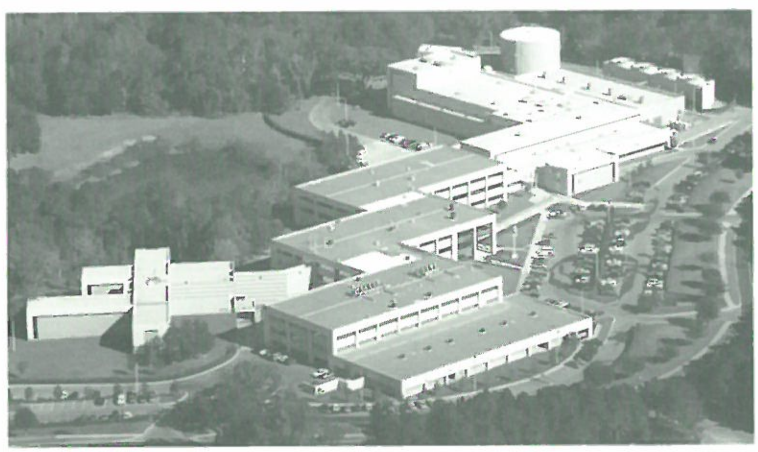
A Large Magnet Component Test Laboratory at the DC Field Facilities in Tallahassee was developed initially to fulfill the requirements of the Magnet Science and Technology group for the complex development needs of the 45 T Hybrid magnet and the 900 MHz wide bore NMR magnet system. More recently, however, these testing facilities have been used for the research and development needs of various government organizations and the private sector. These facilities will continue to address both internal and external user needs. Extensive work is underway to perform tests on the Navy's superconducting magnetic energy storage (SMES) prototype magnet system.

The number of research reports in Volume 1 of the 1998 NHMFL Annual Report, published in the first quarter of 1999, grew by 15 percent over the previous year–to 293 individual reports. These reports represent fifteen scientific disciplines, including biology, chemistry, geochemistry, materials engineering, magnet technology, cryogenics, and all aspects of condensed matter physics. While the growing number of reports is noteworthy–the quality and interdisciplinary nature of the research activities are greater measures of the strength and maturity of the scientific program of the laboratory.

Two separate international conferences attracted over 400 leading scientists to the NHMFL in October, 1998. Among the conferees were two of the three new Nobel Prize winners in physics, Horst Störmer and Robert Laughlin, for the fractional quantum Hall effect. The third Nobel laureate, Daniel Tsui, was unable to attend the conference, but both he and Störmer are frequent users of NHMFL facilities in Tallahassee and Gainesville. The Second North American FT-ICR Mass Spectrometry Conference was held on the West Coast and attracted 128 researchers, a significant increase from the first conference in 1997. The larger participation is indicative of the increasing number and use of FT-ICR mass spectrometers around the world.

"Science, Tobacco & You" curriculum materials

The NHMFL's Center for Integrating Research and Learning has developed into an impressive and important contributor to all aspects of teaching and learning science and has combined unique approaches to exploring scientific inquiry with hands-on instruction. This year, the Center unveiled its newest curriculum product, *Science, Tobacco & You*. The State of Florida Anti-Tobacco Program funded the development of this educational product. *Science, Tobacco & You* is aimed at 4th and 5th graders and has been distributed to all elementary schools in Florida. The curriculum encourages students to use science while reinforcing tobacco prevention; it includes an interactive compact disc that allows students to create a "virtual you," hands-on activities for the classroom, access to a specially designed web site, and other materials. The Center's educators held training workshops for teachers in eleven Florida cities and received rave reviews for their interesting and exciting new approaches to teaching science.



NHMFL in Tallahassee

The number of NHMFL collaborations with the private sector, other research institutions, federal agencies, and international laboratories has grown at an impressive rate and scope. Industrial collaborations have increased by 60 percent, and NHMFL researchers engage in significant projects with most other national and international magnet laboratories.

USERS PROGRAMS

CHAPTER 1

Highlights • While the highest field magnets get most of the glory, magnets with different bore diameters and other special properties are also needed to do important experiments. A new Bitter magnet provides 27 T steady fields for users who need a 50 mm room temperature bore. Coils are being designed to be wrapped on bore tubes of other diameters to provide modulating fields for magnetometry and NMR.

- Stan Tozer developed a new high pressure sample probe that allows one to change the pressure in a diamond anvil cell without removing it from the cryostat. The amount of data that can be taken in a given shift was thereby increased about eight times.
- The 60 T Long-Pulse magnet at NHMFL-Los Alamos is proving to be an experimentalist's dream because of its high field, long pulse, and especially the ability to tailor the magnetic field pulse shape. This spectacular new pulsed magnet and some ingenious experimenters have made sensitive specific heat measurements feasible in magnetic fields up to 60 T, twice the field possible before.
- A high resolution, optical spectroscopy capability has been developed around a sensitive, high speed CCD camera. This capability is in high demand for use in the 40 T and 60 T long-pulse magnets because hundreds of spectra can be taken as the field sweeps through a single pulse.
- Scientists from all over the world have called to learn about an innovative heat exchanger for cooling samples to 1 mK at the High B/T Facility in Gainesville. This heat exchanger was first used to answer a long standing question about the fractional quantum Hall effect.
- Fred McLafferty and coworkers at Cornell and Harvard used the NHMFL's 9.4 T electrospray FT-ICR mass spectrometer to resolve and identify 571 peptides in a complex 191 kDa protein digest *without prior separation.* Peptide masses ranged from 300 to 30,000 Da and varied in concentration by 3 orders of magnitude. The work appeared in a technical feature article in *Science* magazine (*Science* **284**, 1289-1290 (1999)).
- Geochemistry researchers have continued and expanded their work on the evolution of the earth and the application of high magnetic field mass spectrometry to environmental problems.

General Purpose DC Field Facilities-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 major systems provide a broad magnetic field-temperature-pressure-angle "parameter space" to researchers. Two dilution refrigerators offer 40 mK sample temperatures in fields to 33 T. Diamond anvil high pressure cells permit optical and transport measurements to 14 GPa at temperatures from 40 mK to 300 K. Magneto-optical measurements can cover wavelengths from the near ultraviolet to far infrared. Non-optical measurements of transport properties can be done at DC through audio frequency AC to millimeter and microwave frequencies. Magnetic properties of materials can be measured optically, by AC susceptibility, cantilever force and torque, and vibrating sample magnetometry. Nuclear magnetic resonance (NMR) and electron magnetic resonance (EMR) (both spin and cyclotron resonance) provide unique insights into materials, including many of interest to biologists and chemists. Sample rotators allow researchers to vary not only the amplitude of the applied magnetic field but also its angle with respect to the sample. NHMFL staff often help visitors develop new instruments for unique experiments not possible with the general purpose instrumentation that is kept on hand for everyone.

The research in the DC general purpose facility is supported by magnet-plant and cryogenic system operators and by mechanical, electronic, and computer engineers and technicians. Eight scientists and an engineer whose specialties cover the kinds of measurements commonly done at the NHMFL work directly with users. Other members of the

NHMFL's scientific staff also support the user program by developing instrumentation and collaborating with visitors.

We continue to support remote collaborators with hardware and software that allow any member of a research group to connect directly to the experimental areas at all three NHMFL sites. Remote collaborators can view data and modify experimental strategies "live" during the magnet runs.

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

Continuous Field General Purpose Magnets, Changes Since July 1, 1998

The 25 T, 52 mm bore Bitter magnet, developed with funds from the Keck Foundation and NHMFL, ***was used several times for EMR and solid state NMR measurements.*** Ferromagnetic shims were added to the bore tube to bring the homogeneity to within about 12 ppm over a 1 cm DSV.

The cryogenic systems and the resistive insert for the 45 T Hybrid were tested successfully. We expect to test the complete hybrid magnet system in early July, 1999.

A 27.1 T, 54 mm ID Bitter magnet was first used June 1, 1999. A variety of bore tubes will be developed for it to improve homogeneity, add a gradient to the maximum field, and/or modulate the magnetic field. This magnet also provides a field over 25 T for users who need a 50 mm room temperature bore and do not need the high homogeneity "Keck" magnet.

Table 1. Magnet systems available to users at the DC Field Facility, Tallahassee, as of June, 1999, and the kinds of experiments that can be done in them.

Superconducting Magnets

Field (T), Bore (mm)	Temperature	Supported Research
18/20, 52 17.5/19.5, 52 15, 45	20 mK - 2 K 0.4 - 300 K 10 mK - 1 K	Magneto-optics (ultraviolet through far infrared); magnetization; specific heat; transport; high pressure; low to medium resolution NMR; dependence of optical and transport properties on field orientation, etc.

Resistive and Hybrid Magnets

Field (T), Bore (mm)	Power (MW)	Supported Research
20, 195 24.5, 32* 25, 52* 27, 32 to 50 30, 32 33, 32 45, 32**	20 15 19 15 20 30	Magneto-optics (ultraviolet through far infrared); magnetization; specific heat; transport; high pressure; low to medium resolution NMR; EMR; dependence of optical and transport properties on field orientation, etc. Temperatures from 40 mK to 800 K.

* Higher homogeneity magnet
** Under development

Magnet Power Supply and Cooling System Update

A recent decision to upgrade the magnet plant control system allowed us to change the way users control and read the magnetic field. Scott Hannahs created the new interface, which is much faster than the original system and makes automatic control from within data acquisition programs much cleaner and easier. The new system also makes it possible to read the magnet current directly from the high precision, high accuracy current sensors built into the power supplies instead of reading it via analog summing and dividing circuits.

Instrumentation for Users of the Continuous Field General Purpose Magnets

Stan Tozer has developed a new high pressure sample probe using diamond anvils for use in the resistive DC magnets. This new apparatus allows one to load liquid helium, the most hydrostatic fluid/solid available, as a pressure medium and subsequently change the pressure *in situ*. Thus the amount of data (number of pressures) that can be taken in a given shift is dramatically increased. In its first week of use, the cell was taken to 120 kbar, brought back to 5 kbar, and then stepped between 5 and 80 kbar. The optical data (peak width at half maximum and peak position) showed that there was no degradation of the sample. The cell was adjusted to sixteen different pressures during four 4-hour shifts, about four to eight times more data than was previously possible in that time.

Eric Palm and Tim Murphy have developed a new rotator for the portable dilution refrigerator. It has a single, horizontal axis of rotation and is driven by a micrometer screw that is turned by a stepping motor with computer control software developed by Mark Whitton and Scott Hannahs. The sample space is a cylinder 0.300" in diameter, and it accommodates samples that can be rotated inside of a 0.600" diameter cylinder. The repeatability is better than 0.1 degree. The resolution is better than 0.01 degree. The range of motion is 300 degrees. Users can now change the angle between the sample and the field in all DC magnet systems over a temperature range from 20 mK to 300 K. A two-axis rotator is available for fields up to 20 T.

Phil Kuhns developed an NMR probe with multiple nuclei in a single sample so that a magnet can be calibrated at five fields between 4 T and 33 T without re-tuning the spectrometer. A magnet that has been calibrated with this spectrometer can then be used to calibrate field sensors to better than 100 ppm accuracy at the same fields.

A higher resolution, GPIB-controlled power supply was purchased for the 18/20 T Oxford superconducting magnet that contains a dilution refrigerator. It allows more automated data acquisition and greater resolution in setting the field.

Color LCD monitors have been installed on all the data acquisition computers in the DC field facility. They greatly ease the problem of observing multiple data traces on computers in the magnet cells.

Donavan Hall built two two-position AC susceptometers: one for the resistive magnets and one for the 18/20 T dilution refrigerator. He also has put together a mutual inductance bridge for use with the AC susceptometers.

Donavan also adapted for use at the NHMFL the metal film cantilever magnetometer developed by Taichi Terashima, a Visiting Scientist from the National Institute for Research on Metals in Tsukuba, Japan. The metal film cantilever nicely fills the sensitivity gap between the silicon cantilevers and the vibrating sample magnetometer.

DC Facility Operation and User Statistics, July 1, 1998 through June 30, 1998

Number of Projects	110
Number of Research Groups	101
Number of Students	83
Number of Postdocs	20

Magnet Day Statistics	Resistive	Superconductor	Percent
User Affiliations			
NHMFL, UF, FSU, FAMU, LANL	179	234	30%
U.S. Universities	172	208	27%
U.S. Government Labs	23	13	3%
Industry	55	0	4%
Overseas	155	95	18%
Test, Calibration & Maintenance	51	70	8%
Idle	10	130	10%
Total: 1395	645	750	100%

Pulsed Field Facility-Los Alamos

LANL is home to the NHMFL's Pulsed Field Facility because of that laboratory's unique facilities for the production of pulsed electrical power. The Pulsed Field Facility provides experimental capabilities for a wide variety of measurements in pulsed magnetic fields. The 50 T and 60 T short-pulse magnets (25 ms pulse) and the 40 T long-pulse magnet (600 ms pulse) are powered by a 1.2 MJ capacitor bank. The newly-commissioned 60 T Long-Pulse magnet (2000 ms pulse) is driven by a 1.4 GVA motor generator set and five 64 MW power supplies. The power supplies regulate the voltage applied to the 60 T Long-Pulse magnet and provide the capability to tailor the magnetic pulse shape to the requirements of the experiment and the desires of the experimentalist.

All of the NHMFL pulsed magnets are available to qualified users from the United States or abroad, from universities, national laboratories, or industrial laboratories. This past year, approximately 50 different user groups came to the Pulsed Field Facility to perform high field experiments. Additional information on magnets, instrumentation, and personnel, as well as a Research Proposal Form can be found at the Pulsed Field Facility web site *(http://www.lanl.gov/mst/nhmfl/)* or by contacting Alex H. Lacerda at *lacerda@lanl.gov* or 505-665-6504.

Magnet Update

The most exciting magnet development at the Pulsed Field Facility during 1998 involved the 60 T Long-Pulse magnet, which has been available for user experiments since September 1, 1998. The 60 T Long-Pulse has proven to be quite reliable, having already provided around 400 full field pulses to experimentalists measuring transport, specific heat, and photoluminescence.

The pulsed magnet design group is developing the next generation of capacitor-bank-driven magnets reaching 77.8 T non-destructively in a 10 mm bore. The pulsed magnet group also builds state-of-the-art pulsed magnet systems for other national laboratories and universities.

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

Table 2. Magnet systems available to users at the Pulsed Field Facility at Los Alamos, as of June, 1999, and the kinds of experiments that can be done in them.

Pulsed

Field (T), Bore (mm)	Pulse Rise/Duration (ms)	Supported Research
50, 24 60, 15 40, 24[1] 60, 32	6/15 6/15 70/600 1000/2000 (100 ms at 60 T)	Magneto-optics (ultraviolet through far infrared); magnetization; transport. Temperatures from 50 mK to 300 K. Pressure from ambient to 3 GPa.

Superconducting

Field (T), Bore (mm)	Supported Research
19.5, 52	Same as pulsed fields, plus thermal expansion and specific heat. Temperatures from 20 mK to 600 K.
9, 32	Magneto-optics (ultraviolet to near infrared)

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

The 19.5 T superconducting magnet is now equipped with high pressure capabilities. Under the auspices of the National Science Foundation Division of International Programs, a pressure cell was built and tested to 10 kbar. The cell was built at the Czech Academy of Sciences by Prof. Jiri Kamarad. The first results utilizing this new capability include high field, high temperature, magnetotransport measurements on a single crystal sample of the heavy Fermion compound UNiGe. Analysis of relevant resistivity and magnetoresistance anomalies allows one to determine pressure-induced changes of critical temperatures and magnetic fields of the magnetic phase transitions in this material.

The Short-Pulse Users' Program is steadily growing, with 49 different research projects and groups and 150 group visits between July, 1998, and June, 1999. These numbers are roughly double those from last year. This large one-year increase resulted from the extra commitment to the Users' Program by everyone at the Pulsed Field Facility immediately prior to the moving of the experimental hall to a new building. The new 14,000 square foot experimental hall will offer expanded user capabilities when the Pulsed Field Facility reopens early in 2000. The international reputation of the Pulsed Field Facility is evidenced by the fact that 20 percent of our users travel from overseas to perform their experiments here.

The short-pulse magnets are extensively used for magnetotransport and magnetization measurements. Recently R. G. Goodrich (LSU), N. Harrison (NHMFL), A. Teklu (LSU), D. Young (NHMFL), and Z. Fisk (FSU) demonstrated the unique capability of pulsed magnetic fields to measure the effective carrier mass in a heavy Fermion alloy, mapping the development of the heavy mass with increasing Ce concentration in $Ce_xLa_{1-x}B_6$ alloys (*Phys. Rev. Lett.* 82, 3669 (1999)).

One key feature of the 60 T Long-Pulse magnet is the incredible flexibility offered to experimentalists to tailor the magnetic field pulse shape in response to experimental demands. Magnetic fields for the "flat-top" pulses have been held constant at 60 T for as long as 100 ms, at 50 T for 200 ms and at 40 T for 500 ms. This spectacular new pulsed magnet has made sensitive specific heat measurements feasible in magnetic fields up to 60 T, a doubling of the peak magnetic field at which this important thermodynamic quantity can be measured. This achievement by R. Movshovich, M. Jaime (LANL), G. Stewart (University of Florida), and W.P. Beyermann (UC Riverside) was made possible through funding from an NHMFL In-House Research Program award. Preliminary measurements of the heat capacity of UBe_{13} (a heavy Fermion compound) and $Ce_3Bi_4Pt_3$ (a Kondo insulator) have been performed and manuscripts are in preparation.

Over the past 18 months, a high resolution, optical spectroscopy capability has been developed around a sensitive, high speed CCD camera. This capability is in high demand for use in the 40 T and 60 T long-pulse magnets. For example, Yongmin Kim (NHMFL), F. Munteanu, C.H. Perry (Northeastern), X. Lee, H.W. Jiang (UCLA), K.S. Lee (ETRI-Korea), and J.A. Simmons (Sandia) have studied the high magnetic field exciton states in a series of heavily doped GaAs/AlGaAs single heterojunctions (SHJ). In the regime of small Landau-level filling factor, $\nu<1$ and $1<\nu<2$, they have found strong excitonic bound states. Since SHJs have an open valence band structure, these bound states result from strong Coulomb interactions in intense magnetic fields.

Another optical spectroscopy experiment is the study of photoluminescence polarization from nanometer-scale CdSe quantum dots by S.A. Crooker (NHMFL), E. Johnston-Halperin, D. Awschalom (UC Santa Barbara), and P. Alivisatos (UC Berkeley). Chemically synthesized CdSe quantum dots are studied in high magnetic fields to 60 T, and show a strong polarization of the photoluminescence at low temperatures. This result is somewhat surprising, considering that leading models of quantum dot band structure indicate that the ground state should be a J=2, optically-inactive exciton. These data suggest an additional, spin-conserving channel for optical recombination.

An effort to develop instrumentation for thermodynamic measurements in microsecond flux-compression experiments has led to two designs for nano-fabricated inductive magnetometers. These devices, developed by D. Rickel (NHMFL) and R. Clark's group (University of New South Wales, Australia), feature extremely precise magnetic flux cancellation due to the precision of the lithographically-defined coils. One design has been tested in non-destructive magnets and delivers very good signal-to-noise de Haas-van Alphen measurements with little pickup of the background magnetic field.

The magnetic field capabilities of the Pulsed Field Facility will continue to increase in the coming years. A non-destructive 100 T pulsed magnet has been designed at the NHMFL. This working design is the first major milestone in a jointly-funded effort of the U.S. Department of Energy and the National Science Foundation, and the 100 T non-destructive magnet is projected to be operational in 2002. Experimental techniques suitable for use in the 100 T non-destructive magnet are under simultaneous development. In addition to expanding existing magnetotransport techniques, Fedor Balakirev recently developed a micromachined "trampoline" magnetometer in collaboration with Bell Laboratories (V. Aksyuk, F.F. Balakirev, G.S. Boebinger, P.L. Gammel, R.C. Haddon, and D.J. Bishop, *Science* **280**, 720 (1998)).

Pulsed Field Facility Operation and User Statistics, July 1, 1998 through June 30, 1998

The user activity is summarized below in units of magnet-days, the number of days the magnet is pulsing.

Number of Projects	49
Number of Research Groups	49
Number of Group Visits	150
Number of Students	21
Number of Postdocs	11

Magnet Day Statistics				**Magnets**			
	20 T-SC	**40 T-LP**	**50 T-SP**	**60 T-SP**	**60 T-LP***	**Total**	**Percent**
User Affiliations							
NHMFL	16	25	23	48	21	133	14%
LANL	11	0	68	12	28	119	13%
U.S. Universities	128	44	55	69	58	354	39%
U.S. Government Labs	29	0	0	10	0	39	4%
U.S. Industries	10	0	0	0	4	14	2%
Overseas	57	4	34	42	16	153	17%
Maintenance	12	15	15	15	N/A	57	6%
Idle	5	30	5	5	N/A	45	5%
Total	**268**	**118**	**200**	**201**	**127**	**914**	**100%**

* The 60 T Long-Pulse magnet did not come on-line until September 1, 1998.

High B/T Facility-Gainesville

The High B/T Facility at the University of Florida provides experimental capabilities for studies that require temperatures down to 0.4 mK and fields up to 20 T (when design capabilities are reached). Special features of the facility include an ultra-quiet environment with "tempest" quality shielding from electromagnetic disturbances, and carefully designed vibration isolation for the cryostats. A number of new instrumentation capabilities are described below.

Applications for use of the facility proceed the same as for other NHMFL facilities. Given the specialized nature of experiments and long running times that some experiments require, prospective users should contact the facility manager, Dr. J.S. Xia (352-392-0484, *jsxia@phys.ufl.edu*), or facility director, Prof. E. Dwight Adams (*adams@phys.ufl.edu*) well in advance.

Magnet, Instrumentation, and Services Update

The high field, superconducting magnet, which initially reached only 15.3 T because of failure of the fourth $NbSn_3$ coil, has been returned to the factory for replacement of the coil. It has now reached 17.1 T at 4 K, but has not been tested yet at 2 K.

A new, higher speed roots pump for circulation of the dilution refrigerator gas has been purchased to replace one that had never given satisfactory service. This should shorten considerably the time required for pre-cooling of the magnetic cooling stage.

The most significant advancement for transport studies has been the development of a special heat exchanger for cooling samples to 1 mK. The samples are immersed in liquid ^{3}He that is cooled by a high surface area sintered silver heat exchanger. In addition, all leads to the samples have individual silver heat exchangers cooled by the liquid ^{3}He. The first use of this heat exchanger has been for a study of the fractional quantum Hall effect by Horst Störmer, Dan Tsui, Wei Pan, and others. Two $GaAs/Ga_{1-x}Al_xAs$ samples were cooled down to 1 mK, in a field of 12.5 T, to study the $\nu=1/2$ filling factor. Two other samples were cooled down to 2.5 mK in fields from zero up to 15.2 T. A new quantum Hall state at $\nu=5/2$ was identified, and a series of related parameters have been determined. Papers on this work submitted to conferences are receiving invitations for oral presentation. Additionally, calls have come from as far as Germany for information on design of the heat exchanger.

A 650 MHz NMR spectrometer for diluted ^{3}He mixture study is under construction at the University of Massachusetts and the University of Florida, and will be put together at UF later this year. This ultra-high frequency NMR system will be available for other users after the spin diffusion in diluted ^{3}He measurement is conducted.

Several new commercial instruments have been ordered recently, most of them have been tested and are ready to be put in service. A particularly noteworthy one is the pressure calibration system that will allow calibration of pressure gauges and transducers to standards laboratory precision. The instruments are listed in Table 3.

Table 3. New commercial instruments available at the High B/T Facility at UF.

Equipment	Feature	Usage
125 amps bipolar magnet power supply	Positive to negative current ramp without a reversing switch	Superconducting magnet
180 MHz RF SQUID	High sensitivity, low noise	Magnetism measurements
DC SQUID	High sensitivity, low noise	Magnetism measurements
DHI Pressure Calibration System, PG 7601	Ultra high accuracy	Pressure calibration
LCR Meter HP 4263B	Mutual inductance option	Magnetic thermometry in the range 10 to 1000 mK
DSP Lock-in amplifier, EGG726	Built-in oscillator with frequency sweep	Helium viscosity and temperature measurements

Center for Interdisciplinary Magnetic Resonance (CIMAR)

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

Table 4. CIMAR facilities at the NHMFL in Tallahassee, as of June, 1999, and the kinds of measurements that can be done in them.

Frequency	Field (T), Bore (mm)	Homogeneity	Measurements
1066 MHz	25, 52	1 ppm	Solid state NMR
900 MHz*	21.1, 110	1 ppb	NMR
833 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
600 MHz	14, 52	1 ppb	Solution state NMR
500 MHz	11.75, 50	1 ppb	Solution state NMR
400 MHz	9.4, 89	1 ppb	Solid state NMR
400 MHz	9.4, 89	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	10 ppm	Multifrequency EMR
470 GHz	17, 61	3 ppm	Multifrequency EMR
400 GHz*	14, 89	3 ppm	Transient EMR
9 GHz			X-band EPR
	15-17, 110*		ICR
	11, 220*	1 ppm	ICR
	9.4, 220	1 ppm	ICR
	7, 150	1 ppm	ICR
	6, 150	1 ppm	ICR
	3, 150	10 ppm	ICR

* Under development

Table 5. CIMAR facilities at the University of Florida, as of June, 1999, and the kinds of measurements that can be done in them.

Frequency Bore (mm)	Field (T),	Homogeneity	Measurements
750 MHz*	17.5, 89	1 ppb	Solution state NMR & MRI
600 MHz	14, 51	1 ppb	Solution state NMR & MRI
500 MHz*	11.75, 400	0.1 ppm	MRI/S of animals
500 MHz	11.75, 50	1 ppb	Solution state NMR
500 MHz	11.75, 50	1 ppb	Solution 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

* Under development

NMR Spectroscopy and Imaging Program

The NMR spectroscopy and imaging program at the NHMFL has two user missions: the development of a premier high field NMR technology and application development facility for external and internal users, and the development of an in-house NMR facility for a very broad range of NMR spectroscopy and imaging activities. This second mission is closely associated with a number of academic units on the FSU and UF campuses. In particular, the University of Florida Brain Institute has contributed a great deal of resources to this joint venture.

The first mission aims to attract science and technology investigators as users interested in advancing the frontiers of NMR technology and developing new scientific applications for spectroscopy and imaging. The NHMFL's aggressive magnet development efforts will be matched by equally aggressive efforts to develop new NMR probes and instrumentation, both through in-house efforts and through partnerships with industry. The present NMR spectroscopy and imaging program at the NHMFL has several significant magnet systems around which unique capabilities have been developed. Now we are looking toward the development and installation of very high field superconducting, resistive, and hybrid magnets for the continuing growth of this mission.

NMR User Facility Capabilities

To attract external users, this program must have unique capabilities. Described below is a set of capabilities divided into two categories–technology developments and application developments. The technology developments will position the NHMFL NMR spectroscopy and imaging program as an international leader in NMR technology through the efforts of its staff scientists and users. World leadership in NMR applications science will grow upon these unique capabilities.

Technology Development

- **NMR Technology for Inhomogeneous Magnetic Fields**
  Optimizing Homogeneity and Stability in Resistive Magnets. The world's highest stability (1 ppm) and homogeneity (12 ppm over a 1 cm dsv) resistive magnets are at the NHMFL. A 0.8 ppm Na-23 linewidth at 25 T has been obtained by MAS and further improvements are anticipated with improved flux stabilizers, field-frequency locks, ferroshims and shim coils.

  High Resolution Spectra in Low Homogeneity Magnets. Professor Warren at Princeton has demonstrated a zero quantum approach for obtaining spectra with a resolution exceeding the homogeneity of the magnetic field across the sample volume. This technique is being implemented on the 25 T Keck magnet. An HX probe with PFG tuned to 1066 MHz for ^1H has been procured.

  Microcoils for Solution NMR. The goal is to develop microcoil technology for minimizing the amount of protein required for structural characterization by solution NMR. Preliminary results in collaboration with Prof. Webb at the University of Illinois have demonstrated adequate suppression of bulk magnetic susceptibility effects and spectral sensitivity for 2D spectroscopy of proteins.

  Stray Field Imaging. In collaboration with Dr. Samoilenko at the Institute of Chemical Physics, Russian Academy of Sciences, the world's highest field STRAFI facility is being developed in the NHMFL's 19.6 T superconducting magnet with a 70 T/m stray field at an ^1H frequency of 440 MHz. Spatial resolution approaching 1 μm is anticipated.

- **Increasing Sensitivity & Resolution**
  High Sensitivity Probes. An ^1H HTS probe with ^2H lock on a 400 MHz spectrometer has dramatically improved sensitivity for macrocyclic organic characterizations. Additional development with both HTS and cryogenically-cooled probes are underway for high field spectrometers.

  Hyperpolarized $^{129}Xenon$ and ^3He Facility. Resources for a large volume hyperpolarizer have been secured—low volume hyperpolarization is currently available to take advantage of the >2000 fold polarization enhancement to study surfaces, binding sites, phase transitions, molecular packing, etc.

  Double Rotation (DOR) NMR for Observing Quadrupolar Nuclei. In collaboration with Dr. Samosan at the Institute of Chemical Physics and Biophysics, Estonian Academy of Sciences, this DOR technology has been implemented for 17.2 T (720 MHz for ^1H) at the NHMFL and is being implemented at 25 T (1066 MHz for ^1H) to characterize odd-halves quadrupolar nuclei. Most nuclei in the periodic table have spin $S>1/2$ and two-thirds of these nuclei have a half-integer spin number. DOR, which averages both second and forth rank tensors, can directly achieve high resolution spectra of such quadrupole nuclei.

  High Field ^{19}F Solid State NMR. A double resonance H/F static probe has been ordered for the 19.6 T magnet system and a triple resonance H/F/X MAS probe has been ordered for the 14 T, 89 mm bore magnet system. Solid state orientational and distance constraints for protein structure will be obtainable with this capability.

  Magic Angle Turning at High Magnetic Fields. A triple H/X/Y MAS probe capable of MAT has been ordered for the 14 T magnet. High spectral resolution will be achieved and enhance polarization transfer through level crossing, which compensates for the large spin energy differences at high B_o.

Application Development

- **High Field Phenomena**
Orienting Samples in High Magnetic Fields. The goal is to align samples via their anisotropic diamagnetic susceptibility without having to resort to shear alignment. The glass in shear aligned samples accounts for almost half of the sample volume. Avoiding this can decrease signal averaging time by a factor of four.

^2H Wideline Spectroscopy of Short T_{2e} Samples. A wideline ^2H probe for the 19.6 T and 25 T magnet systems has been ordered. Short quadrupolar echo times are possible at high frequencies making it possible to obtain spectra that are unobtainable at low fields.

Observing Low Gamma Nuclei. A 2 mm diameter MAS double resonance probe is available at 19.6 T and a 4 mm diameter MAS double resonance probe is on order. A slim shim set to achieve 0.1 ppm homogeneity has also been ordered. These nuclei are difficult to observe because of their low sensitivities, low resonance frequencies, and large quadrupole interactions in case of quadrupolar nuclei. High field leads to higher frequencies and reduced second order broadening of the central transition of quadrupole nuclei.

Dynamics in Deuterated Proteins. Uniformly deuterated proteins required for high molecular weight protein studies lead to unique spin 1/2 line shapes for those sites attached to the quadrupolar ^2H nuclei. These field dependent line shapes can be interpreted for characterization of local dynamics.

GAMMA. This important spectral simulation platform continues to be expanded for additional applications as worldwide usage of this tool escalates. 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 or very complex experiments.

- **High Fields for Sensitivity, Spatial and Spectral Resolution**
PFG NMR Diffusion Measurements. Robust apparatus, pulse sequences, and rapid analysis methods for measuring isotropic diffusivities, apparent dispersion coefficients, and complete diffusion tensors as a function of the diffusion time in a wide variety of media have been established at 14 T. Unique information about transport and structure for systems ranging from rocks and soil, to synthetic engineering materials, to biological tissue will be obtained.

High Resolution Velocimetry. High spatial and velocity resolution NMR/MRI methods including novel hardware, pulse sequences, and data analysis methods have been implemented at 14 T. Most non-invasive velocimetric methods, except PFG NMR, are difficult to apply to systems that are optically opaque. Applications include flow in porous media (soil, rocks, packed beds reactors, chromatographic columns, biological tissue), flow of highly scattering concentrated dispersions, simultaneous measurement of molecular orientation and deformation, rapid rheometry.

Spatially Resolved Electrophoretic Mobilities and Electroosmotic Flow. Hardware, pulse sequences, and data analysis methods have been established for measuring electrophoretic mobilities, a fundamental physico-chemical parameter. Applications include electrophoretic separations and other electric field driven transport (e.g. transdermal drug delivery).

Single Cell Microimaging. Single cells have been imaged on the 14 T magnet. Dynamic studies of perturbed single cells provide information on the characteristics and dynamics of MR signals in single cells (T_2, T_1, diffusion), which is being used to aid in the interpretation of signal changes in macroscopic assemblies of cells (i.e. tissues). Single cell spectra offer similar potential for macroscopic studies at the single cell level.

High Field Structural Constraints for Membrane Proteins. The goal is to establish a high field facility for the collection of solid state NMR structural constraints on membrane proteins. An H/X static probe for the 14 T, 89 mm bore magnet has been ordered. The development of a robust structural approach for high resolution structures of membrane proteins is of major scientific and medical importance.

Additional Facility Developments

- A 750 MHz, 89 mm bore system is on order with a Bruker console (Gainesville: 10/99)
- The 14 T, 51 mm bore spectrometer system is being upgraded and a cryogenic probe added (Gainesville: 10/99)
- A Bruker console will be delivered with a phased array system for the 400 mm bore, 11.7 T magnet system (Gainesville: 10/99)
- A small animal research facility has been funded and is being constructed (Tallahassee: 12/99)
- A Bruker triple resonance 833 MHz console will be delivered (Tallahassee: 7/99).

NMR Operations and User Statistics

Number of Projects	104
Number of Research Groups	72
Number of Users	214
Number of Students	68
Number of Postdocs	25

Magnet Day Statistics for Principal NMR User Facilities in Tallahassee	WB 300**	WB 400**
User Affiliations		
NHMFL, UF, FSU, FAMU, LANL	345	355
U.S. Universities	0	0
U.S. Government Labs	0	0
Industry	10	0
Development, Calibration & Maintenance	5	5
Idle	5	5

Magnet Day Statistics	500**	WB 600**	720
User Affiliations			
NHMFL, UF, FSU, FAMU, LANL	305	330	315
U.S. Universities	15	10	22
U.S. Government Labs	0	0	0
Industry	0	0	0
Overseas	0	10	0
Development, Calibration & Maintenance	15	10	20
Idle	30	5	8

Magnet Day Statistics	NB 833*	Keck*
User Affiliations		
NHMFL, UF, FSU, FAMU, LANL	N/A	2
U.S. Universities	10	5
U.S. Government Labs	N/A	N/A
Industry	N/A	2
Overseas	N/A	N/A
Development, Calibration & Maintenance	60	20
Idle	N/A	N/A

* Instrument not fully commissioned for the external user community

** Limited availability to external users

Magnetic Resonance

NMR User Facility Faculty

We have an excellent group of faculty who are available to help users from training on the instruments to collaborating in a wide range of scientific disciplines. Bill Brey and Peter Gor'kov just joined the NHMFL to initiate our RF program for the development of unique NMR probes and console capabilities.

- Dr. Nagarajan Murali - expertise in macromolecular solution NMR, pulse sequence development and theory
- Dr. Scott Smith - expertise in spin system simulations, relaxation phenomena, and theory; developer of GAMMA
- Dr. Zhehong Gan - expertise in solid state NMR, pulse sequence and hardware development, and theory
- Dr. Riqiang Fu - expertise in solid state NMR, pulse sequence development, biological and chemical applications
- Dr. William Brey - expertise in high temperature superconducting probes, cryogenic probes and *in vivo* spectroscopy and imaging
- Mr. Peter Gor'kov - expertise in probe development for imaging and *in vivo* spectroscopy.

Fourier Transform Ion Cyclotron Resonance Mass Spectroscopy Program

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. An instrumentation director and a biological applications director were added to the machinist, technician, and three rotating postdocs who 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 electrospray 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, mass accuracy, efficient tandem mass spectrometry (MS^n as high as MS^8), and long ion storage period. The magnet is passively shielded to allow proper function of all equipment and safety for users.

A 7 T electrospray FT-ICR instrument has been dedicated to high sensitivity biological analysis. HPLC and CE interfaces are available. Picomolar concentration detection limit has been demonstrated. Sample amounts as low as 2 fmol loaded (in biological matrix) have been detected. The instrument is currently available for use.

A 6 T instrument is optimized for volatile mixture analysis. Samples are volatilized in a heated glass inlet system (at 200-300 °C) and introduced into the mass spectrometer through a 50 µm orifice. Samples are ionized by an electron beam (0-100 eV, 0.1-10 µA). Mass resolving power ($m/\Delta m$) greater than 10^5 and mass accuracy within 1 ppm can be achieved routinely. Hundreds of components in a complex mixture (e.g. petroleum distillates) can thus be resolved and identified. This instrument is also available for use.

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 1999. A 17 T, 110 mm bore superconducting magnet is due for fall 1999 delivery. Both magnets will be passively shielded.

ICR Applications

Biomolecular sequence verification continues to be in high demand. Protein and oligonucleotide masses can be determined with ppm accuracy. Molecules can be fragmented (by collisions or photons) to yield sequence-specific products. In-house software has been developed for rapid data analysis.

Tertiary structure can also be probed. ***Hydrogen/deuterium exchange*** can be carried out (in solution or gas phase) and monitored with the mass spectrometer. Details of biomolecular conformation and surface contact between molecules in a noncovalent complex can be deduced. For example, conformational changes in Yersinia tyrosine phosphatase were induced by point mutation and inhibitor binding and monitored by H/D exchange and FT-ICR (*Biochemistry* 37, 15289-15299 (1998)).

The 6 T instrument is primed for immediate impact in ***environmental analysis***, where intractably complex mixtures are common. Several environmental applications of FT-ICR MS are underway. For example, diesel fuel is analyzed to evaluate removal of sulfur-containing organics that contribute to air pollution (*Anal. Chem.* **70**, 4743-4750 (1998)). Initial characterization of a jet fuel (JP-8) contaminated site has been completed. The site is now targeted for remediation, and FT-ICR will be used to monitor progress.

ICR Operations and User Statistics

User activity is summarized below for the 11-month period August 1, 1998, through June 30, 1999.

Number of Projects	53
Number of Research Groups	35
Number of Students	26
Number of Postdocs	8

Magnet Day Statistics	**9.4 T**
User Affiliations	
NHMFL, UF, FSU, FAMU, LANL	220
U.S. Universities	32
U.S. Government Labs	0
U.S. Industry	13
Overseas	5
Maintenance	16
Idle	38
Total	**324**

EMR Program

The continuing trend in the development of electron magnetic resonance spectroscopy toward higher field and frequency ranges is providing the advantages that can be gained from the increase in both these parameters for a broad variety of applications. The applications of high field/high frequency EMR can be roughly classified into two categories. The first one includes studies of highly concentrated spin systems, typical for material sciences. The second category of applications mainly concerns chemical, biochemical, and biological paramagnetic spin systems that are usually characterized by low spin concentrations. Low spin density systems require high spectrometer sensitivity. The high field, multifrequency spectrometers at the NHMFL were originally developed for investigations of highly concentrated spin systems. The EMR users program spans biology, chemistry, and condensed matter physics, with an emphasis on chemistry and a clear trend toward more biological science.

There are two different regimes in the frequency domain for EMR spectroscopy: (1) from 1 GHz to about 150 GHz, and (2) above 150 GHz. From 1 GHz up to about 150 GHz, the electromagnetic waves propagate in single-moded or over-moded waveguides, and one can use single mode cavities. Above 150 GHz, one cannot use single mode cavities because they become impracticable, one has to use Fabry-Perot type cavities. In EMR spectroscopy, increasing the frequency increases the sensitivity, but there is a drop when one changes from the low frequency regime to the high frequency regime, because the technologies are different. Also it should be noted that pulsed techniques are only available up to 140 GHz, there are no pulse switches available for higher frequencies.

Very High Field EMR Spectrometers

The development of EMR spectrometers at the NHMFL has focused on very high field/very high frequency machines. Presently there are two high field EMR spectrometers: the 17 T superconducting magnet based spectrometer and the 25 T resistive "Keck" magnet.

The 17 T spectrometer has been built around a 17 T Teslatron magnet made by Oxford Instruments Inc. It comprises a main 17 T coil with a +/- 0.1 T sweep coil. We use different sources in the 23 GHz to 3 THz range. The detector is either a Schottky diode or a "hot electron" InSb bolometer. The system performance specifications are:

Frequency range: <95 GHz up to 475 GHz for a g=2 system, optimized at 220 GHz and 330 GHz
Sensitivity with a Fabry-Perot cavity: 10^{11} spins/gauss second at room temperature and 10^{9} spins/gauss second at 4 K
Averaging: up to about 100 spectra
Field calibration: g determination error: $\pm 3 \cdot 10^{-5}$
Resolution: 1 ppm to 10 ppm
Sample temperature: 1.6 K to 300 K.

The 25 T "Keck" magnet spectrometer is built around the 25 T, high homogeneity Keck magnet. The "Keck" magnet is perfectly poised for EMR–fast ramping to the magnetic field of interest, very convenient sweepability, homogeneity better than 10 ppm over a typical sample size (a few mm^3), good field stability. It uses a far infrared laser for its source and an InSb "fast electron" bolometer detector with a

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magnetically extended response. A Fabry-Perot cavity is under development. The system performance specifications are:

- Frequency range: up to 700 GHz for a g=2 system
- Sensitivity: 10^{12} spins/gauss second at room temperature
- Field calibration: g determination error: $+/-3 \cdot 10^{-5}$
- Resolution: better than 10 ppm
- Sample temperature: 1.6 K to 400 K.

Developments in EMR Since July 1, 1998

Improved Sensitivity and Ability to Measure Phase. Two of our goals are to increase the sensitivity of the spectrometers and to obtain information regarding the phase of the signal. An accurate knowledge of the phase is necessary to correctly analyze the response to an excitation by an electromagnetic wave. The response is made up of two components: dispersion and absorption. We are currently implementing quasi-optical (QO) techniques that will decrease the losses between the source and the detector and thus increase the sensitivity. QO techniques will allow for the detection of both the in-phase and quadrature components of the signal, with respect to the phase of the incident electromagnetic wave.

Transient VHFI EMR. With a grant from the NSF and matching funds from the NHMFL, University of Chicago, and North Carolina University, we are developing a transient EMR spectrometer that will operate at 360 GHz and in the subnanosecond time scale. This effort involves ten scientists from five different universities: Florida State University, the University of Florida, University of North Carolina, University of Chicago, and Northeastern University. The completion date will be determined by the availability of the 14 T room temperature wide bore (89 mm) magnet. A temporary machine is being installed with a 9 T magnet, which will operate up to 240 GHz; this machine will be operational in late 1999.

EMR Operations and User Statistics

All the research projects of the EMR program involved measurements made with the spectrometer using the 17 T superconducting magnet. Twelve of these projects also used the Keck magnet, and are noted in Appendix A by a "(K)" reference.

Number of Projects	34
Number of Research Groups	23
Number of Students	13
Number of Postdocs	8

Number of magnet days (17 T only)	
NHMFL, FSU, UF, LANL	108
U.S. Universities	127
Government Labs	9
Overseas	82
U.S. Industries	0

Geochemistry

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. The research funded through these programs mostly concerns the study of the chemical evolution of the Earth through trace element and isotope analyses and the lab has a major program on mid-ocean ridge basalt (MORB) genesis.

The Geochemistry Program continued this year its expansion of activities in the environmental science area. The program receives funding from both the South Florida Water Management District (PI: V. Salters) for research on the sources, speciation, and bioavailability of phosphorous in the Everglades as well as the Department of Energy (PI: Y. Wang) for research on the global carbon cycle. Dr. Salters is also heading a group of faculty from both the NHMFL and FSU that is actively pursuing the application of high magnetic field analytical techniques to environmental sciences. This group is concentrating on metal speciation, including organic-metal complexation, in natural waters. In addition to the geochemistry facilities at the NHMFL the "environmental scientists" use both FT-ICR-MS and EPR instrumentation.

The Geochemistry Program houses a mass spectrometry facility that includes a chemistry clean lab that approaches a Class 100 clean lab. This 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, used mainly for difficult to ionize elements like Hf, Th and 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 equipped with a RPQ-system for increased abundance sensitivity and a 13 sample turret. This mass spectrometer is 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" for elemental analyses.

In addition to the mass spectrometers, all peripheral equipment, such as mineral picking stations, atomic absorption and decay counting systems, is present.

Instrumentation improvements are concentrated on developing novel analytical techniques for the High Resolution Inductive Plasma Mass Spectrometer. Considerable time has been spent on integrating capillary electrophoresis with the ICP-MS. This combination of techniques potentially allows determination of metal speciation in natural waters. The initial tests have been promising, but further measurements are needed to assess the applicability to environmental samples. Furthermore, we designed and acquired the components for an Electric Pulse Disaggregator. This instrument disaggregates materials

Table 6. Types and configuration of mass spectrometers.

Name	Type of Ionization	Mass Analyzer Configuration	Detection Systems	Measurements	Sample Introduction
Isolab	Thermal and Sputtering	E-M-D1-E-D2	D1: 4 Faraday cups after M D2: Daly Ion counting and Faraday cup	Isotope ratios: Th, Hf and Hg	Solids and chemical separates
262/RPQ	Thermal	M-D1-E-D2	D1: 7 Faraday cups, 1 electron multiplier D2: Electron multiplier	Isotope ratios: Pb, Sr, Nd, Os	Chemical separates
ICP-MS	Thermal-Plasma	M-E-D	D: Electron multiplier	Concentrations and isotope ratios	Solutions

E=Energy filter *M=Magnetic mass filter* through discharge of a high potential (>100 kV) through the material. Our instrument is designed for discharges of 120 kV to 150 kV. One advantage of Electric Pulse Disaggregation is that the material preferentially breaks up material along grain boundaries. This allows for an easier separation of the different phases. Final assembly and testing of the instrument awaits appropriate housing.

Geochemistry Operations and User Statistics, July 1, 1998 to June 30, 1999

Number of Projects	24
Number of Research Groups	9
Number of Students	13
Number of Postdocs	3

Magnet Day Statistics	Isolab	262/RPQ	ICP-MS	Total
User Affiliations				
NHMFL, UF, FSU, FAMU, LANL	120	220	200	540
U.S. Universities	20	40	0	60
U.S. Government Labs	0	0	0	0
U.S. Industry	0	0	0	0
Overseas	0	0	0	0
Maintenance	80	20	40	140
Idle	40	20	0	60
Total	**260**	**300**	**240**	**800**

Large Magnet Component Test Laboratory

To support the continued development of a variety of cryogenic/electrical components for large superconducting magnet systems, the Large Magnet Component Test Laboratory (LMCTL) has been established in Cell 16 of the DC Field Facility in Tallahassee. These facilities have been essential in recent years to programs within the Magnet Science and Technology Group at the NHMFL, as well as to external groups from both the government and commercial sectors. In the past year, the facilities were completed, tested, and approved for regular use. In addition, the following improvements were made.

General Facilities

- The fixed, water-cooled, DC buswork was upgraded and tested to the full 20 kA available from the building power supplies. In addition, the DC system was demonstrated to be capable of being ramped at 1000 A/s to 19.5 kA.
- A high-power shunt resistor was permanently installed in the bus system to provide passive protection for both test components and test facilities.

Magnets and Instrumentation

Several small but important improvements were made:

- The pneumatically actuated fixture mated to the Oxford magnet for applying transverse compressive load to test conductors was rebuilt for added reliability. This fixture has been tested and calibrated to well over 250 kN applied load.
- A remote trip circuit was installed in the controls of the building power supply giving the capability to bring down the current with a time constant determined by the impedances of the test component and the bus circuit. For typical test components (negligible resistance and ~1 μH or less) the current discharge time constant is now of the order of a few milliseconds. The trip circuit is operable by relay with local manual override.
- The Navy SMES magnet has been brought into the LMCTL and is being prepared for first operation. Initially, this magnet will be used as part of a demonstration of critical SMES components, the magnet itself and a Power Electronics Building Block (PEBB) module supplied by Virginia Polytechnic Institute and State University. This work is being carried out under contract with the Office of Naval Research.

Magnets presently available for use in the LMCTL are listed below:

Identifier	Type	Max. Field (T)	Bore (mm)	Special Features
Oxford Split	Nb_3Sn/NbTi split solenoid, high-J, impregnated winding	14	150	30 x 70 mm^2 radial access
CWTX	NbTi split solenoid, low-J, ventilated winding	8	380	67 mm dia. radial access
TACL	NbTi cos θ dipole, high-J, ventilated winding	7	40	1 m long uniform field region
SMES CTA	NbTi simple solenoid, low-J, ventilated winding	4	2000	Separate cryogenic test volume in bore

LMCTL Usage in 1998

- High-current, transverse load testing of model conductors for high field accelerator dipoles — Lawrence Berkeley National Laboratory
- Experimental study of ramp-rate limitation in cables — Korean Advanced Institute of Science and Technology
- Test of high-current HTS busbars (J-Bars) for a superconducting fault-current limiter — EURUS/ General Atomics
- Test of high-current HTS components for cryogenic current leads being developed for the CERN Large Hadron Collider — EURUS Technologies
- AC-loss measurements of model cable-in-conduit conductors (CICCs) intended for a 100 MJ SMES system — BWX Technologies.

Access to NHMFL Facilities

User access to the NSF-funded NHMFL facilities is controlled by a two-step proposal and review process that is administered by the directors of the DC Field 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 1% to 2%) within the previous twelve months are required to submit a more extensive proposal based on their present and future work in high fields. Users in this category are the largest users and collectively account for at least 80% of the annual total facility use. Each major proposal is reviewed by a panel of scientists chosen for their familiarity with the fields of research commonly done at the NHMFL. The panel also can seek input in the form of mail reviews. A grade from A to C is given to each proposal with an A being required for heavy use of facilities, and especially, use of "expensive" or high demand facilities. A "C" grade means the user has access only after other demands are met. (Work that would merit a failing grade is blocked or stopped by the directors of the facilities before it reaches the major proposal process.) The final decision for use of the High Field Facility rests with the director of the NHMFL.

The ICR mass spectrometer facilities, isotope geochemistry facilities, and many of the magnetic resonance spectroscopy and imaging facilities are supported by grants other than the NHMFL Cooperative Agreement with 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.

Twenty three proposals were reviewed in May, 1998, six in November, 1998, and four in March, 1999. The grades were 21% A+; 30% A; 24% A-/B+; 12% B; 6% B-; and 1 C.

MAGNET SCIENCE & TECHNOLOGY

CHAPTER 2

The Magnet Science and Technology group has three main responsibilities within the NHMFL:

- Major magnet development projects
- Research and development programs
- External activities such as magnet design and development in collaboration with other organizations.

The first of these activities — major magnet development projects — includes both in-house magnet systems and those funded by external organizations and represents the largest of the group's efforts. MS&T has developed this dual role to best utilize the human capital developed through the many NHMFL magnet projects. With the pending completion of major projects such as the Hybrid, 900 MHz, and many of the resistive magnets, external activities are expected to increase as a percentage of MS&T workload.

MS&T continues to work on a number of external programs and projects with outside agencies. This is part of the natural evolution of the organization and exemplifies the high regard the MS&T group has worldwide. A few examples of major external project activities are as follows:

- Magnet and cryogenic design for the DuPont ore separation magnet
- Magnet design and construction for the Michigan State University, National Cyclotron Laboratory
- Design and construction of a radiography pulsed magnet system for Sandia National Laboratory
- Magnet design for the muon collider with Fermi National Laboratory
- Magnet system design for the MECO experiment proposed for Brookhaven National Laboratory.

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

Major Projects Highlights

- The 60 T Long-Pulse (quasi-continuous) magnet at LANL was first operated as a user facility in September, 1998. Since then approximately 350 full field pulses have been produced.
- The 45 T Hybrid magnet system is nearing completion. The resistive insert has been tested to 32.4 T. The superconducting outsert is scheduled for first test in July, 1999. The complete magnet system should be available to users in early fall 1999.
- The 900 MHz project is proceeding at a rapid pace in order to complete construction of the magnet system. Most materials and major

components are in house and coil winding has begun at both the NHMFL and IGC. Testing of model Nb_3Sn coils and other major components is planned for fall 1999. The preliminary design of the cryostat is complete and Ability Engineering and Technology has been selected for the final design and construction. A fully assembled test of the magnet system is planned for spring 2000.

- The pulsed magnet group continues to deliver capacitively driven magnets for the NHMFL Pulsed Field Facility. Recent advances have allowed the 50 T, 24 mm bore magnets to be upgraded to 55 T.
- The 100 T project achieved significant progress over the last year. A self-consistent design exists for 100 T on 15 mm bore. Insert test coils are being developed and tested.
- The NHMFL is developing a split pulsed magnet for the Los Alamos Neutron Science Experiment (LANSCE). This magnet is scheduled for delivery of its first coil in early 2000.

Development Programs Highlights

- A detailed scoping 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 and represents a cost effective option critical to the further expansion of powered magnets for general user activities.
- The HTS Magnets and Materials group, in collaboration with Oxford Superconductor Technologies, is nearing completion of a 3 T high field insert coil to be tested in the 20 T, 200 mm bore resistive magnet.
- The Cryogenics group continues to investigate two-phase He II flow theory and experiment in collaboration with the DESY laboratory in Hamburg.
- The High Strength/High Conductivity Materials group is investigating strengthening of pure copper by cryogenic deformation. Yield strengths in the range of 500 to 600 MPa have been achieved by this process, which represents a 50% increase over typical hard drawn copper conductors.

External Activities Highlights

- MS&T staff have performed a number of scoping studies for different magnet systems. These include design of a muon collider for Fermi National Laboratory and the MECO experiment at Brookhaven.
- The MS&T group is working with Sandia National Laboratory to build a radiography pulsed magnet.
- In collaboration with Michigan State University, MS&T is building a sweeper magnet for particle control at the National Superconducting Cyclotron Laboratory.

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

MAJOR PROJECTS:

Hybrid Magnet

Report Date: May 31, 1999

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

Fabrication and assembly of the set of three subcoils comprising the superconducting outsert is complete, the set has been installed in the outsert magnet vessel, the vessel installed in the cryostat, and cooldown for full-current testing is underway. Preliminary tests to ensure openness of individual flow passages, electrical insulation integrity, and leak tightness of conductors, joints, piping, and vessel were all successful. Low-current field maps confirm that the outsert is properly positioned relative to the cryostat warm bore within ~1 mm.

(2) Resistive Insert Magnet

All five coils have been stacked and installed in the insert housing. The insert housing has been positioned in the outsert cryostat and both the insert and outsert fields have been mapped at low current. Field center alignment has been verified through two independent measurements. The plumbing for the insert has been welded.

The magnet was tested without the superconducting outsert on May 17, 1999. The peak on-axis field was 32.4 ±0.2 T. The insert is expected to make at least 31.0 T with the 14.0 T superconducting magnet energized.

(3) Outsert Cryogenic System

The various shields, shells, and cryogen lines that had to be removed for installation of the outsert have all been reinstalled and successfully leak tested. Cooldown to operating temperature is in progress.

(4) Outsert Power/Protection System

The power supply and emergency current interrupters have been tested to 11 kA for 4 hours without incident. The magnet control computer is complete and operational with most critical interfaces tested. The quench-detection system, including high-voltage isolation amplifiers and quench-detection computer, is complete and has undergone preliminary tests using inductive signals generated by operating the resistive insert inside the warm outsert with shorted terminals.

(5) System Integration and Test

The outsert is presently being cooled down for test, which now is planned (outsert only) mid July, 1999. The insert was operated without the outsert to 32.4 T on May 17, 1999. Combined tests are planned for the third and fourth weeks in July, 1999.

Budget Summary ($K)

	Cost to 5/31/99	Cost to Complete	Total Estimated Cost	Budget 7/31/96	Variance -(over) +(under)
Resistive Insert					
Labor	411	0	411	297	-114
Equipment/ Subcontracts	678	0	678	457	-221
Travel/Expense	23	0	23	22	-1
Subtotal	1112	0	1112	776	-336
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	309	0	309	289	-20
Equipments/ Subcontract	371	0	371	296	-75
Travel/Expense	44	0	44	22	-22
Subtotal	724	0	724	607	-117
Superconducting Outsert/Assembly & Enclosure					
Labor	562	0	562	503	-59
Equipment/ Subcontract	81	0	81	60	-21
Travel/Expense	65	0	65	43	-22
Subtotal	708	0	708	606	-102
Cryogenic System					
Labor	561	0	561	518	-43
Equipments/ Subcontract	1857	0	1857	1857	0
Travel/Expense	57	0	57	54	-3
Subtotal	2475	0	2475	2429	-46
Outsert Power/Protection System					
Labor	261	0	261	242	-19
Equipment/ Subcontract	433	0	433	433	0
Travel/Expense	47	0	47	41	-6
Subtotal	741	0	741	716	-25
System Integration					
Labor	372	40	412	418	+6
Equipments/ Subcontract	384	0	384	384	0
Travel/Expense	144	35	179	180	+1
Subtotal	900	75	975	982	+7
Project Totals					
Labor	3869	40	3909	3526	-383
Equipments/ Subcontract	7109	0	7109	6792	-317
Travel/Expense	588	35	623	549	-74
Subtotal	11567	75	11642	10867	-775
Overhead	2050	35	2084	1875	-209
Project Grand Total	13617	110	13727	12742	-985

Milestone Schedule Summary

	7/31/96 Schedule	Actual (A) or Current Schedule (C)
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 (A)
Outsert Magnet Assembled in Vessel	8/7/97	12/10/98 (A)
I&C System Ready for Operation	6/1/97	7/12/99 (A)
Outsert System Ready for Test	9/2/97	6/30/99 (C)
Superconducting Outsert Operational	10/21/97	7/12/99 (C)
Resistive Insert		
Coil Design Complete	10/31/96	1/13/98 (A)
Mechanical Design Complete	2/15/97	5/12/98 (A)
Component Fabrication Complete	7/31/97	3/2/99 (A)
Assembly Complete	8/31/97	5/16/99 (A)
Resistive Insert Tests Complete	7/30/97	5/17/99 (A)
45 T Hybrid System		
System Ready for Combined Tests	10/28/97	7/12/99 (C)
System Operational for Users	11/8/97	7/26/99 (C)

MAJOR PROJECTS:

High Field Magnetic Resonance Magnet System

Report Date: May 31, 1999

Objective

The 900 MHz magnet is a major part of the long term program to achieve high resolution at 25 T, corresponding to a proton resonance frequency of 1.066 GHz. The future 25 T magnet will consist of an HTS inner coil operating in the field of a large 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 current 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 with JT refrigerator, and power supply.

The program is a collaboration between the NHMFL and the principal industrial partner Intermagnetics General Corporation. Additional industrial suppliers include Supercon, Vacuumschmelze, and Ability Engineering Technologies for the cryostat fabrication.

Status

The activity on the 900 MHz program presently includes winding of coils for the main magnet, a high level of activity in preparation of manufacturing drawings for components and assemblies, and the completion of outstanding development tasks.

The coil forms for all the long solenoids are nearly complete. The coil forms for the inner three Nb_3Sn coils have been received. The coil forms for the outer two Nb_3Sn coils encountered problems in the first fabrication, and are well along in being replaced. The coil forms for the NbTi long solenoids have been received by IGC. The materials for the outer compensation coil set have been placed on advanced order. The coil forms for the superconducting shim coils are being fabricated.

The wire for the magnet, including Nb_3Sn conductor, NbTi conductor, and reinforcement wire has been received. The conductors have been performance tested and qualified for the design. The procurement of long lengths of high quality Nb_3Sn wire (that meets specifications) is considered particularly successful.

The fabrication of model coils has been an essential part of the technology and process development activities. Over ten small test coils, including both NbTi and Nb_3Sn conductors, with a conductor weight between 5 kg and 10 kg, have been prepared. A model of the Nb_3Sn coil 3 containing 100 kg of conductor has been wound. A model of the NbTi coil 6 containing 300 kg of conductor has been wound.

Winding has begun on the actual coils for the main magnet. The Nb_3Sn coil 2 and the NbTi coil 6 are in progress.

Detailed design activities continue for the compensation coil set and the superconducting shims. Major material involved in these structures have been identified and placed on order.

The facilities required for the fabrication of the 900 MHz coils and magnet assembly are in place. The winding equipment is currently being utilized. The NHMFL is fortunate to have a large furnace installed allowing the heat treatment of the Nb_3Sn coils to be done in house. The epoxy impregnation chambers have been installed and used in the processing of the smaller model and test coils.

The engineering design of the cryostat has been completed. A supplier has been selected and the manufacturing issues presented by the system are being addressed prior to the preparation of manufacturing drawings.

There are aspects of the technology and component performance that need to be verified for the magnet. The technology for all the types of persistent joints in the magnet has yet to be demonstrated to a fully satisfactory level. The performance of critical components and time constants in the protection circuit remain to be measured.

External Review

An external review of the magnet design, production plan, and schedule was conducted by an independent review committee in May, 1999. In a debriefing, the committee expressed the view that the design has been thorough and well executed. They acknowledged that the program represents a truly cutting edge development program that is advancing the state of the art. They recommended an extensive program of testing of components such as the superconducting test coils, model coils, and joint technology before making irretrievable commitments in the manufacturing process. The external reviewers also recommended a broad ranging bucket test of the magnet system, preferably at reduced temperatures of about 2.2 K to maximize the information obtained about the magnet system before it is sealed in the final cryostat.

Cost and Schedule Issues

Several events have developed in the past year that have had a significant impact on schedule and less impact on cost. Braided fiberglass insulation required for the conductor and reinforcement wire has been a problem. Efforts were made to locate and develop a U.S. source for the insulation application. This was unsuccessful, and we had to resort to using a German source through VAC. This, along with some problems in the final production of NbTi and Nb_3Sn conductor, delayed the start of coil winding and due to the close scheduling of overseas shipments of wire and return has resulted in delays in the start of winding of the coils. Second, unforeseen problems in joint development have held up the heat treatment program for the Nb_3Sn coils. Our fall-back program, as suggested by the External Review Committee has been to put greater emphasis on the bucket test, designing the test to operate at 2.2 K to achieve maximum field. We should be able to achieve 21.1 T at 2.2 K, which would prove the system and provide an opportunity for some initial spectra before we install the magnet in the permanent cryostat.

MAJOR PROJECTS

Budget Summary ($K)

	Cost to 5/28/99	Cost to Complete	Total Estimated Cost	Budget 7/31/96	Variance -(over) +(under)
900 MHz R&D (4411+4401)					
Labor	1,823	86	1,909	1,234	-675
Materials/Subcontract	163	0	163	261	98
Travel/Expense	140	10	150	118	-33
Subtotal	2,126	96	2,223	1,613	-610
900 MHz Fabrication NHMFL					
Labor	508	615	1,123	644	-479
Materials/Subcontract	1,651	200	1,851	2,110	259
Travel/Expense	-485	200	-285	67	352
Subtotal	1,674	1,015	2,689	2,821	132
IGC Subcontract					
Labor					
Materials/Subcontract	1,110	100	1,210	901	309
Travel/Expense	0	0	0	0	0
Subtotal	1,110	100	1,210	901	-309
Facility Completion					
Labor	230	39	269	161	-108
Materials/Subcontract	177	100	277	900	623
Travel/Expense	162	50	212	15	-197
Subtotal	569	189	758	1,076	318
Project Total					
Labor	2,561	740	3,301	2,039	-1,262
Materials/Subcontract	3,101	400	3,5011	4,172	671
Travel/Expense	-182	260	78	200	122
Total Direct Cost	5,480	1,400	6,880	6,411	-469
Overhead	1,094	460	1,554	1,138	-453
Total Project Cost	**6,574**	**1,860**	**8,434**	**7,549**	**-922**

Milestone Schedule Summary

	7/31/96 Schedule	Actual (A) or Current (C) Schedule
Issue Engineering Design (NHMFL)		
Engineering Design	8/30/96	9/12/96(A)
Even/Integer Design		3/26/97(A)
Conductor Procurement (NHMFL)		
Nb_3Sn Specification	8/30/96	8/30/96(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 4,5		12/30/98(A)
NbTi Specification		5/6/97(A)
NbTi Order		6/30/97(A)
NbTi Delivery		3/30/99(A)
900 MHz Research & Development (NHMFL)		
Nb_3Sn Jc (B,T) Development	6/30/96	6/30/96(A)
Nb_3Sn Mechanical Properties	11/30/96	11/30/96(A)
Epoxy-Fibers Composites Development	1/31/97	1/31/97(A)
Winding Composites	3/31/97	3/31/97(A)
Persistent Joint Development	5/31/97	8/30/99(C)
Persistent Switch Development	6/15/97	7/30/99(C)
Model/Test Coils Fabrication		1/30/99(A)
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		4/30/99(A)
IGC Design and Fabrication		
Prepare Manufacturing Drawings		
Start Manufacturing Design	12/16/96	9/22/97(A)
Manufacturing Design Complete	11/15/97	7/31/99(C)
Fabricate NbTi Coils		
Ti Coil Forms and Tooling Delivered	2/2/98	
Coils 6 and 7		2/15/99(A)
Coils 8, 9 and 10		7/15/99(C)
Start Winding of Ti Coils	2/2/98	3/1/99(A)
Ship Ti Coils to NHMFL	9/30/98	10/30/99(C)
Fabricate Shim Coils		
Shim Tooling Received	1/10/98	7/1/99(C)
Complete Winding of Shim Coils	2/15/98	8/30/99(C)
Assemble Shim Coil Set	7/10/98	10/15/99(C)
Ship Shim Coil Set to NHMFL	9/30/98	10/30/99(C)

Milestone Schedule Summary (cont.)

	7/31/96 Schedule	Actual (A) or Current (C) Schedule
NHMFL Fabrication Program		
Fabricate Nb_3Sn Coils		
Nb_3Sn Coil Forms and Tooling Delivered	11/20/97	7/1/99(C)
Start Winding Nb_3Sn Coils	11/21/97	5/1/99(A)
Complete Nb_3Sn Coil Assembly	9/30/98	11/30/99(C)
Cryostat and Cryogenic System		
Start Cryogenic System Design	TBD	3/1/98(A)
Receive Cryostat and Components	4/15/98	11/30/99(C)
Power Supply and Protection Controls		
Start Electronic Components Design	TBD	5/1/99(A)
Complete System Assembly and Test	8/30/98	10/1/99(C)
Magnet Assembly and Test		
Start Final Assembly of Magnet	10/1/98	10/1/99(C)
Installation of Magnet in Bucket Cryostat	12/23/98	1/15/00(C)
Magnet Bucket Testing		3/15/00(C)
Installation of Magnet in Cryostat		6/30/00(C)
Magnet Testing	12/26/98	7/30/00(C)

MAJOR PROJECTS:

50 mm Bore Multipurpose Magnet

Report Date: May 5, 1999

Objective

This magnet is a combination of two previous resistive magnet projects: the 52 mm bore high field magnet and the multipurpose resistive magnet. It will have at least four configurations: (1) high field, (2) high uniformity, (3) modulation, and (4) gradient.

Status

This magnet is constructed by taking the inner coil of an old 30 T magnet and enlarging the inner diameter of the Florida-Bitter disks. In the high field configuration the magnet will provide greater than 27 T in a 50 mm bore. In the high homogeneity configuration a piece of 1018 steel, of rather intricate shape, will be installed in the bore to provide 27 T in a 36 mm bore with uniformity of roughly 20 ppm over 1 cm DSV. In the modulation configuration, the 50 mm bore tube will be replaced with a bore of roughly 45 mm, with a small coil wound on the outer diameter. This will provide approximately 0.1 T of modulation. The high gradient configuration should provide 0.05 T/cm in the 45 mm bore.

The new Florida-Bitter innermost coil is complete, and is to be installed in June, 1999. The design of the ferroshim for high homogeneity is complete and should also be ready in June, 1999. The wire for the modulation and gradient system is undergoing mechanical and electrical quality control measurements. Modulation and gradient coils should be available in September, 1999.

Budget Summary ($K)

	Cost to 5/5/99	Cost to Complete	Total Estimated Cost	Budget 5/5/99	Variance -(over) +(under)
Labor (incl. fringes)	4.6	13.7	18.3	18.3	0.0
Equipment/Materials	4.3	15.0	19.3	19.3	0.0
Travel/Expense	0.0	0.0	0.0	0.0	0.0
Subtotal	**8.9**	**28.7**	37.6	**37.6**	**0.0**
Overhead	2.1	6.3	8.4	8.4	0.0
Total	**11.0**	**35.0**	**46.0**	**46.0**	**0.0**

Milestone Schedule Summary

	5/11/99 Schedule
27 T, 50 mm Bore Complete	6/30/99
Ferroshim Complete	7/30/99
Modulation Complete	9/30/99
Gradient Complete	12/15/99

MAJOR PROJECTS:

Pulsed Magnets for User Facility

Report Date: June 1, 1999

Objective

The objective of this activity is to provide the magnets necessary to sustain and advance the capacity at the NHMFL Pulsed Field Facility at LANL. Magnet performance is upgraded 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 24 mm, 50 T magnet will be upgraded to 55 T based on the test results. The coil survived three pulses of 64 T. Three 60 T magnets with a 15 mm bore and ten 50 T magnets with a 24 mm bore have been delivered to LANL users.

The lifetime of a magnet depends on the magnetic field level it is operated at on a regular basis. The higher the field, the shorter the lifetime. Until now there is no theoretical model to predict the lifetime of a magnet. Experimental verification can be achieved by continuously pulsing an identical magnet to destruction. For this purpose, five magnets (two with 24 mm bore, three with 15 mm bore) have been made and shipped to Los Alamos to determine the lifetime of the standard user magnets at different field levels. The 24 mm bore magnets will be tested at 55 T and 60 T, and the 15 mm bore magnets will be tested at 60 T, 65 T, and 68 T.

MAJOR PROJECTS:

60 T Long-Pulse (Quasi-Continuous) Magnet

Report Date: June 30, 1999

Objective

The objective of this now-completed project was 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 was designed to furnish a variety of pulsed shapes including steps, linear ramps, field reversals, and long decays, in response to user needs. With suitable modifications to the power supply, a crowbar decay from full field could be added to the already available user pulse shapes. The system design includes the following:

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

Status

Design field and duration (60 T and 100 ms) were attained on April 20, 1998. Full field operation with field pulse profiles specified by restricted access users began August 3, 1998. The magnet and power supplies were shut down for routine inspection and maintenance October 2, 1998. Full operations (with the magnet available to all users) resumed November 3, 1998. The magnet typically has operated four out of five weeks with the fifth week used for maintenance and operator relief. Approximately 620 pulses have been provided in 127 user days. Full field pulses (60 T) accounted for about 350 of the pulses produced. A dilution refrigerator has been ordered and is expected to be ready in late 1999. The 60 T Long-Pulse magnet has proven to be quite reliable. No outstanding issues are identified at this time.

MAJOR PROJECTS:

100 T Insert Magnet Project

Report Date: June 1, 1999

Objective

The objective of this activity is to design, construct, and test a 15 mm bore capacitor powered magnet coil capable of producing a total field of 100 T together with an outer coil set operated in a quasi-continuous mode.

Status

Three different insert coil designs based on different conductors (CuNb, CuAg, and CuSS) were developed. Coil geometry, required conductor properties and dimensions, and the reinforcing materials have been determined.

The CuNb conductor will be delivered from the Bochvar Institute before the end of September. IGC-AS is developing the CuAg conductor. The CuSS conductor will be produced by Toulouse by the end of September. The internal reinforcement for all the designs are the cobalt based multiphase alloy MP35N combined with Zylon fibers.

The magnetic field reduction due to eddy currents in the MP35N reinforcement has been modeled by computer simulation. Experimental verification will be carried out through a series of test coils that contain MP35N reinforcement of different thickness and interlayer insulation.

A duplex test magnet system has been designed. Both coils will be powered with their own capacitor bank power supplies. The objective of this system is to simulate the performance of the 100 T insert by building a small test outsert with a bore of 85 mm to provide a 40 T background field for a small 4 layer test insert. The total magnetic field in the center of this test magnet system will be 80 T. At this field, the stress and strain in the test insert will be comparable with the real 100 T insert. Fabrication of the duplex magnet system incorporating CuNb conductor is scheduled in October of 1999. 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 at these high field levels.

MAJOR PROJECTS:

Los Alamos Neutron Science Experiment (LANSCE)

Report Date: May 15, 1999

Objective

The object of the Los Alamos Neutron Science Experiment (LANSCE) high frequency, split-pair pulsed magnet, which is funded by the Department of Energy, is to supply the LANSCE with two 20 mm bore, split-pair magnets that can achieve fields up to 30 T and up to 23 T for 10 million cycles. The magnetic field will be pulsed at a rate of 2 Hz, and will be synchronized with the LANSCE neutron source to provide a combination of high magnetic fields and neutron scattering unique in the world.

Status

- The required magnet system pushes the limits of magnet technology by requiring a clear split at the center of the coils and a 2 Hz pulse frequency. The clear split allows a higher sensitivity measurement by allowing the neutrons to travel unobstructed (except for the sample material) and, therefore, unattenuated from source to detector. The clear split, however, creates a 147 ton magnetic force acting to pull the two coil halves together and close the split. This force must be supported from the top and bottom of the coil halves while maintaining a clear bore through the coil axis to allow clearance for experimental probes. The 2 Hz frequency requires that the coils be continuously cooled with de-ionized water flowing at 15 m/s across the inner diameter of each of the coils. The water must flow into the coil from the top (or bottom) plate, turn around at the gap and return through the top (or bottom) plate, which requires that the entire housing for the coil system be leaktight and capable of withstanding up to seven atmospheres pressure on the split-side wall. All of these requirements are in addition to the basic requirement of providing the highest possible field up to 30 T on axis for 10 million cycles.
- The engineering design of the coil system was reviewed in January, 1999, and the review committee was, "very excited about the achievements made in the magnet design, and the many innovative solutions found," while further development was recommended in the 10 million cycle materials strength characterization due to the scarcity of information available in that area for magnet materials. Finally, the committee recommended that the detailed engineering drawings and construction of the first prototype magnet system begin.
- The coil system consists of four concentric coil pairs. The three innermost coil pairs are single layer coils made from CuAg conductors reinforced with MP35N. The fourth and outermost coil is made from CuZr discs configured into a Bitter coil, which employs existing and proven technology used to provide the steady state, resistive magnets to the NHMFL user community.
- Due to the 2 Hz pulsing requirement, it was necessary to prevent overheating from eddy currents in the hard-to-cool reinforcing structure. An insulated "jelly-roll" reinforcement configuration is being employed where six, 5 mil thick strips of MP35N are wound onto the conductor at the same time. This "six-in-hand" feature allows a tighter reinforcement winding and reduces the induced voltages in comparison to a single wound strip of six-times the thickness. The reinforcement strips are insulated with an NHMFL patented insulation applied by a sol-gel process that allows insulation thicknesses of as little as fractions of a micron. As a result, the mechanically weaker insulating material is minimized and more stress-bearing MP35N material can be applied to the limited volume allowed for reinforcement on each coil. Verification of the sol-gel insulated jellyroll reinforcing configuration will be done with model coils to be tested at NHMFL-Los Alamos in fall 1999.
- The first prototype coil system is scheduled to be delivered to Los Alamos by February, 2000.

RESEARCH & DEVELOPMENT ACTIVITIES:

Cryogenic Component Development

Report Date: June 1, 1999

Objective

The objectives of this program are to develop and better understand cryogenic systems in order to improve our ability to support superconducting 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 on two main projects. These are as follows:

- Support the completion of the 45 T Hybrid. The cryostat was tested several more times to increase experience with operation and reduce heat loading. On installation of the superconducting magnet, the cryostat was re-assembled and cooldown of the outsert began in May, 1999.
- Design and development of the 900 MHz NMR magnet cryostat. The preliminary design of this system is complete and we have entered into a contract with Ability Engineering and Technology for final design and fabrication. Two major sub-component tests are scheduled for summer 1999 to check the operation and reliability of the design.

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

- Heat and mass transfer in horizontal two phase He II/ vapor: This program is supported by a grant from the National Science Foundation. The work involves understanding the thermal-hydraulic nature of He II coexisting with its vapor. Both numerical modeling and experimental confirmation are included in the project. Experiments are being preformed using the Liquid Helium Flow Facility in the Cryogenics Laboratory.
- Liquid Helium Fluid Dynamics Studies: This program is supported by a grant from the Department of Energy. The work focuses on cryogenics issues of future particle accelerators. Current studies include: (1) propagation of intense thermal shock and second sound attenuation; and (2) high Reynold's number forced flow He II and instrumentation development using the Cryogenic Helium Experimental Facility.

Collaborations

- DESY- Hamburg: We are working together on a He II two phase flow experiment to confirm the operating characteristics of the cooling system for the TESLA electron accelerator. We are also performing Kapitza resistance measurements in support of RF cavity development.
- University of Oregon: We are collaborating with the Physics Department on a Liquid Helium Wind Tunnel project. Our task has involved measurements of drag on a spherical body at high Reynold's numbers.

RESEARCH & DEVELOPMENT ACTIVITIES:

Resistive Magnet Development

Report Date: May 11, 1999

Objective

As a part of the Resistive Magnet development activity, a hydraulic test stand facility has been constructed. This facility permits 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 a 50 T Hybrid insert, a 35 T resistive magnet, a split pair, series connected hybrid inserts, etc. The device also will serve to benchmark theoretical calculations on turbulent flow in channels with periodic roughness structures.

Status

Six combinations of coils have been tested in the resistive magnet test stand. We have determined the following:

- The hydraulic friction factor for recently fabricated coils is about half that of some of our early coils.
- It is possible to safely run high field resistive magnets in the nucleate boiling heat transfer regime.
- At low Reynold's number the heat transfer coefficient is approximately 20% higher than previously believed.

The next step is to install instrumentation of higher sensitivity to allow more precise measurements. The information obtained to date has already proven valuable in determining operating parameters for the large bore magnet and the 45 T hybrid. This information should play a substantial role in future magnet design activities.

High Strength/High Conductivity Materials/Conductors

Report Date: May 25, 1999

Objective

The objectives of this program can be classified into two areas: (a) to develop high strength conductor materials for pulse magnet applications, and (b) to provide a better understanding of the strengthening mechanism from a fundamental point of view. The study is focused on two types of materials, pure Cu and composites. In order to achieve the required high level of strength, the processing of the materials will involve heavy deformation. The first type of material (pure Cu) will be deformed at cryogenic condition, in order to avoid dynamic recovery. With the composite material, deformation will be carried out at either ambient or cryogenic temperatures. It must be noted that the composites will include both metal-metal composites (MMC) or metal-ceramic composites (MCC). Some of the composites are Cu-Ag, Cu-Nb, Cu-Ti, Cu-SiC and Cu+SS (stainless steel) composites. It is anticipated that the microstructural, mechanical and electrical properties of the materials will be monitored at various stages during the processing.

Status

1. Cryogenic deformation of pure Cu: The deformation of pure Cu at 77 K has given the strength level of 500 to 600 MPa. The dynamic recovery was partially suppressed. Extensive microstructural characterization has been carried out using scanning and transmission electron microscopy. Texture evaluation was done via X-ray diffraction and orientation imaging microscopy (OIM).

2. Fabrication of large cross-section Ag-Cu conductors. An optimization scheme has been developed to fabricate large cross-section Ag-Cu conductors in collaboration with IGC. Yield strength level of 1 GPa has been achieved with the cross-section of 5.2 x 8.6 mm^2. The conductor is composed of a very fine structure with a significant amount of internal stresses.

3. Cu-Nb conductors: Very high strength and resistivity ratio have been achieved in this material. The internal stresses were more pronounced in Cu-Nb than Cu-Ag. These internal stresses resulted in very strong an-elasticity in stress-strain curve.

4. The Cu-Ti/Nb composite: The Cu-Ti/Nb composite was fabricated in collaboration with Oxford Instrument. The evolution of microstructure and texture of the wire during processing has been studied. The tensile strength and electrical resistivity of the wires have been evaluated as a function of fabrication mode. Drawing produced the highest strength ~800 MPa.

5. Cu+SS: The property and interface between Cu+SS has been investigated. The compression test at room temperature indicated there was no de-bonding between Cu and SS.

6. GlidCop®: The Cu+alumina composite was fabricated in collaboration with OMG America and IGC. Strength levels of 600 MPa or higher have been achieved in large cross-section wires.

7. Cu-SiC: The Cu-SiC composite was produced in collaboration with 3M (Minnesota Mining and Manufacturing). Very high strength tapes have been made and tested, and the properties are promising.

RESEARCH & DEVELOPMENT ACTIVITIES:

Delta B Program

Report Date: May 25, 1999

Objective

The ultimate goal of the Delta B program is the development of high temperature superconducting (HTS) magnets for research and 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, and
- 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 been focused on the 3 T insert coil to be tested in June 1999. Specifically, we have focused on understanding the heat treatment processes of long-lengths of Bi-2212 conductor and of large react-and-wind coils, on the impact of the strain dependence of the critical current density on coil design, and on improving the sol-gel insulation process for large batches of conductor. Specific progress and current activities are listed below.

Insulation

- The NHMFL sol-gel insulation process has been significantly improved, enabling us to coat HTS conductors of kilometer lengths with a variety of high temperature compatible oxide insulators. The coating thickness is controllable and can range from sub-micron to tens of microns. The insulation materials now include ZrO_2, Al_2O_3, CeO_2, Y_2O_3, MgO, and yttria-, magnesia-, ceria-, semaria-, and erbia-doped zirconia for HTS conductors, and lead- and tin-doped zirconia for LTS conductors. The process has also been modified to produce submicron, pinhole-free coatings on Ni tapes suitable as buffer layers for surface coated YBCO conductors. Lastly, it is finding applications such as eddy current reduction in the reinforcement of pulsed magnets.
- 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 with the addition of more baths and furnaces as well as running several conductors in parallel.
- More than three kilometers of HTS tape conductor have been insulated and used in several HTS coil applications, including the 3 T HTS coil. Batches of round HTS and LTS conductors have been insulated.
- Short sample tests have studied application of the oxide sol-gel insulation to Nb_3Sn conductors. No adverse effects were observed in Jc measurements. For small conductor diameter, the insulation improved the packing density of the superconducting windings. Furthermore, the coil fabrication, heat treatment and handling become much less delicate than with existing glass braid insulation.
- 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 the filament coupling and a three-fold reduction in AC losses was achieved.
- A methodology for measuring the adhesion strength of coatings using tensile tests of lap joints has been developed.

Characterization

- To facilitate measurements of large coils, including the IGC prototype insert coil and the 3 T coils being developed with OI-ST (see Chapter 5, Collaborations), a support structure was successfully developed and tested within the cryostat of the 20 T resistive magnet. The support features large load bearing capacity, multiple current leads, and ample instrumentation wiring.

- In support of the 3 T coil development, the critical current density at 4.2 K, self-field of over 2000 short samples and over 120 double pancake coils has been measured.

- Two of the facilities used to measure the mechanical properties and the effects of mechanical strain on the critical current of HTS tapes have been improved. The *in-situ* Lorentz forced device has been modified to operate without the capacitive strain gauge. This was accomplished by connecting a manganin wire to the HTS conductor sample, and basing the strain measurement on the resistance of the manganin. This required detailed characterization of the resistivity of manganin at low temperature in a magnetic field. Secondly, the linear stress-strain device that formerly operated only at room temperature has been modified to facilitate measurements at 77 K in liquid nitrogen. Furthermore, this facility now allows direct measurement of the critical current at 77 K under mechanical strain, without intermediate handling of the conductor.

Coil Development

- The primary activity of the Delta B program has been the construction of a 3 T insert coil (in the 20 T background field of the large-bore resistive magnet) based on Bi-2212 wind-and-react technology. This activity is a close collaboration with Oxford Instruments, Inc., Superconducting Technologies, in which OI-ST provides the conductor, the NHMFL insulates the conductor and winds it into double-pancake coils. Both OI-ST and the NHMFL heat treat the coils, converting the unreacted conductor into the superconducting phase. The NHMFL then stacks the double pancakes and tests the coil. Testing of the insert coil is scheduled for June, 1999.

- A react-and-wind double pancake coil has been wound in collaboration with Nordic Superconductor Technologies (NST). With fully-processed Bi-2223 Ag-alloy clad superconducting tape provided by NST, the NHMFL has evaluated the conductor in terms of the effects of high magnetic fields and mechanical strain on the critical current density. Furthermore, a double pancake coil wound and tested in self-field validates the NHMFL's capability to form wind-and-react coils. This double pancake will be tested in-field in June,1999.

Collaborations

The Delta B program maintains important ongoing collaborations with EURUS Technologies, Intermagnetics General Corporation, Nordic Superconductor Technologies, and Oxford Instruments, Inc., Superconducting Technologies that are reported in Chapter 5, Collaborations.

Series–Connected Hybrid (SCH) System

Report Date: May 20, 1999

Objective

Series-Connected Hybrid (SCH) systems are being considered, not as a means for attaining the highest possible DC fields within the capabilities of the NHMFL power and cooling systems, but as a cost-effective means of providing the presently available level of fields to the most users without sacrificing the functionality and flexibility afforded by all-resistive systems. The SCH will be especially effective for providing services to users who spend long periods at the highest fields, e.g. NMR researchers. As a result of pre-conceptual design studies, we can make the following observations:

- The SCH system being considered will be capable of providing approximately 35 T with reasonable uniformity using a single 10 MW module of the NHMFL power supply, leaving the other three available to other users.
- Because the SCH can be designed to operate at both lower current and lower power than a comparable all-resistive magnet (roughly one-third as much in either case) the natural time constant is longer (more than three times as long), which aids in the suppression of field ripple and noise.
- Some off-normal and fault scenarios that complicate the design and significantly increase costs of the superconducting outsert in a conventional hybrid are significantly ameliorated.
- Significant savings can result from a structural combination of the resistive-insert housing and the bore tube of the outsert cryostat.
- It appears reasonable that a 35 T system using a single 10 MW power supply can be built for a total cost between \$3M and \$4M, depending on uniformity requirements.
- When operating costs are included, the projected total cost of the SCH system after five years of operation (one four-hour shift per day, three days per week) is less than that for a comparable all-resistive system.

Status

The pre-conceptual design studies are complete and development work has begun on critical technologies identified therein. These include: (1) 20 kA HTS current leads with approximately one-fourth the total refrigeration requirement of conventional cryogenic current leads, (2) NbTi-based cable-in-conduit conductor (CICC) exhibiting very low coupling and hysteresis losses, and (3) CICC splice joints with low losses (both AC and DC). An assessment will be made of the development in the third quarter of 1999, and a more detailed conceptual design of the SCH will be produced by the first quarter of 2000 as a basis for a detailed proposal, including cost projections and schedule for completion.

HTS Reciprocating Magnetic Ore Separator

The magnetic ore separator project is being conducted in collaboration with DuPont Superconductivity and Carpco, and is funded by the Department of Energy. When complete, the system will be a quarter-scale, working prototype in operation at one of DuPont's demonstration facilities. The magnet system consists of a 2+ T, 200 mm warm bore HTS magnet made with Ag/BSCCO composite conductor with a room temperature iron shield. The magnet will be conductively cooled and operate at approximately 30 K. The goal is to provide a robust, industrial unit, which is competitive with existing LTS superconducting separators. During Phase I of this project (until December, 1999), the NHMFL is conducting a magnet and cryogenic system design. The magnet will have a 250 mm cold bore and an overall length of 300 mm. It will be conductively cooled with a G.M. cryocooler. The cryostat will have a warm iron shield to minimize fringe field. During Phase II, the NHMFL will fabricate the cryogenic system, install the magnet and test the entire system before it is transported to DuPont for ore separation studies.

MECO Solenoids Design Study

MECO is an experiment to test muon and electron number violation by searching for muons converting to electrons in the field of a nucleus. The experiment is intended to discover this process if it occurs as infrequently as once for 10^{16} muon captures on the nucleus. The experiment will be performed in a new pulsed muon beam to be constructed in the experimental hall of the Alternating Gradient Synchrotron at Brookhaven National Laboratory.

The magnet system of the MECO experiment consists of three main superconducting solenoids. The magnet's field ranges between 5 T, 0.6 mm bore for the production solenoid to 2 T, 0.9 mm bore for the detector solenoid. The system includes iron pole pieces to shape the field between the three solenoid systems (Production, Transport and Detector solenoids.)

The NHMFL is conducting a two-phase study for the muon collider magnet system. Phase I (May to June 1999) is an electromagnetic and thermal-mechanical analysis including cost scaling. The electromagnetic analysis will include magnet optimization, field uniformity, and a 3D field FEM analysis. In Phase II (July to October 1999), the NHMFL will perform, in cooperation with industry, a preconceptual design of the MECO magnet system in order to develop a cost estimate.

Pulsed Magnets for the Advanced Hydrodynamic Radiography Program at Sandia National Laboratory

Collaborating with the Radiographic Physics Department at Sandia National Laboratory, the pulsed field group of the MS&T is developing a pulsed high magnetic field system for the Advanced Hydrodynamic Radiography Program to generate intensive electron beams. The magnetic field profile along the axis of the system is required to be 30 T at the center of a 110 mm bore pulsed magnet, increasing gradually up to 60 T at the center of a magnet with a bore of 45 mm. Each of the two magnets will be energized with their own bank. The total energy of the system will be about 5 MJ. The preliminary design of the pulsed magnet system has been completed. The unique pulse magnet involves high voltage and high energy, new materials and new technology. The project will be carried out in two steps. The first step is to develop a 50 T system. After gaining experience with the system construction and experiments, the second step will upgrade the magnet to 60 T. The materials required for the magnet construction of the first step are on order.

Navy SMES

A contract has been entered into with the Office of Naval Research for a demonstration of major components being developed for future electrified ships. Components to be tested initially include a 19-t, 2 m bore, 4 T Superconducting Magnetic Energy Storage (SMES) magnet provided by the Naval Surface Warfare Center-Annapolis and a Power Electronics Building Block (PEBB) module provided by Virginia Polytechnic Institute and State University. The SMES magnet is being assembled in its cryostat (delivered separately) and installed in the Large Magnet Component Test Laboratory (LMCTL). The test program involves operations of the SMES magnet and PEBB both together and separately, supported by other utility and power/ protection systems available in the LMCTL.

LBNL Transverse Load Testing

The Lawrence Berkeley National Laboratory high field, dipole development program supports operation of a specially designed NHMFL facility that allows simultaneous application of high field, high current, and high transverse load to large test conductors. The facility is based on our superconducting split-pair solenoid, produced by Oxford Instruments and located in the Large Magnet Component Test Laboratory (LMCTL). At present, the facility is capable of applying up to 13 T, 19.5 kA, and 250 kN to a test conductor fitting into the 30 x 70 mm^2 radial-access port of the Oxford magnet. A variety of large Rutherford-style cables based on multifilamentary Nb_3Sn/Cu composite wires have already been tested and have provided insight to the performance of an experimental model dipole magnet tested at LBNL. Future test plans include cables fabricated with high temperature superconductor wires based on Ag-matrix Bi-2212.

Muon Collider Design Study

The Fermi National Accelerator Laboratory is conducting a conceptual design of a future muon collider and has contracted the NHMFL to address magnet design issues. To date, our contributions have dealt with two superconducting magnet systems important to cooling a muon beam created by pion capture and decay. These systems include a "bent" solenoid/dipole system and an alternating-field solenoid system. The bent solenoid/dipole system requires modest fields (approximately 3 T from the solenoids and <0.6 T from the dipole), but high homogeneity over a significant volume along the path of the beam. On the other hand, the alternating-field solenoid system requires quite high fields (approximately 15 T in the present system) as well as a precisely defined field profile along the beam path, which includes field reversal with a gradient at the zero crossing of nearly 50 T/m. Sizes of the coils are moderate. The bent solenoid/dipole system must fit around a 300 mm diameter beam tube. A liquid hydrogen adsorber (150 mm o.d.) sets the bore of the high-field coils for the alternating-field solenoid system, while a 400 mm o.d. RF cavity defines the bore of the coils in the zero-crossing region. The field profile for the alternating-field system is cyclic with a period of 1.5 m. Challenges of this system include the production of high fields over large volumes, handling the high forces of repulsion, and integration of the magnet cryogenic system with that of the liquid hydrogen adsorber.

NSCL: Sweeper Magnet

The National Superconducting Cyclotron Laboratory at Michigan State University has contracted with the NHMFL to build a 4 T superconducting sweeper magnet. The magnet is referred to as a sweeper because it "sweeps" charged particles out of a neutron beam and into a mass spectrometer. It is required to bend beams of 4 T/m rigidity though 40 (on a one meter radius. The magnet consists of 2 D shaped coils with a split of 140 mm. The conductor is epoxy impregnated niobium titanium operating at 4.2 K. There is a yoke of approximately 16 tons to enhance the peak field and reduce the fringe field.

Although 4 T is not a tremendously high field, attaining 4 T in a gap of 140 mm with a D-shaped magnet leads to high stresses and requires substantial analytical work in the design process to ensure reliable operation.

NRIM: High Field Florida-Bitter Magnets

The National Research Institute for Metals of Tsukuba, Japan, purchased a 30 T resistive magnet from the NHMFL in 1996, which was delivered in 1997. We are presently working on a long term collaboration to provide magnets to the NRIM. In late 1998 a contract was signed for a replacement A coil. A contract for a replacement B coil is expected to be completed in the next few months and a contract for a replacement C coil is expected next year. Preliminary discussions have begun regarding a new insert for their "40 T class" hybrid magnet.

IPR-India

Due to delays in completing their model-coil test program at the Kurchatov Institute in Moscow, the Institute of Plasma Research-India has extended our contract to allow us to help with the analysis of that data. The tests at the Kurchatov Institute included a variety of transient-field scenarios and forced quenches conceived to characterize the losses, stability, and protection requirements of the cable-in-conduit conductors used in the model coil and planned for use in magnet systems of the IPR's SST-1 tokamak. Our participation in this analysis task is extremely relevant to the NHMFL mission in that the cable-in-conduit conductor technology used by the IPR has many similarities to that used in the present 45 T Hybrid as well as the proposed Series-Connected Hybrid.

In-House Research Program

Chapter 3

The In-House Research Program (IHRP) was established as part of the National Science Foundation's charge to support competitive research that utilizes the NHMFL facilities and advances the laboratory's facilities and its scientific and technical capabilities. The program funds projects that are normally of one- to two-years duration falling into one of 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.

We are now in the review process for the fourth solicitation. For the three years 1996-1998, a total of 135 proposals were submitted; 70 were sent out for external review after an initial internal review; and 32 projects were funded. Of the 32 grants awarded, 16 have the main principal investigator at Florida State University (10 on campus, 6 at the laboratory), 10 at the University of Florida, and 6 at Los Alamos National Laboratory. In 1999, 33 proposals were submitted, of which 22 are now being externally reviewed.

Below are presented reports for the funded projects.

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. Following are the most recent reports as of June 30, 1998. Since all the 1996 proposals have been granted a six-month, no-cost extension, final project reports are not due until June 30, 1999.

Experimental and Theoretical Aspects of Quasi-Three Dimensional Quantum Hall Systems

PI: J. S. Brooks (FSU)
Funding: $86,185 over 2 years

The purpose of the research carried out by J. Brooks and Z. Wang has been to systematically investigate the nature of the quantum Hall effect and the chiral edge state phenomenon in nearly three dimensional structures comprised of many (200) two dimensional electron gas layers.

- We have shown that in a 200-layer quantum well structure with quasi-three dimensional electronic structure, complete quantization is achieved at integer filling factors.
- We have shown that in the chiral edge state scenario, all three transport tensor components, Rxx, Rxy, and Rzz follow the same temperature and tilted magnetic field behavior.
- We have found that beyond a critical value of in-plane magnetic field, the quantization is removed systematically. At present there is no model for this behavior, which is not expected to occur, based on a simple model for in-plane localization of the "thickness" of the two dimensional electron gas.
- We have discovered a new type of quantum oscillation that appears for purely in-plane magnetic field.
- We have provided a new method to determine the corrections to the temperature brought about by the magnetoresistance of resistive sensors used for thermometry.
- In related work, the samples used in this study were also investigated in the DIRAC II series of flux compression experiments to 800 T, and new optical oscillations in the reflectivity were reported.

This grant is in the final stages of its two-year duration. Hence the program now moves to the external funding application cycle. We have used all funds associated with this grant.

Mr. Biao Zhang, a graduate student from Boston College, has made this research his Ph.D. dissertation project. He will receive his Ph.D. degree this summer, 1999, based on this work.

Publications and Presentations Based on this Research Project

Theoretical Publications (5)

Wang, Z., Phys. Rev. Lett. **79**, 4002 (1997).
Wang, Z. and Plerou, V., Phys. Rev. Lett. **81**, 1747 (1998).
Plerou, V. and Wang, Z., Phys. Rev. B **58**, 1967 (1998).
Wang, Z., Physica C, **282-287**, 1662 (1998).
Wang, Z., Phys. Rev. Lett **78**, 126 (1997).

Experimental Publications (5)

Zhang, B. *et al.,* Physica B, **258**, 279 (1998).
Zhang, B. *et al.,* Rev. Sci. Instrum. **70**, 2026 (1999).
Zhang, B. *et al., In-Plane Magnetic Field Effect on the Transport Properties of the Chiral Edge State in a Quasi-3D Quantum Well Structure*, Phys. Rev. B, submitted 3/20/99.
Brooks, J.S. *et al.,* Physica B **246-247**, 319 (1998).
Zhang, B. *et al., Systematic Study of Quasi-Three-Dimensional Transport in the Quantum Hall States of 200-Layer Quantum Well Structures*, Phys. Rev. B, in preparation.

Presentations (4)

Brooks, J.S., *Quantum Hall Effect in Multi-Layered Systems and Organic Conductors http://www.itp.ucsb.edu/online/qhall_c98/brooks/* (Invited). Institute for Theoretical Physics-Santa Barbara; Conference on Disorder and Interactions in Quantum Hall and Mesoscopic Systems; August 9-13, 1998.
Wang, Z., *Role of Coulomb Interactions at the IQHE Plateau Transition, http://www/itp.ucsb.edu/online/qhall_c98/wang/* (Invited), Institute for Theoretical Physics -Santa Barbara; Conference on Disorder and Interactions in Quantum Hall and Mesoscopic Systems; August 9-13, 1998.
Zhang, B. *et al., Chiral Edge State Properties in Nearly 3-D Quantum Well Structures*, Bull. Am. Phys. Soc. **44**, 1197 (1999).
Zhang, B. *et al., Observation of the Integer Quantum Hall Effect in 200-layer GaAs/AlGaAs Superlattice Heterostructures*, Bull. Am. Phys. Soc. **43**, 394 (1998)

Thesis Work

Zhang, B., *Quantum Hall Effect and Chiral Edge State Transport in Nearly 3-D Quantum Well Structures*, Boston College, to be completed in summer, 1999.

Design of a High Frequency, Short Pulse Gyrotron for Pulsed EPR

PI: L. C. Brunel (FSU)
Funding: $79,491 for 1 year

This proposal was for the development of a gyrotron to provide radiation for an instrument for pulsed and CW electron paramagnetic resonance spectroscopy. EPR spectroscopy is a powerful tool for the study of a number of aspects of matter, including chemical reaction kinetics (for example, in photosynthetic systems), molecular dynamics of biomolecules, structural, and kinetic studies of laser-induced paramagnetic transients, as well as others. It was commonly performed with commercial spectrometers with microwave sources at 9 GHz; more experimental systems at 94 GHz and 140 GHz have been developed. Both CW and pulsed systems are used. A pulsed system allows determination, through a Fast Fourier Transform (FFT), of the response spectrum of a sample almost immediately, over the bandwidth of the pulse. Shorter pulses give wider bandwidths, an advantage for many measurements. Higher carrier frequencies allow both the production of shorter pulses as well as the matching of the resonance frequency (in the sample) of stronger magnetic fields. Such fields, now routinely produced in laboratories at magnitudes over 20 T, allow observation of phenomena not visible with lower fields. Unfortunately, the required frequency of the radiation scales as the magnetic field, with the result that the frequency for EPR can substantially exceed 100 GHz, where there are few appropriate sources. For short pulse EPR, there are no sources, other than fixed frequency FIR lasers, above 140 GHz. The desired pulse widths are from 1 ns to 10 ns, with a power of about 10 watts (at the sample) at frequencies to at least 600 GHz.

This combination of pulse width, power, and frequency is possible only with a gyrotron. The gyrotron is a relatively new type of microwave source. Gyrotrons have been realized specifically for spectroscopy with frequencies to 830 GHz and power levels of 10's of watts. These devices produced power on a continuous wave (CW) basis and were designed to meet specific requirements for spectroscopy. Unfortunately, the design approach taken in these gyrotrons—in particular, the use of cavity Q's over 10,000—makes it impossible for them to be operated with pulse lengths below 10 ns. A significantly different approach is therefore required to meet the goals put forth above.

We have designed a gyrotron that has a cavity Q an order of magnitude lower, allowing pulse rise times down to about 1 ns. Such Q's are used routinely in higher power, lower frequency gyrotrons. To achieve oscillation with the lower Q, a cavity mode similar to those used in some high power devices will be used, but with a lower voltage electron beam as is appropriate for the power required for EPR. Switching, to produce the short pulses, will be achieved through the so called "modulation anode" of the electron gun. Based on reported tests, a modulation of less than 10% of the mod-anode voltage will be required to fully modulate the gyrotron output. This makes the design of the modulator relatively straightforward.

The gyrotron that has been designed is a single cavity, free running oscillator, or gyromonotron. This will produce pairs of short pulses, where the phase of the radiation in the pairs is coherent. The separation between the pulses will be accomplished by optically splitting and differentially delaying the pulses. Limits on the size of the delay unit will keep the separation between pulses to less than about 20 ns.

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

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

Experimental Effort. One of the main objectives of the initial proposal was achieved, namely a complete EPR characterization of the Spin-Peierls material $CuGeO_3$. This effort includes measurements at six different frequencies (95, 110, 190, 220, 330, and 440 GHz) both in the undoped and Zn-doped compound (the latter using six different dopant concentrations x=0.00, 0.01, 0.02, 0.03, 0.04, and 0.05). Measurements were conducted at fields as high as 17 T using the NHMFL facilities. The samples were grown by Dr. G. Cao, also at the NHMFL. 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 allowed 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.

Highlight. These measurements and their interpretation were a sufficiently original work to allow for publication in the Physical Review Letter,[1] as well as to provide material for the Ph.D. degree obtained by one of the researchers involved in the grant (A.K. Hassan). The global effort represents a collaboration between theorists and experimentalists as outlined in the original proposal.

Theoretical Effort. The efforts on the theoretical front have been focussed 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 S=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 references 2 and 3. From a computational point of view, an important step forward was made recently with the development of a new numerical technique.[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. This new algorithm, once fully developed, will represent a powerful tool in the interpretation of a variety of experimental measurements in strongly correlated systems. Thus far, it has been applied to the interpretation of Angle-Resolved Photoemission, and Inelastic Neutron Scattering measurements in doped ladder materials.[5,6] These results were also presented in the "Strongly Correlated Electrons Workshop" held in Tallahassee from March 12 to 14, 1998. The title of the talk (given by G. Martins) was *Roles in Ladders: Dynamical Properties and Influence of Coulombic Interactions.*

Future work in $CuGeO_3$ will include performing EPR experiments on single crystals of the pure and doped compound. The single crystal measurements will complement the work already done on the polycrystalline samples discussed above, and they will help in clarifying the effect in the measurements of the magnetic field direction with respect to the crystal axes. For this purpose, large single crystals are being grown using a floating zone furnace. The effect of doping on the incommensurate phase will also be studied by performing the ESR measurements at higher fields up to 25 T.

The theoretical part of the proposal will now benefit from the recent purchase of five workstations. The previous work was done with great difficulty due to the lack of adequate computational resources. We believe that these new machines, and other machines that hopefully will be purchased in the future, will improve the productivity in our group using the new algorithm described in the theoretical effort section above.

References:

1 Hassan, A.K. *et al.,* Phys. Rev. Lett. **80**, 1984 (1998).
2 Martins, G. *et al.,* Phys. Rev. Lett. **78**, 3563 (1997).
3 Laukamp, M. *et al.,* Phys. Rev. B **57**, 10755 (1998).
4 Dagotto, E. *et al.,* Phys. Rev. B **58**, 12063 (1998).
5 Gazza, C. *et al.,* Phys. Rev. B **59**, R709 (1999).
6 Martins, G. *et al., Hole-Density Evolution of the Quasiparticle Band in Doped Ladders*, submitted to PRL.

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High Resolution Solid State NMR Techniques and Applications to Materials Science

PI: N. Dalal (FSU)

Funding: $109,070 over 2 years

This is the first annual report of this In-House Research Program project. As proposed, we have focused on two related areas of high resolution NMR spectroscopy of solids (1) acquisition, modification and installation of an NMR probe that extends the range of variable temperature, high resolution NMR measurements on solids previously possible at NHMFL; and (2) development of a CP-MAS technique that will help obviate the line broadening effects of anisotropic bulk magnetic susceptibility (ABMS) in solid state NMR. 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 Zeeman fields. The methodology proposed herein, based on the utilization of single crystals, significantly reduces (and, in some cases, even eliminates) the ABMS broadening, thereby enabling one to utilize the advantages of high Zeeman fields for NMR measurements on solids.

Development of a Variable Temperature Probe For MAS Studies. After a detailed evaluation of various designs for MAS probes, we selected an MAS-double resonance, multinuclear probe of the Bruker design that could be adapted to our 300 MHz for variable temperature CP-MAS measurements on solids. To accomplish this we needed to develop a high-pressure (pure) nitrogen gas system that enabled us to spin the sample at high MAS speeds, while maintaining low temperatures. The variable-temperature range of this probe is from 123 K to over 500 K, in comparison to the earlier-possible range of about 220 K to 400 K. With this probe we have been able to extend the phase transition studies to many new ferroelectric solids. It is believed that this probe adds an important new dimension to the NMR instrumentation and unique facilities at NHMFL and will find extensive use by outside users.

Technique Development for Obviating Magnetic Susceptibility Broadening in High Field NMR Spectroscopy of Solids. A major part of our proposal was to find a technique that could obviate the signal broadening due to anisotropic bulk magnetic susceptibility (ABMS). Through systematic CP-MAS studies, we have now established (see the list of papers published) that at least for carbon-13 NMR of crystalline solids, the utilization of single crystals in a CP-MAS experiment significantly reduces the ABMS line broadening effects. As a test sample, we selected squaric acid, $H_2C_4O_4$, which exhibits a paraelectric-antiferroelectric transition at 373 K. Our measurements demonstrate that the utilization of single crystals in ^{13}C CP-MAS studies of squaric acid leads to a reduction in the signal line-widths by a factor of about 4.5: from 1.3 ppm (powders, as done by others previously) to 0.3 ppm, as obtained in our experiments using single crystals. These accomplishments have been documented: Number of publications (4); Number of invited talks (7); and posters presentations (4).

We propose to carry out the following, remaining sub-tasks of our original proposal.

Development of a Novel 2-Dimensional NMR Technique for Correlating the Exchange of Molecular Reorientations Exchange Across a Phase Boundary of a Solid Lattice in the Vicinity of a Phase Transition. We are in the process of the development of an NMR methodology that will enable us to identify the conformational change in a lattice as it changes from one solid phase (molecular structure) to another. The technique is to use temperature jump as a parameter, with the condition that the sample can be made to change from one structure to another in a time that is shorter than the spin-lattice relaxation time T_1, of the nuclei under consideration. Thus our two dimensions are the sample temperature and the isotropic chemical shift. The correlation appears as cross peaks in the 2-D presentation. We are using squaric acid as the model lattice for this study because of several reasons: its structural simplicity, and its usage as a model for a phase transitions in a (pseudo) two-dimensional system. If successful, then this study will open up a powerful new technique for probing the molecular basis of a wide variety of structural phase transitions.

We believe that an important application of this technique would be a method for a quantitative distinction between the order-disorder and displacive character of a structural phase transition. There is currently no experimental technique with which one can obtain data that can serve as a convenient basis to delineate the order-disorder effects from displacive characteristics.

Utilization of High Zeeman Fields for Enhancing the NMR Spectral Resolution of Spin 1/2 Nuclei Coupled to Quadrupolar Nuclei in Solids. We are in the midst of developing an important technique: the utilization of very high Zeeman fields for obviating the line broadening effects of the NMR spectra of solids containing spin 1/2 nuclei, such as ^{13}C and ^{31}P, when these spins are coupled to quadrupolar types. An important class of compounds are the ferroelectrics of the KH_2PO_4 family, the mechanisms of whose phase transitions are still not understood, despite several decades of study. Here the spin 1/2 nucleus is, for example, ^{31}P, while the quadrupolar nuclei are $^{39,41}K$. Our comparative studies at 7 T and 14 T. Zeeman field show that the resolution is substantially enhanced as the higher field. We need to explore this phenomenon further by investigating other lattices such as NH_4, H_2PO_4, and RbH_2PO_4. These lattices are particularly important because when grown as mixed crystals, they exhibit the phenomenon of "proton glass" formation. The proton glass-state is the electric analog of the spin glass-state in magnetism. However, the molecular mechanism of the proton glass-state is not yet clear. We believe that the present study will shed important new light on the role of the proton tunneling and possibly other modes in the mechanism underlying this fascinating new phenomenon.

Additionally, this study will demonstrate that the higher the Zeeman field the better could be the resolution in NMR studies of many solids that exhibit novel phenomenon such as the formation of the proton glass state.

This project is supporting two graduate students toward their Ph.D.s in Physical Chemistry: P. Brant Cage, year III, and Randall Achey, year II.

This project has also supported a postdoctoral fellow, Dr. Riqiang Fu, who is now employed as a new Assistant Scholar/ Scientist at the NHMFL. This project is thus making a significant contribution toward graduate education as well as human resource development.

Publications (4)

Klymachov, A.N. and Dalal, N.S., Z. Phys. B **104**, 651-656 (1997).

Klymachyov, A.N. and Dalal, N.S., Sol. St. Nuc. Magn. Reson. **9**, 85-89 (1997).

Klymachyov, A.N. and Dalal, N.S., J. Korean Phys. Soc. (Supplementary Issue) **32**, S629-S633 (1998).

Klymachyov, A.N. and Dalal, N.S., Ferroelectrics **206**, 103-112 (1998).

Presentations-Invited (7)

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 Physics, Sicily, Italy, June 10-14, 1997.

Dalal, N.S., *Magic Angle Spinning with Single Crystal Significantly Enhances the Spectral Resolution in Solid State NMR*, 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.

Dalal, N.S., *Overcoming the Anisotropic Magnetic Susceptibility Broadening in High Resolution NMR Spectra of Solids*, Southeastern Magnetic Resonance Symposium, Gainesville, FL, October 30, 1997.

Fu, F. and Dalal, N.S., *Advantages of High Field NMR in High Resolution NMR of Solids*, ACS Regional Meeting, Orlando, FL, May 8, 1998.

Talks/Posters-Contributed (3)

Klymachyov, A.N. and Dalal, N.S., *Magic Angle Spinning with Single Crystals to Enhance the Spectral Resolution*, Experimental NMR Conference in Orlando, FL, March 21,1997.

Fu, R., Klymachyov, A.N., Bodenhausen, G. and Dalal, N.S., *A Temperature -Jump NMR Technique for Studying Phase Transitions*, Experimental NMR Conference in Orlando, FL, March 21, 1997.

Fu, R., Klymachyov, A.N., Bodenhausen, G. and Dalal, N.S., *TOESY: A New Technique for Detecting Slow Dynamics Near Structural Phase Transitions*, Experimental NMR Conference , Asilomar, CA, March 18, 1998.

Materials Processing in Magnetic Fields: High Strength Polymers

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

Preliminary work has shown that through processing via a magnetic field the amount of bulk orientation obtained in a liquid crystalline epoxy system can be increased significantly.

Work conducted using a liquid crystalline epoxy system, 4, 4'-diglycidyloxy-α-methylstilbene and sulfanilamide, processed in a magnetic field has revealed that the bulk orientation can be increased significantly. High orientation parameter values of 0.75, on a scale of 0 to 1, can be obtained even at low field strengths of 3 T. Dynamic mechanical spectroscopy studies have also revealed a corresponding increase in the storage modulus of the material of nearly 60%.

Measurements of orientation as a function of magnetic field strength for two levels of B-staging (pre-curing) 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 2 hours B-staging time. Preliminary results indicated the presence of a threshold magnetic field strength required to orient the B-staged samples as compared to the non-B-staged samples. Preliminary results, however, also indicate that at high magnetic field strengths orientations are higher for the B-staged materials than for the non-B-staged material.

We have designed a statistical design experiment in order to investigate the combined effects of magnetic field strength, processing time, and B-staging on the orientation and mechanical properties of the liquid crystalline thermosets. The model resulting from the statistical analysis can be used to predict the processing conditions required for a given degree of orientation.

Table 1. Four sample results using statistical model.

Time in field (min)	Field strength (Tesla)	B-staging time (min)	Predicted orientation parameter	Experimental orientation parameter
5	12	8.4	1.48	0.5714
40	10	90	0.95	0.8859
40	9.4	90	0.90	0.9221
40	8.8	90	0.85	0.9196

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. The response studied in this work is the orientation parameter, which is used to measure the amount of bulk orientation obtained in the bulk material. A preliminary experimental error analysis conducted on several pairs of replicate samples revealed an error percent of 5.82%, which translates into an error in the orientation parameter of ±0.0627. Analysis of the results of the orientation parameter data gathered from the samples included in the statistical design yielded a model that describes the effects of the three input variables on the orientation parameter. The coefficient of determination for the model is 0.8577. An optimization of the model revealed a very good predictability of the input variables given the desired orientation parameter. Table 1 displays the results from four samples that were made according to the predicted input variables from the model for a given orientation parameter.

The last three sample results are well within the 95% confidence limits of ± 0.2378 given for the model. The first sample has a predicted orientation parameter well above the theoretical limit of 1. The model cannot account for the upper limits of the orientation parameter without severely distorting the model. The results for the three other samples, however, indicate that the model can predict the orientation parameter for a given set of processing conditions.

While the results described above provide considerable insight into the use of magnetic fields in processing of polymers, a number of significant issues remain if the process is to be made practical. For commercial applications, low field strengths would be required. Analysis of the statistical model for a constant field strength of 1.5 T, however, indicates that significant orientation may only be obtained at processing times of 1 hr or greater. One significant factor may be the material system we are currently using. This material is initially isotropic, and forms a smectic phase during the processing. Thus, orientation will not begin until the viscosity has already increased due to the partial cure, and the smectic phase that forms has a considerably higher viscosity than a corresponding nematic. Thus, to improve the orientation process we intend to synthesize a new thermosetting liquid crystal that exhibits a nematic phase at the beginning of the processing cycle. Investigation of the kinetics of the orientation process for this system will allow us to determine if the field strength and processing time can be lowered to make magnetic field processing of polymers more commercially viable. Once the processing parameters for this new system are established, we will examine the mechanical properties and orientation effects on those properties.

Novel Syntheses and Fourier Transform Mass Spectrometric Analysis of Combinatorial Libraries

PI: J. R. Eyler (UF)
Funding: $148,897 over 2 years

The purpose of this project is to build a part of the bridge between the physics and engineering programs at the NHMFL and biological and biomedical applications, a general goal of the NHMFL and the NHMFL In-House Research Program. The specific goal is to develop a new technology known as "Receptor Assisted Combinatorial Synthesis" (RACS), which should allow the search of libraries with effective sizes of up to 1 trillion compounds to find organic molecules with high affinity for proteins and nucleic acids. RACS is foreseen as a powerful tool for discovering lead compounds that can be developed to give therapeutic agents. Significant progress has been made in each of the areas for which research was proposed under this grant.

Graduate students Joseph Nawrocki and Amy Howe in Professor Eyler's group have studied conditions under which quantitative assessments of the relative concentrations of components in peptide combinatorial libraries can be obtained using electrospray ionization (ESI) combined with Fourier transform ion cyclotron resonance (FTICR) mass spectrometry.

Graduate student Lisa Lang has studied the infrared laser-induced dissociation of small peptides found in combinatorial libraries, as a way of identifying the structures of peptides that may be identical in mass to other library components.

Graduate student Maria Wigger in Professor Benner's group has been investigating novel syntheses of combinatorial libraries and developing the capability to use FTICR to determine directly which components of these libraries are preferentially bound to receptor molecules. In addition to studies at UF, numerous experiments have been carried out, particularly by Ms. Wigger, on the 9.4 T FTICR instrumentation at the NHMFL.

Also essential to this technology are synthetic organic chemical methods for preparing libraries of non-peptidic ligand fragments. Peptide, peptoid, olefin metathesis, and thiamine-catalyzed chemistries have been developed for this purpose. A publication describing the RACS concept has appeared together with experimental data describing the preparation and composition of libraries prepared by the olefin metathesis reaction. Additional progress has been made toward applying the RACS approach to identiligands that bind to DNA.

This work has resulted in two papers and numerous presentations during the time period covered by this report. Publications and presentations are listed below.

Presentations by Prof. Eyler (3)

The ABC's of Fourier Transform Mass Spectrometry. From Atoms to Biomolecules to Combinatorial Libraries, presented at Abbott Laboratories, Abbott Park, IL, February 24,1997.

The ABC's of Fourier Transform Mass Spectrometry: From Atoms to Biomolecules to Combinatorial Libraries presented at the Laboratoire Physico-Chimie des Rayonnements, Universite de Paris-Sud, Orsay, France, April 1997.

Recent Advances in Fourier Transform Mass Spectrometry. From Atoms to Biomolecules to Complex Ions presented to the Department of Chemistry, SUNY at Buffalo, Buffalo, NY, November 1997.

Presentations by Prof. Benner (1)

Nolan Summer Lecture, March 1998, University of Nebraska.

Presentations by Prof. Eyler's and Prof. Benner's Students (3)

Characterization of Combinatorial Libraries via Electrospray FTICR Mass Spectrometry, poster presented by Joseph Nawrocki at the First North American FT-ICR MS Conference, Tallahassee, FL, March 13-15, 1997.

Characterization of Combinatorial Libraries Using ESI-FTICR Mass Spectrometry, poster presented by Joseph Nawrocki and Maria Wigger at the 45th American Society of Mass Spectrometry Conference, Palm Springs, CA, June 1-5, 1997

Assessing Enzyme-Substrate Specificity Using Combinatorial Libraries and Electrospray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry, poster presented by M.Wigger, *et al.*, at the 1997 Research Affiliates Meeting, Department of Chemistry, University of Florida, October, 1997.

Publications (3)

Wigger, M. *et al.*, Rapid Comm. Mass Spectrom. 1997, II, 1749-1752.

Giger, T. *et al.*, Libraries for Receptor-Assisted Combinatorial Synthesis (RACS). The Olefin Metathesis Reaction, Syn. Lett. 1998, 688-692.

Eyler, J.R., (non-refereed) *FTICR Offers New Insights and Research Opportunities*, NHMFL Reports, March 1998, for the Chief Scientist's column of this quarterly NHMFL publication.

We anticipate that the research during the remainder of the grant will not differ significantly from that proposed for year two in the original proposal.

We anticipate that all funds will be spent in a timely manner, and that no more than 20% will be remaining at the end of the grant period. Depending on developments during the next six months we may request a six-month, no-cost extension.

Doped Hole Physics in Single-Layer Perovskites

PI: Z. Fisk (FSU)

Funding: $138,194 over 2 years

Results to date:

- Measurement of the optical conductivity *vs.* doping and temperature in Li-doped La_2CuO_4
- Measurement of the two-magnon Raman scattering spectrum in Li-doped La_2CuO_4
- Measurement of the pressure-dependent optical transmission in $Sr_2CuO_2Cl_2$.

We have recently completed and submitted a manuscript to Physical Review Letters entitled *Mid-Infrared and Raman Magnon Excitations in $Sr_2CuO_2Cl_2$ at High Pressure*. This work demonstrates that the mid-IR optical excitations in the lamellar undoped cuprates are clearly due to composite phonon-multimagnon excitation. Such excitations have not been observed before in any other antiferromagnet, suggesting that quantum fluctuations are involved. This raises important questions, as these excitations are almost 2 orders of magnitude stronger than expected. We are working in collaboration with George Sawatzky (Groningen) in understanding this important question.

In $La_2Cu_{1-x}Li_xO_4$ (LCLO), we made several important observations. First, we find this insulating compound possesses a "mid-IR band" that is identical to that observed in other doped cuprates. As this material is insulating, however, this unambiguously rules out the "one-band explanation" for its existence, i.e., that the mid-IR band arises from energy-dependent scattering of the Drude tail. Second, we find that LCLO has essentially no broadening of the charge-transfer band with doping, unlike all previously studied metallic doped cuprates. This suggests that mobile

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carriers may play an important role in this part of the spectrum. Third, we find no effect of high magnetic fields on any part of the optical spectrum. Fourth, we find that the Raman spectrum is very different from other (metallic) doped cuprates, as it shows reduced broadening of the 2-magnon peak. This suggests reduced frustration relative to Sr-doped La_2CuO_4. We are in the process of writing up these results.

Next 12 months: We expect to move to doped nickelates as originally proposed. We may also examine the pressure-dependence of the mid-IR band in LCLO, to determine the role of magnetic excitations.

Remaining funds: We have only very minor expense funds remaining from the first year's funding.

Applications of Magnetic Resonance Imaging Velocimetry for Flow in Porous Media and Fiber/Composite Manufacturing

PI: S. J. Gibbs (FSU)
Funding: $141,543 over 2 years

Results to date:

- Demonstrated reliable, high-resolution velocimetry in model systems by MRI on the 600 MHz wide bore system in Tallahassee
- Implemented data acquisition protocols and wrote data analysis software for high resolution velocimetry
- Identified several porous materials compatible with high resolution MRI
- Paper accepted for presentation at the 1998 Fall American Institute of Chemical Engineering National Meeting in Miami, Composite Materials session: *Magnetic Resonance Imaging Study of Liquid Flow in Porous Materials Containing a Transverse Permeability Discontinuity.*

Postdoctoral research associate Dr. Galina Pavlovskaya joined the research project October 1997; therefore the project is behind schedule. An extension will be requested.

Estimated remaining unobligated: $5,500 in salary and benefits for the postdoctoral research associate. We would like to carry forward these funds into the six-month extension period.

Very High Magnetic Field Studies of the Cuprate Spin Gap

PI: P. C. Hammel (LANL)
Funding: $143,759 over 2 years

One of the most actively researched questions in understanding the cuprates concerns the origin of a strong suppression of the spin susceptibility with decreasing temperature first observed in NMR Knight shift measurements in underdoped $YBa_2Cu_3O_{6.63}$.[1] This suppression has come to be known as the spin gap. Recently it has become clear that the spin gap can be observed in optimally doped $YBa_2Cu_3O_{6.96}$ as well.[2] We are studying the response of the spin gap in $YBa_2Cu_3O_{6.96}$ to applied magnetic fields to better understand its nature and origin.

We have made extensive and precise measurements of the field dependence of the normal state spin susceptibility of $YBa_2Cu_3O_y$ for y=6.96 and 6.63. These measurements have been obtained by means ^{17}O Knight shift measurements made in the resistive 24 T magnet at fields of 24 T and 16 T along with a 9 T superconducting solenoid at Ohio State University. We have performed these experiments on aligned powders, which enables us to make measurements with the field applied both parallel and perpendicular to the crystalline c-axis (perpendicular to the CuO_2 planes). Cu NMR has been used to allow precise determination of the applied field in which the measurements were made. In order to obtain the highest accuracy, these measurements have been corrected to provide agreement with results obtained on the same sample in a high homogeneity 8.8 T superconducting magnet. We have also carefully measured the field dependence of the copper spin lattice relaxation rate. We find that neither the static susceptibility (Knight shift) nor the relaxation rate displays any field dependence. These results will place serious constraints on proposed theories of the spin gap.

Specific project achievements:

- Purchase and installation of broadband NMR spectrometer optimized for solid state NMR studies of correlated electronic systems
- Determination of the field dependence of the Knight shift of $YBa_2Cu_3O_x$ in fields up to 24 T for x=6.63 and 7
- Determination of the field dependence of the Cu relaxation rate in $YBa_2Cu_3O_{6.63}$.

We will focus on refining the results obtained, by extending the studies to new materials (i.e. different oxygen dopings and different cuprate superconductors), and filling gaps in field not yet measured.

References:

1 Takigawa, M. *et al.*, Phys. Rev. B 43, 247 (1991).
2 Martindale, J.A. *et al.*, Phil. Mag. B 74, 573 (1996).

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

A range of solenoidal microcoils have been constructed and tested for spectroscopy and imaging on the 600 MHz instruments at UF and the NHMFL. The coils were integrated into suitable probe bodies and tested for spectral line-width on phantoms using unlocalized spectroscopy. The line-widths and SNR in phantom images were then tested at the NHMFL. Subsequently, the first NMR microimaging of single neural cells isolated from the marine snail *Aplysia California* were obtained at the NHMFL. Similar images have been obtained only at two other institutions. In themselves, however, these data are not unique, but demonstrate the capability of the NMR coils developed. Resolutions of 20x20x100 microns were obtained in a few minutes. Most encouraging were the excellent line-widths achieved (again a few Hz).

For the first time we then performed spatially localized ^1H spectroscopy on these single cells. Spectra were obtained using STEAM for localization from voxels as small as 180x180x180 microns in a few minutes. 14 animals were used resulting in the successful examination of 8 cells The spectra from the L7 neurons from *Aplysia* showed 4 major resonances that, when compared to water and phantom measurements were realized to be a few hundred micromolar in concentration. This is two orders of magnitude larger from signals from animal brain and quite a surprise to us. It turns out, however, that these marine cells are very different in the way they balance osmotic forces and they are known to have very high concentrations of amino acids in them. Work is now underway to assign these resonances after which a paper dealing primarily with the technological aspects of this work will be submitted for publication. A final report on this work will then be submitted.

Because this work is incomplete a six-month extension has been applied for. This will allow time for the completion of the above single cell spectroscopy studies, and also allow the testing of some double tuned coils presently being constructed in Illinois.

A problem with the studies in the original proposal is that the 900 MHz instrument originally targeted for coil development has not yet been constructed. In addition there is not yet any imaging hardware on the intermediate field strength (750 and 830 MHz) magnets. We have thus continued to focus our efforts on the 600 MHz instrument. A full description of the final achievements and publications will be submitted when the project has been completed after the six-month extension.

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

Over the past year the condensed matter NMR group has worked on a number of problems covered in the broad sense of the proposal. Some of this work has derived its primary support from the funding for this proposal, and for some it has been a secondary source of support. The problems receiving primary support are: ^{11}B NMR studies of SmB_6, ^{13}C NMR in $\alpha(BEDT\text{-}TTF)_2\ KHg(SCN)_4$ (J. S. Brooks collaborator), ^{17}O studies of Tb doped $YBa_2Cu_3O_7$, and $^{63,65}Cu$ NQR studies of $PrBa_2Cu_3O_7$ (Cao and Crow collaborators on sample preparation). Work that has received secondary support includes high field studies of the $YBa_2Cu_3O_7$ vortex phase diagram, upper critical field, and fluctuation effects, by ^{17}O NMR. This work was carried out in collaboration with W. P. Halperin, Northwestern University (NU) (listed as a collaborator in the proposal), and was initiated before this grant was active. Another work using secondary support under this grant was a study of the organic spin Peierls system $(TMTTF)_2PF_6$ by ^{13}C NMR, a collaboration with Stewart Brown and W. G. Clark (UCLA, listed as a collaborator in the proposal). Finally, some of the resources used to develop facilities will be used in ^{13}C studies of Mn clusters in manganese acetate.

This work contributes to the goals of the NHMFL and the IHRP in three ways: (1) contributions to the CM/T research program through providing site-specific NMR data on systems of interest to both the experimentalists and theorists. Collaborations (Fisk, Crow, Brooks) include provision of high quality samples exhibiting interesting new phenomena, their characterization, and discussions of the physics with both theorists and experimentalists leads to better understanding of the behavior of highly correlated electron systems. (2) The further development of unique high field NMR facilities that have attracted a number of outside collaborators and users to come to the NHMFL to use these unique high field NMR facilities. (3) This program provides an excellent training ground for graduate students and summer interns. It not only provides training in condensed matter NMR experimental and theoretical techniques, but in low temperature methods, sample characterization by x-ray diffraction, magnetization, transport, etc., and sample preparation through collaboration with the excellent condensed matter experimentalists and theorists at the NHMFL.

SmB_6. The hexaborides are a class of compounds exhibiting a wide range of unusual magnetic, semiconducting, and metallic properties, which are as yet not well understood after

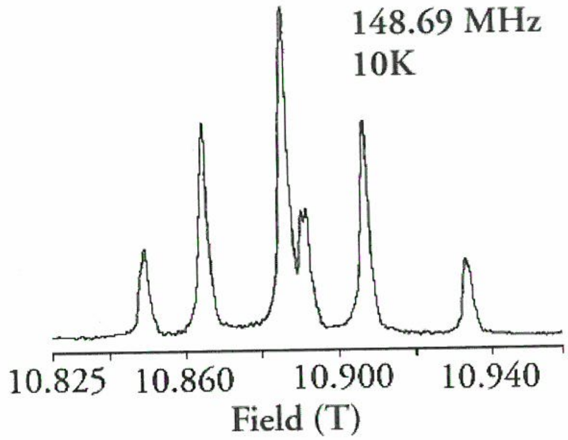


Figure 1. Field-stepped FFT-summed ^{11}B NMR spectrum in SmB_6.

many years of study. In spite of the fact that these materials were not specifically part of the original proposal, it was felt that the great current interest and the unusual properties justified their study. They do fall in the general class of correlated electron systems. The work on these systems began with SmB_6 This is thought to be a classic mixed valence system (0.4^{2+}, 0.6^{3+}), showing Kondo-like behavior below 15 K. To our knowledge there have been no ^{11}B NMR studies since the 1.2 T 1982 work of Takigawa. Two single crystals were obtained from Zach Fisk's group (David Young), and were characterized by them as being semiconducting from 4 to 300 K and of high quality as determined from x-ray and magnetization data. We have measured the ^{11}B NMR spectra over the temperature range from 2.5 to 120 K, and fields from 3 to 14 T.

A sample spectrum is shown in Figure 1. The spectrum showed no ($\Delta H/H$) field or temperature dependence. The spectrum shown is along 001, which places 2 of the Boron's in apex positions with the field along the direction connecting them and 4 in a plane perpendicular to them. The main splitting of the spectrum is completely explained as an anisotropic Knight shift with K_{axial}=-0.02 and K_{iso}=-0.02, in contrast to Takigawa's values of -0.06 and -0.04. Both of these disagree with the earlier work of Jaccarino. The earlier work was carried out at low field and since ΔH is proportional to H, the spectra were incompletely resolved, while ours were fully resolved. Whether the difference is due to inaccuracies at low field, or sample is not completely clear. Rotation of the crystals bringing 2 of the planar Borons into apex positions gave the same spectrum. Thus, the main splittings can be completely explained as one coming from the apex B's and the other from the planar B's. The 2:1 intensity ratio further confirms this. The entire splitting can be accounted for by the orbital (van Vleck) contribution. Any shift coming from localized moment on the Sm should be temperature dependent following the Boltzman population of the Zeeman levels. The concentration of carriers (of order $10^{17}/cm^3$ from Hall data at high temperature) is too small to produce observable shifts, and even then they should be temperature dependent since there is no Fermi surface. The complete lack of temperature dependence clearly indicates there is no localized moment (<0.1 μ_B) on the Sm site. This is in agreement with the early Mossbauer work and at least one interpretation of the susceptibility data. A model is invoked that the last electron added to the Sm goes into a 6s state that shields the Sm moment, which appears to us to be a bit dubious at this point. The small, 12 kHz splitting is accounted for by the B dipole-dipole coupling, and a dipole calculation gives a B-B bond length essentially the same as the x-ray data. This splitting was not observable in Takigawa's data. His line widths were about twice ours. The quadrupole coupling tensor is very sensitive to lattice distortions. No evidence is seen of any temperature dependence of the quadrupole tensor, and conclude that there is no distortion, as has been suggested from band structure calculations. We have just begun taking T_1 data, with plans to study temperature and any field dependence that appears. In Takigawa's T_1 data, the B in the 111 direction that is close to the angle which collapses the splittings, which was his primary emphasis, shows a large minimum in 1ff near 14 K. Our data to date, at 10 T and along 001, shows a similar minimum but the rates are about an order of magnitude less. Further work will determine whether this is due to the high field, or orientation of these data, or whether there is a difference in the samples. Takigawa postulates the high temperature linear behavior of T_1 arises from a Wigner lattice localization with no attempt to explain the data below 30 K. It is anticipated that the new data will help to more completely understand the behavior of this interesting system.

Low Dimensional Organic Conductors. Work on α-(BEDT-TTF)$_2$KHg(SCN)$_4$ was presented in the six-month report in some detail, and is reproduced here for completeness of this annual report, along with the latest results. α-(BEDT-TTF)$_2$KHg(SCN)$_4$ is a quasi lD 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 be 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

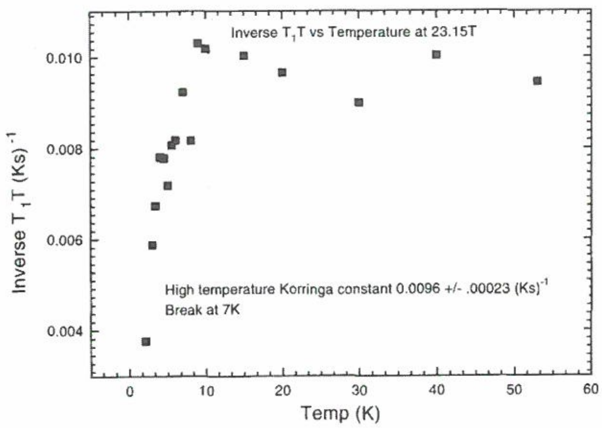


Figure 2. Temperature dependance of T_1 at 24 T.

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 μ_B 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 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.

Complete T_1 data have been taken from 5 to 24 T. The results of the temperature dependence at 24 T are shown in Figure 2.

While the T data have not yet been fully analyzed, it is clear that there is no spin-density wave in the region where one is postulated in the current phase diagram. The T_1 is field dependent, decreasing with field. This work has already shown that some published B-T phase diagrams are incorrect, and completion of the analysis should further elucidate the correct phase diagram. This work will be ready for journal submission within the next few weeks.

^{13}C NMR Studies of $(TMTTF)_2PF_6$. This work was performed in collaboration with Stewart Brown and W. G. Clark (UCLA), and while only indirectly supported under this grant through use of facilities developed under this grant, it is work that probably could not have been done without these resources, and is thus briefly included. Details may be found in PRL **80**, 5429 (1998). $(TMTTF)_2PF_6$ is a spin-Peierls system. The phase boundaries between the uniform, (U), dimerized (D), and incommensurate (I) phases were mapped by ^{13}C NMR. The D-I phase boundary is at 19.1 T, in contrast to the $CuGeO_3$ at 14 T, thus requiring the use of the resistive magnet high field NMR capability. The soliton behavior was studied and evidence for pinning of the solitons by defects (finite chains) was found.

^{17}O NMR Studies of Tb Doped $YBa_2Cu_3O_7$. The rational and importance of ^{17}O NMR studies of to help elucidate the strong difference between Tb and Pr doping were explained in the proposal. The progress on this aspect of the research has been slow, due to difficulties with sample preparation. The initial idea was to use aligned powder made from high quality single crystals, since it was believed that only single crystals with this doping would have the necessary high quality. After considerable effort under the tutelage of Gang Cao, we were still unable to obtain sufficient single crystal yield to produce the required sample size, of order 50 mg, in any reasonable amount of time. There were reports U. Staub that at and below 0.10 doping high quality powder could be made using a standard solid-state reaction technique. This approach at the 0.10 doping level yielded powders with very clean x-ray spectra, but transition widths several degrees broad. Two subsequent oxidation cycles improved this to 5- to 7-K width, but further attempts at oxidation gave no improvement. We subsequently contacted U. Staub at the Scherrer Institute in Switzerland, who had made the high quality powders and has carried out extensive neutron experiments on them. We found that his transition widths were the same as ours. We will now proceed with this powder.

$PrBa_2Cu_3O_7$. Dow has suggested that superconductivity in the cuprate superconductors occurs in the copper oxide chains as opposed to the CuO_2 layers as widely believed. This is evidenced by the fact that Pr unlike other rare-earths when doped in $YBa_2Cu_3O_7$ drastically depresses T_c. This depression in superconductivity. he claims, is due to pair-breaking from Pr local moments, which, because the atomic size match, can easily dope into the Ba sites. This phenomena has also been observed in $NdB_2Cu_3O_7$ when Nd is substituted for Ba. In a standard solid-state reaction, it is estimated that 5 to 10% of Pr resides in the Ba sites in pure $PrBa_2Cu_3O_7$. Indeed, surface resistance measurements in well-synthesized samples of PrBCO has recently revealed existence of granular superconductivity.

When Pr substitutes into the Ba site, charge balance requires that an excess oxygen is pulled into the anti-chain site 05. The presence of this oxygen modifies the electric field gradient in the neighboring copper and thus its quadrupole resonance. In oxygen-deficient $YBa_2Cu_3O_{7-y}$. the NQR spectra of coppers in the chain show a wide distribution which represents disorder attributed to sites with 2, 3, or 4 neighbors, while those that are in the planes remain almost unchanged compared to y~0 samples. Our NQR data in YBCO doped with 20% Pr showed a chain Cu spectra three to four times broader from undoped compound, indicating some form of disorder. NQR work in progress in pure PrBCO should directly verify the existence of this excess oxygen and provide a convincing proof or disproof of the theory. A new powder sample has been prepared and will be aligned within the next week or two.

^{17}O Studies of the Vortex Phase Diagram, Upper Critical Field, and Superconducting Fluctuations in YBCO. This grant provided some secondary support for this work through utilization of facilities and other infrastructure developed under the grant. The vortex phase diagram. superconducting fluctuations above the transition, and upper critical field of $YBa_2Cu_3O_7$ were investigated by ^{17}O NMR up to 24 T. Details may be found in PRL **80**, 5429 (1998). Surprising results include the fact that the glass-liquid vortex phase boundary becomes field independent above 9 T , and that there is a region of mixed glass-liquid phase.

A study of fluctuations at the Cu site for T>120 K show the NMR rate decreases with increasing field indicating a suppression of the low energy spectral weight from the DOS superconducting fluctuations. The sign of the fluctuation contribution implies the order parameter fluctuations are primarily d-wave. A manuscript on this is in the final editing stage, and will be submitted shortly.

NMR measurements of the electronic spin susceptibility up to 24 T were measured, and the temperature dependence can be accounted for by DOS fluctuations that result in a smooth crossover from normal state to vortex behavior. A phase diagram constructed from this shows H_{c2} has a strong upward curvature with field. This manuscript is also in the final editing stage and will be submitted shortly.

Mn Clusters in Manganeses Acetate. A field of research that has sparked recent interest is the investigation of systems of molecular clusters that show the phenomenon of quantum tunneling of the magnetization (QTM). One characteristic of this effect is the presence of steps in the magnetization hysteresis loops at low temperatures. Recent research in this laboratory has focused on the compound Mn_{12}Acetate, or $Mn_{12}Ac$, which has the chemical formula $[Mn_{12}O_{12}(CH_3COO)_{16}(H_2O)_4]\cdot 2CH_3COOH\cdot 4H_2O$. First synthesized by T. Lis, this compound did not attract attention until only recently when it was found that it exhibited the characteristics of QTM. The core of the compound consists of 12 Mn and 120 ions. Four Mn(IV) ions in the center, each with electronic spin S=312, and eight outer Mn(III) ions, each with spin S=2, couple via super exchange through the oxygens to give an overall spin of S=10 for the cluster. The low-field energy states of the molecule are proportional to $-S^2$, which leads to a doubly degenerate ground state of spin +10 and -10. Transition from one ground state to another requires that the molecule cross a potential barrier, and at very low temperatures experiments indicate that the dominant mechanism for this transition is quantum tunneling. The interaction between separate molecules in the crystal lattice is weak, as evidenced by the fact that the relaxation time is similar for molecules in a crystal and in a dilute solution. One objective of these NMR experiments on $Mn_{12}Ac$ has been to determine the exact extent of the coupling between the clusters, and the nature of the coupling between the atoms within the cluster. Another problem is how the magnetic moment is distributed over the cluster. Investigations of the ^{55}Mn and ^{13}C nuclei in $Mn_{12}Ac$ hope to answer these questions.

Facility Development. Considerable effort has gone into improving the condensed matter NMR facilities, both for the 14 T cold bore superconducting magnet dedicated to this work, and the resistive magnets. Much of this has been in improved variable temperature (VT) inserts and NMR probes. A VT insert and NMR probe were designed and constructed for the superconducting magnet, and has been in operation for several months. A new VT insert, with and NMR probe that allows sample rotation from the top has been designed and parts are under construction in the machine shop. A new VT flow system has been designed and built for the resistive magnets, which should give improved and simplified temperature control from 2 to 300 K. Unfortunately the performance did not meet our expectations and is currently being modified. One of the problems encountered in work in the resistive magnets is power supply fluctuations (10 to 20 ppm). This limits the accuracy of T_2 measurements. A NMR flux lock has been designed and built and is being tested. This should improve T_2 requiring long signal averaging by an order of magnitude.

The work done under this proposal has, in some cases, been modified. This is partially due to sample availability and problems, and partially to new and even more interesting physics that has developed. All of the work falls in the category of highly correlated and low dimensional systems proposed.

Specifically, work on the hexaborides is planned to continue through the period of the proposal. Upon completion of the work on the SmB_6 over the next two or three months we plan to begin work on La doped CaB_6, which is a new system showing unexpected magnetic behavior at low La concentrations. We only recently became aware of the proposal of Dow that the reason PrBCO was thought not to superconduct was some of the Pr occupied Ba sites. The $^{63,65}Cu$ NQR, as described above, should provide definitive information on this "conjecture," and is being actively pursued. We have been unable to start the Zn doped $CuGeO_3$ due the fact the floating zone furnace has been down for some time and Damon Jackson has been unable to grow crystals.

A six-month, no-cost extension has been requested, due to the fact we were unable to pick up a graduate student until May 1997, the end of the academic year. No funds will be unexpended at the end of the extension.

A proposal to the NSF is being written and will be submitted in early October.

There are currently three graduate students carrying out dissertation research under our direction in this group: M. Abdelrazek, supported by this grant; T. Caldwell, supported by start up funding for A. P. Reyes; and R. Achey, supported by N. Dalal.

Heat Capacity Measurements in NHMFL 60 Tesla Quasi-Continuous Magnet

PI: R. Movshovich (LANL)
Funding: $127,860 over 2 years

The work on this project during the last months has focused on four aspects: (1) final design, machining and assembling of the heat capacity probe, (2) vacuum and temperature control tests, (3) sample preparation, and (4) thermometer calibration in the 60 T short pulse magnet.

The heat capacity probe is at present in the final stage of testing mode, after identifying and fixing vacuum problems in the plastic jacket that contains the sample. We estimate that we will be able to run the first experimental determination of heat capacity in high magnetic fields as soon as the 60 T Long-Pulse magnet is ready for user service. At the moment the magnet is operated in engineering mode and will be available for users soon.

The machining and assembling of the stainless-steel/G-10/epoxy heat capacity probe was finished in time as expected, and the first leak checks indicated that the chosen design is appropriate for the experimental goals. The probe was wired and demonstrated to be vacuum tight at room temperature. The low temperature tests, however, showed a small leak at liquid helium at the plastic tapered seal. To connect this problem a novel composite 0-10/epoxy tapered seal was designed and successfully tested in liquid helium. The probe is now in the final stages of reassembling and will be immediately ready for temperature control and sample relaxation time tests.

Powder samples of LaSrCuO were synthesized and mixed with fine grain size silicon powder. The goal of the sample preparation stage is to produce electrically insulating highly-compact pellets, that contain a minimum amount of silicon and show maximum thermal conductivity. They are required to be electrically insulating to minimize self-heating effects during the magnetic field pulse, and good thermal conductors to minimize the thermal relaxation time. Superconductors and metallic samples are naturally bad thermal conductors and good electrical conductors, respectively, but these difficulties can be solved with an appropriate mix using fine grain crystalline silicon powder, which is electrically insulating but is a good thermal conductor. Composite samples with different silicon content were pelletized in high pressures and sintered in order to improve the pellets compactness. Insulating pellets were successfully prepared with only 10% silicon. Finally, sintering temperatures were optimized to preserve the superconducting properties of LaSrCuO grains. The properties were verified by means of magnetization measurements in a Quantum Design commercial magnetometer. Thermal relaxation experiments will be done immediately after final vacuum tests in the heat capacity probe.

Cernox thermometers and metallic oxide thin films (heaters) were calibrated in magnetic fields up to 60 T in the short pulse 60 T magnet at NHMFL-Los Alamos in the interest temperature range from 2 K to 6 K. These calibrations allowed us to determine the magnetoresistance of the thermometers to be used in the heat capacity cell, both on the main temperature control stage and on the sample platform. We also verified that magnetoresistance of the thin film heaters is negligible, confirming that they are an excellent choice for our high magnetic field experiments. Further calibration runs are pending (upon the availability of the 60 T long pulse magnet) to extend our calibration to higher temperatures. These calibrations, prevented in the short pulse magnet because of self-heating problems, will be limited to a few shots. We do not expect excessive self-heating in the long pulse magnet because of its substantially smaller dB/dt characteristics during the pulse (300 T/sec against 900 T/sec in the short pulse magnet).

The following work will be performed during the next 12 months:

- We will conclude the tests of the low temperature probe
- Test operation of the heat capacity cell in a DC superconducting magnet in a field up to 10 T
- Begin the heat capacity experiments in quasi-continuous magnet as described in our proposal
- Technical details and preliminary results will be presented in the PPHMF-III meeting to be held October 24-27, 1998 at NHMFL, Tallahassee, Florida.

We do not expect any funds to remain unobligated by the end of the funding period. Dr. Marcelo Jaime is working full time on the project.

Time Resolved Photoluminescence Studies of Semiconductor Heterostructures in High Magnetic Fields

PI: D. G. Rickel (LANL)
Funding: $128,390 over 2 years

Experimental Progress. The intent of this exploratory research proposal is to undertake *time-resolved spectroscopy* of the low temperature ground states of two-dimensional electron gas (2DEG) systems in ultra-high (to 60 T) magnetic fields in the millikelvin temperature range. In the last year, experiments on 2DEGs in modulation-doped n-type GaAs/AlGaAs single heterojunction (SHJ) and coupled-double quantum well (CDQW) samples using photoluminescence spectroscopy were conducted in the newly commissioned 60 T Long-Pulse magnet (LPM). So far, these studies have been limited to 1.5 K.

A Northeastern University graduate student, Mr. Florin Munteanu, was assigned to the project and has been in residence at NHMFL-LANL for the past year. Due to the delay in funding to LANL and in the hiring of a senior postdoctoral research associate, the TRS portion of the project was put off by six months. After the arrival of Dr. Scott Crooker in February, 1998, the time-resolved equipment, UV laser, and other optical components were ordered.

A passively mode-locked Ti-Sapphire laser (Coherent, MIRA 900) pumped by the multiple visible line output from a cw argon laser (Coherent, INNOVA 310) at NHMFL-LANL is used as the ultra-fast light source. The mode-locked output has a maximum of ~1W in the 700 to 1000 nm region. A frequency-doubler was built in-house using a BBO crystal (INRAD) and ~300 mW in the 350 to 500 nm range with ~100 f-s or ~2 p-s operation has been obtained. A pulse compressor has been assembled to maintain the f-s pulse-width after frequency doubling. An interferometric non-colinear auto-correlator was purchased and set-up to measure the ultra-fast pulse widths for the red and blue light, respectively.

In a typical time-resolved PL measurement, the sample is excited by a train of light pulses that have a time duration, T, much shorter than the characteristic decay time, τ of the PL peak. Each pulse creates electron-hole pairs in our quantum wells; the intensity of the PL subsequently decaying in time. By recording the PL intensity as a function of time, one can obtain the decay time τ. Lifetimes associated with QW structures are in the ns time scales. The detection technique that is utilized has an adequate time-resolution (~25 ps). It employs a thermoelectrically-cooled micro-channel plate-photomultiplier tube (Hamamatsu MCP-PMT, R3809U-51) that is sensitive from 200 to 900 nm with a peak QE of ~10%. The PMT is used to time the arrival of signal photons by means of time-correlated single photon counting (TCSPC). The time resolution is determined by a number of factors: the pulse width of the light source and the transit time spread (TTS) of the monochromator/detection system. The jitter associated with the MCP-PMT is less than 25 ps; the pulse width of the laser output is considerably shorter (100 fs or 2 ps). The TCSPC timing electronics measures the time duration between the arrival of a reference pulse that has been synchronized with the excitation laser pulse (and the magnetic field value in a pulsed/quasi-continuous magnetic field operation) and that of the output pulse from the MCP-PMT. This will be done with a time-amplitude converter (TAC; ORTEC 457 or 567), a constant fraction discriminator (CFD; TENNELEC TC454 or ORTEC 935), and a fast amplifier (ORTEC FTA420 or HAMAMATSU C3360). The output pulses from the TAC are recorded using a fast multichannel analyzer. A dedicated PC generates a histogram of pulse number versus their heights (arrival times). The 2048-channel mode gives a duration time of ~25 ps/channel when used with the TAC's minimum time range of 50 ns. Aperturing reduces the TTS associated with the spectrometer but also the signal intensity. Spectral isolation of the PL signal is achieved using an Acton f/4 monochromator.

Low temperatures down to 1.5 K are achieved by pumping the ^{4}He bath. Sample temperatures in the 0.5 K to 1 K range will be obtained shortly when the ^{4}He and ^{3}He-exchange gas system is put into operation. A commercial temperature controller will maintain the desired temperature using a feedback resistive heater on the sample probe. A separate calibrated ReO thermometer is used to measure the temperature. A single fiber input/output probe has been installed in the 60 T LPM for perpendicular field (Faraday geometry) and parallel field (Voigt geometry). Circular polarization analysis for spin dependent studies are routinely made using a linear polarizer plus a quarter wave plate placed between the end of the fiber and the sample.

Research Progress. The PI presented an invited papers at the Research in High Magnetic Fields Conference in Sydney Australia and at APS March 1998 meeting in Los Angeles on "Spectroscopic Studies of Quantum Well Structures in Pulsed Fields." A contributed paper on "Magneto-Optical Investigations of a GaAs/AlGaAs Single Heterojunction" was presented by Florin Munteanu. A paper on "Magneto-Luminescence Oscillations of a Doped (Al,Ga)As/GaAs Single Heterojunction" by Y. Kim, C.H. Perry, K-S Lee, and D.G. Rickel has been accepted for publication in Phys Rev. B. Associated studies of a coupled double quantum well structure were presented by our collaborators from Sandia National Laboratory at the "Four Corners" APS meeting in April, 1998. A report on our work on "Magneto-luminescence Studies of Skyrmion-Hole Transitions of a Modulation-Doped GaAs/AlGaAs Single Heterojunction" by Y. Kim, C.H. Perry, and J.A. Simmons is in preparation.

Recently, Florin Munteanu, in collaboration with Yongmin Kim, have studied the PL at 1.5 K in magnetic fields to 47 T using circular polarization analysis. Two new bands emerge above 40 T that have been attributed to singlet and triplet states of negatively charged X⁻excitons. The sample was a very high quality GaAs/AlGaAs SHJ that has lightly modulation-doped with a carrier density of 1.1×10^{11} cm^{-2}. The field that these excitons appear, are at a filling factor less than 1. We believe that the TRS system soon to be finalized will aid in the analysis, as there should be large differences between the recombination times for neutral and charged excitons.

Publications associated with our work at NHMFL-LANL in the last year:

1. Perry, C. H., Physica B **246-248**, 182-187 (1998)
2. Munteanu , F. *et al.*, Bull. Am. Phys. Soc., **43**, 105 (1998)
3. Kim, Y. *et al.*, Phys. Rev. B **59**, 1641 (1999).

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 has been 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.

AFMR has been used to characterize the canted antiferromagnetic state and to probe magnetostructural correlations of a series of layered solids including $KMnPO_4 \cdot H_2O$, four manganese alkylphosphonates, $Mn(O_3PC_nH_{2n+1}) \cdot H_2O$ n=3-6, and manganese phenylphosphonate. All samples were investigated as powders. AFMR provides a microscopic probe of antiferromagnetic materials. The high field EMR facilities at NHMFL, with field sweep capabilities from 0 to 17 T, the availability of several frequency sources, and variable temperature capabilities, make this technique applicable to a wide range of materials. AFMR measurements reveal that while the magnetic structures are similar among these materials, differences can be detected using AFMR (table). Since the superexchange pathways in these materials are nearly identical, the observed differences in the magnetic exchange are thought to arise from electronic perturbations caused by the phosphate/phosphonate substituents. It was observed that the symmetric exchange field decreased as the electron donating ability of the substituent decreased, following the trend $H_E(KMnPO_4 \cdot H_2O) > H_E(Mn(O_3PC_nH_{2n+1}) \cdot H_2O) > H_E(Mn(O_3PC_6H_5) \cdot H_2O)$, Analysis of the frequency and field dependence of the AFMR signals revealed that the canting angle, β, for these materials was 0.7-0.9° ± 0.2°. In addition, the anisotropy of the magnetic interactions was determined from analysis of the frequency and field dependence of the AFMR signals. The values of the exchange field determined from the AFMR mean molecular field formulation, can be related to the value of the super exchange constant, J, determined from magnetic susceptibility measurements. Some of the advantages of AFMR over other microscopic probes have been demonstrated, including high sensitivity to subtle differences in magnetic interactions, and the ability to work with a small amount of material. The method has now been extended to Langmuir-Blodgett films, the first measurement of its kind on thin film samples.

Magnetic Parameters Determined from AFMR

	H_E ±0.1 (T)	H_{A1} ±0.3 (T)	H_{A2} ±0.3 (T)	H_{SF} ±0.1 (T)	H_{D-M} ±0.1 (T)	$\beta_{\pm 0.2}$ (deg)
$KMnPO_4H_2O$	18.5	0.26	0.65	3.1	0.5	0.9
$Mn(O_3PC_6H_5) \cdot H_2O$	12.2	0.18	0.66	2.2	0.4	0.9
$Mn(O_3PC_3H_7) \cdot H_2O$	14.1	0.21	0.82	2.3	0.3	0.7
$Mn(O_3PC_4H_9) \cdot H_2O$	13.9	0.22	0.74	2.5	0.4	0.8
$Mn(O_3PC_5H_{11}) \cdot H_2O$	15.8	0.20	0.67	2.5	0.5	0.7
$Mn(O_3PC_6H_{13}) \cdot H_2O$	14.8	0.19	0.73	2.4	0.4	0.8

This work has been published in the *Journal of the American Chemical Society* **120**, 5469 (1998).

1996 SOLICITATION

High Field Optical Studies of Highly Correlated Metals

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

An infrared detector cryostat has been designed and built. This apparatus has the following characteristics:

- Use in resistive magnet cells
- Possibility of up to three detectors for far/mid infrared regions
- Isolated 1.2 K pot for cooling the far-infrared detector
- Large 4.2 K bath
- Heat exchanger for sample region allows 2 to 350 K sample temperatures without affecting detector pot temperature
- Light-pipe optics for removable sample probes
- Reflection or transmission sample probes
- Reflection probe allows exchange *in situ* of sample/reference mirror
- Transmission probe allows *in situ* exchange of sample/reference (or measurement of two independent samples).

In addition, studies of the high field properties of three systems were made:

- Organic superconductors. First measurements of the reflectance of salts of BEDT-TTF salts were made.
- High-T_c superconducting films. A paper about the field dependence of $YBa_2Cu_3O_7$ films was finished and submitted to Solid State Communications.
- Colossal Magnetoresistance. The reflectance of the CMR material $LaSrMnO_3$ was measured at temperature of 4.2 K to fields up to 18 T. At this low temperature, no field-induced effects were seen. The measurements will be made at temperatures around the transition temperature (200 to 300 K) using the cryostat described above during the fall.

The detector cryostat was the Senior Honors Project of Mr. Jonathon Wrubel. Jonathon graduated with highest honors in June, 1998, and will attend graduate school at Cornell University in the fall.

1997 Solicitation

The second NHMFL In-House Research Program solicitation was released in January, 1997. 28 proposals were submitted, 15 were sent out for external review, and 7 were funded. Following are the most recent reports on these projects as of December 31, 1998.

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

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

Results were presented at PPHMF III, held at NHMFL Tallahassee, and have been submitted to PRL. Analysis of results from the summer indicates that pinning in high B insulator of high quality two-dimensional hole system (2DHS) is weak. The resonance line shifts upward with decreasing hole density, indicating that carrier-carrier interaction is important in the resonance and hence in all low energy properties of the insulator. The density dependence of resonance frequency is consistent with a weakly pinned Wigner crystal in which domain size increases with density due to larger carrier-carrier interaction.

Enhancement of NHMFL Facilities. A microwave probe with 40 GHz coaxial cables for standard NHMFL resistive-magnet compatible ^3He systems has been constructed and tested to 4 K. It is ready to use. The cables show a slight increase in loss at low temperature, and a very slight (roughly 3 mm per cold meter) shift in electrical length.

NHMFL Operations reports there are four user groups with interest in high quality coax probes for dilution fridges. We are finishing work on adding coax cables to top-loading dilution fridge probes, as called for in the proposal. (The probes were bought as part of the PI's start-up package). Adding the probes to the coax turns to be a somewhat complicated task: Space is limited in the resistive magnet probe, and the superconducting magnet probe needed to be drilled out through the center. We have designs of small parts that will allow users enough versatility for a wide range of projects on the resistive magnet probe, and when these parts are fabricated, the resistive magnet probe will be completed. Work on the superconducting magnet system's probe is nearly complete, needing only final re-assembly and testing of the wired probe.

Advancing Microwave Techniques. The advancement of technique required for experiments that probe the high B limit of the insulators is progressing well. At the frequencies needed to look at the resonance, phase sensitive as well as magnitude measurements have been tested on undoped samples at 4 K, by means of a vector network analyzer with two microwave coaxial cables (one to send in microwaves to sample, one to send out from the sample to the receiver). The vector analyzer technique will be fast enough to fully utilize resistive magnets, and should eventually be helpful to users.

We have achieved adequate sample mounting techniques to work up to 40 GHz, which should be useful in the proposed bi-layer studies.

External Collaboration. A. Starobin, a student of Prof. D. C. Tsui, worked at NHMFL for the summer, occupying a position set out by the proposal. He performed the tests mentioned in the above paragraph. Dr. Peide Ye started work at NHMFL as a postdoc on November 1. His support is shared between the PI and Prof. Tsui.

We will complete work on the dilution fridge probes, as mentioned above. When this is done we will be able to do experiments on the resonance in resistive magnets, in a search for true high B limiting behavior of the resonance. Meanwhile, at lower magnetic fields available in the PI's laboratory we will try higher frequency experiments on correlated insulating phases of bi-layer systems. The bi-layer experiments will require elaborate gating techniques and should be tried first without the time pressure imposed by resistive magnets.

One set back is the high loss of the coaxial cables as delivered. This high loss turns out to limit dynamic range and accuracy in some experiments. We have ordered a few more cables for the key places where this loss is important. We expect delivery within one month and will incorporate the cable into the systems as needed.

The project is proving to be an excellent tool for education of students in advanced microwave measurement techniques and problem solving, especially in the 20 to 40 GHz frequency range. For example, summer student Starobin picked up operation and calibration techniques for the HP 8722D network analyzer. Dr. Ye is also learning this technologically important instrument.

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

PI: Art Hebard (UF)

Funding: $141,881 over 2 years

Theoretical. The main goal of the theoretical part of this project is to construct a theory of magnetic-field induced instabilities in anisotropic, multivalley, compensated semimetals, such as bismuth (Bi) or graphite (C), that are the main candidates for the experimental observation of these effects. It is very important to distinguish between these instabilities of many-body nature from the single-particle semimetal-insulator transition arising from the evolution of the band structure in magnetic field B. To this end, we have performed calculations of the band structure of Bi in the presence of magnetic field in a three-band model for a number of orientations of B with respect to crystallographic axes. The results show that the gap between the conduction and direct valence bands decreases with the field and vanishes at B around 10 T. A further development of the band structure depends on the symmetry of conduction and valence bands. If this symmetry is the same, the crossing of the bands is forbidden, which means that the bands should repel each other. In this case, the band-gap first decreases with the field but then increases again leading finally to vanishing overlap between conduction and indirect valence bands, and thus to a semimetal-insulator transition at B around 80 T. This value of the field is outside the current capacities of permanent magnets. If the symmetry is different, the bands overlap and the metallic-like states formed, which can exhibit instabilities upon further increase of B. The work on discriminating between these two scenarios is currently in progress.

A system of electrons quantized by the magnetic field and interacting with each other can be mapped onto that of fermions occupying fictitious fibers. We have formulated the latter problem in terms of the bosonization procedure and identified processes leading to charge-density-wave (CDW) and superconducting (SC) instabilities as inter-chain back-scattering and "Cooper scattering," respectively. ("Cooper scattering" is a coherent jump of electron pair with zero center-of-mass momentum from one fiber to another). In the bosonized language, inclusion of these processes reduces the problem of interacting electrons to a sine-Gordon model. Analyzing the scaling dimensions of corresponding nonlinear (cos) terms, we have determined the boundary of instabilities as functions of bare coupling constants.

Experimental. Bismuth crystals with purity ranging from 99.9995% to 99.99995% have been obtained from three different sources. The crystals have been cleaved perpendicular to the trigonal axis at liquid nitrogen temperature and then cut along the bisectrix and binary directions to form rectangular parallelepiped pieces. To qualify samples for NHMFL runs at low temperature and high field, we are simultaneously pursuing the objectives of obtaining high resistance ratios, low contact resistance, and accurate crystal alignment. The angular dependence of the magnetoresistance is presently being measured at UF on a variety of cut samples to 7 T and 4 K. Shubnikov-de Haas oscillation periods in both bisectrix and binary directions have been measured and checked against literature values. Vacuum annealing close to the melting point of Bismuth has given resistance ratios of 140, close to our objective of at least 200. We have also found that contact resistance can be considerably improved by a controlled application of an electrical discharge to the epoxied contacts. We have also obtained HOPG graphite samples of large size. These samples are presently being vacuum annealed to improve their resistance ratio. We anticipate NHMFL runs on qualified bismuth and/or graphite samples by early Spring.

Optical Probe. After careful consideration of the available cryostats and magnets at NHMFL, we have decided to build an IR reflectance probe for the 15 T/mK system. This probe is in the late design stage, and should be ready for initial trials by late spring 1999. This probe will be capable of performing polarized reflectance studies of surfaces that are themselves parallel to the applied field.

Magnetization Measurements on NaV_2O_5. In collaboration with Donavan Hall at NHMFL, AC magnetization measurements were made on the NaV_2O_5 sample mentioned in our previous semiannual report. Our apparatus comprises a solenoidal primary and astatic secondary. Each coil of the secondary has about 3000 turns of .001" Cu wire. We use a stepper motor to run the sample through both coils and then subtract out the background. The set-up works reasonably well at low fields and we were able to get susceptibility data which agrees well with Quantum Design Squid data acquired at UF. Unfortunately, we were not able to acquire high field data because of electrical pick-up. Version 2 of the apparatus, which we hope to run this March, will have a preamplifier as close to the coils as practicable and will incorporate improved wiring, a smoother mechanical drive, and better thermal isolation.

Development of Quasi-Optical Methods for High-Field EPR Spectroscopy

PI: J. Krzystek (FSU)
Funding: $119,682 over 2 years

It was decided between the PI and co-PI's to purchase the quasioptical (QO) elements from a single company (Thomas Keating, UK) which guaranteed not only the performance of individual elements but also of the complete bridge. A price was negotiated with Thomas Keating that would be within the proposed limits ($86,000) and an order has been placed with the expected delivery of the elements in the fourth quarter of this year. The actual delivery of the basic QO structure and approximately half of ordered QO elements took place in November 1998. The structure and elements were put in place under supervision of Dr. Richard Wylde from Thomas Keating CO. The remaining elements will be delivered late January or February, 1999.

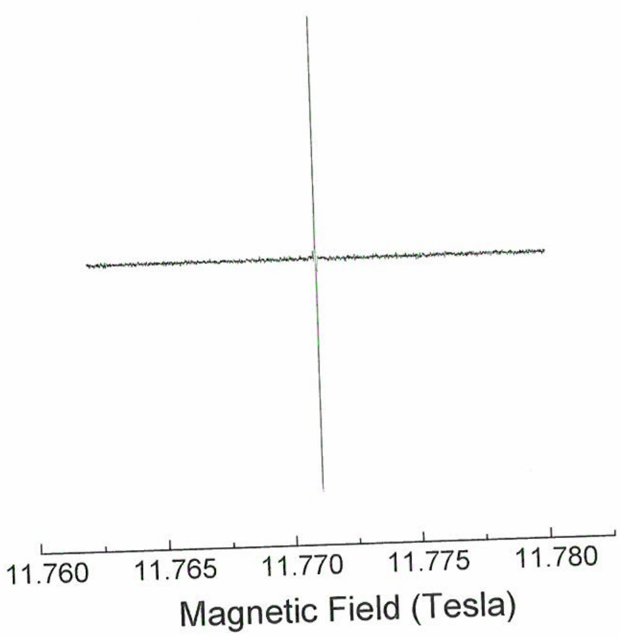


Figure 1. 330 GHz EPR spectrum of Lithium Phthalocyanine single crystal at 273 K. This is the narrowest EPR signal ever recorded—to the best of our knowledge—at 12 T field. The spectrum was recorded using a Fabry-Perot resonator being a prototype of the one constructed within this grant.

The design of the quasioptical EPR bridge has been agreed on in detail during a four-day meeting between the PI, co-PI's, and representatives of Thomas Keating in Tallahassee in June, 1998.

A series of frequency and temperature-dependent EPR experiments was performed in the existing Fabry-Perot resonator on quasi-one-dimensional system $Li(DCNQ)_2$ (a radical ion salt) which was proposed in the grant to serve as a standard compound to test the properties of the QO bridge under construction, and on an analogous LiPc crystal. The results on the latter were extremely valuable and proved the worth of the original idea of employing an FP resonator to investigate radical ion salt systems even if the sensitivity of a single-pass EPR spectrometer currently in operation is in principle sufficient to detect EPR signals. In particular, we were able to measure the narrowest—to the best of our knowledge—EPR signal recorded at 12 T: 20 μT peak-to-peak (Figure 1).

A visit of the collaborator Dr. J. U. von Schuetz from Stuttgart University was arranged in May, 1998.

So far the work on the project has progressed according to the original proposal. The following technical problems, however, arose which made changes in the designs necessary.

It was found that given the warm bore diameter of the current superconducting (SC) magnet, it is not possible to accommodate both the CF cryostat and Fabry-Perot resonator at the same time. As a result, there will be needed two probes at each frequency band, instead of the planned one: one probe (A) will fit the cryostat but will contain a non-resonant sample structure, the other (B) will fit the warm bore and contain a Fabry-Perot resonator. Therefore, probe (A) will enable temperature-dependent experiments in the full originally proposed range (LHe - room T), while probe (B) will be specifically meant for experiments near room T. Since the scientific part of the current grant called for experiments on samples of biological significance, the limited temperature range will not have a negative bearing on the grant progress. Eventually a third probe (C) will be constructed that will be equipped with a resonator, and will fit the cryostat which will come with the new SC magnet of Dr. Brunel. That cryostat will have a 88 mm warm bore as compared to 61 mm for the current one, and will provide more space for resonator controls. The 88 mm bore SC magnet is being shipped by Oxford Instruments, to arrive at NHMFL first week of January, 1999.

It was decided to place magnetic field modulation coil on a separate support from the resonator. We have received the support material from Dr. von Schuetz at Stuttgart University as a gift, and are currently winding up the modulation coil on it.

There are needed transitions between the current sources output waveguides that are over-moded, to single-moded waveguides at each frequency band. One transition has been purchased, another is on order.

There will be extra costs involved due to the necessary decision to build separate probes for low-T, and high-T experiments, as explained above. I am currently trying to estimate these costs, and will request separately an adjustment to the second-year budget, but it will not exceed the $10,000 threshold.

ODMR of Mass-Selected Gas-Phase Ions

PI: Alan Marshall (FSU)
Funding: $112,463 over 2 years

The postdoc hired for this project arrived in October, 1998. He has been occupied with assembling the various components for the proposed experiment. Specifically, he

- Brought the laser vendor here to realign our Nd:YAG laser
- Had our photomultipliers checked (one was defective) and installed one
- Worked with our machinist, Dan McIntosh, to re-engineer the electron ionization module. They also diagnosed and fixed the source of a faulty weld in the vacuum chamber.
- Had our optical fibers checked and replaced
- Is redesigning the ion trap
- Is redesigning the laser ionization module, including a new source of barium (our old source was contaminated).

As a result of these efforts, signal-to-noise ratio for the fluorescence excitation spectrum of atomic barium ions has improved by a factor of 100 relative to our previously published effort [G.Z. Li, B. A. Vining, S. Guan, and A. G. Marshall, *Rapid Commun. Mass Spectrom.* **10**, 1850-18564 (1996)]. We are now ready to attempt the first direct detection of fluorescence from molecular ions in a Penning trap.

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

Advances in superconducting materials are critical to future NHMFL magnets. Although resistive materials and magnets continue to make impressive advances, NMR magnets at 1 GHz and above, hybrid magnets above 50 T, and future ICR magnets will depend on improved superconducting materials. The research results to date are the first-step toward expanding the maximum magnetic field *and* operating temperature of superconducting magnets. The results to date are also the important steps toward forming samples suitable for characterizing the transport J_c at high field as a function of temperature in the DC users facility.

Identification of Suitable Dopant. The phase stability and processing parameters of HgX1223 significantly depend on the dopant X. A systematic study has been carried out to identify suitable dopants to enable the synthesis of HgX1223 in conjunction with silver. Since silver readily forms an amalgam that melt at significantly lower temperature than silver, it has been decided to identify dopants that will allow the formation of HgX1223 at temperatures lower than 800 °C. Among the dopants investigated, Pb and Re were observed to allow the formation of pure HgX1223 at temperatures as low as 750 °C. Based on these studies it had been decided to pursue HgPb1223 and HgRe1223 for the fabrication of silver-clad conductors of HgX1223 superconductor.

Studies on the Role of Silver Interface on the Formation of HgX1223. Studies on the role of silver interface on the formation and texture development of HgPb1223 were conducted. Thick films of precursor powders were deposited on silver foil by coating methanol slurry of BaCaCuO followed by drying in flowing oxygen. The coated silver foils were reacted in sealed quartz tubes using $CaHgO_2$ source to form HgPb1223 superconductor. Microstructure of HgPb1223 formed on silver foil was significantly superior than that in the bulk samples in terms of grain size and texture. These results indicate a positive influence of silver on the formation of HgX1223.

Optimization of Mercury Loading in Silver Tubes. To avoid depletion of mercury from the superconductor by amalgamation during the heat treatment of silver-clad conductors, it has been decided to use silver tubes preloaded with mercury for the fabrication. Among the several methods examined, a room temperature diffusion of liquid mercury has been observed to be suitable for the purpose of loading controlled amounts of mercury into silver tubes. The thickness of the Ag-Hg layer can be controlled by adjusting the loading temperature.

As discussed in the previous semi-annual report, the only change from the original proposal is to investigate surface-coated geometries in addition to the powder-in-tube geometry discussed in the proposal. The conceptual approach has not changed.

Field-Induced Relaxation of Spin Currents in Dilute Fermi Liquids

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

Experimental Status. Dr. Hikota Akimota, an expert in ultra-low temperature physics, has been appointed to the Postdoctoral Associate position funded by the award. He has taken over responsibility for the design and construction of the thermal links to the ultra-low temperature NMR probe and the design of the thermal links to the NMR cell. The full group of collaborators met in Gainesville in October to review the design and scheduling of the experiment.

NMR spectrometer. The RF power amplifiers and the pulse gating sequencing VXI modular instrumentation mainframe for automated data acquisition has been purchased and tested. The system will be operated under Labview software developed by the University of Massachusetts team to be available to future users of the facility.

Theory Status. Professor Bill Mullin at the University of Massachusetts is leading a theoretical effort to focus on the predictions for the transport behavior of polarized dilute Fermi fluids. In addition to continuing work on computer simulations of NMR echo response in the presence of anisotropic diffusion, the group is examining the dependence of the calculated transport coefficients on the Zeeman energy difference between the spin states. A collaborative effort with Robert Ragan of the University of Wisconsin/Lacrosse is planned.

Summary of Work to be Performed During the Next Six Months. The low-frequency coaxial cables for the thermometry and thermodynamic measurements and the ultra-high frequency low loss coaxial cables for the NMR probe will be designed and added to the High B/T facility. This will be completed while Cryomagnetics is completing the replacement of the fourth coil of the magnet system.

The thermal link design and vibrating wire thermometer will be completed in the first quarter of 1999 and in this time frame an experimental test of the thermal cell and cabling will be carried out. The schedule plans for completing the NMR electronics by the end of April, depending on the successful replacement of the magnet system.

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 2 years

Hardware and Software Development. The goals of this project are (1) to develop novel relaxation calorimeters for measurements at millikelvin temperatures in high magnetic fields for the users of the NHMFL Millikelvin Facility and for in-house research at UF in Gainesville, and (2) to investigate the thermodynamic properties of strongly correlated electrons and low-dimensional magnets using these instruments. The primary objective for the first year was to develop the calorimeter hardware and software that can be easily and uniformly implemented in the Gainesville laboratory and the NHMFL in Tallahassee. Two tasks have been completed.

A portable ^{3}He cryogenic probe for the calorimeters has been constructed for measurements down to 0.343 K. The two key features of the probe are (1) an internal ^{3}He gas storage, which greatly simplifies the gas handling system and makes the probe portable between the two facilities, and (2) the adjustable probe length to account for different heights of the magnet dewars at the two facilities. The probe will be used in the 16 T magnet at UF, where the main developmental work of the calorimeter is under way, and in the Millikelvin Facility for tests at higher magnetic fields.

A Labview program has been developed for experiment control, data acquisition, and analysis. The program can be run both on the Apple computer platform in the NHMFL in Tallahassee and the PC platform used in the Gainesville laboratory. It will provide the NHMFL users with a powerful and yet simple interface to the experiments and a convenient tool for on-site data analysis.

Science. In addition to the instrumentation development, we have investigated low-temperature thermodynamic properties of several metallic systems of fundamental interests. Some of them may serve to demonstrate the capabilities of our calorimeters under development.

We have measured the heat capacity and the electrical resistivity of $UPt_{5-x}Au_x$ in collaboration with Greg Stewart's group. The low temperature properties were consistent with the Fermi-liquid behavior for all compositions studied. The ratio A/γ^2, where A is the coefficient of the T^2 -dependent electrical resistivity and γ is the coefficient of the T-linear specific heat, was found to vary with the gold concentration x between a value characteristic of normal metals and that typical of heavy fermions. This work represents the first systematic study of A/γ^2 in a single alloy system. Our results suggest an existence of correlation between A/γ^2 and χ/γ, indicating the dependence of A/γ^2 on the strength of antiferromagnetic spin fluctuations. Here χ is the low-temperature magnetic susceptibility. This last point will be further investigated in other alloy systems and will require the lowest possible temperatures.

We have also studied several new YbTM intermetallics in collaboration with the Trzebiatowski Institute of the Polish Academy of Sciences and University of Vienna. Specific heat at temperatures to 1 K were performed at UF. Sample characterization and the measurements of magnetization, DC magnetic susceptibility, heat capacity, and electrical resistivity were done at the collaborating institutions. The compounds YbTBi with T = Cu, Ag, Au and YbTSn with T = Ag, Au, Zn were shown to be non-magnetic due to divalent Yb ions. The bismuthide YbPdBi as well as the stannides YbRhSn and YbPtSn were found to exhibit localized magnetism of almost trivalent Yb ions. The electrical behaviors of these three intermetallics is characteristic of dense Kondo systems, and their low-temperature specific heat suggests heavy-fermion ground states. Measurements of magnetoresistance and specific heat to lower temperatures are being planned to investigate the ground states of YbPdBi, YbRhSn, and YbPtSn.

In addition, we have studied electrical resistivity of porous gold. This work was started purely as a preparation of a test sample for our novel calorimeters. The results indicate that the material will actually serve as an excellent heat exchanger for the microkelvin cryostat of the NHMFL High-B/T Facility. Development of prototype heat exchangers for this new application is under way.

Papers Presented

Andraka, B. and Takano, Y., *Relaxation Method of Heat Capacity for High Magnetic Fields and Low Temperatures*, March Meeting of the American Physical Society, March 16-20, 1998, Los Angeles.

Papers Submitted

Andraka, B. *et al., Relationship between Resistivity and Specific Heat in a Canonical Non-magnetic Heavy Fermion Alloy System* $UPt_{5-x}Au_x$, to be published in Eur. J. Phys. B.

Kaczorowski, D. *et al., Magnetic, Thermodynamic, and Electrical Properties of Ternary Equiatomic Ytterbium Compounds YbTM (T=transition metal, M=Sn or Bi)*, to be published in Phys. Rev. B.

Summary of Work to be Performed During the Next 12 Months. The development of the calorimeters will be the main goal of the project for the next 12 months. In addition to the design utilizing a quartz substrate as originally proposed, a design using single-crystal silicon wafer is also being developed for the calorimeters. In this alternative design, the sample will be directly mounted on the bare silicon surface, while the heater and the thermometer will be deposited on an oxidized patch on the opposite surface. Calorimeters of both designs will be fabricated in house during Year 2. Thorough testing and calibration of the calorimeters will be performed using the cryogenic probe developed during the period of this report and a 16 T magnet at UF, prior to the final installation at the Millikelvin Facility.

Statement of Remaining Unobligated Funds. 29% of the funds for the first year is expected to be unobligated at the end of this period. This is because the transfer of funds from FSU, which administers the NHMFL, to UF did not occur for several months into the project period, delaying the actual start of the project.

Richard Pietri, a graduate student of Andraka, and Randolph Ertenberg, an undergraduate assistant for Takano, have actively participated in the various aspects of the project.

1998 Solicitation

The 1998 IHRP solicitation was released in January, 1998. 40 proposals were submitted, 17 were sent out for external review, and 10 were funded. Following are the most recent reports as of February 28, 1999.

Experimental Investigation of States at Half-Filled Landau-Levels in Very High Magnetic Field and Very Low Temperature

PI: E. Dwight Adams (UF)
Funded: $138,757 over 2 years

Work begun prior to the grant continued and resulted in a significant achievement of cooling the 2D electron system down to 4 mK, showing for the first time vanishing Rxx at nu = 5/2. This has been reported in *NHMFL Reports*, vol. 6, No. 1, and Wei Pan presented a paper on the results at the March 1999 APS meeting (Bull. Am. Phys. Soc. 44, 303, 1999).

Some delay will result because of time taken to upgrade magnet and time taken by other users. Considerable difficulty has occurred in getting a subcontract for funds for stipend for Wei Pan, a Princeton graduate student.

A Proposal to Establish an Optically Polarized Noble Gas NMR and MRI program at NHMFL

PI: C. Russell Bowers (UF)
Funded: $142,471 over 2 years

No report received as of publication deadline.

Simulations of EPR Spectra of Muscle Proteins

PI: Peter Fajer (FSU)
Funded: $217,504 over 2 years

In last six months we have accomplished the following:

- Developed the X-PLOR code for conformational searching
- Created two mutants of myosin light chains with defined geometry of binding site
- Performed first experiments at high fields (90 GHz) on muscle fibers.

Advancement of Condensed Matter NMR Facilities and Instrumentation at the Highest Magnetic Field

PI: Phillip L. Kuhns (NHMFL)
Funded: $192,507 over 2 years

A major accomplishment during this period has been the development of a new NMR spectrometer for condensed matter NMR research. The design, construction, and software have been completed. This spectrometer represents a major advance in NMR spectrometers for condensed matter physics at the highest available fields. It incorporates computer-controlled complex pulse sequences, 50 MHz data acquisition, and improved receiver recovery time. Currently in operation, this spectrometer covers frequencies from 2 to 2000 MHz, allowing a wide range of experiments at fields to the highest fields available, 45 T, and will be used in the NHMFL Hybrid as well the resistive magnets.

Other major accomplishments include two variable temperature systems offering greatly improved temperature control over the range 2 to 300 K. Clamp cells for high pressure NMR studies utilizing new high strength materials are in the design stage for high pressure NMR work. A goniometer NMR probe, with optical access, allowing sample rotation studies at low temperature and high field, has been completed and is in operation. Methods of noise reduction for experiments in the resistive magnets, including lower noise and cooled preamplifiers, are being studied to increase data acquisition rates.

Investigations of Entangled Vortex States at High Magnetic Fields

PI: Martin P. Maley (LANL)
Funded: $222,300 over 2 years

Note: The start of this project was delayed because of the longer-than-anticipated process in transferring funds from FSU to LANL. Therefore, since this project's semi-annual report will not be due before the publication of this annual report, we have included the project summary of this proposal.

The combined effects of high transition temperature, short coherence length and large anisotropy have introduced a rich variety of entirely new physical phenomena in the field of "vortex matter" in high temperature superconductivity. Thermally driven melting of the vortex array at temperatures far below the mean-field phase transition is now well established. In addition several solid vortex phases with differing kinds of order, determined by the competition between inter-vortex interactions and the underlying "quenched disorder" in the crystal lattice, are now believed to exist at low temperatures. Much of the present knowledge about these vortex phases and the transitions between them comes from investigations at magnetic fields below 10 T. The present proposal is to explore some outstanding issues that involve entangled vortex states at high magnetic fields.

We will focus primarily on the least anisotropic HTS compound YBCO where the integrity of vortex lines is maintained up to and perhaps beyond the melting line, depending on the strength and morphology of the quenched disorder. In this system, the lateral vortex line wandering promoted by the random point disorder or by an extended (columnar) "splayed" disorder, causes destruction of the longitudinal (c-axis) correlation, i.e., the identity of vortex lines becomes lost over long distances and vortices entangle like a bundle of cooked spaghetti. We plan to study the entangled vortex states by the c-axis transport and by magnetization measurements using miniature Hall sensors. C-axis resistivity measurements at high magnetic fields will be used to probe the loss of c-axis correlation in the liquid state both in clean (untwined) crystals and in crystals with correlated disorder (columnar defects)—these measurements will be followed through the melting line. We expect that very high magnetic fields will lead to entanglement even in the presence of columnar defects (CDs), which at low fields are known to disentangle assemblies of vortices over a wide range of temperatures by restoring the c-axis coherence. The proposed experiments will clarify many unresolved issues related to vortex elasticity at high fields.

C-axis critical current and magnetization measurements will be employed in the low temperature solid phase to study c-axis correlation vs. magnetic field up to 60 T in the long pulse system. At fields above 30 T, vortices in YBCO may undergo a crossover to a 2D dynamical behavior where the in-plane interactions dominate over interlayer coupling, and the melting (irreversibility) line becomes magnetic-field-independent. Above this crossover the critical current density should also be enhanced. The high magnetic fields available at the NHMFL will enable a previously unexplored realm of vortex matter to be accessed, where many new and important phenomena may be observed.

The proposed project incorporates a focused joint effort of groups at LANL and at IBM T.J. Watson Research Center, with extensive expertise in magnetic and transport measuring techniques and a well established record in the area of vortex dynamics, pinning, and equilibrium behavior in the presence of point and correlated disorder.

Magnetic Polarons in $ZnSe/Zn_{1-x-y}Cd_yMn_xSe$ Quantum Wells

PI: Hon Kie Ng (FSU)
Funded: $144,403 over 2 years

This report is on the cyclotron resonance measurements performed on dilute magnetic semiconductor, $ZnSe/Zn_{1-x-y}Cd_xMn_ySe$, and also on the non-magnetic analogue, $ZnSe/Zn_{1-x}Cd_xSe$. The experiments were done at the NHMFL using (optical) Fourier Transform spectroscopy and with fields from 4 T to 30 T. The experiments are in line with the proposal.

Two-dimensional electron gas (2DEG) structures based on modulation doped $ZnSe/Zn_{1-x-y}Cd_xMn_ySe$ single quantum wells show novel spin-dependent effects in both diffusive and quantum transport (PRL **78**, 3571(1997), PRB **58**, R4238 (1998)). Our cyclotron resonance (CR) is the first such measurements on these compounds. This is due primarily to the high mobility of the samples. From the CR absorption the effective mass for both the magnetic and non-magnetic 2DEG are obtained. While the CR frequency shows the expected linear variation with magnetic field in non-magnetic control samples, the magnetic 2DEGs exhibit clear deviations from linearity in the vicinity of the $\nu=2$ and $\nu=1$ filling factors. Beyond $\nu=1$, the data for the magnetic and non-magnetic 2DEGs become indistinguishable.

An effective mass is obtained for the non-magnetic semiconductor. This mass depends slightly on Cd concentration. For the two samples studied with Cd concentration of 0.12 and 0.24 the effective mass is 0.138+/-0.002 m_e and 0.148+/-0.002 m_e respectively. This is the first time that an effective mass has been determined for the $ZnSe/Zn_{1-x}Cd_xSe$ films. This important parameter is crucial for understanding other experiments such as photoluminescence. A paper is being written for submission to Applied Physics Letters.

The corresponding cyclotron resonance measurements on the magnetic semiconductor $ZnSe/Zn_{1-x-y}Cd_xMn_ySe$ yield some surprising results. The effective mass shows oscillatory behavior as the Landau levels goes from filled to half-filled. The apparent change in effective mass is large, around 15%. Previous observations of oscillatory effective mass in GaAs/AlGaAs is around 0.5%. An obvious different between the two types of heterostructures is the presence of the Mn ions in the magnetic semiconductor. These results are still being analyzed. A summary of the main results is shown in Figures 1 and 2.

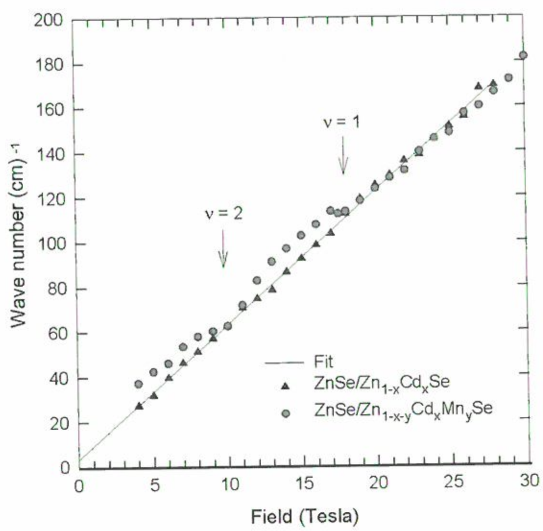


Figure 1. Cyclotron resonance frequency as a function of magnetic field. There is significant deviation from linearity for the magnetic semiconductor.

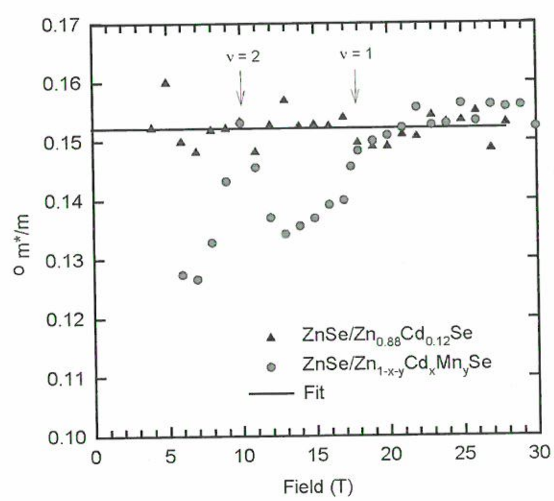


Figure 2. Oscillatory effective mass for the dilute magnetic semiconductor.

A summary of the major accomplishments is given below.

- Successfully determined the effective mass of ZnSe/$Zn_{1-x}Cd_xSe$ for different concentrations of Cd. This is the first such determination of the effective mass.
- Observed oscillatory cyclotron resonance effective mass in dilute magnetic semiconductor, ZnSe/$Zn_{1-x-y}Cd_xMn_ySe$. The change in effective mass is significantly larger than that observed in GaAs/AlGaAs.
- For the magnetic semiconductor, the electron gas goes from 2D to 3D behavior as the field is increased from 0 to 17 T.

The success of this project depends on tight external collaboration with Professor Samarth of Pennsylvania State University. Professor Samarth has grown some of the best II-VI heterostructures. He has also suggested different sample configurations for studies in the magnetic fields. Recently, he has sent me three new samples, one of which is a variant of ZnSe in that Se is replaced by Te. I anticipate that the collaboration will remain active for the duration of the project and beyond. The IHRP fund has made the experiments possible.

A major effort in the next six months is to incorporate a Martin-Puplett polarizing spectrometer with the magnetic fields. (The spectrometer belongs to the PI.) Presently our measurements are limited to frequencies greater than 30 cm^{-1}. With the use of the polarizing spectrometer the low frequency is extended down to 10 cm^{-1}. The spectrometer has already been modified for use at the NHMFL.

The primary reason for going to lower frequencies is to observe any deviations at low fields. (In Fig. 1, we note that the straight line fit for fields greater than 4 T passes above the origin.) One possible reason may be due to bound energy from impurity centers. This seems unlikely since the offset does not appear to depend on the mobility of the sample. An intriguing possibility is magnetic polarons, which is predicted to be significant (refs. as given in the proposal) at low fields (<6 T). Thus it is crucial to examine any deviations at low frequencies. (At 10 cm^{-1}, the CR should correspond to a field of around 1.5 T.)

In line with the proposal a postdoc, Young-Ahn Leem, will start working on this project on April 1, 1999. Dr. Leem graduated from Seoul National University, South Korea, working on photoluminescence of GaAs/$Al_{1-x}Ga_x$ quantum wells. He started working at the NHFML in July 1998 with Prof. Woo of Seoul National University. His contract with Prof. Woo expired on March 31, 1999. Dr. Leem is thus very familiar with the operations of the NHMFL.

The PI receives 0.6 month of summer support from the Center for Materials Research and Technology for this project. This support is for the duration of the project. For summer 2000, the PI will receive an additional two weeks summer support as Director of the Undergraduate Affairs committee. In addition a proposal is being prepared for submission for external funding.

A physics graduate student, Kevin Storr, is collaborating on this project. Kevin is self-supporting. Kevin is a minority student, and he has a strong desire to earn a Ph.D. degree in physics.

Two-Dimensional Metal Insulator Transitions in Si Based Devices

PI: Dragana Popovic (NHMFL)
Funded: $142,511 over 2 years

We have been studying the effect of local magnetic moments on the metallic behavior in two dimensions (2D). The experiments were carried out on a two-dimensional electron system in Si metal-oxide-semiconductor field-effect transistors. The local magnetic moments were induced by disorder, and their number was varied systematically by changing the substrate (back-gate) bias. We have found that:

- In the limit T->0, the metallic behavior (first discovered by Kravchenko *et al.* several years ago) is suppressed by an arbitrarily small amount of scattering by local magnetic moments
- The local moments lead to a new and unexpected kind of metal in 2D, apparently dominated by the Kondo interaction of the conduction electrons and the local moments
- A novel type of a metal-insulator transition occurs between this new metal and an insulating state as the carrier density is reduced. This transition is unlike any known quantum phase transition in two dimensions.

Our results have been submitted for publication to Physical Review Letters (*Effect of local magnetic moments on the metallic behavior in two dimension*) and to Nature (*A new metal in two dimensions*).

Our discoveries are bound to have a major impact on the whole field of metal-insulator transitions, and thus provide an intellectual leadership for both experimental and theoretical research in this field, in accord with the IHRP objectives.

In the next six months, we will study the effect of a magnetic field on the transport properties of the new 2D metal that we have just discovered. Since this metallic phase appears to result from the Kondo effect, we expect that the sufficiently high magnetic field will suppress the metallic behavior. Experiments will be carried out in parallel magnetic fields to avoid complications due to orbital effects. Preliminary measurements suggest that the metallic behavior will indeed be suppressed by high magnetic fields but that it persists in fields of even up to 9 T. Higher magnetic fields (at the NHMFL user facility) will most likely be required.

A postdoctoral research associate has been involved in this project, and a graduate student from the University of North Carolina at Chapel Hill joined the group on Feb. 1, 1999, for a year, as requested in the proposal.

Normal State Transport of High Temperature Superconductors in High Magnetic Fields

PI: Joe Thompson (LANL)
Funded: $165,000 over 2 years

Note: The start of this project was delayed because of the longer-than-anticipated process in transferring funds from FSU to LANL. Therefore, since this project's semi annual report will not be due before the publication of this annual report, we have included the project summary of this proposal.

This proposal presents an experimental program to explore the normal state transport properties of the high-temperature superconductors in the zero-temperature limit ($T/T_c \rightarrow 0$, where T_c is the superconducting transition temperature). Many researchers believe that the key to explaining the superconductivity in copper-oxide materials lies in understanding their normal state properties and the mechanism underlying their apparently non-Fermi-liquid behavior. Near optimal doping, the normal state exhibits unusual transport properties whose low-temperature limiting behavior is ordinarily obscured by the onset of superconductivity. The goal of the proposed experiments is to reveal and measure several low-temperature normal state electrical transport properties (resistivity, magneto-resistance, Hall effect, and current-voltage linearity) by suppressing the superconducting phase using intense pulsed magnetic fields.

Intense magnetic fields, routinely exceeding 60 T, have been demonstrated to be able to suppress superconductivity in $La_{2-x}Sr_xCuO_4$ to temperatures as low as 0.03 T_c, even for samples near optimal doping with T_c as high as 40 K. More importantly, these experiments have demonstrated the ability to perform sensitive, temperature-controlled magneto-transport experiments on $La_{2-x}Sr_xCuO_4$ at temperatures from 300 K down to 0.7 K. These experiments have revealed an unexplained logarithmic divergence of the resistivity, an insulating behavior that appears to extend throughout the underdoped regime. A variety of different mechanisms have been proposed to account for this behavior, including suppression of the two-dimensional density of states due to electron-electron interactions, universal insulating behavior arising from quasiparticle-impurity scattering in non-Fermi liquids, and development of charge density wave order in the underdoped regime near a quantum critical point.

There are three specific scientific objectives of this proposal: (1) to develop experiments at lower temperatures and higher precision to test the robustness and explore the extent of this regime, as well as to explore whether similar or contrasting behavior occurs (2) in $YB_2Cu_3O_{7-\delta}$ or (3) in $Sr_{14-x}Ca_xCu_{24}O_{41}$, a related compound (which is non-superconducting except at high pressures) containing Cu-O ladders instead of the Cu-O planes found in the cuprates.

The proposed high magnetic field measurements will bring to the pulsed field laboratory of the NHMFL those magneto-transport techniques recently developed in pulsed magnetic field experiments at Bell Labs. More importantly, through collaborative efforts of the LANL and Bell Labs investigators, these techniques will be extended in several significant ways: (1) an increase in signal-to-noise beyond that of standard lock-in techniques through development of high resolution digitization and digital filtering techniques; (2) optimization of "quasi-fixed-field" experimental techniques, such as I-V experiments, to be performed at the peak magnetic field; (3) extension of all these techniques to dilution refrigerator temperatures and (4) to the new 60 T Long-Pulse magnet once it becomes available for experiments. These developments will enhance the facilities and capabilities at the NHMFL and, by fostering scientific collaboration between LANL and Bell Labs, will improve the overall effectiveness of the nation's high magnetic field research. Finally, because the majority of the budget is to fund a postdoctoral position, this proposal involves the education and development of a young scientist in pulsed field techniques and experimental condensed matter physics.

New Approaches to the Development of High Strength-High Conductivity Wires for Magnet Applications

PI: Steve Van Sciver (FSU)
Funded $225,506 over 2 years

Introduction. The project involves a new approach to the development of suitable wire products for pulsed magnet applications. The first portion of the project involves the development of a cryogenic drawing process that improves the properties of copper and stainless steel in unique manners. The benefit realized by drawing copper at low temperature is the inhibition of dynamic recovery within the microstructure of the copper. With this method, it may be possible to draw pure copper wire to a higher strength than previously possible while retaining conductivity of more than 90% IACS. The drawing of stainless steel at low temperature causes an accelerated strain hardening rate (compared to 295 K) due to the occurrence of a low temperature phase transformation. This rapid strain hardening can be utilized to produce high strength with less strain resulting in a larger final cross-section wire. The second portion of the project will concentrate on the fabrication of macroscopic composites consisting of copper and stainless steel (Cu-SS composite). The goal is to produce a conductor with the desired strength and conductivity. The success of a macrocomposite wire relies on the properties of the two components, the integrity of the bond between the copper and stainless steel, and the ability to geometrically constrain the copper during the co-deformation.

Results

Copper Wires. Copper material was produced at three deformation temperatures (295 K, intermediate-cold-temperature and 77 K). The 9.6 mm diameter copper rods were successively drawn down to a 2.02 mm final diameter. The 295 K material condition was produced on the bench drawing machine using standard wire drawing practice. The intermediate-cold-temperature (ICT) material condition was produced on the bench drawing machine using a modification to the standard wire drawing practice. The copper and the draw die were cooled in a liquid nitrogen bath (77 K) then quickly transferred to the room temperature drawing machine. The cold wire was drawn through the cold die without regard to temperature control. The success of this ICT experiment lead to design modification of a mechanical test cryostat on a servo-hydraulic test (MTS) machine to allow cryogenic drawing under temperature controlled conditions.

A new drawing facility was designed and assembled in order to guarantee the temperature control during the processing. The drawing dies are mounted on the base of a mechanical test cryostat, which is in turn mounted to the MTS machine. With this set-up the wire and draw die are immersed in boiling liquid nitrogen at 77 K. The wire tip is passed through the die, gripped, and attached to the test machine stroke to be pulled through the die opening.

The 77 K deformation temperature material was produced using the mechanical test cryostat. The material condition was monitored at intermediate stages of deformation by securing material at the 5 mm, 4.14 mm, 3.0 mm and 2.02 mm diameter die sizes, for tensile and metallography samples. These samples were submitted to tension tests, electric resistivity tests, microstructure, and crystallographic texture analyses. Samples of the material processed at room and intermediate-cold temperatures, for the same die diameter, were also characterized and used for comparison and evaluation.

Figure 1 shows the tensile strength versus true strain for the copper material processed at all three temperatures. Two distinguishing behaviors can be observed. The tensile strength of the wire drawn at room temperature changes from 392 MPa for $\varepsilon = 1.30$ to 405 MPa for $\varepsilon = 3.11$, which shows that the strength is relatively independent of the strain in this range of deformation. It can be explained via dynamic recovery of the copper at processed at room temperature. In contrast with that, the strength of the ICT processed material increased from 430 MPa to 495 MPa indicating that the cold temperature inhibited the dynamic recovery.

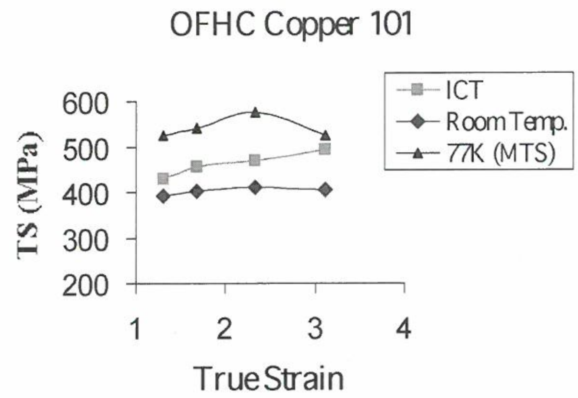


Figure 1. Tensile strength of Cu wires with several diameters drew at room, cryogenic temperature in the drawing line and at 77 K.

The strengths of the 77 K processed material show a marked increase compared to the material produced at the two higher temperatures. A maximum tensile strength of 576 MPa was attained for the 77 K processed material at a $\varepsilon = 2.3$. At a higher true strain the tensile strength dropped. This reduction is probably associated with either dynamic recovery or dynamic recrystallization during the late stage of the drawing process. The texture and microstructure analyses also supported this assumption.

Stainless Steel. Two austenitic stainless steel rods, 304L and 316L, approximately 10 mm diameter were wire drawn at 77 K. This drawing operation has proved difficult. The starting grip areas of the rod tips are failing during the first stages of the drawing. The first material was drawn until 8.1 mm diameter and the second failed as it was passing through the 7.7 mm diameter die. The rapid strain hardening of the stainless material being deformed at 77 K causes the tensile stress necessary to pull the rod through the die to exceed the available strength of the gripping area. Recall the gripping area is produced by a room temperature swaging operation. Steps are being taken to solve the problems. In both cases the tensile force to draw the material exceeds 40,000 N. Martensitic transformation was noted after initial 77 K deformation strains. The martensic phase was observed via magnetic test, but the microstructure analysis is going on.

The fracture analysis of the 316 L rod (that failed in the 7.7 mm die due to the stress necessary to pull it through the die) was performed using electron fractography. The fracture mode is basically dimple rupture. Intergranular fracture is a result of microvoid coalescence at grain boundary under the presence of tensile and shear stress components indicating that the material was overloaded.

Conclusion and Future Work. Based on the experimental results reported here, it is reasonable to conclude that both copper and stainless steel, for different reasons, have limitations in the properties that can be achieved with cryogenic deformation. In the future, we will try to optimize the properties that can be reached in the base materials using cryogenic drawing along with conventional processing techniques. The additional microcharacterization of these materials will help us to understand the underlying mechanisms responsible for the resultant physical and mechanical properties.

The cryogenic drawing of the copper stainless steel composites are planned. Stainless steel tubes (ID = 19 mm, OD = 25 mm) of 304L and 316L have been purchased to produce new composites with approximately 60% copper. During the first stage of fabrication C10100 copper rod (about 19 mm) will be inserted into the stainless steel tubes and then swage reduced at 295 K to about 9.3 mm diameter. Intermediate heat treatment will be used in order to avoid the exhaustion the ductility of the stainless steel. Then the composite will be drawn at 77 K to according to a schedule similar to that used for the base materials. Tension test, resistivity measurements and microcharacterization techniques will be used for material characterization.

Research Team. Dr. Luiz Brandao, visiting scientist at NHMFL, was added to the original research team formed by Dr. Steve Van Sciver, Dr. J. David Embury, Dr. Ke Han, and Mr. Robert Walsh.

Fund Estimated to Remain Unobligated. The project is just six months old. Part of this time was allocated for its implementation, bibliographic review, and preliminary test in order to check the viability of some experimental procedures. In light of this, we have not spent the budget yet and more than 20% will likely remain unobligated at the end of this period. We have many needs, however, and are planning some important purchases soon.

Contribution to the Education Development. An undergraduate student, Gabrielle Penn, of the FAMU-FSU College of Engineering is working for this project in the sample characterization experiments.

Magnetic Damping and Pattern Formation in a Simulated Crystal Growth Configuration

PI: J. Vinals (NHMFL)
Funded $129,620 over 2 years

The proposed research involves the experimental and theoretical study of magnetic damping on convection. The experiment is currently being set up at UF. The experiment consists of a fluid gas bi-layer compartment that is heated from its underside. The viewing of the convective cells will take place using an IR camera. There are two phases to setting up the experiment. One of these is the measurement and control of the temperatures and the second is the flow visualization.

- At present the electronic equipment that is needed for accurate control of temperatures in the experiment is complete. It is expected that experimental runs will commence during the summer.
- The theoretical development of the bi-layer convective model in the presence of a magnetic field is also underway.
- Two students are being trained in the experiment. They are Mr. Josh Sims and Mr. Colby Watford. Both are undergraduates in Chemical Engineering.

Once the experimental setup is functional at the PI's lab in Florida, it will be moved to NHMFL for testing during this summer. As described in the proposal, we will address the interaction of a magnetic field with flow in a bi-layer system. The bottom fluid is a conducting metal and hence and magnetic field will act to dampen buoyancy induced flows. The top fluid interacts with the bottom layer through their common, deformable, interface, but it is not conducting. Such a configuration is a model of conventional encapsulated crystal growth of a semiconductor.

- Fluid Flow in a Random Acceleration Environment (JV, pending, NASA).
- Diffusivity Measurements in Liquid Metals (RN, pending NASA).
- Separation through Oscillatory Flow (RN, pending, NASA).
- An Electrochemical Method to Measure Diffusivity and Detect Flows in Liquid Metals (RN, current, NASA. Co-I with T.J. Anderson, funding level is $75,000 each/ year for each investigator).

1999 Solicitation

The 1999 In-House Research Program solicitation was released in September, 1998. 33 proposals were submitted and 22 proposals have been sent out for external review. We hope to have all reviews completed and funding decisions made by the end of the summer, 1999.

Education Programs

Chapter 4

One of the core missions of the NHMFL is education. During the last year, the laboratory, through its ***Center for Integrating Research and Learning at the National High Magnetic Field Laboratory***, expanded educational opportunities for students and teachers, developed new resources, and engaged more people than ever before. It was an extremely active and productive year.

NHMFL educational activities permeate all aspects of the laboratory and flow across the three institutions—Florida State University, the University of Florida, and Los Alamos National Laboratory. The Center's various programs—K-12, technical, undergraduate, graduate, or postdoctoral—are developed in close consultation with the scientists, engineers, and technicians who conduct or support the laboratory's research activities. In addition, discussions are frequently held with members of the visiting science community. This ongoing dialogue with faculty and staff has been, and will continue to be, vital to the strength and success of the laboratory's educational programs.

In order to provide continuity, infrastructure, and educational leadership, the Center has been organized around seven major efforts:

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

Through these areas, the Center enhances 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). 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.

As National Science Board (NSB) Chair Eamon Kelly highlighted in his release of the report, *Preparing Our Children: Math and Science Education in the National Interest*, "Believing that education is simultaneously a local responsibility and a national priority, the NSB asserts that scientists, engineers, and their institutions must have a key responsibility to assist K-12 schools, teachers, and students to improve the nation's math and science achievement."

This report summarizes 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 Training Solutions Interactive (TSI) is listed under "Partnerships," but this partnership spawned projects cited elsewhere, such as ***Science, Tobacco & You***, a major curriculum development effort brought to fruition this year. *Science, Tobacco & You* is a multidisciplinary science resource that engages students in developing skills in language arts, mathematics, social studies, and other subjects. It encourages students to use *science* to ask and answer questions (thereby enhancing scientific literacy); and in this case, the platform for learning is the issue of tobacco use and prevention. Through statewide training and distribution, over 1,818 *Science, Tobacco & You* packages were delivered to Florida elementary schools.

Highlights of the current reporting period (July 1, 1998 through June 30, 1999) are presented below, followed by expanded descriptions of each program.

Student Education Highlights

- As part of our *Science, Tobacco & You* program, we engaged students across Florida through a Town Hall event. Over **6,000** students participated through the web site (*http://scienceu.fsu.edu*) and video telecast. The Florida Department of Health projects that **400,000** students will be reached each year through this program.
- Our outreach efforts were shifted this period to emphasize student experiences that were more hands-on and substantive by working with smaller groups for longer periods. This year our outreach program was highlighted as an invited program for the 1999 Centennial Meeting of the American Physical Society (APS). These multifaceted and interdisciplinary programs reached **2,500** 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 **80** middle or high school students and at least **81** undergraduate students, including students in our Research Experience for Undergraduates Program (see *http://k12.magnet.fsu.edu/intern/index.html*).
- We continued to receive a large number of visitors to the laboratory while enhancing their educational experience. Approximately **4,000** grades 4-12 students toured the NHMFL during the reporting period.
- NHMFL faculty reported advising over **164** undergraduate students and serving on over **90** graduate committees during the reporting period, with **15** NHMFL-affiliated graduate students earning Ph.D.s.

Teacher Education Highlights

- We expanded our workshops and training programs—**doubling** the number of teachers reached during the previous reporting period. We provided statewide and regional workshops for **472** elementary, middle grades, high school, and community college teachers during the period.
- Our Ambassador program continues to flourish with active participation from over **75** regional K-12 teachers representing over **50** schools.
- Drawing upon the success of the Research Experience for Undergraduates, the Center is conducting the first annual Research Experience for Teachers targeting middle grades (5-9) teachers and senior preservice teachers. Experienced educators are paired with prospective elementary and secondary teachers to work with scientists and researchers at the Tallahassee site of the NHMFL on research projects.
- NHMFL educators offered undergraduate and graduate level courses for prospective teachers through the Florida State University College of Education, and we provided a series of experiences for **56** Elementary Education students as part of their formal course of study.

General Public Awareness Highlights

- Approximately **2,600** members of the general public experienced guided tours of the laboratory during the reporting period. In addition, the 5th Annual NHMFL Open House held in October, 1998, attracted over **3,100** visitors.

Curriculum Materials Development Highlights

- We completed development and launched a curriculum resource package called *Science, Tobacco & You*, an integrated science, standards-based program that is designed to encourage students to use science to ask and answer questions to promote scientific literacy; in this case, the medium used is the issue of tobacco use and prevention. We distributed **1,818** packages to Florida schools.
- *MagLab: Alpha,* our first commercially available curriculum product is now being marketed nationally through Sempco Incorporated and Sargent-Welsh. *MagLab: Alpha* is an integrated science, standards-based program that is designed to enhance the teaching and learning of magnet-related science in middle grades (grades 6-8).

Educational Research Highlights

- Center faculty gave invited presentations at several national and regional conferences and participated in a host of other professional education meetings and international activities. Interest in the Center's educational research activities continues to be high, as evidenced by the number of requests for papers presented in 1998. These requests came from both scientific researchers and educational experts.

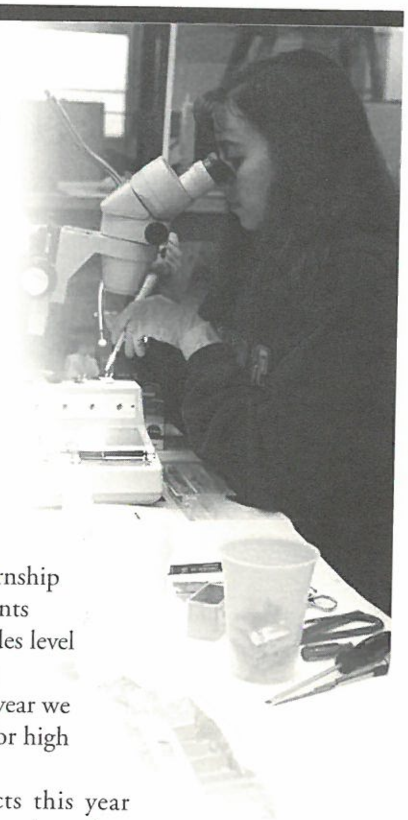
Education Resource Laboratory Highlights

- This state-of-the-art laboratory houses multimedia development equipment, manipulative development equipment, curriculum materials, and instructional resources, and is used 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 Research Experience for Undergraduates (REU) Program.
- Training Solutions Interactive (TSI), a private business headquartered in Atlanta, Georgia, and the laboratory have formed a partnership to develop and market NHMFL curriculum materials.
- We have continued our active role as a member of the Community Classroom Consortium, working with the Florida Science Center Consortium, and establishing stronger links with regional schools through our Ambassador program.

Student Education



Through our expanded curriculum resources and comprehensive programs, the Center now supports educational experiences and opportunities that reach well over half a million students each year. 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. All of our programs reflect research and practice at the cutting-edge in both education and science. 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 teacher wrote, "This is definitely an A+ project!"

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 web site 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 **2,500** students between July 1998 and June 1999. 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. We have shifted our programs to provide more interactive, small-group learning experiences rather than large group "shows." Other outreach efforts included school fund raising events, assistance with science fairs, mentoring science projects, providing equipment to teachers for special activities, and four Saturday morning Storytime Outreach sessions at the local Barnes & Noble Bookstore. An average of 20 preschool and primary children (and parents) heard age-appropriate stories chosen for their relationship to a scientific concept. Each child created a product based on the following: magnets, prisms, and liquid nitrogen.

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 **80** middle or high school students. The research projects this year spanned topics ranging from studying the engineering design of structures, to JAVA programming development, to the design and construction of a superconducting magnet system. The success of this program was evidenced by researchers requesting that the students stay on for further research.

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.

The NHMFL hosted the Integrated ARTS (Art, Research, Science & Technology) program. Integrated ARTS was one of the thirteen 1998 Governor's Summer Programs for gifted and high achieving students funded by the Florida Legislature and administered by the Florida Department of Education. Ten high school students from three rural counties participated in the six-week program that paired students with researchers at the laboratory. While at the NHMFL, the students used the processes of science to observe the unobservable. Using the visual arts, as a communication tool, the scholars developed a web site (*http://arts.magnet.fsu.edu/*) to turn research experiences into educational resources.

Young Scholars Program. The NHMFL supported the Young Scholars Program by providing mentorships and speakers for the summer program.

Web Site. The lab maintains and continues to develop extensive web-based resources for students. Please visit our sites at *http://k12.magnet.fsu.edu, http://scienceu.fsu.edu, http://arts.magnet.fsu.edu, http://micro.magnet.fsu.edu/primer/index.html,* and *http://www.magnet.fsu.edu.*

Table 1. NHMFL Internship Class of 1998.

Student	Home Institution	NHMFL Advisor, Location	Research Experience
Hansen, Rachel	San Juan College	Neil Harrison, Los Alamos	Mathematical Calculations of Magnetic Fields, Induced EMF, and Magnetic Flux
Yarbough, Dale W. Jr.	Lane College	Donovan Hall, Tallahassee	Design, Construction, and Testing of Commercially Manufactured Silicon Die Pressure Sensors for Use with High Field, Low Temperature Magnetometers
Williams, Kareem	Florida State University	Benny Lesch, Tallahassee	Pulsed Magnet Design and Fabrication
Harden, Sitafa	Florida Agricultural and Mechanical University	Gang Cao, Tallahassee	Magnetic Properties of Double Perovskite Ruthenates
Gleason, Lauren	University of Florida	Mark Bird, Tallahassee	Installation and Calibration of Pilot Tube; Design of Parts for Hybrid Insert; Update Drawing Files and Inventory
Ringus, Erin	Columbia College	Alex Angerhofer, Gainesville	Electron Paramagnetic Resonance
Romand, Rachel	Occidental College	Alex Lacerda, Los Alamos	Low Temperature Magnetotransport Mesurements on Intermetallic Compounds
Koch, Krissi	University of South Florida	Leroy Odom, Tallahassee	Development of a Method to Extract Metals from Plant Material for Use in Low-Contamination, Isotopic Analyses
Le, Elizabeth	Mississippi State	Art Edison, Gainesville	Production of a Protein in Bacteria for NMR Analysis
Levarty, Kristy	Florida State University	Vince Salters, Tallahassee	The Speciation and Sources of Dissolved Phosphorous in the Everglades
Bond, Heidi	Brown University	Tim Cross, Tallahassee	Computer Modeling of Proteins
Van Sciver, Courtney	Duke University	Mike Davidson, Tallahassee	Assistant Webmaster
Bissett, Maria	Mary Baldwin College	Justin Schwartz, Tallahassee	Effects of Temperature and Thickness on High Temperature Superconductors
Goga, Ledia	Carlow College	Peter Fajer, Tallahassee	The Aging Effect of Oxidation on Muscles

Tours. We have enhanced the tour experience by expanding the overview portion of the program and by offering extended tours that include mini-classes. For example, this year students and teachers have been encouraged to attend a "build an electromagnet" class as part of their tour experience. Approximately **4,000** students in grades 4-12 toured the NHMFL during the reporting period.

Newspaper in Education. The Center for Integrating Research and Learning supported nine classrooms by providing a year-long class subscription to the *Tallahassee Democrat* through its Newspaper in Education program. Six classrooms in Leon County and two in Gadsden County received the newspaper, training in the use of newspapers in the classroom, and support from the Newspaper in Education staff. Science classes were chosen by Center staff to promote connections between classroom science instruction and real-world issues.

Future plans include seminars and courses available through distance learning strategies (such as telecasts and web-based resources), new curriculum resource materials, a "women and girls in science" day at the laboratory, science fair workshops for students and parents, and a resource library for teachers, students, and parents.

Undergraduate Student Education. The NHMFL provides a variety of opportunities for undergraduate students. NHMFL faculty reported advising 164 undergraduates and teaching over 20 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 coursework, undergraduates also have opportunities for internship, research, and work experiences throughout the laboratory.

In 1998 we hosted the sixth consecutive NHMFL Minority/Women Summer Internship Program. 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 1998."

The 1999 program initiated our shift from the NHMFL Minority/Women Summer Internship Program to the Research Experiences for Undergraduates (REU). Interest this year was unusually high: 200 undergraduates majoring in science or engineering applied; 45 submitted full application packets; and 18 were selected—an increase of 26 percent. Table 2 provides details about the 1999 REU program. Part of the renewed program includes a weekly seminar series during which the undergraduates will interact with the teachers participating in the Research Experiences for Teachers (RET) program.

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 (FAMU). Our faculty reported teaching 15 graduate courses and serving on over 90 graduate committees during the reporting period.

Through these efforts, NHMFL graduate students continue to learn while contributing to the work and educational efforts of others at the laboratory. Fifteen NHMFL-affiliated graduate students (see Table 3) earned their Ph.D.s during the reporting period 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.

Vocational Coop Programs at the NHMFL. The NHMFL cooperative programs with two regional vocational and technical schools continued during the period. Students from Lively Technical Center and Thomas Technical Institute continue to work closely with senior staff members in our Facilities and Electronics Instrumentation programs. The purpose of the externships is to offer students hands-on, "real-world" experience in the workplace. The students genuinely appreciate the opportunities and report that their experiences are very worthwhile. Through the Job Training Partnership Act, the Center provided the opportunity to encourage school completion or enrollment for youth ages 14-21.

Table 2. Research Experience for Undergraduates, 1999

Student	Home Institution	NHMFL Scientist	Location	Research Experience
Betts, Sonia	University of New Mexico	Alex Lacerda	Los Alamos	The Process of Dealumination of Zeolites
Burks, Rene	Lady of the Lake College	L.-C. Brunel	Tallahassee	Electron Magnetic Resonance
Burton, David	University of Florida	Justin Schwartz	Tallahassee	Processing of High Temperature Superconductors
Davis, Sarah	Tennessee State University	Leroy Odom	Tallahassee	ICP for Metal Composition in Spanish Moss to Determine Point Source Pollution
deAzeredo, Vivian	Instituto Militar de Engenharia	Luis Brandao	Tallahassee	High Strength, High Conductivity Copper Niobium Microcomposite Wires for Pulse Magnets
Gullatt, Darrell	University of Maryland	Donavan Hall	Tallahassee	AC Susceptibility Measurements on Superconducting Tapes
Jackson, Rochelle	Claflin College	Leroy Odom	Tallahassee	Soil Permeability of CO_2
Johnson, Derrick	Xavier University	Scott Smith	Tallahassee	Creation of Virtual NMR Utilizing Java Programming
Kanakoqui, Miguel	University of Texas El Paso	Benny Lesch	Tallahassee	Cataloging Properties of Magnetic Materials
King, Alexandra	Rice University	Fajer/Smith	Tallahassee	Software Development for Muscles Contraction Modeling Using EPR
Mulvey, Colleen	Florida State University	Fajer/Krzystek	Tallahassee	EPR Myosin Spin Lables for Muscle Contraction
Nuttall, Ben	Florida State University	Benny Lesch	Tallahassee	The Process of Analytical Design to Finished Magnet
Peabody, Lydia	Smith College	Eric Palm	Tallahassee	Creating a Coupling Device to Measure Very Low Temperatures
Platero, Alesha	San Juan Community College	Leroy Odom	Tallahassee	Rubidium-Strontium Dating of New Mexico Rocks
Ringus, Erin	Columbia College	Alex Angerhofer	Gainesville	Pulsed EPR and ENDOR to Investigate Mechanisms of Triplet Energy
Romero, Melissa	Florida State University	Leroy Odom	Tallahassee	Strontium Isotopes in Ancient Foraminifera as a Test of Punctuated Evolution
Rowan, Dana	Rice University	Leroy Odom	Tallahassee	Strontium Isotopes in Ancient Foraminifera as a Test of Punctuated Evolution
Ubillus, Gonzalo	University of Maryland	Scott Crooker	Los Alamos	High Field Magneto-Optic Spectroscopy of Gold Nanoshells

Table 3. NHMFL Affiliated Graduate Students Earning PhD.s in 1998 and 1999.

Graduate Student, Institution and Department	Dissertation/Thesis Title
Myriam Cotton, FSU Chemistry	Molecular Basis of Channel Folding and Function in Membranes: A Solid State NMR Study Featuring Aromatic Amino Acids in a Model System, Gramicidin A
Christopher D. Immer, FSU Physics	Pressure, Doping and Magnetic Field Effects on the First-Order Valence Transition in $YbInCu_4$
Gui-Hua Lisa Lang, UF Chemistry	Studies of Organometallic and Biological Systems with Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
Weiqun Li, FSU Chemistry	Characterizations of Protein Masses, Sequences, and Structures by Fourier Transform Ion Cyclotron Resonance Mass Spectrometry
Ann McCarty, FSU Physics	High Field EPR of Diluted Magnetic Semiconductors
Vilen Melik-Alaverdian, FSU Physics	Theory of Excitations in the Quantum Hall Effect
Sawako Nakamae, FSU Physics	Magnetothermal Conductivity of $Bi_2Sr_2Ca_nCu_{n+1}O_x$ Bulk Superconductors
John Panek, FSU Mechanical Engineering	Heat and Mass Transfer in Two-Phase Helium II
Michelle Shepard, FSU Physics	Magnetic and Transport Properties of Selectively Doped $SrRuO_3$
Stone Shi, FSU Chemistry	Ultrahigh Resolution Fourier Transform Ion Cyclotron Resonance Mass Spectrometry Based on Digital Quadrature Heterodyne Detection and High Magnetic Field Strength
Fang Tian, FSU Chemistry	Structure-Function Correlations of an Ion Channel Probed by Solid State NMR
Bryan Vining, FSU Chemistry	Investigation of Gas Phase Ion Tertiary Structure
Maria Wigger, Swiss Federal Institute of Technology (ETH) in Zurich. She worked with Prof. Steve Benner, UF Chemistry	Receptor Assisted Combinatorial Synthesis [RACS]: A New Approach for Combinatorial Chemistry
Lei Yang, UF Physics	Diffusion Tensor Imaging and the Measurement of Diffusion Tensors in Biological Systems
Habio Zou, FSU Geoscience	Studies of Mantle Melting Process and Compositions Using Major and Trace Elements, Neodymium-Strontium-Lead Isotopic Systematics, and Uranium Series Disequilibria: Mathematical Modeling and Experimental Analyses

Teacher Education

The Center's teacher education efforts have continued to mature and expand. In collaboration with the FSU College of Education, science education centers and museums, and local school districts, the NHMFL has 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.

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 472 teachers attended workshops ranging in subject from the use of the new standards-based curriculum products developed at the NHMFL to integrating science and mathematics in the primary classroom using literature and hands-on activities.

Statewide training for the *Science, Tobacco & You* program was conducted for 321 of Florida's elementary school teachers at sites in 11 Florida cities. Participants attended a one-day training session where they learned ways to incorporate technology into classroom instruction and had opportunities to work with the *Science, Tobacco & You* science curriculum. Participants also received training in how to conduct inservice sessions at their schools or districts in order to facilitate dissemination of the *Science, Tobacco & You* materials. Comments at the end of the training indicated that the sessions accomplished far more than their original goals. For example:

> *"This was more exciting than I was expecting! I never expected to receive this many tools to work with. This program should spark every child's interest... I'm pumped." (5th grade teacher).*

> *"There are so many wonderful lessons and help that I would be foolish not to use Science, Tobacco & You with my students." (4th/5th grade teacher).*

> *"It is very exciting to see science promoted as a means to teach required Sunshine State Standards and to teach health issues." (5th grade teacher).*

> *"It is one of the most innovative curriculum I have ever seen and I have been around a while. I love it all—I'm excited and I know the kids will be too." (4th grade teacher).*

> *"It went beyond (my expectations)—GREAT use of tobacco settlement funds!! Bravo." (4th grade teacher).*

Further evidence of the training sessions and program is that several Florida school districts have contracted with the Center to conduct additional sessions during fall 1999.

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. Through the Teacher Quest Scholarship Program, Summer 1998, the Center supported three teachers. Two elementary school teachers from Leon County and one middle school teacher from St. Johns County participated in a curriculum development program to translate the science and technology of optics and magnetism to students and teachers.

RET. Drawing upon the success of the Research Experiences for Undergraduates, the Center is conducting the first annual Research Experience for Teachers targeting middle grades (5-9) teachers and senior preservice teachers. Experienced educators are paired with prospective elementary and secondary teachers to work with scientists and researchers at the Tallahassee site of the NHMFL on research projects. Participants will spend a portion of their day translating what they have learned and experienced in their research mentorships into classroom materials and activities. Five experienced teachers and five preservice teachers are mentored by five research scientists representing areas such as photomicroscopy, instrumentation, operations, and condensed matter physics. Teachers will extend the RET program beyond its immediate focus by disseminating strategies through workshops at their schools and becoming teacher-leaders in the science education community.

The NHMFL Ambassador Program involves teachers from elementary, middle, and high schools and community organizations 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. From this network of 75 regional K-12 teachers representing over 50 schools, community members, and school board personnel, the NHMFL receives valuable suggestions and guidance that influence 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 to introduce them to new strategies for implementing national and local standards in the science classroom. Papers were presented at the annual conference of the Association for the Education of Teachers in Science (AETS), at the regional meeting of the National Science Teachers Association, and at Southeastern AETS. Additionally, a team of teachers and students who worked on developing *MagLab: Alpha* represented the NHMFL at the 25th annual SIGGraph Conference, the world's largest computer graphics conference (32,210 attendees). SIGGraph is the Special Interest Group on Computer Graphics for the Association for Computing Machinery Special. The NHMFL team presented to an audience of educators the model process that the Center for Integrating Research and Learning uses to turn research experiences into educational materials. They also discussed how science, technology, and the arts can be integrated into the K-12 curriculum.

The NHMFL education group members and students from the Practical Learning Utilizing New Gadgets in Education (P.L.U.N.G.E.) program teamed up to present a "School-to-Work Model" used by the Center to develop the MagLab series of science curriculum materials. The presentation was given to 300 teachers and district administrators at the annual Florida Arts in Education Conference.

Technology and its uses in education was the topic of the Center's display at the Florida Government and Technology Conference. The Center, in collaboration with the Florida State University School and the Department of Management services, shared with policymakers technology-based curriculum materials developed at the Center.

Graduate level courses taught by Center faculty continued to be offered through the FSU College of Education. This year, faculty members led courses in Curriculum Theory and Curriculum in Science for both Master's and doctoral level students. The Center's involvement in teaching graduate courses provides a foundation for future research efforts.

Supporting Graduate Students and Prospective Teachers through work and assistantships provides the students with models and experience in education. These students also contribute to the Center through their enthusiasm and energy.

An undergraduate level course is 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 with an overview of issues in education today. We also developed a series of educational experiences for 57 Elementary Education students as part of their core course of studies.

Web-based resources of particular interest to teachers (*http://k12.magnet.fsu.edu* and *http://scienceu.fsu.edu*) 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. We also engage in conversation with teachers about curriculum, teaching science, and answering student questions through e-mail and other means.
- 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.

For example, on the *Science, Tobacco & You* web site, the teacher resource sector allows teachers to share ideas (journals), share curriculum (lesson plans), and ask questions (bulletin boards). The sector includes six areas, including the "Student and Teacher Guidebook."

1. Bulletin Boards. Teachers and other curriculum experts have an opportunity to post questions related to the *Science, Tobacco & You* program. Questions can be answered by the staff of the Center for Integrating Research and Learning or by other teachers.

2. Lesson Plan Sharing Board. Teachers have an opportunity to share successful lesson plans. The plan includes the teacher's name, e-mail address, school name, city, grade, additional comments on the school or students, title of the lesson plan, content area, a description of the activity, assessment strategies, student comments on the activity, and additional comments on the activity. At this time, 40 teachers have submitted lesson plans to share with their colleagues.

3. Teacher Journals. Teachers have an opportunity to share their thoughts on the *Science, Tobacco & You* program and general curriculum issues. Twelve (12) teachers and pre-service teachers have submitted their thoughts on the curriculum and other education issues.

4. Program Information. As the program evolves, information for the *Science, Tobacco & You* district level facilitators and teachers is posted. Users can visit this area to find out the latest developments (i.e., contest winners, package shipment, names of teacher trainers), general information (i.e., project overview, district facilitators, training sites), and print documents (i.e., answer keys, activity databases).

5. Student and Teacher Guidebook. From the web site, teachers can download and print the latest edition of the guidebook. A PDF reader is provided to make downloading easy. The Guidebook can be downloaded in its entirety (12.31 MB), in five sections, or by module. As additional activities are developed or improvements made on existing modules, the teachers can update their document without having to purchase a new text. Because the guidebook is in electronic format, the format can be adapted to fit the individual style of the teacher.

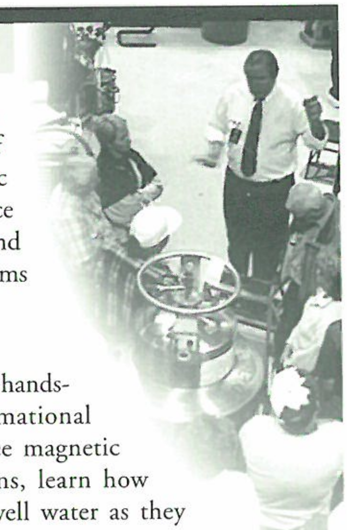
6. Registration & Evaluation. Teachers can register their class as *Science, Tobacco & You* users. After completion of the program, evaluation data can be posted and the class can enter a contest for their participation. Rebecca Howland's 4th grade class from Talbot Elementary School recently won a Phillips DVD player.

In addition to the six areas listed, "Teacher Resources" also include contact information so that the teachers or facilitators can contact the Center with questions and comments. Like all of the pages within the web site, there is a link at the bottom of the page that allows users to e-mail *Science, Tobacco & You* (*stu@magnet.fsu.edu*) with questions or comments. The e-mail link makes it convenient so that the user can ask a question as it arises rather than having to search for the contact information. The same is true for the bulletin boards. The link to the bulletin board page is found throughout the web site.

Responses to the web site from teachers participating in the train-the-trainer sessions and students who have reviewed the site have been positive. The teachers enjoy the richness and the multidisciplinary approach of the content, its user-friendliness, the teacher resources and notes, the matching of the content to the Sunshine State Standards, and its interactivity. Students also enjoy the interactivity of the site. They have also commented on the colored graphics that are not only entertaining but also support the text, as well as the ease of navigation. Since the October launch of the web site, 2,893 unique IP addresses have logged on to the web site. This does not include the computers used for the train-the-trainer sessions.

Future teacher education plans include expanded technology workshops for teachers, seminars and courses offered through distance learning strategies, more web-based resources for teachers to use in classrooms, and collaborations on teacher enrichment workshops with science centers.

General Public Awareness



In addition to our efforts to educate students and teachers through formal settings, we also strive to inform the general public about the NHMFL and to be contributing members of the community and region. Our public awareness program seeks to promote scientific literacy, to inform 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. Each year we attract approximately **2,500** members of the general public for tours of the laboratory. Each tour comprises an overview of the laboratory and a walking tour of the main research areas at the Tallahassee facility.

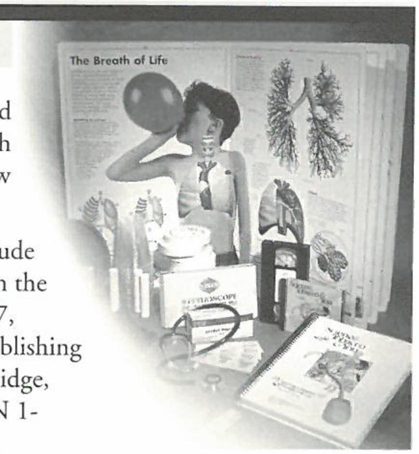
Open House. Every October, in recognition of the laboratory's dedication in 1994, the NHMFL hosts an open house. The 5th Annual NHMFL Open House on October 3, 1998, attracted over **3,100** visitors, and included a greeting by the director of the laboratory, Dr. Crow, an orientation video, and self-guided tours of the facility. The 1998 event was expanded significantly by the inclusion 20 community organizations that have an interest in science education. The addition of our "Community Partners in Science & Education" (groups such as the ODYSSEY Science Center, the St. Marks Wildlife Refuge, and the Sea-to-Sea Program) broadened our open house offerings and attracted great local interest. Throughout the laboratory, guests experienced a wide range of demonstrations, hands-on activities, and informational videos. Visitors could see magnetic levitation demonstrations, learn how contaminants get into well water as they dissipate through the soil, or enjoy an interpretive dance with original music by the FSU Dance Theater designed to portray research at the laboratory. Additionally, a local radio station helped sponsor the event by giving air-time to promote the Open House and providing celebrity hosts at the lab throughout the day conducting live broadcasts and interviews. We expect the 1999 event to be even more community-oriented, interactive, and exciting.

The First Annual Youth Art Contest was launched in conjunction with the 1998 Annual Open House. Comprising four divisions—Primary, Intermediate, Junior, and Senior—the contest attracted over 100 entries. "Mind Blowing

Magnetism: The Art of Magnetism, Science and Me" encouraged students to use artwork as a way to understand their world and extend classroom learning. First, second, and third place winners were awarded in each division and prizes donated by local merchants were awarded. The *Tallahassee Democrat* featured winning artworks and artists in a supplement to the newspaper.

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.

Curriculum Materials Development



The Center has dramatically expanded its curriculum development capabilities and has established itself as a leader in creating innovative curriculum materials. With funding from the Florida Department of Health, we developed and launched a new program this year called *Science, Tobacco & You*.

Science, Tobacco & You is a multidisciplinary science curriculum resource that engages students in developing skills in language arts, mathematics, social studies and many other subjects. All of the materials reflect the Sunshine State Standards and the activities are cross referenced to the Standards as well as Florida's assessments (such as FCAT, Florida Writes!, and Terra Nova). The goal of *Science, Tobacco & You* is to encourage students to use science to ask and answer questions to promote scientific literacy; in this case, the medium used is the issue of tobacco use and prevention.

Beginning with a knowledge of human body structures and function, students are encouraged to learn more about how the use of tobacco products affects their lives. *Science, Tobacco & You* provides multi-sensory experiences, through which students explore the harmful effects of tobacco on *their* bodies, strategies for handling peer pressure to use tobacco products, and how they can use a scientific perspective to make decisions. Each package contains:

- a **box of manipulatives** that contains all the equipment necessary for up to 250 students to conduct over 22 activities (presented in the guidebook). The equipment is selected to provide hands-on opportunities that allow students to quantify their observations, explore related questions, and experience the process of data generation.
- an ***electronically published*** **Teacher/Student Guidebook** that is located on the web site and CD-ROM. Comprising 9 modules and 22 activities, the Guidebook is set up so that each module and activity is consistent with the others, so you will know exactly where to look for the features that you need.
- a "**big book,**" *How Your Body Works*, provides a nicely illustrated overview of the human body and the major functions. It works well for whole class instructionas well as individual and group review. We are pleased to be able to include this resource in the package. (1997, Henderson Publishing LTD: Woodbridge, England. ISBN 1-890409-43-x).
- an interactive **CD-ROM** for teachers and students that provides science inquiry activities and tools with which to collect and present data and formulate and communicate ideas. Its three main areas (Virtual Body Lab, Community Research Lab, and Teacher's Lab) are resources that further support *Science, Tobacco & You* activities and encourage individual research.

The CD-ROM includes opportunities for students to write, draw, graph, and enter on a spreadsheet data gathered through the activities, use of the web site, and exploration of the CD- ROM itself.

Virtual Body Lab. This section provides an opportunity for students to assemble their "virtual you" through which they will explore the human body's nervous, circulatory, and respiratory systems. Students are encouraged to "see" changes in their own bodies. Teachers can chart student progress through the Virtual Body Lab by accessing the Teacher's Lab.

Community Research Lab. Students explore their feelings about the use of tobacco products to compare them with the attitudes of friends, teachers, community members, and health and science experts. A Lab Notebook, Data Entry and Analysis Tools, and ways of presenting student research are provided.

Teacher's Lab: This section contains resources for the teacher. Instructions for taking digital pictures and entering them into the computer so that students can work with the Virtual You are found here. Also in this section is the opportunity to check student lab notebooks and to chart student progress as they move through the activities on the CD-ROM. The *Science, Tobacco & You* Guidebook can be downloaded and printed, as can the Nutrition Database that supports several activities found in the Guidebook.

- a **training/promotional videotape**.

The *Science, Tobacco & You* web site (*http://scienceu.fsu.edu*) provides a comprehensive resource for students and teachers to ask questions about how tobacco impacts their lives. It also facilitates communication through the Asking and Sharing sector. This outline provides you with a brief description of the web site, its features, and suggested uses. Although the best way to learn about a web site is to explore it yourself, this outline will serve as a quick and easy resource for finding specific features. The web site has five major sectors: Navigation Help, Looking and Thinking, Asking and Sharing, Bulletin Boards, and Teacher Resources. Within each category there are subdivisions that each have links to each other and to other sites.

Science, Tobacco & You was released throughout Florida in March 1999 through statewide training and distribution sessions. Over 1,818 packages were delivered to elementary schools, and 321 teachers participated in workshops to learn how to integrate the program effectively into their classrooms. Feedback on the program has been unprecedented. For example one Florida county has already purchased enough additional packages to have one in every 4th and 5th grade classroom. In another county, the superintendent was so impressed with the materials that she read the guidebook and ordered 130 sets of all of the suggested reading materials we listed as extensions to the activities. She is delivering the sets to each 4th and 5th grade teacher in her county. Below are some comments from teachers about the program.

> *"The most beneficial aspect of the workshop was the introduction to the most useful curriculum on this subject available with materials supplied for each activity. WOW!"*

> *"It [Science, Tobacco & You workshop] exceeded my expectations. I did not expect the curriculum to be so easy to integrate into the existing requirements [in the classroom]."*

> *"I expected an anti-smoking workshop, but I was actually introduced to a wonderful science-based curriculum that can be incorporated in many other areas of elementary school curriculum."*

MagLab: Alpha, the laboratory's first major curriculum product, was developed and fielded in 1996 and 1997. It is now commercially available nationwide. *MagLab: Alpha* was developed for use in middle grades classrooms and is being used in over 240 classrooms. An integrated, standards-based curricular resource package, MagLab: Alpha promotes hands-on, collaborative, interdisciplinary learning based on science concepts. *MagLab: Alpha* three components—Alpha Guide, Alpha Pack, and Alpha Interface—take 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 instructions on how to use the materials presented and 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. We are in the process of revamping these resources to provide a more substantive tour experience.

Activity Books were created for elementary age 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 is being used by the Odyssey Science Center as part of the visitor's experience to the *Magnetics: The Invisible Force* exhibit.

Open House Curriculum Resources were developed to enhance the experience for learners in grades K-14. The materials included a scavenger hunt that was well received by all visitors to the Open House.

Future curriculum development efforts will build on our existing programs and experiences. We anticipate expanding the *Science & You* series as well as the *MagLab* series.

Educational Research

Conference papers and presentations were not as numerous as in previous years due to a shift in resources to accommodate the development and delivery of the *Science, Tobacco & You* program. Nonetheless, Center faculty were invited to participate in several national and international conference activities, and they did so whenever possible. Requests for papers presented in 1998 were received from researchers and established educational experts.

An important aspect of the concept behind the Center for Integrating Research and Learning is research, not only science research but science education research. We have continued our research efforts to evaluate our education programs overall, as well as specific features of the program. The curriculum products that the NHMFL develops are the subjects 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 and professional development. The curriculum development process has become an area of intense interest for the program making the NHMFL's affect on science teaching and learning fertile ground for our research efforts.

Conference Papers and Presentations

Association for the Education of Teachers in Science (AETS), 1999, Panel, *Preservice Learning Opportunities at a National Laboratory—Imagine the Possibilities.* Samuel A. Spiegel, NHMFL/FSU and Patricia J. Dixon, NHMFL/FSU.

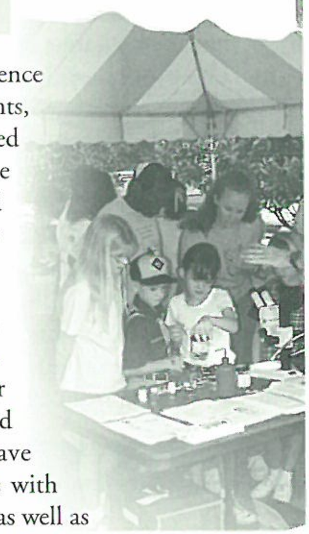
Florida Alcohol and Drug Abuse Association (FADA), 1999, Florida Statewide Prevention Conference, Workshops, *The Magic of Partnerships and Collaborations.* Samuel A. Spiegel, NHMFL/FSU.

Educational Resource Laboratory

In support of our vision to create a unique learning center for students of all ages (including K-12 students, teachers, and undergraduates), 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, Florida.

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:

Training Solutions Interactive (TSI) has joined us as a partner this year in our curriculum development efforts. TSI is an internationally-recognized leader in the development of innovative interactive programs for education and training. TSI specializes in the implementation of programs, systems and strategies to improve efficiency and productivity for a wide variety of applications, businesses, and industries. Since its inception in 1995 by former Philips Electronics executive, Phil Ingram (a pioneer in the interactive video field), the consistent delivery of high quality products, services and systems, highly responsive customer service, and a reputation for impeccable workmanship have propelled TSI to a position of industry leadership.

TSI began its rise to national prominence with the development of the first interactive video food safety-training program for restaurant employees. Designed to specifically address the Florida Department of Business and Professional Regulation's mandate on food safety training, this program is still widely used throughout the state. TSI has since evolved from the production of superlative video programs to its current capabilities of multimedia services that include CD-I-based training, CD-ROM programs, Internet and the latest in advanced technology, interactive DVD. TSI's state-of-the-art production facilities boast a totally digital environment with a 13,000 square foot fiber-optic linked sound stage, non-linear video editing systems and a full compliment of top-of-the-line software tools.

TSI received the 1998 TELE Award for "Best Interactive Program," but a more notable sign of TSI's success is its list of clients, which includes Fortune 500 companies like Coca-Cola, Rank America (Hard Rock Cafes), Disney World, and Lucent Technologies. TSI is also a strategic partner with Philips Electronics. Together TSI and the NHMFL have established a strong ongoing partnership, the results of which are important and innovative curriculum resources.

Sempco, Incorporated. This private business located in Nashua, NH, has been working with the NHMFL to develop and mass produce our curriculum materials projects. 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 Other 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."

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 Research Experiences for Undergraduates (REU) program (formerly the Minority/Women Summer Research Internship program).

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. We are also working with these two organizations on traveling and permanent exhibits for science museums and centers. In addition, 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." The CCC will assist us again this year in providing hands-on activities and displays for the 6th Annual Open House of the NHMFL.

COLLABORATIONS

CHAPTER 5

The technological expertise and the critical mass of human scientific capital that exists at the NHMFL is attracting an increasing number of collaborators each year and at all levels. This list of collaborations for 1998 is a striking illustration of the breadth and scope of activities undertaken by the researchers and staff of the laboratory. Collaborations are an excellent means of fulfilling the laboratory's mission to advance magnet related technologies and to promote U.S. economic competitiveness while advancing the user facilities.

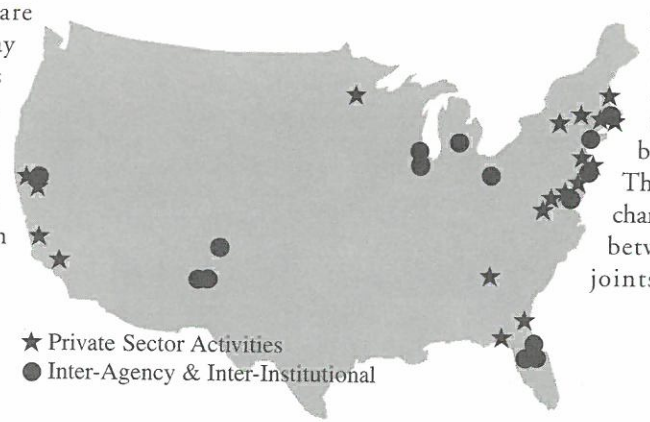
While collaborations with the private sector have increased by 60 percent, it is important to note how frequently the NHMFL is being sought to advise and work with industry to advance new technologies and test prototypes. Hardly a week goes by that the NHMFL is not meeting with corporations and other research institutions to explore common interests and problems. The laboratory is engaged in significant collaborations with almost all of the Department of Energy national laboratories and is working with the Office of Naval Research on a long-term research and development program for the electrification of naval ships. Likewise, with regard to international collaborations, the NHMFL has interactions with every active magnet laboratory. Since the NHMFL has set the benchmark for advanced research magnets, European and Asian laboratories have entered into agreements with us to procure our state-of-the-art resistive and pulsed magnet systems.

Private Sector Activities

Biospace International, *College Park, MD.* Researchers at the NHMFL are developing SBIRs for NIH and NASA to look at protein crystal growth in a high magnetic field force/gradient environment. This environment allows a variation of the effective gravity on materials to vary from zero to several times the Earth's gravitational force in the presence of high magnetic fields. Preliminary testing has been conducted at the NHMFL in a high field resistive magnet. Methods are being developed to accurately control temperature in the magnet core for future biological studies. Crystals grown in preliminary high field experiments are presently undergoing x-ray analysis at NIST. The results will be compared with corresponding studies in Space Shuttle experiments to evaluate the Earth-based low gravity effects on protein crystal growth.

BWX Technologies (BWXT), *Lynchburg, VA.* The NHMFL and BWXT are collaborating on the development of a superconducting magnetic energy storage (SMES) 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. The primary activity of the collaboration is superconducting magnet component testing.

BWXT, Naval Nuclear Fuel Division, *Lynchburg, VA.* The NHMFL performed precision resistance measurements characterizing solder splices between NbTi wires and cables. The specific tasks included the characterization of six splice joints between wires and two splice joints between cables.



Measurements were performed at fields in liquid helium at 4.2 K. The objective of the research was to produce measurement data to validate the design criteria and processing methods for making resistive splice joints in superconducting magnetic energy storage coils.

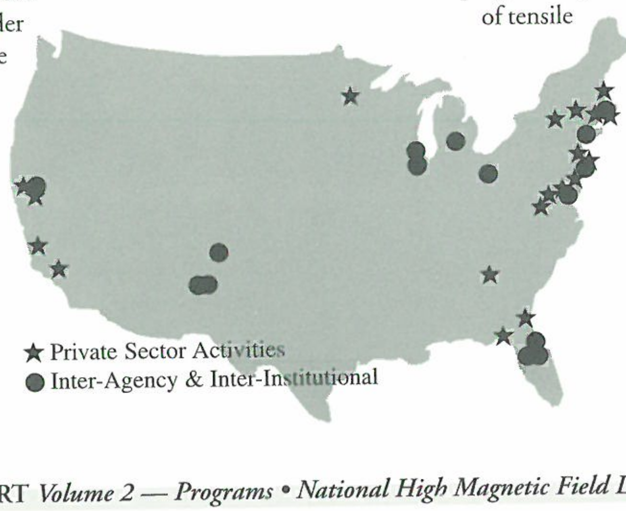
Conductus Inc., *Sunnyvale, CA.* The NHMFL is partnering with Conductus Inc. and Bruker Instruments on the development of a high temperature superconducting probe for the NHMFL's 900 MHz superconducting NMR magnet system. This collaboration has successfully completed an NSF Phase I SBIR grant with the characterization of HTS probe coils in the 25 T Keck magnet. These coils were made from thin films of $YBa_2Cu_3O_{7-\delta}$, patterned using designs developed by Conductus and Bruker. Q values dropped by less than 12% between zero field and 21.1 T and only an additional 12% in going up to 25 T. These numbers demonstrate the feasibility of using YBCO coils at very high fields for high sensitivity NMR probes.

DuPont Superconductivity, *Wilmington, DE,* and **Carpco**, *Jacksonville, FL.* The NHMFL is working with DuPont Superconductivity and Carpco, and the NHMFL to develop a quarter-scale high temperature superconducting magnetic ore separation system. The NHMFL has responsibility for the magnet design and the cryogenic system. Carpco is building the ore separator equipment. The working prototype system will be assembled and tested at the NHMFL and then shipped to DuPont for process engineering studies. This $6 million project is funded under the Department of Energy's Superconductivity Partnership Initiative (SPI) program.

EURUS Technologies, Inc., *Tallahassee, FL.* The close proximity of the NHMFL and EURUS (both located in Innovation Park) 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 superconducting and hybrid magnet systems while minimizing the influence of head 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.
- In the development of high-current leads, the principal focus of this collaboration is a pair of 20 kA HTS current leads for the proposed Series-Connected Hybrid (SCH). A design code for these leads has been constructed, including a detailed design database for the various materials and components used in the lead system. The latter continues to be tested and improved as part of the collaboration. While work is underway to build and test major components and a pair of 20 kA prototype leads for the SCH, the design tools and fabrication processes are also being tested through participation in a EURUS project to produce 13 kA prototype leads for the CERN Large Hadron Collider.

General Atomics, *San Diego, CA.* General Atomics is involved in the DOE-funded Accelerator Production of Tritium (APT) Project at Los Alamos. They must design structural components for the linear accelerator that operate at liquid helium temperature and utilize specialty construction materials (pure Niobium, pure Titanium, and Austenitic steel). Structural materials problems (such as the welding of dissimilar metals) and the lack of available data in the literature has necessitated the development of a mechanical properties database. The NHMFL's Materials Development and Characterization Group is conducting a mechanical properties test program to provide design data. Measurements of tensile and fracture toughness are made on base metals and welds over a temperature range from 295 K to 4 K.



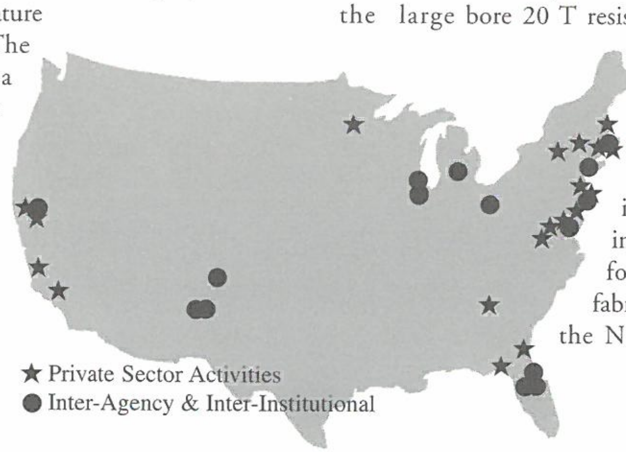
Intel Corporation, *Santa Clara, CA*. In exchange for information and wafers containing their latest integrated circuits, NHMFL researchers provide Intel with photomicrographs of their computer chips. Intel, in turn, uses these photomicrographs in advertising and as stock photography for journalists who need illustrations to accompany stories.

Intermagnetics General Corporation (IGC), *Latham, NY*. The IGC-NHMFL collaboration on the ambitious wide-bore 900 MHz NMR magnet system continues at an active pace. Weekly conference calls are held between the two partners to discuss and coordinate the complex fabrication schedules and other technical issues. IGC is completing five NbTi coils and a NbTi shim set. The shim set design review was held in February, 1999, and construction of the shim set and the five NbTi coils is proceeding. IGC has honored the technology transfer potential of this collaboration with a $1 million contribution to the project.

Intermagnetics General Corporation (IGC), *Latham, NY*. Researchers at IGC in collaboration with the HTS Magnets and Materials group at the NHMFL developed an HTS insert coil as a prototype for the 1.1 GHz NMR application. IGC constructed the coil, and the NHMFL has begun testing its performance within the 20 T large bore resistive magnet. Final testing of the coil is scheduled for May, 1999.

Lucent Technologies/Bell Labs, *Murray Hill, NJ*. Measurement of magnetic moments on new materials is best done when complementary sensing techniques are used. Lucent has developed sub-millimeter capacitive "trampoline" devices from silicon for use as magnetometers. This collaborative relationship allows users of the NHMFL to carry out studies on magnetic materials with the Lucent devices.

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 high strength polymers at ambient and cryogenic temperatures. Initial applications of the polymers in magnet instrumentation probes that require the strength and insulating characteristics of the polymers show promise for other low temperature and magnet applications. The research has resulted in a collaborative report to be published at this year's International Cryogenic Materials Conference.



Minnesota Mining and Manufacturing Company (3M), *Saint Paul, MN*. The NHMFL is collaborating with 3M to produce an ultra high strength, high conductivity composite electrical conductor by means of 3M's proprietary composite fabrication processes. This composite conductor has demonstrated a very significant increase in tensile strength as compared to present high performance conductors such as CuNb or CuAg. In addition, it has better electrical conductivity. This conductor may have applications in pulsed high field magnets and in high current, high frequency AC coil applications. Basic fabrication trials were made by 3M, then the NHMFL sponsored a pilot production run of 120 meters (currently in progress) of this very promising conductor. This collaboration occurred as a result of the NHMFL's experience with materials and high field pulsed magnets and as a result of NHMFL's knowledge of fabrication process capabilities in the private sector.

Nikon Instrument Group, *Melville, NY*. A collaboration between Michael W. Davidson and the industrial division of the Nikon Instrument Group has helped in the development of advanced optics for reflected differential interference contrast applications that will benefit the semiconductor industry. Davidson's group is also involved with Nikon in the development of web-based instructional materials that are used to train both the technical and sales forces.

Nordic Superconductor Technologies (NST), *Denmark*. The NHMFL is collaborating with NST on the development of wind-and-react double pancake coils that could ultimately play a role in a 1 GHz NMR magnet system. In the past year, NST has sent over 100 meter of fully-processed Bi-2223 Ag-alloy clad superconducting tape to the NHMFL. The NHMFL has evaluated the conductor in terms of the effects of high magnetic fields and mechanical strain on the critical current density. Furthermore, a double pancake coil was wound and tested in self-field and validate the NHMFL's capability to form wind-and-react coils. This double pancake will be tested in field in June, 1999.

Oxford Instruments, Inc., Superconductor Technologies (OI-ST), *Carteret, NJ*. The NHMFL is collaborating with OI-ST 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 kilometer of HTS conductor, is an important development on the path toward a 1 GHz NMR magnet system. OI-ST is providing all of the powder-in-tube BSCCO 2212 conductor for the program. After OI-ST 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 stacked at the NHMFL and electrically joined. Testing is planned for August, 1999.

Physical Sciences Inc., *Alexandria, VA.* A Phase I SBIR proposal has been funded by NIH for the development of a gyrotron to provide radiation for an instrument for pulsed and continuous wave electron magnetic resonance (EMR) spectroscopy. A pulsed system allows determination of the response spectrum of a sample over the bandwidth of the pulse. Higher carrier frequencies allow both the production of shorter pulses and the matching of the resonance frequency (in the sample) of stronger magnetic fields. The required frequency of the radiation scales with the magnetic field, so the frequency for EMR can substantially exceed 100 GHz. For short pulse EMR, there are no sources, other than fixed frequency FIR lasers, above 140 GHz. For the instrument we propose to build, the desired pulse widths are from 1 ns to 10 ns, with a power of about 10 watts (at the sample) at frequencies to at least 600 GHz. The gyrotron we propose to develop will be perfectly poised for use in the Keck magnet with its unique capabilities.

Resonance Research Inc., *Billerica, MA.* The NHMFL is partnering with Resonance Research on the development of shim systems for the 25 T Keck magnet. The present goal is to achieve 1 ppm homogeneity over a spherical volume of 1 cm in this 52 mm bore resistive magnet. Without shims the peak to peak homogeneity is approximately 50 ppm. The approach that has been taken is to use a combination of ferroshims and resistive coils. The first attempt with ferroshims mounted on the outside of the bore tube improved the homogeneity by a factor of 4. Currently, the next generation of ferroshims is being developed as well as the first generation of resistive shims.

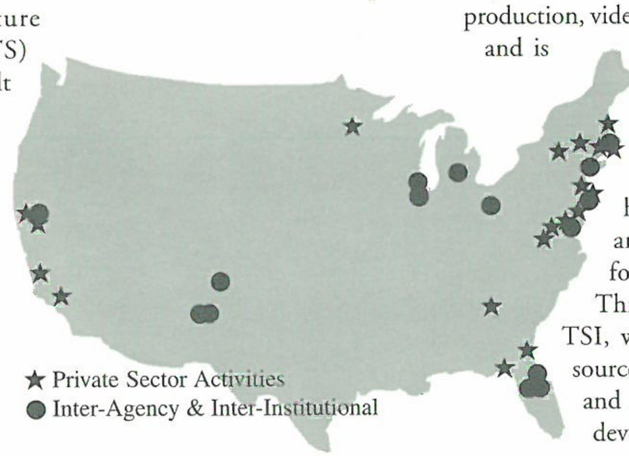
Southern California Edison, General Atomics, Intermagnetics General Corporation, *San Diego, CA.* NHMFL researchers at the Pulsed Field Facility at Los Alamos have worked on this collaboration to design and build a state-of-the-art fault current limiter to reduce short circuit currents in a medium voltage utility system. The fault current limiter uses large high temperature superconducting (HTS) magnets. The first HTS fault current limiter was tested successfully at Los Alamos, and the overall fault current limiter controller was designed by Los Alamos.

Sempco Incorporated, *Nashua, NH.* The Center for Integrating Research and Learning at the NHMFL has continued to develop curriculum products in conjunction with Sempco. Sempco has taken on the licensing responsibility for the national marketing of *MagLab: Alpha*, our first commercially available curriculum resource package. Sempco continues to aid in the development of the physical materials for our curriculum packages efforts and demonstration resources. Sempco is also the production company for the manipulatives packages of *Science, Tobacco & You* (see Chapter 4 or *http://scienceu.fsu.edu*).

Stonehenge, Ltd., *New York, NY.* Stonehenge is a commercial partner that licenses photomicrographs generated at the NHMFL as patterns for men's and women's silk neckwear. To date, royalties from this license have generated over $1 million for the NHMFL that has been used to equip a state-of-the-art photomicrography facility and custom color darkroom. Royalties have also enabled NHMFL researchers to produce an online microscopy tutorial in partnership with Olympus America, Inc. This educational effort includes over 100 interactive Java tutorials that have risen to a prominent position on the worldwide web.

Supercon Inc., *Shrewsbury, MA.* The development of high strength/high conductivity, composite conductors requires evaluation of the mechanical and electrical properties by the NHMFL's Materials Development and Characterization Group. By evaluating the properties we can help assess manufacturing process variables (thermal or mechanical) and their influence on properties.

TSI, Inc., *Atlanta, GA, Washington D.C., Tallahassee, FL.* TSI is an internationally recognized leader in the development of innovative interactive programs for education and training. TSI specializes in the implementation of programs, systems, and strategies to improve efficiency and productivity for a wide variety of applications, businesses, and industries. In conjunction with the Center for Integrating Research and Learning at the NHMFL, TSI has been collaborating with laboratory educators, scientists, and classroom teachers to develop and market the *Science, Tobacco & You* program (see *http://scienceu.fsu.edu*). TSI spearheaded the Town Hall production, video, and CD-ROM development, and is the marketing company for the *Science, Tobacco & You* program. As an extension to the *Science, Tobacco & You* program, TSI is developing a home version that is designed as an interactive CD-ROM game format called "Hitting Home." Through our collaborations with TSI, we are exploring new funding sources and have expanded our video and interactive educational software development capabilities.



Vacuumschmelze, *Hanau, Germany.* In the framework of the 900 MHz ultrawide bore NMR magnet, the NHMFL has initiated a cooperation with Vacuumschmelze to evaluate different approaches to high strength Nb_3Sn conductors. Vacuumschmelze has further offered to send some lengths of HTS conductors to the NHMFL to be characterized and wound into high field insert coils.

Varian Associates, *Palo Alto, CA.* The NMR program at the NHMFL is a beta test site for a new HTS probe that 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

Advanced Photon Source, Argonne National Laboratory, *Chicago, IL.* The unique features of the Advanced Photon Source can be further enhanced with the addition of high magnetic fields in the experimental area. The two laboratories are planning to add several magnetic field configurations to exploit the capabilities of x-rays for elastic and inelastic magnetic scattering, time dependence of magnetism, and magnetic microscopy. The NHMFL will perform preliminary basic magnet design studies with a detailed analysis of the split, parameter studies, and cryostat options. A second study will include micro-coils to match the 10 nanosecond photon pulse with a repetition rate of 3.68 microseconds.

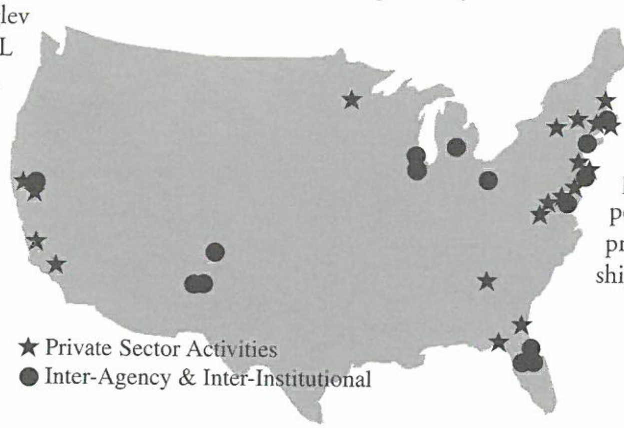
Center for Advanced Microstructures and Devices (CAMD), Louisiana State University, *Baton Rouge, LA.* Together with CAMD, the NHMFL has begun fabrication of silicon cantilevers and torquemeters for use as magnetometers at high magnetic fields. The primary goal of this collaboration is to provide an inexpensive and (essentially) unlimited supply of silicon cantilever devices for use at the NHMFL by internal and external users.

Center for Advanced Transportation Systems, Department of Transportation, and University of Central Florida, *Orlando, FL.* The NHMFL, in cooperation with the FAMU-FSU College of Engineering, is working with the University of Central Florida to establish the Center for Advanced Transportation Systems (CATS). A grant from the U.S. Department of Transportation is funding the multidisciplinary center for simulation-based design, manufacturing, and testing focused on multimodal advanced transportation systems, with particular emphasis on maglev technologies. The NHMFL and the FAMU-FSU College of Engineering have formed the Institute of Transportation Technologies (ITT) as the vehicle for focusing and coordinating all transportation research activities at the two institutions to provide a wider range of options for collaborations and interdisciplinary efforts.

Clark University, *Worchester, MA.* The Pulse Field Magnet Group has established a collaboration with the Department of Physics at Clark University to design and build a magnet for its pulsed field facility. The magnet will have a 18 mm bore and is designed to achieve a field of 60 T.

Department of the Navy, Office of Naval Research (ONR). The NHMFL is working on a feasibility study and investigative program that will lead to a research and development program in support of the electric ship concept for the Navy. The initial program will identify power distribution and power management issues with a primary focus on the next generation of aircraft carriers. The feasibility study will identify new research activities that will most likely produce both near-term and long-term benefits for the ultimate Navy objective of the all-electric ship. As an initial step, a productive workshop was held at the NHMFL to outline the numerous R&D issues that need to be addressed in these studies. The workshop included representatives from ONR, academia, shipbuilding, power engineering, utility, and superconductor industries.

Department of the Navy, Office of Naval Research. The NHMFL is cooperating with the Navy to test a superconducting magnetic energy storage (SMES) system. Virginia Polytechnic Institute and State University (VA Tech) is providing the power electronic equipment for the test. All components of the large-scale SMES system are on-site at the NHMFL. The project is part of the Navy's power electronic building blocks program for the electrification of ship drives and related systems.



Fermi National Accelerator Laboratory, *Batavia, IL.* The Magnet Science and Technology group at the NHMFL is participating in a broad collaboration to study the feasibility of building and operating a muon-muon collider. Our primary contact in this collaboration is the Fermi National Accelerator Laboratory, whom we provide design support for specific magnet systems. In actuality, however, we work in close cooperation with all the major high—energy physics laboratories—Fermi, Brookhaven, and Lawrence Berkeley-as well as with other university collaborators. Our primary focus is presently a set of large, high-alternating-field solenoids required in a system proposed for cooling the muon beam. This is a large magnet system with technical similarities to both the NHMFL 900 MHz system and the 45 T Hybrid solenoid system.

Gulf Coast Alliance for Technology Transfer (GCATT), *Shalimar, FL.* The NHMFL has been a founding member of GCATT for several years. GCATT comprised nine federal and defense laboratories, five universities, including Florida State University and the University of Florida, and one community college. It provides an excellent vehicle to network and exchange technologies and support among its members. Its principle mission, however, is to promote technology transfer among the laboratories and universities and to look for shelf technologies that are good candidates for commercialization.

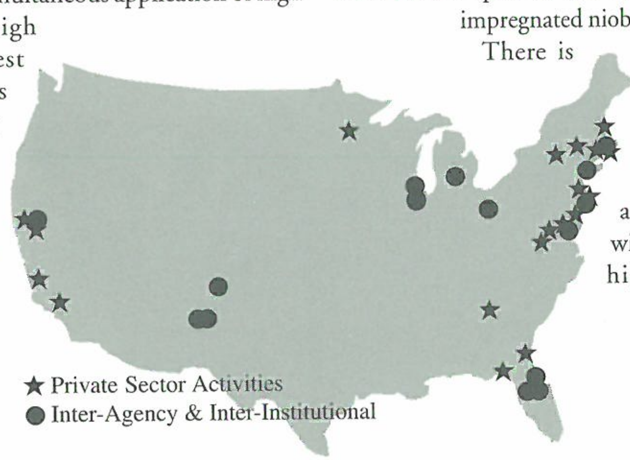
Lawrence Berkeley National Laboratory (LBNL), *Berkeley, CA.* The Superconducting Magnet Group at LBNL collaborates with the NHMFL's Magnet Science and Technology Group to measure the current transport characteristics of Rutherford-style superconducting cables for dipole magnet development. The NHMFL Large Magnet Component Test Laboratory, with its unique capabilities, is used to simultaneously apply high magnetic field, transverse compressive loading, and high current to the LBNL conductors.

Lawrence Berkeley National Laboratory, *Berkeley, CA.* The laboratory continues to support LBNL's high field, dipole development program through operation of a specially designed facility that allows simultaneous application of high field, high current, and high transverse load to large test conductors. The facility is based on our superconducting split-pair solenoid, produced by Oxford Instruments, Inc., and is located in the Large Magnet Component Test Laboratory. At present, the facility is capable of applying up to 13 T, 19.5 kA, and 250 kN to a test conductor fitting into the 30 x 70 mm^2 radial-access port of the Oxford magnet. A variety of large Rutherford-style cables based on multifilamentary Nb_3Sn/copper composite wires have been tested already and have provided insight to the performance of an experimental model dipole magnet tested at LBNL. Future test plans include cables fabricated with high temperature superconductor wires based on Ag-matrix Bi-2212.

Los Alamos National Laboratory, *Los Alamos, NM.* The object of the Los Alamos Neutron Science Experiment (LANSCE) high frequency split-pair pulsed magnet, funded by the Department of Energy, is to supply the LANSCE with two 20 mm bore, split-pair magnets that can achieve fields up to 30 T and up to 23 T for 10 million cycles. The engineering design of the coil system was reviewed at Los Alamos in January, 1999, and we are now proceeding with fabrication. These high frequency magnets will be pulsed at 2 Hz in the LANSCE facility to provide a unique high magnetic field and neutron beam scattering capability in the world. This magnet is being designed and fabricated by the NHMFL's Magnet Science and 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 an ongoing interest in maglev technology as the next-generation alternative to high-speed rail in congested central and south Florida. A 1,000-foot demonstration track has been completed.

National Superconducting Cyclotron Laboratory (NSCL), Michigan State University, *Lansing, MI.* The Magnet Science and Technology Group of the NHMFL were contacted by the NSCL to build a 4 T superconducting sweeper magnet. The magnet is referred to as a sweeper because it "sweeps" charged particles out of a neutron beam and into a mass spectrometer. It is required to bend beams of high rigidity 40° on a 1 meter radius. The magnet consists of 2 D shaped coils with a split of 140 mm. The conductor is epoxy-impregnated niobium titanium operating at 4.2 K. There is a yoke of approximately 16 tons to enhance the peak field and reduce the fringe field. Although 4 T is not a tremendously high field, attaining 4 T in a gap of 140 mm with a D-shaped magnet leads to high stresses and requires



substantial analytical work in the design process to ensure reliable operation.

New York University and Brookhaven National Laboratory, *Upton, NY.* The NHMFL is designing the magnets for a muon and electron number violation experiment (MECO) searching for muons converting to electrons in the field of the nucleus. The magnets consist of a series of moderate field superconducting solenoids for controlling beam dynamics in the experiment. The MECO experiment will be performed in a new pulsed muon beam to be constructed in the experimental hall of the Alternating Gradient Sychrotron at Brookhaven.

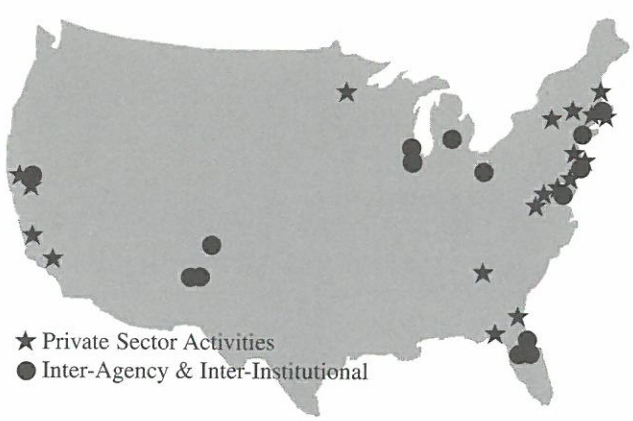
Ohio State University, *Columbus, OH.* The NHMFL is collaborating with Ohio State University to measure the magnetic field dependence of the critical current density of "jelly rolled" Nb_3Al conductors at 4.2 K and up to 26 T. Ohio State, IGC, and NRIM have developed the conductors by Ohmic heating and quenching. The aim of this collaboration is to evaluate the capacity of conductors as possible candidate conductor for high field NMR applications due to the high Bc_2 of a-15 Nb_3Al.

Princeton Plasma Physics Laboratory, *Princeton, NJ.* One of the future options for the next generation of fusion experiments will involve resistive field coils. The NHMFL is participating in a cooperation with the Princeton Laboratory on optimizing the choice of conductor materials, insulators, and magnet design for the Fusion Ignition Research Experiment (FIRE). With the limitations on energy sources, the utilization of high strength, high conductivity materials, combined with a magnet design that reduces stress concentrations, will allow FIRE to extend the pulse length of plasma experiments.

Sandia National Laboratories, *Albuquerque, NM.* Collaborating with the Radiographic Physics Department at Sandia, the pulsed field group at the NHMFL is developing a pulsed high magnetic field system for the advanced hydrodynamic radiography program to generate intensive electron beams. The magnetic field profile along the axis of the system is required to be 30 T at the center of a 110 mm bore pulsed magnet. The field will gradually increase up to 60 T at the center of another 200 mm long magnet with a bore of 45 mm. The two magnets will be energized with their own bank. The total energy of the system will be about 5 MJ. The preliminary design has been completed. The materials required for construction of the magnets have been ordered.

Sandia National Laboratories, *Albuquerque, NM.* The measurement of magnetic moments requires high sensitivity sensing methods. Cantilevers have proved effective and sensitive sensors of magnetic moments. Sandia provides a wealth of knowledge and technical skill in the fabrication of GaAs devices to construct new cantilever devices. Once Sandia fabricates the devices, they will be tested and calibrated at the NHMFL. Devices will be made available to users. In the coming year, microcantilever devices will be constructed for the imaging of local magnetic fields. Such capabilities are useful for mapping domain wall structure in permanent magnets, and vortex structure in high temperature superconductors. Technological applications include magnetic information storage and retrieval, land mine detection, measurement of small changes in the gravitational constant, etc. The collaboration intends to lay the groundwork for the development of nanocantilevers.

National Museum of American History, Smithsonian Institution, *Washington, D.C.* The NHMFL is working with curators from this Smithsonian museum to develop an interactive display to be placed in the Information Age exhibition. The laboratory is contributing a collection of computer chips that features microscopic graffiti placed on the surface of computer chips by their designers. The collection uncovers a once-hidden practice of etching art on the chip and provides an interesting historical perspective of integrated circuit development. The exhibition will feature contributions from chip designers at Intel, Hewlett-Packard, MIPS, Analog Devices, Dallas Semiconductor, VLSI, Texas Instruments, Advanced Micro Devices, Cyrix, National Semiconductor, and NCR.



International Activities

A.A. Bochvar Institute, *Moscow, Russia.* Researchers at the NHMFL's Pulsed Field Facility at Los Alamos and Tallahassee have maintained a long-standing relationship with the Bochvar Institute. As a result, high quality Cu-Nb micro-composite wires with outstanding characteristics (strength, conductivity, and resistive ratio) were developed and are now available for the construction of high field coils. Another activity concerns the development of stainless-steel-clad copper conductors in long lengths and large cross sections. Both types of conductors are of great importance to the 100 T development project (outsert and inner coils) and other high field user magnet systems with long decay times.

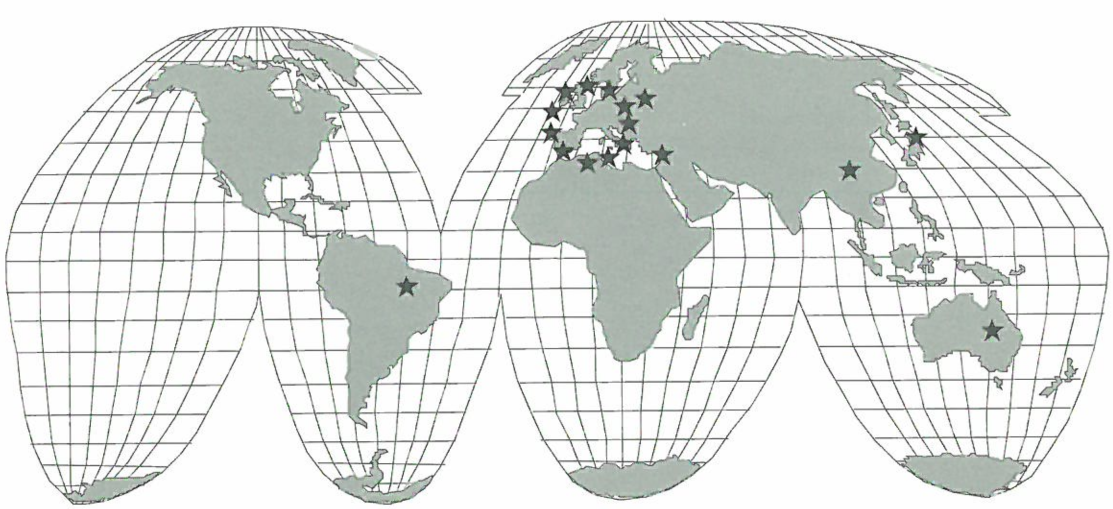
ALCATEL, *France.* The NHMFL is collaborating with ALCATEL to measure the magnetic field dependence of the critical current density of ALCATEL Bi-2212/AgPd short samples at 4.2 K up to 30 T. A 1-T class, layer wound, wind & react HTS insert coil is being built. This layer wound coil will use the NHMFL sol-gel insulation and high J_c ALCATEL Bi-2212/AgPd tape conductor, and it will be more compact than what was achieved with nickel oxide insulation. The coil (1 T at 20 T background and 4.2 K) will be tested at the NHMFL in the cold bore of the 20 T superconducting magnet.

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 is providing components to study the flow characteristics of two-phase He II for the test facility and measurements of the Kapitza conductance of the niobium cavity material.

Grenoble High Magnetic Field Laboratory, *Grenoble, France.* Since the start of the NHMFL, the cooperation between the two high field laboratories has been very successful and productive. Recent accomplishments are the cost saving common construction of two nearly identical magnets for the two laboratories, resulting in the 20 MW, 20 T, 20 cm bore magnet for the NHMFL and an additional insert for a 31 T magnet in Grenoble. Plans have been developed to repeat this cost saving approach for the design of two split-coil magnets for the two laboratories. The NHMFL has also offered to design, manufacture, and deliver a 2.5 MJ/60 T pulse magnet for the inductive energy storage system at Grenoble and proposed to design and manufacture insert coils in the highly efficient Florida-Bitter design for the future Grenoble hybrid magnet.

High Field Magnet Laboratory, University of Nijmegen, *The Netherlands.* A Memorandum of Understanding was signed between the Nijmegen High Field Magnet Laboratory (NHFML) and the NHMFL. The collaborative programs will lead to the establishment and sharing of facilities to produce intense magnetic fields in support of scientific research. In particular, the NHFML expressed the desire to adopt the Florida-Bitter technology for operation in their facilities. Joint production of a number of resistive magnet coils is planned, and comparative pricing of expensive magnet items, such as housings, is in progress.

Institut für Experimentalphysik, Technische Universität, *Wien, Austria.* The NHMFL Pulsed Magnet Group made a first design of a magnet that will match the new quasistationary energy source (10 MW, 1 s) of the Institut für Experimentalphysik. Magnets to generate a 100 ms flat top at 35 T and a peak field of 35 T for a triangular 1 second pulse shape are feasible. The two partners are identifying funding sources for this new and exciting facility. The development of ultra-low noise magnets for magnetization measurements also will be further pursued.



Institut für Technische Physik, University of Braunschweig, *Germany.* In response to a request, the NHMFL Pulsed Magnet Group designed a very low energy, high field magnet (50 kJ, 60 T) for the Institut für Technische Physik of the University of Braunschweig. The magnet will complement its Pulsed Field Facility. The NHMFL is also proposing high field DC magnet coils for the High Field Facility at the university.

Institute of Low Temperature Physics, University of Sao Paulo, *Brazil.* The NHMFL 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 Facility at Los Alamos are collaborating on the investigation of correlated metals at the facility's sophisticated low temperature and very high pressure instrumentation.

Institute of Plasma Physics, Academia Sinica, *Hefei, China.* In the framework of the Memorandum of Understanding between the Institute of Plasma Physics and the NHMFL, the NHMFL will carry out tests of the conductor for the new advanced tokamak, HT-7U, in Hefei. The conductor is of U.S. provenance and will be characterized for its performance in the facilities of the NHMFL.

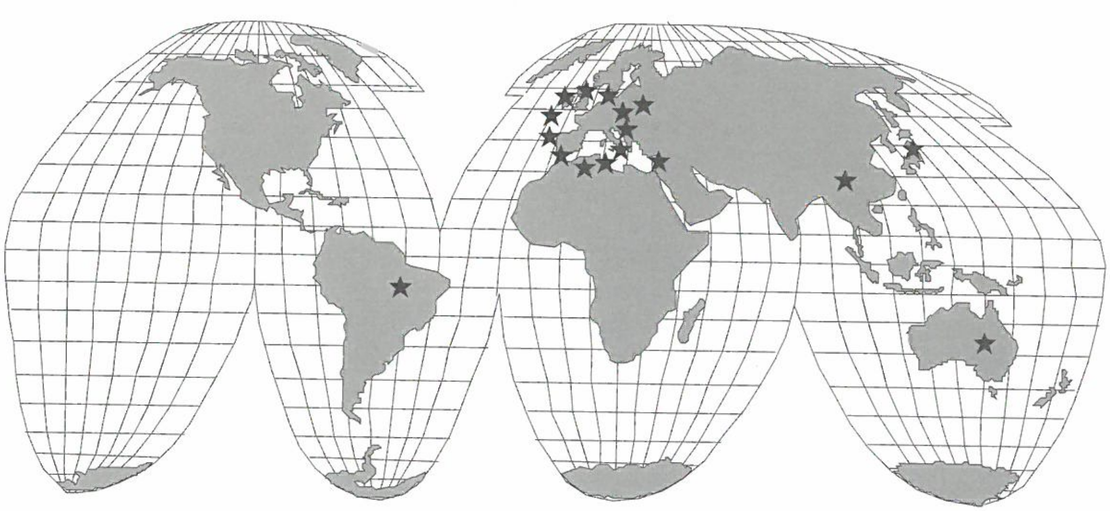
Institute of Solid State and Materials Research Dresden (IFW Dresden)/Research Centre Rossendorf *(FZ Rossendorf), Germany.* The NHMFL has signed an Agreement of Cooperation with IFW Dresden and FZ Rossendorf. The goal of the collaboration is the design and construction of pulse magnets for the non-destructive generation of the highest magnetic fields possible. Among other contributions, the German partner will develop and provide high-strength micro- and macro-composite conductors, their characterization, and offers the use of their facilities. The NHMFL will provide, among other things, magnet design, access to its materials database, and at-cost supply of high field pulse magnets. In 1999, four 60 T magnets will be delivered.

National Pulse Magnet Laboratory, University of New South Wales, *Sidney, Australia.* The NHMFL has benefited from a long-standing collaborations with the University of New South Wales in pulsed fields and flux compression magnets. Currently, researchers at the Los Alamos facility and the Australian university are working on a nanofabricated inductive magnetometer project.

National Research Institute for Metals (NRIM), *Tsukuba, Japan.* The Japanese NRIM purchased a 30 T resistive magnet from the NHMFL in 1996 that was delivered in 1997. We are presently working on a long-term collaboration to provide magnets to the NRIM. In late 1998, a contract was signed for a replacement A coil. A contract for a replacement B coil is expected to be completed in the next few months and a contract for a replacement C coil is expected next year. Preliminary discussions have begun regarding a new insert for their 40 T class hybrid magnet.

National Research Institute for Metals (NRIM), *Tsukuba, Japan.* Nuclear magnetic resonance measurements were made on Hg-based superconducting materials as a collaboration with NRIM. HgRe1223 superconductor, with composition $Hg_{0.8}Re_{0.2}Ba_2Ca_2Cu_3O_8$, was synthesized at the NHMFL using $CaHgO_2$ as the external mercury source. NRIM used ^{63}Cu NMR to study the spin echo decay in an external magnetic field applied perpendicular to c-axis.

Physics and Engineering Research Institute (PERI), Ruppin Institute of Higher Education, *Ruppin, Israel.* A Memorandum of Understanding is being drafted and will be signed with the Physics and Engineering Research Institute (PERI) of the Ruppin Institute of Higher Education. It is planned to install a pulsed magnetic field facility in cooperation with the NHMFL. Scientific applications of high pulsed magnetic fields, the development of new industrial



technologies using magnetic fields, and the development of new and advanced methods for the generation of high fields will be part of the program.

Physikalisches Institut, Johann-Wolfgang-Goethe Universität, *Frankfurt, Germany.* In the spirit of cooperation with the Physikalisches Institut of the Johann-Wolfgang-Goethe Universität, the Pulsed Magnet Group has delivered two 50 T pulse magnets for its pulse field facility. Presently, the design of a 60 T, 650 kJ magnet with an inner diameter of 22 mm is being developed at the NHMFL.

Service National des Champs Magnétiques Pulsés, CNRS, *Toulouse, France.* Extending the successful cooperation with the pulsed high field laboratory of Toulouse, the Pulsed Magnet Group has agreed to wind a 150 kg magnet for use as an external coil of a duplex 80 T system. This will be the largest pulse magnet ever wound in our facility. It will generate 48 T in a bore of 70 mm with an energy of 8 MJ. The NHMFL receives in return a variety of high strength, high conductivity macro-composite CuSS wires, with the following cross sections: 2.8 x 5.6 mm^2, 3 x 5.5 mm^2, and 3.2 x 6.2 mm^2. The wires (a total of about 80 kg) have different Cu-SS ratios to match the requirements of the new generation of high field magnets being developed at the NHMFL.

The Versaille Project on Advanced Materials and Standards (VAMAS). VAMAS is an international collaboration of laboratories that is organized into Technical Working Areas. The NHMFL's Materials Development and Characterization Group participates in pre-standards measurement research to foster the development of internationally acceptable standards for advanced materials. This year's research was related to the development of a new low-temperature, fracture-toughness test method for structural alloys used in cryogenic and magnet applications.

WORKSHOPS & CONFERENCES

CHAPTER 6

The NHMFL sponsored, hosted, or supported nearly a dozen significant science-related workshops or conferences during the year. Summary information is provided in this chapter.

In addition, however, the laboratory engaged in a large number of local and regional meetings. Most of these activities focused on education and economic development issues of direct interest to the laboratory, and all of them offered the laboratory new opportunities to become further integrated into community affairs. A brief sampling of these varied activities follows:

- Discussions with the superintendent of Leon County Public Schools, the FSU president, and others about the possible relocation of the university's K-12 laboratory school
- Meetings with representatives of St. Joe Paper Company (the largest private landowner in the region) and FSU on local planning issues
- Education and economic development meetings and tours with Tallahassee Chamber of Commerce and Leadership Tallahassee
- Various discussions and group meetings with Enterprise Florida
- Overview, laboratory tour, and workshop (sponsored by the City of Tallahassee Utilities Department) for a large group of civil engineers
- Advanced Automotive Technology Combustion Workshop
- Internet 2 meetings with the FSU Vice President for Research Office
- American Association of University Women meeting and tours
- State of Florida Department of Labor Workshop and tour; also Job Academy
- Fundraiser dinner and tour with the Tallahassee Symphony Orchestra
- Overview and tours for a legislative group and the FSU Class of 1949
- Dinner meeting and tour, as part of Smith-Kline Lecture Series
- "Intellectual Property Presentation" sponsored by the Economic Development Council (Research and Technology Committee) and the Tallahassee Chamber of Commerce.

Major scientific meetings of the NHMFL, July, 1998 through June, 1999.

September 17-18, 1998
High Frequency Electron Magnetic Resonance: Scientific Opportunities & Challenges
Washington, D.C.

The NHMFL, Pacific Northwest National Laboratory, and the Albert Einstein College of Medicine co-sponsored this workshop. Fifty scientists from academia and national laboratories, along with representatives of several U.S. funding agencies were invited to participate.

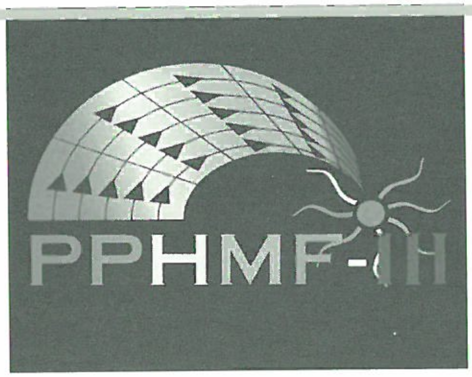
The workshop focused on the changing face of science, particularly over in the next two decades, and the unique contributions that HFEMR could make in solving scientific and societal problems. Discussions and talks identified ways that HFEMR could address scientific issues and the needs of structural and functional biology, chemistry and biochemistry, and materials science and physics.

October 18-23, 1998
VIIIth International Conference on Megagauss Magnetic Field Generation and Related Topics (Megagauss VIII)
Tallahassee, Florida

This international conference drew over 175 scientists from Russia, the United States, and other countries. Steve Younger of Los Alamos National Laboratory opened the conference with a talk, *From Swords to Plowshares: The U.S./Russian Collaboration in High Energy Density Physics Using Pulsed Power*, on the importance and scientific potential of the conversion of cold war military assets to non-defense applications. Among the other honored guests were Professor V. Fortov, the vice president of the Russian Academy of Science; Dr. Maxwell Fowler of Los Alamos National Laboratory; and Nobel Laureate J. Robert Schrieffer, NHMFL Chief Scientist. Fritz Herlach of Katholike University gave the banquet dinner presentation, *A View on Megagauss Fields from 40 Years Ago Into the Next Century.*

The Megagauss conference series, started in 1965, initiated the first scientific exchanges between the research centers at Los Alamos and Arzamas 16 in Russia and resulted in the Dirac Series of ultra-high field experiments that were conducted at Los Alamos in 1996 and 1997. Megagauss IX will be held in St. Petersburg, Russia, in July, 2002.

October 24-27, 1998
Physical Phenomena at High Magnetic Fields (PPHMF-III)
Tallahassee, Florida



PPHMF-III was planned back-to-back with the Megagauss VIII conference because many of the interesting science and research developments in these areas overlap. Approximately 30 researchers took this opportunity and attended all or part of both conferences.

The PPHMF-III conference attracted over 200 participants, including Nobel Prize winners (Physics) Horst Störmer and Robert C. Laughlin. These were only two of the four Nobel laureates on hand, as NHMFL Chief Scientist J. Robert Schrieffer chaired the event, and Klaus von Klitzing, of the Max Planck Institute, chaired one of the sessions.

This conference, initiated by the NHMFL in 1992, has become a major scientific event. It brings together experts from around the world to assess ongoing research, new directions for science and technology, and the uses of high magnetic fields in both basic and applied research. It is held every three years in Tallahassee.

November 6-7, 1998
Biomagnetics Metabolism Research
Tallahassee, Florida

Thirty-five scientists and researchers from various disciplines attended this workshop, which focused on defining the scientific and technological challenges presented by using magnetic resonance spectra to assess *in vivo* chemical structures and functions.

December 15, 1998
NHMFL–LANSCE Workshop
Los Alamos, New Mexico

This workshop was organized by Alex Lacerda (NHMFL-LANL). The primary purpose was to enhance working relationships and initiate close collaborations among scientific staff at the two major Los Alamos National Laboratory user facilities: NHMFL and Los Alamos Neutron Scattering Center.

Participant presentations crossed a broad spectrum of topics, including *Using NMR to Understand the Magnetism of Inhomogeneous Materials* (Hammel); *Inelastic Scattering at LANSCE using PHAROS* (McQueeney); *Heat Capacity in Pulsed Fields* (Movshovich); *Spin Fluctuations Near a Quantum Critical Point* (Bao); *Optics in High Fields* (Kim); and *Neutron Scattering from Molecular Magnetic Clusters* (Robinson).

February 17-19, 1999
BF Goodrich
Directors of Industrial Research, Analytical Group Meeting
Tallahassee, Florida

Fifty NMR directors and managers, representing the major chemical companies, pharmaceuticals, and "Big Three" automobile companies, attended the Winter Meeting of the DIR-AG. The meeting was hosted by BF Goodrich and held in Tallahassee so that members of the group could tour the NHMFL and meet with laboratory directors and faculty.

February 27-March 5, 1999
39th Sanibel Symposium on Atomic, Molecular, Biophysical, and Condensed Matter Theory
St. Augustine, Florida

The University of Florida Quantum Theory Project organized an international conference on all aspects of theoretical and computational quantum biology, quantum chemistry, and physics of materials. This annual conference brought together about 300 scientists from all over the world for eight intense days that included meetings, presentations, discussions, and a poster session. It was sponsored by the Army Research Office, Office of Naval Research, Hypercube, Inc., IBM Corporation, and the University of Florida, with assistance from the NHMFL.

Several sessions focused on topics of particular interest to the NHMFL and NHMFL-related researchers: *New Functionals of DFTs, Polarization and Current DFTs, Transport in Nano-Structures,* and *Time-Resolved Molecular Spectroscopy of Extended Systems.*

March 18-20, 1999
Second North American FT-ICR Mass Spectrometry Conference
San Diego, California

128 members of industry, academia, and national laboratories were in attendance for the FT-ICR MS Conference, a significant increase when compared to the 107 who attended the first conference. Members came from around the world to check out the latest research being done in FT-ICR MS. The topics included a broad range of FT-ICR MS research, including: instrumentation/technique development, biological applications, polymers, mixture analysis, ionization methods, ion-molecule chemistry, ion spectroscopy, and others.

The conference featured 24 oral and 45 poster presentations on four different symposia—Instrumentation, Ion Chemistry and H/D Exchange, Front-End Techniques (Ionization Methods, HPLC, CE, etc.), and MS/MS (SORI, IRMPD, SID, BIRD, etc.). John D. Baldeschwieler, California Institute of Technology, was the featured lecturer and gave a talk on the *Early Days of ICR.*

March 27, 1999
Workshop on Non-Fermi Liquid Behavior
Gainesville, Florida

The focus of the workshop was to further the understanding of non-fermi liquid physics. The workshop took an informal format with short talks that focused on both theory and experimental physics, followed by a roundtable discussion of each topic. This format gave ample opportunities for question and answer sessions. Participants came from universities in England and both U.S. coasts. Several NHMFL-related talks were particularly noteworthy: *Non-Fermi Liquid Physics in Uranium Materials* (Daniel Cox); *Scaling, Griffiths Singularities and All That Good Stuff* (Antonio H. Castro Neto); *On the Role of Chemical Disorder and Proximity to Magnetism in Two Closely Related Heavy-Fermion Alloy Systems:* $UCu_{5-x}Pd_x$ *and* $UPt_{5-x}Au_x$ (Bohdan Andraka); and *Quantum Critical Points in Heavy Fermion Materials: Genesis of the Local Moment vs. Spin Density Wave Instability?* (Piers Coleman).

April 19-20, 1999
High B/T Workshop
Gainesville, Florida

This workshop, held at the NHMFL High B/T Facility at the University of Florida, was dedicated to "Physical Phenomena at High Magnetic Fields and Very Low Temperatures." The purpose of the workshop was to review new and prospective experiments that require the simultaneous use of high magnetic fields and very low temperatures; the special techniques required; and new system configurations that the NHMFL might consider in its vision for the future.

The meeting included invited talks on recent research efforts in the field and overviews of High B/T facilities at the University of Florida and elsewhere, followed by an informal reception.

April 23-24, 1999
American Association of Physics Teachers
Florida Section
Spring 1999 Meeting
Gainesville, Florida

The NHMFL and the University of Florida hosted the annual meeting of Florida physics teachers. This year's meeting focused on critical issues in physics education, with presentations using the Internet and multimedia in the classroom. There also were numerous opportunities for exchanging ideas and projects brought by the participants. Along with the presentations and projects, three workshops were held: a tour of the New Physics Building at the University of Florida; uses for stand-alone Photogates, and a look at LabVIEW, a graphical software system for developing high-performance scientific and engineering applications from National Instruments.

2000 BUDGET

CHAPTER 7

Budget Background

The National Science Foundation 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. 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. Five-Year Budget Plan. (Total Cost Allocation)

Function			Percent		
	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%

1998 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, 1997, and 1998 to the five-year plan allocations.

Table 2. 1996, 1997, and 1998 Actual New Commitment Allocation.

Function	1996 Budget	1996 Actual	1997 Budget	1997 Actual	1998 Budget	1998 Actual
Administration & Facilities	5.9%	7.5%	7.2%	10.5%	8.2%	13.3%
User Operations DC Fields & NMR	25.0%	24.6%	25.7%	30.4%	29.5%	26.8%
Magnet Science & Technology	34.2%	30.6%	23.2%	32.3%	22.0%	27.6%
Science Program	6.9%	0.9%	9.9%	4.2%	12.2%	7.5%
Los Alamos Pulsed Field Facility	26.5%	34.6%	32.8%	20.6%	26.1%	23.1%
University of Florida High B/T and MRI	1.5%	0.0%	1.2%	2.0%	2.0%	1.8%

The first year of the renewal–1996–was funded at the full $17.5 million rate for a period of 10 months; this 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 1998 five-year plan budget reflected a planned growth in emphasis on User Operations and the Science Program and a reduction in the Magnet Science & Technology effort.

Administration & Facilities. The growth of Administration & Facilities cost share reflects the cost of personnel responsible for maintaining the magnet power supplies, cooling systems and related systems that have not been charged against indirect costs as originally budgeted.

User Operations. Capital equipment expenditures are down and the budget allocation reflects the planned operating level. The 1997 Actual allocation included commitments for equipment that was delivered in 1998.

Magnet Science & Technology. Major commitments related to the 900 MHz and Hybrid Resistive insert were not made in 1996 as originally planned. Those commitments were made in 1997 and 1998.

Science Program. Initial In-House Research Program awards were not made until 1997. Many of the projects are funded for 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 has been committed in 1996, 1997, and 1998. 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 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. The 1998 program is essentially as planned.

1999 Projected New Commitments

Projected new commitments for 1999 based on five months of actual data (through May 1999) are presented in Table 3. The 1999 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 Commitment Allocation.

Function	1999 Five-Year Plan	1999 Projected Actual
Administration & Facilities	8.1%	8.1%
User Operations DC Fields & NMR	29.0%	28.7%
Magnet Science & Technology	21.3%	27.6%
Science Program	13.0%	10.3%
Los Alamos Pulsed Field Facility	26.2%	22.9%
University of Florida High B/T and MRI	2.5%	2.4%

The primary reason for the expenditure variation is due to the use of Director's reserve funds to support extended development, fabrication, and testing work on the 45 T Hybrid and the 900 MHz program. This increases the proportion of total funds allocated to Magnet Science & Technology and reduces the proportion to other functions. (The Director's reserve was not included in the budget base when the percentage allocations in the five-year budget plan were determined.)

Staffing Analysis

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

Table 4. Staffing Summary.

	1996 Actual	1997 Actual	1998 Actual	1999 Actual	2000 Five-Year Plan
Administration & Facilities	10	18	31*	21	10
User Operations DC Fields & NMR	34	31	37	45**	37
Magnet Science & Technology	36	35	44	41	35
Science Program	2	2	7	6	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**	**133.5**	**129.5*** **	**100.5**

* Includes education program summer staff and graduate students.
**Includes 4 ICR user personnel funded from another grant.
***Reflects staff on board as of June 1, 1999.

Staffing is somewhat above the five-year renewal plan. The 1999 increases in Facilities & Administration correspond to the actual levels resulting from (1) FSU administration decisions to keep magnet power and cooling water systems maintenance personnel on the NSF grant budget rather than on indirect cost funds and (2) temporary summer personnel on educational program activities. The increases in User Operations result from additional staff and the inclusion of ICR user personnel. The Magnet Science & Technology staff reduction reflects some normal attrition. It is expected that at least two vacancies will be filled.

Table 5 gives a breakdown of the staff by category and funding.

Table 5. 1999 Staffing Detail.

Classification	NSF Core Funded	State Core Funded	Other Funds (Talla only)	Total
Faculty (9-month) at UF & FSU	0	21	0	21
Research Faculty (12-month)	18	35	4	57
Engineers	23.5	3	0	26.5
Technicians	44	25	22	91
Graduate Students	15	13	20	48
Postdoctoral Research Assoc.	15	8	5	28
Administration	14	42	1	57
Total*	**129.5**	**147**	**52**	**328.5**

* Total comprises 173.5 permanent NHMFL staff, 21 Faculty (9-month) and 124 temporary employees, which includes graduate students, postdocs, visitors, and other temporary staff.

2000 Proposed Budget

The proposed new commitment allocation for 2000 is given in Table 6, based on projections of 1999 actual costs adjusted for known changes.

Table 6. 2000 Projected New Commitment Allocation.

Function	2000 Five-Year Plan	2000 Projected Budget
Administration & Facilities	8.1%	8.1%
User Operations DC Fields & NMR	28.6%	28.7%
Magnet Science & Technology	21.2%	27.6%
Science Program	12.8%	10.3%
Los Alamos Pulsed Field Facility	26.8%	22.9%
University of Florida High B/T and MRI	2.6%	2.4%

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. Hybrid operation also will impact operating costs.

Magnet Science & Technology. The proposed budget reflects completion of funding for the 900 MHz magnet program. Capital costs for this program have been committed out of core NSF funds through 1998. Small capital allowances are provided to support continued replacement coil activities for the resistive magnets and the small pulsed magnets. Additional capital costs for the 900 MHz for 1999 and 2000 will be funded in large part from credit for work for others and state funds.

Science Program. The Science Program budget reflects the planned In-house Research Program awards and the cost of managing the solicitations, reviews, and awards. In-house science awards cannot extend beyond 2000 due to limitations of the NSF Cooperative agreement. Hence, the science program budget is decreasing.

Budget Details

Detailed information on actual costs and proposed budgets for 1999 will be submitted to the National Science Foundation and the Site Review Committee separately.

USERS & PROJECTS

APPENDIX A

NHMFL - DC HIGH FIELD FACILITY

USER	INSTITUTION	FUNDING	PROJECT
Agosta, Charles	Clark U.	NSF	Tunnel Diode Oscillator Experiment. Transport Measurement
Coffey, Thomas	Clark U.		
Bayindir, Zeynel	Clark U.		
Aronson, Meigan	U. of Michigan	NHMFL	High Pressure Fermi Surface of SmB_6
Tozer, Stan	NHMFL		
Whitton, Mark	NHMFL		
Bogdanovich, Snezana+	U. of Michigan		
Awipi, Mebenin	Tennessee State U.		Focused Electromagnetic Field as Replacement for Ionizing Radiation in SEU Testing
Babcock & Wilcox	Babcock & Wilcox	Babcock & Wilcox	AC Loss Measurement on NbTi Cable in Conduit
Van Sciver, Steve	FAMU-FSU CoE		
Boudouy, Bertrand+	NHMFL		
Balicas, Luis	VISR - Venezuela	NSF	Hall Effect in $(ET)_2$ $kHg(CN)_4$
Brooks, James	FSU		
Biskup, Neven+	NHMFL		
Balicas, Luis	NHMFL	NSF	Uniaxial Stress in FISDW Phase Diagram of $(TMTSF)_2$ ClO_4
Brooks, James	FSU		
Eun, Sang	NHMFL		
Benicewicz, Brian C.	Cogswell Laboratory, RPI	DOE	Invoking Polymer Order: High Magnetic Field Orientation of Liquid Crystalline Thermosets
Earls, Jim	LANL		
Zochowski, Nicole*	RPI		
Lu, Ying*	RPI		
Benicewicz, Brian C.	RPI	NSF	Processing of Polymers in Magnetic Fields
Smith, Mark	LANL		
Borsa, Ferdinando	Iowa State U.		High Field ^{139}La NMR in $La_{1.9}$ $Si_{0.1}$ CuO_4
Julien, Marc	Iowa State U.		
Reyes, Arniel	NHMFL		
Moulton, Bill	FSU		
Kuhns, Phil	NHMFL		
Bowers, C.	UF	NSF	Electron Detection of ESR in the Quantum Hall Effect
Vitkalov, Serge+	UF		
Kuhns, Phil	NHMFL		
Engel, Lloyd	NHMFL		
Moulton, Bill	FSU		
Schmiedel, Thomas	NHMFL		
Brey, William	Bruker	Conductus, Inc.	Superconductive 900 MHz NMR Spectroscopy Probe
Withers, Richard	Conductus, Inc.		
Brooks, James	FSU	NSF	Angular Dependent Magnetoresistance Oscillations in $(DMET\text{-}TSeF)_2$ $AuCl_2$
Biskup, Neven+	FSU		
Stalcup, Thomas*	FSU		
Qualls, Jeremy*	FSU		
Han, So Young *	FSU		

+ *Postdoc* * *Student*

USER	INSTITUTION	FUNDING	PROJECT
Brooks, James Ferl, Robert Stalcup, Tom* Paul, A-L	FSU UF FSU UF	NSF	Comparison of Diamagnetic Levitation and Microgravity in Plant Growth (Arabidopsis)
Brooks, James Qualls, Jeremy* Harrison, Neil Biskup, Neven+ Balicas, Luis Anzai, H.	FSU FSU NHMFL - LANL FSU VISR - Venezuela Heniji Institute	NSF	Electronic and Magnetic Mechanisms in Low Dimensional and Novel Materials: $\alpha(BEDT\text{-}TTF)_2 RbHg(ScN)_4$
Brooks, James Wang, Ziqiang Zhang, Biao* Han, So Young *	FSU Boston College Boston College FSU	NSF	Experimental and Theoretical Aspects of Quasi-Three Dimensional Quantum Hall Systems: 200 Layer Quantum Well Structures
Brooks, James	FSU	NSF	Magnetoresistance at High Pressure: $(TMTSF)_2PF_6$
Brooks, James Stalcup, Tom* Reavis, Jennifer*	FSU FSU Florida High	NSF	Many Body Effects During Diamagnetic Levitation: Graphite-Epoxy Composites
Brooks, James Arnowitz, Len Steinberg, Manney	FSU Biospace Biospace	NIH - Pending	Protein Crystal Growth
Brooks, James Stalcup, Thomas*	FSU FSU	NSF	Quantum Oscillations in Cu-Br
Brunel, Louis-Claude Moulton, Bill Sarrao, John Hill, Steven Fisk, Zachary Hassan, Alia*	NHMFL FSU NHMFL NHMFL NHMFL NHMFL	NSF	EPR Measurements
Chang, YuanHuei	National Taiwan U.	Taiwan	Effects of High Magnetic Fields on Low Dimensional Semiconductor Systems
Chen, Ching Pai, Vinay Haik, Yousef * Zimanyi, Laszlo	FAMU-FSU CoE FAMU-FSU CoE FAMU-FSU CoE HAS, Hungary	Johnson & Johnson, Inc	Effects of Magnetic Fields on Biological Fluids
Choyke, Wolfgang Rutsch, Gerald* Devaty, Robert Rowland, Larry Wischmeyer, Frank	U. of Pittsburgh U. of Pittsburgh U. of Pittsburgh Northrup Grumman Daimler Benz Research	NSF	Measurement of the Hall Scattering Coefficient in Different SiC Polytypes
Clark, W. Gilbert Brown, Stuart E. Kuhns, Phil Moulton, Bill	UCLA UCLA NHMFL FSU	NSF	NMR Studies of Conduction Electron Dynamics in the Doped Polymer Plypyrrole $-PF_6$
Coletta, Chuck Sekine, Shignobu	Intertek Testing Services San-ei Kiasei Co., Ltd.	Intertek Testing Services	Magnetization of Novel Ferromagnets - Major Loops
Crabtree, George Moulton, Bill Kwok, Wai-Kwong Karapetrov, Goran	Argonne Natl. Lab FSU Argonne Natl. Lab Argonne Natl. Lab	NSF	Transport Properties of Heavy Ion Irradiated YBCO Single Crystals

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USER	INSTITUTION	FUNDING	PROJECT
Crow, Jack	NHMFL	NHMFL	Magnetoresistance of Ruthenates
Guertin, Robert P.	Tufts U.		
Gao, Gang	NHMFL		
McCall, Scott*	NHMFL		
Dalal, Naresh	FSU	NSF	B Field Dependence of FIR Transmission Spectra
Wang, Yong-Jie	NHMFL		
Achey, Randall	FSU		
Dietderich, Dan	Livermore Berkeley Lab.	DOE	Effect of Transverse Loading Effect of Critical Current on Superconducting Cable
Scanlan, Ron	LBNL		
Miller, John	NHMFL		
Walsh, Bob	NHMFL		
Di Tusa, John	Louisiana State U.	NSF & LEQSF	Investigation of the Magneto Transport and Magnetization of a Disordered Itenerant Ferromagnet at High Magnetic Field
Sidis, Yvan	Saclay		
Aeppli, Gabriel	Nippon Electric Corp.		
Fisk, Zachary	FSU		
Young, David*	Princeton U.		
Manyala, Ncholu	Louisiana State U.		
Douglas, Elliot P.	UF	NHMFL	Materials Processing in Magnetic Fields: High Strength Polymers
Lincoln, Derek*	UF		
Cho, Seunghyun	UF		
Feng, Jianxun*	UF		
Du, Rui R.	U. of Utah	NSF	Magneto Transport of Low Dimensional Electrons in Semiconductors
Simmons, Jerry	Sandia Natl. Labs.		
Zudov, Michael+	U. of Utah		
Furdyna, Jack	U. of Notre Dame	NSF	Exchange Interaction Induced Lineshifts of MN++ EPR in HgSe Semiconductors
Brunel, Louis-Claude	NHMFL		
Hassan, Alia*	FSU		
Saylor, Charlie*	FSU		
Van Tol, Hans	NHMFL		
Gasparov, Vitaliy	ISSP-Russia	VOLNA	Investigations of the Critical Magnetic Fields of Novel Superconductor $BaNbO_{3-x}$
Gatteschi, Dante	U. of Florence	CNR Italy	Zero Field Splittings Measurements of Ni Dioxolene Adducts
Pardi, Luca	Consorzio Interuniversitario Scienza Technologia		
Hassan, Alia*	FSU		
Brunel, Louis-Claude	NHMFL		
Geerts, Wilhelmus J.	Southwest Texas State U.	NSF	Magneto Optical Kerr Experiments at Low Temperatures and High Fields
Wei, Xing	NHMFL		
Schuetze, Andrew*	Math & Science Academy		
Geerts, Wilhelmus J.	Southwest Texas State U.	NSF	Temperature Dependence of the MO Hysteresis Curve
Hall, Donavan	NHMFL		
Weller, D.	IBM/Almaden		
Schuetze, Andrew*	Math & Science Academy		
Hassan, Alia*	FSU		
Goodrich, Roy G.	Louisiana State U.	NSF	Shubnikov/de Haas Effect Studies of Heavy Fermion Systems (UB_{13})
Hall, Donavan	NHMFL		

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USER	INSTITUTION	FUNDING	PROJECT
Gor'kov, Lev	NHMFL	NSF	Non-Equilibrium Phenomena in Doped IV-VI Semiconductors and Related Theoretical Studies
Khokhlov, Dmitriy	Moscow State U.		
Graf, Michael J.	Boston College	Research Corp.	Pressure Dependent Transport in U(Pt,Pd)$_3$
Opeil, Cy*	Boston College		
Guillot, Maurice	Service Natl. des Champs Intenses	French Govt.	Magnetic and Magneto Optical (Faraday Rotation) in Magnetic Insulators
Zach, Ryszard	Tech U. of Cracow		
Wei, Xing	NHMFL		
Hall, Donavan	NHMFL	NSF	Fermi Surface Studies of Highly Correlated Materials
Halperin, William	Northwestern U.	NSF	Flux Melting Phase Transition by NMR
Moulton, Bill	FSU		
Kuhns, Phil	NHMFL		
Mitrovic, Vesna*	Northwestern U.		
Reyes, Arniel	NHMFL		
Bachman, H. Nathan*	Northwestern U.		
Hascicek, Yusuf	NHMFL	NHMFL	Magnetoresistance of Silver and Silver Alloys as Sheathing to HTS Conductors
Osman, Dur	NHMFL		
Hazelton, Drew	Intermagnetics General Corp.	NIH 5-R44-CA60319-03	HTS Magnets for Ultra High Field NMR Spectroscopy
Van Sciver, Steve	FAMU-FSU CoE/ NHMFL		
Weijers, Hubertus	NHMFL		
Heathcote, Peter	Queen Mary and Westfield College		High Field EPR Studies of the Photosynthetic Reaction Center
Scheer, Hugo	U. München		
Bratt, Peter+	UF		
Angerhofer, Alex	UF		
Thurnauer, Marion	Argonne Natl. Lab.		
Brunel, Louis-Claude	NHMFL		
Hebard, Arthur F.	UF	NSF	Three-Dimensional Low-Density Metals in Ultraquantum Magnetic Fields: Search for Instabilities
Graybeal, John	UF		
Maslov, Dmitri	UF		
Bompadre, Silvia+	UF		
Hall, Donavan	NHMFL		
Hill, Steven	Montana State U.	NSF	Millimeter-Wave Spectroscopy of Novel Electronic Systems in High Magnetic Fields
Monty, Mola+	Montana State U.		
Hodges, Richard	EURUS Tech., Inc.	EURUS	Unique Processing Method for Rapid Testuring of Long-Length YBCO High Temperature Superconductors
Muenchausen, Ross	EURUS Tech., Inc.		
Kugler, Oliver	EURUS Tech., Inc		
Schwartz, Justin	FAMU-FSU CoE		
Marin, Juan	EURUS Tech., Inc.		
Hormadaly, Jacob	Ben-Gurion U.	NHMFL	Magnetoresistance of Cobalt Ruthenates
Mergui, Sylvia	Florida Interntl. U.		
Ishiguro, Takehiko	Kyoto U.	CREST/JST	Search for Reentrant Superconductivity in Sr_2RuO_4
Maeno, Y.	Kyoto U.		
Ohmichi, Eiji	Kyoto U.		
Jeong, Sangkwon	Korea Advanced Inst. of S&T	Korea Ministry of Sci. & Tech.	Investigation of Ramp-Rate Limitation of Superconducting CICC (Cable-In-Conduit-Conductor)
Van Sciver, Steve	FAMU-FSU CoE		
Kim, Seokho*	Korea Advanced Inst. of S&T		
Jones, Eric	Sandia Natl. Labs.	NSF	Cyclotron Resonance Measurements of InGaSaN
Wang, Yongjie	NHMFL		
Kurtz, Steve	Sandia Natl. Labs.		

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USER	INSTITUTION	FUNDING	PROJECT
Jones, Eric	Sandia Natl. Labs.	NSF	Studies of Electron-Photon Interactions in Quantum Structures
Wei, Xing	NHMFL		
Jones, Eric	Sandia Natl. Labs.	NSF	The Growth and Electronic Properties of 1 eV Bandgap Semiconductors - InGaAsN
Russell, Michael	Sandia Natl. Labs.		
Tozer, Stan	NHMFL		
Wei, Xing	NHMFL		
Kang, Woowon	U. of Chicago	Packard Foundation	Study of Spin Effects in Quantum Hall Effect
Gossard, Art	U.C. Santa Barbara		
Eom, Jonghwa+	U. of Chicago		
Kang, Woowon	U. of Chicago	Packard Foundation	Testing of CCD Camera in High Field for Sonoluminescence
Young, Joe	U. of Chicago		
Hannahs, Scott	NHMFL		
Kim, Young	U. of Cincinnati	U. of Cincinnati	FIR and DC Transport
Hor, Pei	U. of Houston		
Kispert, Lowell	U. of Alabama	NSF	High Field EPR: Studies of the Carotenoid-Solid Lewis Acid Interactions
Brunel, Louis-Claude	NHMFL		
Hassan, Alia*	FSU		
Saylor, Charlie*	FSU		
Van Tol, Hans	NHMFL		
Kuhns, Phil	NHMFL	NSF	^{13}C NMR Studies of Mn_{12} Acetate Clusters at High Magnetic Fields
Moulton, Bill	FSU		
Reyes, Arniel	NHMFL		
Achey, Randy*	NHMFL		
Kuhns, Phil	NHMFL	NSF	High Field Investigation of Low Dimensional Metals
Reyes, Arniel	NHMFL		
Brooks, James	FSU		
Caldwell, Todd*	FSU		
Moulton, Bill	FSU		
Abdelrazek, M.+	FSU		
Larbalestier, David	U. of Wisconson	DOE-HEP	Cantilever Magnetometry of Nb_3Sn Conductors
Squitieri, Alex	U. of Wisconson		
Lee, Hosun	Kyung Hee U.		
Hawes, Chris*	U. of Wis.-Madison		
Lee, Peter	U. of Wis.-Madison		
Lewis, Roger	U. of Wollongong Australia	ARC	FIR Transmission and Reflectance
Lewis, Roger	U. of Wollongong	ARC	mm Wave Studies of Low Dimensional and Novel Materials
Brooks, James	FSU		
Biskup, Nevin+	FSU		
Qualls, Jeremy*	FSU		
Han, So Young*	NHMFL/FSU		
Maley, Martin	LANL	DOE	Vortex Physics and C-Axis Transport Properties of High Temperature Superconductors at High Magnetic Fields
Krusin-Elbaum, Lia	IBM		
Morozov, Nikolai	LANL		
Coulter, James	LANL		
Bulaevskii, Lev	LANL		
Marchenkov, Vyacheslav	Institute of Metal Physics	NSF	Electronic and Magnetic Mechanisms in Low Dimensional and Novel Materials
Brooks, James	FSU		
Qualls, Jeremy*	FSU		
Terashima, Taichi	Natl. Institute for Metals		
Han, So Young *	FSU		
Biskup, Neven+	FSU		

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USER	INSTITUTION	FUNDING	PROJECT
Marchenkov, Vyacheslav	Institute of Metal Physics	NSF	Magnetotransport Measurements with Pure Metals Under Static Skin Effect Conditions
Weber, Harold	Atomic Institute		
Marinero, Ernesto	IBM Alamaden Research Center	IBM	Study of the Magnetic Anistropy in Amorphous SmCo Thin Films by AC Susceptibility and Kerr Effect
Hall, Donavan	NHMFL		
Kubota, Yukiko	UCLA - Berkeley		
Marken, Ken	Oxford Superconducting Technology	Oxford SC Tech.	Critical Current as a Function of Temperature, Magnetic Field, and Strain in High Field Superconducting Materials
McKinnell, Jim	Oxford SC Tech.		
Hong, Sueng	Oxford SC Tech.		
Zhang, Youzhu	Oxford SC Tech.		
Dai, Weiming	Oxford SC Tech.		
Hentges, Rob	Oxford SC Tech.		
Markiewicz, Denis	NHMFL	NHMFL	Magnetization of Stainless Steel Over Bonding Material
Swanson, Chuck	NHMFL		
Pickard, Kenneth	NHMFL		
Hall, Donavan	NHMFL		
Marshall, Alan	FSU	NSF	FTICR Mass Spectrometry Using a High-Field Resistive Magnet
Drader, Jared*	U. of Texas - Austin		
Hendrickson, Chris	NHMFL		
Missell, Frank	Instituto de Fisica	FAPESP - Brazil	Anisotropy Field of $SmCo_5$ Magnets
Romero, Sergio	IFUSP - Brazil		
de Campos, Marcos	IPT - Brazil		
Landgraf, Fernando	IPT - Brazil		
Moulton, Bill	FSU	NSF	Development Time-Automation of Field Sweep Under Spectrometer Control
Kuhns, Phil	NHMFL		
Reyes, Arniel	NHMFL		
Achey, Randy*	NHMFL		
Musfeldt, Janice L.	SUNY-Binghamton	NSF	FIR of $(TMTSF)_2$ PF_6 in Magnetic Fields
Wang, Yong-Jie	NHMFL		
Dong, Jian*	SUNY-Binghamton		
Musfeldt, Janice L.	SUNY-Binghamton	NSF	Spectroscopic Investigations of Magnetically Driven Phase Transitions in Organic and Inorganic Solids
Wei, Xing	NHMFL		
Zhu, Zheng Tao*	SUNY-Binghamton		
Long, Virginia*	SUNY-Binghamton		
Musfeldt, Janice L.	SUNY-Binghamton	NSF	Spectroscopic Investigations of Oxide Based Solids at High Magnetic Fields
Wang, Yong-Jie	NHMFL		
Jones, Barry*	SUNY-Binghamton		
Naughton, Mike	Boston College	NSF	Accurately Aligned Critical Fields in Superconductors
Sushko, Yuri+	Boston College		
Ren, Zhifeng	Boston College		
Noh, Tae	Seoul National U.	Korea Ministry of Sci & Tech	FIR of Melting Change Ordered States in High Magnetic Fields
Wei, Xing	NHMFL		
Monitomo, Y.	Nagoya Univ., Japan		
Choi, Eunjip	Seoul National U.		
Wang, Yong Jie	NHMFL		
Jung, Jong*	Seoul National U.		
Ouden, Andries Den	U. of Twente	UT, #:17.3.1755	Development of Advanced Powder in Tube Conductors
Godeke, Arno	U. of Twente		
Lindenhovius, Jan	Shape Metal Innovation B.V.		

+ *Postdoc* * *Student*

USER	INSTITUTION	FUNDING	PROJECT
Palm, Eric Murphy, Tim Pekola, J.	NHMFL NHMFL U. of Jyvaskyla	NHMFL	Investigation of Single Electron Tunneling Devices to be Used as Primary Thermometers in High Magnetic Fields and Low Temperatures
Pardi, Luca Brunel, Louis-Claude Hassan, Alia*	CISTM NHMFL FSU	INSTM Italy	Development of ESR Techniques for High Fields
Park, Yung Woo Kim, Dai Sik* Yahng, Ji Sang*	Seoul National U. Seoul National U. Seoul National U.	Korea Sci & Eng Found.	Dynamic Characteristics of Carriers in Semiconductors Under High Magnetic Fields
Park, Yung Woo Choi, Eun Sang* Suh, Dong Seok*	Seoul National U. Seoul National U. Seoul National U.	Korea Sci & Eng Found.	Measurements of Doped Polyacetylene
Pekarek, Thomas Hughes, Samuel	U. of North Florida U. of North Florida	Research Corp. CC4719	Magnetic and Calorimetric Measurements of III-VI and II-VI Diluted Magnetic Semiconductors
Peng, Xiong Watts, Steven* Chien, Chia-Ling Parker, Jeff* Yang, Fengyuan* von Molnar, Steve Coey, Michael	FSU/MARTECH FSU Johns Hopkins U. FSU Johns Hopkins U. FSU Trinity College	NSF	Magnetoresistance and S-dH Oscillations in High Quality Bi Films
Popovic, Dragana Feng, Xiang Guang+	FSU NHMFL	NHMFL	Metal Insulator Transition in Low Mobility Si MOSFET 2D Electron System in Zero Field and Y=3/2
Santos, Mike Murphy, Sheena	U. of Oklahoma U. of Oklahoma		Quantum Hall Effect in InSb
Sarma, Bimal Ketterson, John B. Feller, Jeff+ Cui, Yongjie	U. of Wisconsin Northwestern U. U. of Wisconsin - Milwaukee U. of Wisconsin - Milwaukee	NSF	High Field Ultrasonic Studies in the Heavy Fermion Systems
Schwartz, Justin Trociewitz, Ulf+	FAMU-FSU CoE FSU	NHMFL	HTSC Coil Development
Schwartz, Justin Nakamae, Saco *	FAMU-FSU CoE FSU	NHMFL	Magnetothermal Conductivity of Bi-2212 Crystals
Schwartz, Justin Trociewitz, Ulf+ Pamidi, Sastry+	FAMU-FSU CoE NHMFL NHMFL	NHMFL	Transport Current Measurements on Barium Doped Bi-2212 Superconductors
Shaheen, Shahid Mendoza, William Ozair, Arifa Coey, Michael Neu, Volker Cadieu, Fred	FSU / MARTECH FSU / MARTECH FSU / MARTECH Trinity College, Dublin FSU / MARTECH Queens College, NY	ARO	Processing of Magnetic Materials in High Magnetic Fields
Shivaram, Bellave Patil, Natin Ulrich, Vernon*	U. of Virginia U. of Virginia U. of Virginia	NSF	Magnetic Susceptibility and Magnetoresistance in the Heavy Electron Compound - $U_2Ru_3Si_5$
Shivaram, Bellave Ulrich, Vernon*	U. of Virginia U. of Virginia	NSF	Novel Superconductivity-Using Ultrasound to Explore Phase Changes in Heavy Fermion Materials
Singleton, John Ardavan, Arzhang+ Nam, Moon-Sun* Symington, Jane*	U. of Oxford U. of Oxford U. of Oxford U. of Oxford	Eng & Phy Sci Res Council	Transverse Magnetotransport of Alpha Phase ET Salts in High Field State and Millimeter Wave Studies of Alpha Phase ET Salts

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USER	INSTITUTION	FUNDING	PROJECT
Stampe, Patricia	FAMU	ONR	Antiphase Boundaries in Ferrite Thin Films
Kennedy, Robin	FAMU & NHMFL		
Stewart, Greg	UF	NSF	Specific Heat and Magnetization of Non-Fermi Liquid Systems to 25 T
Kim, Jung Soo	UF		
Thomas, Steve	UF		
Heuser, Karsten	U. of Augsburg		
Störmer, Horst L.	Lucent Technology /Bell Labs	Lucent Technologies	Fractional Quantum Hall Effect
Tsui, Daniel C.	Princeton U.		
Pfeiffer, L.	Lucent Technologies		
Baldwin, Kirk	Lucent Technologies		
West, K.	Lucent Technologies		
Pan, Wei*	Princeton U.		
Tagirov, Murat	Kazan State U.	NSF	High Field EPR Measurements on $LaCl_3$:Tm_{3+}
Tayurskii, D.A.	Kazan State U.		
Moll, H.P.	Siemens		
Hassan, Alia*	FSU		
Van Tol, Hans	NHMFL		
Taylor, P. Craig	U. of Utah	NSF	High Field NMR Studies of ChalCogenide Glasses
Hari, Parameswar	Vanderbilt U.		
Moulton, Bill	FSU		
Sullivan, Neil S.	UF		
Terashima, Taichi	National Research Inst. for Metals	NRIM	Experimental Transport and Magnetization Studies of Strontium Ruthenates
Brooks, James	FSU		
Qualls, Jeremy*	FSU		
Stallcup, Tom*	FSU		
Han, So Young*	FSU		
Tyson, Trevor A.	NJIT	DOE	Magnetic and Structural Properties of Charge Ordered $Bi_{1-x}Ca_xMnO_3$
Woo, D. H.+	Seoul National U.		
Croft, Mark	Rutgers U.		
Cheong, Sang Wook	Lucent Technology /Bell Labs		
Woicik, Joe	NIST		
von Molnar, Stephan	FSU	NSF	Magnetoresistance and Hall Effect of CrO_2 Thin Films
Watts, Steve*	FSU		
Coey, J.M.D.	Trinty College, Dublin		
Anane, Madjid*	FSU		
Walsh, Bob	NHMFL	NHMFL	Magnetoresistance of Manganin Wire at 4.2 K
Meinesz, Maarten	NHMFL		
Wang, Yong-Jie	NHMFL	NSF & ONR	High Field Cyclotron Resonance, Electron-Optical-Phonon Interaction and Many Electron Effects in Quantum Well Structures
McCombe, Bruce D.	SUNY - Buffalo		
Jones, Eric D.	Sandia Natl. Labs.		
Woo, Jong-Chun	Seoul National U.	Korea Ministry of Ed.	Magnetoluminescence Studies of Excitonic State on Quasi-One-Dimensional Quantum Wire Superlattice
Leem, Young Ahn+	Seoul National U.		
Ko, Hyunsung*	Seoul National U.		
Sung, Min Gyu*	Seoul National U.		
Wei, Xing	NHMFL		
Wosnitza, Jochen	U. Institut Karlsruhe	NSF	Electronic and Magnetic Mechanisms in Low Dimensional and Novel Materials
Brooks, James	NHMFL		
Qualls, Jeremy*	FSU		

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USER	INSTITUTION	FUNDING	PROJECT
Yokoi, Hiroyuki	Nat. Inst. of Mat. & Chem. Res.	Science & Technology	Pressure Effect on the Spin Exchange Interaction in Diluted Magnetic Semiconductors with Quantum Well Structures
Tozer, Stan	NHMFL		
Kakudate, Yozo	Natl. Inst. of Mat. & Chem. Res.		
Karczewski, G.	Himeji Institute of Tech		
Fujiwara, Shuzo	Natl. Inst. of Mat. & Chem. Res.		
Takeyama, Shojiro	Himeji Institute of Tech.		
Zheng, Guo-Qing	Osaka U.	Ministry of Ed. - Japan	High Field NMR Studies of the Pseudogap in $YBa_2Cu_4O_8$
Clark, Gil	UCLA		
Moulton, Bill	FSU		
Reyes, Arneil	NHMFL		
Kuhns, Phil	NHMFL		
Zuo, Fulin	U. of Miami	NSF	Upper Critical Fields Measurements as a Function of Angle in Organic Superconductors
Zhang, Yong Ping	U. of Miami		
Brooks, James	FSU		
Su, Xiaoqiang	U. of Miami		

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NHMFL - Pulsed Field Facility

USER	INSTITUTION	FUNDING	PROJECT
Agosta, Charles Coffey, Thomas* Bayinder, Zeynel*	Clark U. Clark U. Clark U.	NSF	Tunnel Diode Oscillator Experiments in Organic Conductors in Pulsed Magnetic Fields
Arko, Al Cornelius, Andrew+ Sarrao, John Hundley, Mike Thompson, Joe	LANL - MST10 LANL - MST10 LANL - MST10 LANL - MST10 LANL - MST10	DOE	Fermi Surface Determination of $CeRhIn_5$, $ThBe_{13}$, UGa_3
Aronson, Meigan Fisk, Zach Harrison, Neil	U. of Michigan, Ann Arbor FSU LANL	NSF	Fermi Surface Studies of Electron Doped Hexaborides
Awschalom, David Johnston -Halperin, Ezekiel* Peng, Xiao Alivasotos, Paul Crooker, Scott+	UC Santa Barbara UC Santa Barbara UC Berkeley UC Berkeley LANL	NSF	Field Dependent Time-Integrated and Time-Resolved Photoluminescence: CdSe Quantum Dots
Balakirev, Fedor+ Boebinger, Gregory Guptasarma, Prasenjit Bonn, Doug Motoyama, Naoki Eisaki, Hiroshi Uchida, Shin-Ichi Jaime, Marcelo+	NHMFL - LANL LANL Argonne Natl. Lab. U. of British Columbia U. of Tokyo - Japan U. of Tokyo - Japan U. of Tokyo - Japan LANL - MST10	NSF	Transport Properties of the Ground State of LaSrCuO High-Temperature Superconductor
Balicas, Luis Brooks, James	VISR FSU	Other	Temperature and Angle Dependence of Quantum Oscillations in the High Field Phase of η- Mo_4O_{11}
Bao, Wei Lacerda, Alex	LANL - MST10 NHMFL - LANL	DOE	Magnetic Field Dependence of the Phase Transition in V_2O_3
Beyermann, Ward Maple, Brian Lacerda, Alex	UC Riverside UC San Diego NHMFL - LANL	NSF	High Field Investigations of Non-Fermi-Liquid Compounds: $UCu_{5-x}Pd_x$
Boebinger, Greg Betts, Jon Balakierev, Fedor+ Kimura, Tsuyoshi Kishio, Kohji	NHMFL - LANL LANL LANL U. of Tokyo - Japan U. of Tokyo - Japan	DOE	High Field Magnetotransport Studies of $La_{2-x}Sr_xCuO_4$ (x = 0.08)
Brooks, James Qualls, Jeremy* Montgomery, L. Han, So Young* Harrison, Neil	FSU FSU U. of Indiana FSU LANL	NSF	Effective Mass Calculation of α-$(ET)_2RbHg(SCN)_4$
Brown, Stuart Clark, Gilbert Hillman, Chris+	UCLA UCLA UCLA	NSF	High-Pressure NMR Investigation of the Field-Induced Phases of $(TMTS)_2PF_6$ and $(TMTTF)_2PF_6$

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USER	INSTITUTION	FUNDING	PROJECT
Bud'ko, Sergey	Ames Labs., Iowa State U.	DOE	Quantum Oscillations in Quasi 2 - Dimensional $RAgSb_2$ Compounds at Ambient and High Pressure
Canfield, Paul	Ames Labs., Iowa State U.		
Myers, Kenneth*	Ames Labs., Iowa State U.		
Mikulina, Olga*	Czech Acad. of Sciences		
Kamarad, Jiri	Czech Acad. of Sciences		
Lacerda, Alex	NHMFL - LANL		
Clark, Robert	Australian Natl. Magnet Lab.	Other	Testing of Lithography Made Magnetometer: REB_6 and $PrBe_{13}$
Smith, James	LANL - LANSCE		
Cooley, Jason+	LANL - STC		
Reilly, David*	Australian Natl. Magnet Lab.		
Rickel, Dwight	LANL		
Harrison, Neil	LANL		
Cooley, Jason+	LANL - STC	DOE	Magnetization of the Kondo Insulator SmB_6 to 60 T
Smith, James	LANL - LANSCE		
Hults, Larry	LANL - STC		
Harrison, Neil	LANL		
Cornelius, Andrew+	LANL - MST10	DOE	Magnetization Measurements on Elemental Pu to 60 Tesla
Arko, Aloysius	LANL - MST10		
Sarrao, John	LANL - MST10		
Harrison, Neil	LANL		
Crooker, Scott+	LANL	DOE	Time-Resolved Photoluminescence of Magnetic 2-D Electron Gases
Awshalom, David	UC Santa Barbara		
Samaith, Nitin	Penn. State U.		
Smorchkova, L	Penn. State U.		
Johnston -Halperin, Ezekeil*	UC Santa Barbara		
Du, Rui-Rui	U. of Utah	NSF	Fermi Surface of DyAs Layers on GaAs
Zudov, Michael*	U. of Utah		
Kim, Yongmin+	LANL		
Fisher, Ian+	Ames Labs., Iowa State U.	NSF	Quantum Oscillations in Y-Mg-Zn Icosahedral Quasicrystals
Canfield, Paul	Ames Labs., Iowa State U.		
Bud'ko, Sergey	Ames Labs., Iowa State U.		
Lacerda, Alex	NHMFL - LANL		
Gama, Sergio	UNICAMP - Brazil	Other	Determination of Anisotropy Fields in $Fe_{17}RE_2$ (RE = light rare earths)
Torikachvili, Milton	San Diego State U.		
Jardim, Renato	USP - Brazil		
Lacerda, Alex	NHMFL - LANL		
Goodrich, Roy	Louisiana State U.	NSF	dHvA in Highly Correlated Materials: $Ca_{0.99}La_{0.01}B_6$, $Ce_{0.95}Sm_{0.05}B_6$, CeB_6, and PrB_6
Fisk, Zach	FSU		
Harrison, Neil	LANL		
Haanappel, Evert	Service National des Champs	Other	dHvA Studies of the Cyclotron Mass of $CeAl_2$
Askenazy, S	SNCMP - France		
Pricopi, Lucia*	SNCMP - France		
Harrison, Neil	LANL		
Harrison, Neil	NHMFL - LANL	NSF	g-Factor and Effective Mass in α-$(ET)_2RuHg[SCN]_4$
Qualls, Jeremy*	FSU		
Brooks, James	FSU		

+ *Postdoc* * *Student*

Pulsed Field Facility Users

USER	INSTITUTION	FUNDING	PROJECT
Jardim, Renato Sandim, Maria* Torikachvili, Milton Lacerda, Alex	U. of Sao Paulo U. of Sao Paulo San Diego State U. NHMFL - LANL	NSF	CMR Materials in High Magnetic Fields
Jiang, Hong Wen Lee, Xiang* Kim, Yongmin+	UCLA UCLA LANL	NSF	Exploratory Experiments of Quantum Hall Devices in High Magnetic Fields
Kim, Yongmin+ Perry, Clive Simmons, Jerry Munteanu, Florin*	LANL Northeastern U. Sandia Natl. Lab. Northeastern U.	NSF	High Field Magneto-Photoluminescence of GaAs / AlGaAs Single Heterojunctions
Kirk-Killer, Edward Srdanov, Vojislav Kim, Yongmin+	UC Santa Barbara UC Santa Barbara LANL	NSF	Spectrally-Resolved PL Measurements of Conductive Polymers Under the Influence of High Magnetic Fields
Krusin-Elbaum, Lia Maley, Martin Torthmolle, Vanner* Morozov, Nikolai+	IBM Watson Research Center LANL - STC LANL - STC LANL - STC	Other	Pseudogap in Bi-2212 Crystals
Lacerda, Alex Sarrao, John Romond, Rachel* Detwiler, Jason*	NHMFL - LANL LANL - MST10 Occidental College Occidental College	DOE	Transverse Magnetoresistance of GdAlSi from 2 K to 200 K
Lawrence, Jon Cornelius, Andrew+ Sarrao, John	UC Irvine LANL - MST10 LANL - MST10	NSF	de Hass-van Alphen Measurements in $YbXCu_4$
Li, Liang Lesch, Benny Cochran, Guy	NHMFL NHMFL NHMFL	NSF	Magnet Test
Maley, Martin Morozov, Nikolai+ Torhmolle, Vanner* Krusin-Elbaum, Lia	LANL - STC LANL - STC LANL - STC IBM - Watson Research Center	DOE	Study of the c-Axis Magnetotransport Properties of $YBa_2Cu_3O_7$ and $Bi_2Sr_2CaCu_2O_8$ Single Crystals
McQueeney, Robert+ Torikachvili, Milton Cooley, Jason+ Smith, James	LANL - LANSCE San Diego State U. LANL - STC LANL - STC	DOE	Magnetoresistance of β - Ce
Mielke, Chuck Harrison, Neil Brooks, James Qualls, Jeremy*	LANL LANL FSU FSU	DOE	Investigation of the Low Temperature Magnetoresistance of $(TMTSF)_2ClO_4$
Movschovich, Roman Stewart, Gregory Sarrao, John Canfield, Paul Jaime, Marcelo+	LANL - MST10 UF LANL - MST10 Ames Labs. LANL - MST10	NSF	High Field Heat Capacity Measurements on Correlated Electron Systems: $YbInCu_4$, $Ce_3Bi_4Pt_3$ and UBe_{13}
Musfeldt, Janice Long, Virginia+ Rezcolezschi, Alex Kool, H. Whanybo, Michael Kim, Yongmin+	SUNY-Binghamton SUNY-Binghamton U. Paris Sud North Carolina State U. North Carolina State U. LANL	NSF	Optical Investigation of the Broken Symmetry Ground State in NaV_2O_5

+ *Postdoc* * *Student*

USER	INSTITUTION	FUNDING	PROJECT
Nakotte, Heinz	New Mexico State U. - Las Cruces	Other	Magnetization Measurements Along the Three Principal Axis of CePtSn Single Crystals
Takabatake, Toshiro	Hiroshima, Japan		
Prokes, Karel	HMI - Germany		
Mikulina, Olga*	Czech Republic		
Chang, Sung*	NMSU, Las Cruces		
Lacerda, Alex	NHMFL - LANL		
Perry, Clive	Northeastern U.	NSF	High Magnetic Field Investigations in GaAs / AlGaAs Samples
Munteanu, Florin*	Northeastern U.		
Simmons, Jerry	Sandia Natl. Lab.		
Kim, Yongmin+	LANL		
Phillips, Norman	UC Berkeley	NSF	Flux-Lattice Melting in YBCO Near the Critical Point
Fisher, Robert	UC Berkeley		
Hundley, Michael	LANL - MST10		
Lacerda, Alex	NHMFL - LANL		
Schilling, Andreas	U. of Zurich		
Prokes, Karel	HMI - Germany	Other	High Field Magnetization Studies on UIrGe Single Crystals
Nakotte, Heinz	New Mexico State U.		
Lacerda, Alex	NHMFL - LANL		
Sarrao, John	LANL - MST10	NSF	Magnetoresistance Measurements from 1.5 K to 200 K
Lacerda, Alex	NHMFL - LANL		
Petrovic, Cedomir*	FSU		
Schmiedeshoff, George	Occidental College	NSF	de Haas-van Alphen Measurements on $PrBe_{13}$
Smith, James	LANL - STC		
Lacerda, Alex	NHMFL - LANL		
Detwiler, Jason*	Occidental College		
Harrison, Neil	LANL		
Sechovsky, Vladimir	Charls U.	NSF	High Field Phase Diagram of UNiAl
Mikulina, Olga*	Czech Acd. of Sciences		
Kamarad, Jiri	Czech Acd. of Sciences		
Beyermann, Ward	UC Riverside		
Nakotte, Heinz	New Mexico State U.		
Lacerda, Alex	NHMFL - LANL		
Singleton, John	U. of Oxford	Other	Fermi Surface Investigation of β-$(BEDT\text{-}TTF)_2SF_5CH_2CF_2SO_3$
Schulster, J.	Argone Natl. Lab.		
Blundell, S.	U. of Oxford - UK		
Ardavan, Arzhang+	U. of Oxford - UK		
Moon-Sun, Nam*	U. of Oxford - UK		
Symington, Jane*	U. of Oxford - UK		
Harrison, Neil	LANL		
Srdanov, Vojislav	UC Santa Barbara	NSF	Saturation Magnetization Measurements of Solid-Electron-Sodalite
Lacerda, Alex	NHMFL - LANL		
Kim, Yongmin+	NHMFL - LANL		
Stewart, Gregory	UF and U. of Augsburg	NSF	Pulsed Field Heat Capacity of Heavy Fermion UBe_{13} and $U_{0.97}Th_{0.03}Be_{13}$
Movshovich, Roman	LANL - MST10		
Marcelo, Jaime+	LANL - MST10		
Tessema, Guebre	Clemson U.	NSF	Search for Superconductivity Beyond H_{c2}
Skove, Michael	Clemson U.		
Gamble, Brian*	Clemson U.		
Lacerda, Alex	NHMFL - LANL		
Torikachvili, Milton	San Diego State U.	NSF	Magnetoresistive Measurements of the Magnetic Phase Diagram of CePtSn
Nakotte, Heinz	New Mexico State U. - Las Cruces		
Lacerda, Alex	NHMFL - LANL		

+ *Postdoc* * *Student*

USER	INSTITUTION	FUNDING	PROJECT
Wosnitza, Jochen	Karlsruhe - Germany	Other	Hall Potential Oscillation Measurements, Eddy-Current Measurements and Magnetotransport of κ-(BEDT-TTF)$_2$I$_3$
Mielke, Chuck	LANL		
Harrison, Neil	LANL		
Yokoi, Hiroyuki	NIMC - Japan	Other	High Field Photoluminescence at Low Temperatures and Under Hydrostatic Pressures: CdMnTe / CdMgTe Multi-Quantum Wells and CdMnTe / CdMgMnTe Multi-Quantum Wells
Kossut, J.	Polish Academy of Sciences		
Tozer, Stan	NHMFL		
Kakudate, Yozo	NIMC - Japan		
Fujiwara, Shuzo	NIMC - Japan		
Takeyama, Shojiro	Himeji Inst. - Japan		
Karczewski, G.	Polish Academy of Sciences		

+ *Postdoc* * *Student*

NHMFL - NMR Facility

USER	INSTITUTION	FUNDING	PROJECT
Alamo, R.G. Huang, T.W. +	FAMU/FSU FAMU/FSU	NSF	Comonomer Partitioning in Metallocene-Type Propylene-Ethylene Random Copolymers
Ben, R.N. Eniade, A. * Lioubomirov, A. * Hauer, L. * Horwath, K.	SUNY-Binghamton SUNY-Binghamton SUNY-Binghamton SUNY-Binghamton SUNY-Binghamton		Synthesis of Structurally Diverse C-Linked Antifreeze Glycoprotein Mimetics
Blackband, S.J. Bui, J.D. * Buckley, D.L. + Phillips, M.I.	UFBI, NHMFL/UF UF UFBI, UF UFBI, UF	NIH and UFBI	NMR Microscopy of Isolated Perfused Brain Slices
Blackband, S.J. Forder, J.R.F. Bui, J.D. * Buckley, D.L. *	UFBI, NHMFL/UF U. of Alabama UF UFBI, UF	NIH and UFBI	NMR Microscopy of Isolated Perfused Heart Tissue
Blackband, S.J. Shi, J. + Bui, J.D. * Yang, S.H. + Buckley, D.L. + King, M.A. Day, A.L. Simpkins, J.W.	UFBI, NHMFL/UF UF UF UF UFBI, UF UFBI, Gainesville VAMC, UF UFBI, UF UFBI, CAN, UF	NIH, Apollo BioPharmaceutics, Inc., and UFBI	MR Imaging of Stroke Reduction After Estrogen Therapy in a Rat Model
Blackband, S.J. Buckley, D.L. + Rice, L. Narayan, P.	UFBI, NHMFL/UF UFBI, UF UF UF	NIH and UFBI	Dynamic Gd-DTPA Studies of the Prostate at 1.5 and 3 T
Blackband, S.J. Mohr, C.M. * Bui, J. D. * Jones, H.C.	UFBI, NHMFL/UF UF UF UFBI, UF	Rudi Schulte Research Inst. and UFBI	MR Imaging and Spectroscopy of a Neonatal Rat Model of Hydrocephalus
Blackband, S.J. Kim, H.W. * Buckley, D.L. * Peterson, D. (rf tech) Duensing, R. Narayan, P.	UFBI, NHMFL/UF UFBI, UF UFBI, UF UFBI UFBI UF	NIH and UFBI	Development of Prostate MRI/S Using Transcieve Coils at 3 T
Blackband, S.J. Bowtell, R. Crozier, S. Beck, B. (rf tech)	UFBI, NHMFL/UF U. of Nottingham U. of Queensland UF	NHMFL and UFBI	Development of Novel Multi-Layer Transverse Gradient Coils
Blackband, S.J. Williams, L.W. Roper, S. Mohr, C. M. * Mladinich, C.	UFBI, NHMFL/UF UFBI, UF UFBI, UF UF UF	Howard Hughes Foundation and UFBI	MRI/S of Irradiated Rats as Model of Cortical Dysplasia and Intractable Epilepsy
Blackband, S.J. Antoinelli, P. Mohr, C.M. * King, W. *	UFBI, NHMFL/UF UFBI, UF UF UF	Deafness Research Foundation and UFBI	fMRI of Auditory Stimulation in a Cat Model at 4.7 T

*+ Postdoc * Student (K) Experiment used the Keck magnet in the DC Field Facility*

NMR Facility Users

USER	INSTITUTION	FUNDING	PROJECT
Blackband, S.J.	UFBI, NHMFL/UF	NIH and UFBI	MRI/S Studies of a Novel Rat Model of Prostatic Cancer
Rice, L.	UF		
Narayan, P.	UF		
Briggs, R.	UFBI, UF		
Bowers, C.R.	NHMFL/UF	NHMFL Visitor Program	Obtaining High Resolution NMR Spectra in Low Resolution Magnets
Warren, W.	Princeton U.		
Ahn, S. +	Princeton U.		
Murali, N.	NHMFL		
Bowers, C.R.	NHMFL/UF	IHRP/UF/NSF	Hyperpolarized Xenon-129: Protein Surfaces and Binding Sites
Storhaug, V. *	UF		
Zook, T. *	UF		
Gianna, R. *	Gainesville H.S.		
Cottone III, A. *	UF		
Webster, E. *	UF		
Braratam, J. +	UF		
Gaffney, B.J.	NHMFL/FSU		
Bowers, C.R.	NHMFL/UF	IHRP/UF/NSF	Hyperpolarized Xenon-129: Hydrate Clathrate Kinetics of Formation
Liebig, F. *	UF		
Storhaug, V. *	UF		
Bowers, C.R.	NHMFL/UF	IHRP/UF/NSF	Hyperpolarized Xenon-129: Microimaging Applications
Zook, T. *	UF		
Blackband, S.	UFBI/ UF/ NHMFL		
Bowers, C.R.	NHMFL/UF	IHRP/UF/NSF	Transport Detection of ESR and NMR in the Quantum Hall Effect
Vitkalov, S. +	UF		
Simmons, J.	Sandia Natl. Labs.		
Reno, J.	Sandia Natl. Labs.		
Bowers, C.R.	NHMFL/UF	IHRP/UF/NSF	Dynamics in Metal Organophosphonates by Dynamic Deuteron NMR
Fanucci, G. +	UF		
Talham, D.	UF		
Bowers, C.R.	NHMFL/UF	IHRP/UF/NSF	Structure of Langmuir-Blodgett Films of Metal Organophosphonates
Fanucci, G. +	UF		
Talham, D.	UF		
Bowers, C.R.	NHMFL/UF	NSF	NMR Studies of Constrained Motion: Basic Probe Molecules Absorbed in Solid Acids
Webster, E. +	UF		
Osegovic, J. +	UF		
Adhyaru, B. *	UF		
Drago, R.S.	UF		
Bowers, C.R.	NHMFL/UF	NSF	Dynamic Polarization of Nuclei by Electrical Current
Patel, A. *	UF		
Johnson, M.	Naval Research Lab.		
Bowers, C.R.	NHMFL/UF	NSF and NSF/REU	Mechanism of Optical Pumping in Semiconductors
Patel, A. *	UF		
Hughes, E. +	UF		
Bharatam, J. +	UF		
Pasquet, O. *	UF		
Brey, W.	Conductus, Inc.	NSF SBIR Phase I	Radio Frequency Tests of NMR Probe Coils Made of High Temperature Superconducting Materials (K)
Withers, R.	Bruker		
Soble, C.	Conductus, Inc.		
Soghomonian, V. +	NHMFL		
Briggs, R.	UFBI, UF	NIH/ UF/UFBI	High Resolution Spectroscopic Studies of Prostate Tumor Extracts
Rice, L.	UF		
Narayan, P.	UF		

+ *Postdoc* * *Student* (K) *Experiment used the Keck magnet in the DC Field Facility*

USER	INSTITUTION	FUNDING	PROJECT
Cross, T.A. Tian, F. * Fu, R.	NHMFL/FSU FSU NHMFL	NSF	^{13}C Spin Diffusion for Resonance Assignment Strategies
Cross, T.A. Zhang, L. * Wang, J. * Fu, R.	NHMFL/FSU FSU FSU NHMFL	NSF	Histidine Gating of the M2 Channel from Influenza A Virus
Cross, T.A. Kovacs, F. * Wang, J. * Mo, Y. * Song, Z. + Lamb, R.	NHMFL/FSU FSU FSU FSU FSU/NHMFL Northwestern U.	NSF	M2 Transmembrane Peptide from the M2 Channel – Towards a Structural Characterization
Cross, T.A. Tian, C. * Tobler, K. + Lamb, R.	NHMFL/FSU FSU Northwestern U. Northwestern U.	NSF	Initial Structural Characterization of the Intact M2 Channel Protein
Cross, T.A. Kovacs, F. * Kim, S. * Quine, J.	NHMFL/FSU FSU FSU NHMFL/FSU	NIH	Validation of Structure Determinations by Solid State NMR
Cross, T.A. Cotton, M. * Tian, C. * Phillips, L.R. * Cole, C.D. * Hendershot, R.J. * Busath, D.D.	NHMFL/FSU FSU FSU Brigham Young U. Brigham Young U. Brigham Young U. Brigham Young U.	NIH	Modulating Dipoles for Structure-Function Correlations in the Gramicidin A Channel
Cross, T.A. Fu, R. Cotton, M. *	NHMFL/FSU NHMFL FSU	NSF	Combining Orientational and Distance Constraints from Solid State NMR for Quartenary Structure Determination
Cross, T.A. Soghomonian, V. + Sabo, M. Murphy, P. Powell, A. Gan, Z. Starewicz, P. Bird, M.	NHMFL/FSU NHMFL NHMFL NHMFL NHMFL NHMFL Resonance Research NHMFL	NHMFL and Keck	Improving Homogeneity and Stability in Resistive Magnets (K)
Cross, T.A. Wang, J. * Davidson, M. Miller, C.	NHMFL/FSU FSU NHMFL Brandeis U.	NSF	The Selectivity Filter of the *Streptomyces* K^+ Channel
Cross, T.A. Epand, R. Naito, A. Saito, H.	NHMFL/FSU McMaster U. Himeji Inst. of Tech. Himeji Inst. of Tech.	Monbusho Grant	Structural Studies of Fusion Peptides from Influenza A Virus
Cross, T.A. Wang, J. * Grage, S. * Ulrich, A. Fu, R.	NHMFL/FSU FSU U. of Jena U. of Jena NHMFL		Development of Orientational Constraints from ^{19}F Labeled Peptides
Cross, T.A. Strandberg, E. * Lindblom, G. Kovacs, F. * Mo, Y. *	NHMFL/FSU U. of Umea U. of Umea FSU FSU	Sweden Science Foundation	Peptide Orientation in Lipid Bilayers

+ POSTDOC * STUDENT (K) EXPERIMENT USED THE KECK MAGNET IN THE DC FIELD FACILITY

USER	INSTITUTION	FUNDING	PROJECT
Cross, T.A. Gao, F.P. + Kaback, R. Wang, J. * Fu, R.	NHMFL/FSU UCLA UCLA NHMFL	NHMFL NHMFL	Structure of Lactose Permease Through ^{19}F Distance Constraints
Dalal, N. Fu, R. Samoson, A. Klymachyov, A. *	FSU/NHMFL NHMFL Estonian Acad. of Sci. FSU	DOE	Obviating the Anisotropic Bulk Magnetic Susceptibility Broadening in Solid State NMR: Single Crystal Spinning and Double Rotation Techniques
Dalal, N. Fu, R. Bodenhausen, G. Klymachyov, A. *	FSU/NHMFL NHMFL U. of Paris FSU	IHRP	Development of the Temperature-Jump, Isotropic Shift Correlation NMR of Solids: Correlation of Molecular Dynamics Across a Solid-Solid Phase Transition
Dalal, N. Fu, R. Gan, Z. Samoson, A.	FSU/NHMFL NHMFL NHMFL Estonian Acad. of Sci.	NHMFL	Development of High Field NMR Techniques for the NMR Characterization of Low-Gamma Nuclei in Solids (K)
Dalal, N. Fu, R. Gan, Z. Samoson, A. Geise, M. *	FSU/NHMFL NHMFL NHMFL Estonian Acad. of Sci. FSU		Development of Techniques for Obtaining High Resolution NMR Spectra of ^{17}O in Solids at 25 T (K)
Dalal, N. Reyes, A. Kuhns, P. Moulton, W. Blinc, R. Achey, R. *	FSU/NHMFL NHMFL NHMFL FSU/NHMFL U. of Ljubljana, Slovenia FSU	FSU/NHMFL	Deuteron and ^{13}C NMR Relaxation Studies of the Quantum Tunneling Phenomenon in Mn12-Based Nanomagnets
Dalal, N. Bussmann-Holder, A. Klymachyov, A. *	FSU/NHMFL Max Planck Inst. FSU	NSF and German Science Foundation	Correlated Isotropic Chemical Shift Measurements and Theoretical Studies of the Nature of Ferroelectric Transition in Hydrogen-Bonded Solids
Drobny, G. Cotten, M. +	U. of Washington U. of Washington	NIH	Structure of Bound Histatin to Biomaterials
Edison, A.S. Thomas, S. * Zachariah, C. *	UFBI, UF, NHMFL UF UF	American Heart Association and UFBI	Structure of FMR Famide Bound to the FaNaCh Receptor
Edison, A.S. Zachariah, C. + Li, C.	UFBI, UF, NHMFL UF Boston U.	American Heart Association and UFBI	Structural Studies of Neuropeptide Precursor Proteins
Edison, A.S. Zachariah, C. + Benner, S. + Cardigan, M. *	UFBI, UF, NHMFL UF UF UF	NSF and UFBI	Structure-Function Relations of FMR Famide-Like Peptides
Edison, A.S. Bubb, M. Lenox, R.	UFBI, UF, NHMFL UF U. of Pennsylvania	UF and UFBI	Biophysical Studies of MARCKS
Edison, A.S. Dunn, B. Green, T. *	UFBI, UF, NHMFL UF UF	UF and UFBI	Structure-Function Studies of IA3, a Novel Yeast Proteinase A Inhibitor
Edison, A.S. Hillman, J. Novak, J. Smith, J. *	UFBI, UF, NHMFL UF U. of Alabama UF	NIH	Structural Studies of the Lantibiotic Mutacin

+ *Postdoc* * *Student* (K) *Experiment used the Keck magnet in the DC Field Facility*

USER	INSTITUTION	FUNDING	PROJECT
Edison, A.S. Carlacci, L. Cheng, H.	UFBI, UF, NHMFL U. of South Florida UF	UFBI	Computational Studies of Peptide Conformational Ensembles
Edison, A.S. Cain, B. Sorgen, P. *	UFBI, UF, NHMFL UF UF	NIH	Structural Studies of Portions of the b-Subunit of F1F0 ATPase
Fitzsimmons, J. Beck, B. (rf tech) Peterson, D. (rf tech) Duensing, R. Blackband, S.J.	UFBI, UF UF, NHMFL UFBI UFBI UFBI, UF, NHMFL	NHMFL and UFBI	Development of Large Volume High Frequency RF Coils
Fitzsimmons, J. Duensing, R. Peterson, D. (rf tech) Beck, B.	UFBI, UF UFBI, UF UFBI, UF UF, NHMFL	NHMFL and UFBI	Development of High Frequency Phased Array Rf Coils
Fitzsimmons, J. Lang, P.J. Bradley, M.M. Cuthbert, B.N. Scott, J.D. Moulder, B. Nangia, V.	UFBI, UF UF UF UFBI, UF UF UF UF	NIH and UFBI	fMRI Studies of Emotional Arousal
Fu, R. Zheng, J.	NHMFL FAMU		Solid State NMR Study of Electrode Materials
Gaffney, B.J. Maguire, B. *	NHMFL/FSU FSU		NMR Structural Studies of Apolipoprotein CII
Gan, Z.	NHMFL	NHMFL	Magic-Angle Turning Solid State NMR at High Magnetic Fields
Gan, Z.	NHMFL	NHMFL	Polarization Transfer in Multi-Spin Systems and High Resolution NMR Dipolar Spectroscopy of Oriented Solids
Gibbs, S. Samoilenko, A. Cross, T.A.	NHMFL and FAMU-FSU CoE Russian Academy of Sciences FSU	NSF Russian Scientist Program	Development of Stray Field Imaging at High Field
Gibbs, S. Shine, J. * Park, J. *	NHMFL and FAMU-FSU CoE FAMU-FSU CoE FAMU-FSU CoE	NHMFL and FAMU-FSU CoE	Flow and Dispersion in Fluidized Beds
Gibbs, S. Pavlovskaya, G. +	NHMFL and FAMU-FSU CoE NHMFL	NHMFL	Applications of Magnetic Resonance Imaging Velocimetry to Flow in Porous Media and Fiber/Composite Manufacturing
Gibbs, S. Park, J. * Whittenberger, F. *	NHMFL and FAMU-FSU CoE FAMU-FSU CoE FAMU-FSU CoE	NHMFL and FAMU-FSU CoE	Flow and Dispersion in Chromatography
Gibbs, S. Raghavan, K. *	NHMFL and FAMU-FSU CoE FAMU-FSU CoE	NHMFL and FAMU-FSU CoE	Parameter Estimation for Pulsed Field Gradient NMR Measurements
Greenbaum, N.L. Newby, M. * Xu, D. *	FSU FSU FSU	NIH	Structural Studies of RNA Elements in PremRNA Splicing
Greenbaum, N.L. Benner, S.	FSU UF		NMR Structural Analysis of Aptamers Built From an Expanded Genetic Alphabet

*+ Postdoc * Student (K) Experiment used the Keck magnet in the DC Field Facility*

USER	INSTITUTION	FUNDING	PROJECT
Greenbaum, N.L. Yeager, S. *	FSU FSU		Structure of the Spliced Leader RNA
Gupta, G. Marriapan, S.V.S. +	LANL LANL	LANL	A PCR-Based Method for Uniform Labeling of Long DNA Oligomers
Halperin, W. Sigmund, E. *	Northwestern U. Northwestern U.		Stray Field Imaging of Materials in a 19.6 T Magnet
Inglis, B.A. Bolch, W. Ladd, A. Meyer, S.	UFBI, UF UF UF UF	DOE and UFBI	NMR Microimaging Studies of Trabecular Bone
Inglis, B.A. Siemann, D. Salmon, H. *	UFBI, UF UF UF	NIH and UFBI	^{19}F NMR of EF5 as a Marker for Hypoxic Cells
Inglis, B. Muir, D. Maria, B.	UFBI, UF UFBI, UF UFBI, UF	UFBI	Diffusion Tensor Imaging of Tumor Models
Larive, C.K. Derrick, T. *	U. of Kansas U. of Kansas	NIH, U. of Kansas, NHMFL	The Use of PFG NMR for the Measurement of Diffusion Coefficients of the Cis and Trans Isomers of Proline Containing Peptides
Locke, B.R. Moerland, T.S. Caban, J. * McFadden, L. Dohmen, C. *	FSU FSU FSU FSU FSU	Whitaker Foundation and NSF	Analysis of Transport in Skin by Iontophoresis and Electroporation Using PFGNMR
Locke, B.R. Moerland, T.S. Gibbs, S. Acton, M. * Hadden, D. * West, A. *	FSU FSU NHMFL and FAMU-FSU CoE FSU FSU FSU	NASA	Transport in Gels and Biomaterials Under Applied Electrical Fields Using PFGNMR
Logan, T. Callihan, D. *	FSU/NHMFL FSU	NIH	Peptide Mimics of Unfolded FKBP
Logan, T. Callihan, D. * King, T. *	FSU/NHMFL FSU FSU	NIH and NSF	Large Fragments of FKBP as Unfolded State Mimics
Logan, T. Korepanova, A. * Guerrero, L.	FSU/NHMFL FSU FSU	NIH and NSF	Stabilizing the Unfolded State of FKBP by Mutations
Logan, T. Callihan, D. * Korepanova, A. * Guerrero, L.	FSU/NHMFL FSU FSU FSU	NIH and NSF	Dipolar Couplings in Unfolded Proteins Using Aligned M_{13} Phage
Logan, T. Callihan, D. * Korepanova, A. * Guerrero, L. Pillow, T.	FSU/NHMFL FSU FSU FSU Trinity Univ.	FSU, NIH, & NSF	Dipolar Couplings in Unfolded Proteins Using Aligned TMV
Logan, T. Marion, W.	FSU/NHMFL FSU	NIH	Structural Characterization of Proteins in Organic Solvents

+ *Postdoc* * *Student*

USER	INSTITUTION	FUNDING	PROJECT
Logan, T. Wang, G. * Wylie, G. * Twigg, P. * Caspar, D. Murphy, J.R.	FSU/NHMFL FSU FSU FSU FSU Boston U. School of Medicine	FSU and NIH	Structure of C-Terminal Domain of DtxR
Logan, T. Wylie, G. * Mertz, L. *	FSU/NHMFL FSU FSU	NIH and American Heart Association	Peptide Ligands for C-Terminal Domain of DtxR
Logan, T. Webb, A. Subramonian, R. +	FSU/NHMFL U. of Illinois U. of Illinois	NSF	Double-Resonance Microcoils for Protein NMR
Logan, T. Wang, G. + Jolivet, C. +	FSU/NHMFL FSU FSU	FSU	Characterizing the 400 MHz High-Temperature Superconducting Probe
Luck, L. Marin, V. *	Clarkson U. Clarkson U.	DOE	^{19}F NMR of Large Proteins
Mareci, T.H. Blackband, S.J. Grant, S. * Webb, A. Gibbs, S. Plant, D.	UFBI, UF, NHMFL UFBI, UF, NHMFL U. of Chicago U. of Illinois NHMFL/FAMU-FSU UFBI, UF	IHRP, NIH & UFBI	NMR Microscopy and Spectroscopy of Single Cells Using Microcoils
Mareci, T.H. Silver, X. * Ni-Xu, W. Inglis, B.A. Wirth, E.D.	UFBI, UF, NHMFL UF UF UFBI, UF UFBI, UF	NIH, State of Florida, Brain and Spinal Cord Injury Research Trust Fund	*In Vivo* ^{31}P Spectroscopy of Spinal Cord Metabolism Using a Novel Inductively Coupled Chronically Implanted RF Coil
Mareci, T.H. Ni-Xu, W. * Silver, X. * Wirth, E.D.	UFBI, UF, NHMFL UF UF UFBI, UF	NIH	Inductively Coupled Quadrature RF Coils
Moerland, T.S. Vanderlinde, O.H. * Carbone, F.A. *	FSU FSU FSU	NSF	Dynamics of Phosphorous Metabolites in Striated Muscle
Murali, N. Smith, S.A.	NHMFL NHMFL	NHMFL	Relaxation Effects in a System of a Spin-1/2 Nucleus Coupled to a Quadrupolar Spin Subjected to RF Irradiation
Pines, A. Meersmann, T. * Pavlovskaya, G. +	UC-Berkeley UC-Berkeley NHMFL	Lawrence Berkeley Nat. Lab. and Humboldt Foundation	Breaking of Atomic Symmetry at High Magnetic Field Strengths
Plant, D. Shachar-Hill, Y. Hanson, A.	UFBI, UF New Mexico State Univ. UF	UFBI	^{31}P and ^{13}C Studies of Perfused Plant Tissue Metabolism
Quine, J.R. Denny, J.K.	NHMFL/FSU FSU	NSF	The Discrete Frenet Frame and Coiled Coil Proteins
Rao, B.D. Lin, Y. * Raghunathan, V. +	IUPUI IUPUI IUPUI	NIH, IUPUI, NHMFL	Conformational Study of Adenosine Nucleotides Bound to *E. Coli.* Adenylate Kinase and Yeast 3-Phosphoglycerate Kinase by NMR Spectroscopy

+ POSTDOC * STUDENT

USER	INSTITUTION	FUNDING	PROJECT
Scott, K. Kim, H.W. * Maria, B.	UF UFBI, UF UFBI, UF	Sturge-Weber Foundation, UFBI and VAMRS	1H Studies of Pediatric Brain at 3 T
Scott, K. Kim, H.W. * Maria, B.	UF UFBI, UF UFBI, UF	Sturge-Weber Foundation, UFBI and VAMRS	Absolute Quantitation of Brain NAA by 1H Studies
Scott, K. Kim, H.W. + Bruner, A. * Pepine, C.	UF UFBI, UF UF UF	NIH	^{31}P Cardiac MRS at 3 T of Women with Ischemic Heart Disease: Women's Ischemic Syndrome Evaluation (WISE) Multicenter Study
Scott, K. Kim, H.W. + Bruner, A. * Pepine, C.	UF UFBI, UF UF UF	NIH and Parke-Davis Pharmaceutical	^{31}P Cardiac MRS at 3 T of Postmenopausal Women
Smith, S.A. Randall, E.W.	NHMFL Queen Mary & Westfield College		STRAFI: A GAMMA Investigation
Wirth, E.D. Mareci, T.H. Anderson, D.K. Bossart, E.L. Inglis, B.A. Mercer, E. Reier, P.J. Silver, X.	UFBI, UF UFBI, UF, NHMFL UF UF UFBI, UF UF UFBI, UF UF	NIH	Magnetic Resonance Evaluation of Spinal Cord Injury and Repair
Wirth, E.D. Mareci, T.H. Bossart, E. L. * Inglis, B.A. Mercer, E. Reier, P.J. Silver, X. *	UFBI, UF UFBI, UF, NHMFL UF UFBI, UF UF UFBI, UF UF	NIH	Magnetic Resonance Diffusion Tensor Imaging of Nervous Tissue
Wirth, E.D. Sheperd, T. *	UFBI, UF UF	UFBI	^{13}C Studies of Isolated Spinal Tissues
Zumbulyadis, N. Fu, R.	Kodak NHMFL	Kodak	Ag_{109} Spectroscopy at 833 MHz

+ *Postdoc* * *Student* *(K) Experiment used the Keck magnet in the DC Field Facility*

USER	INSTITUTION	FUNDING	PROJECT
Angerhofer, A.	UF	NHMFL	The Primary Donor Radical Cation in *Rhodobacter spheroides R26* (K)
Bratt, P. J. +	UF		
Ringus, E.	Columbia College		
Hassan, A. +	NHMFL		
Van Tol, J.	NHMFL		
Rohrer, M. +	NHMFL		
Maniero, A.-L.	NHMFL		
Brunel, L.-C.	NHMFL		
Bubenzer-Hange, C.	U. of München		
Scheer, H.	U. of München		
Angerhofer, A.	UF	NHMFL	The Deuterated Chlorophyll *a* Radical Cation (K)
Bratt, P. J. +	UF		
Hassan, A.+	NHMFL		
Van Tol, J.	NHMFL		
Brunel, L.-C.	NHMFL		
Heathcote, P.	University College London		
Arcon, D.	U. of Sussex	NHMFL	ESR Study of Na_2RbC_{60}
Prassides, K.	U. of Sussex		
Margadonna, S. *	U. of Sussex		
Tanigaki, K.	U. of Osaka		
Maniero, A.L.	NHMFL		
Brunel, L.-C.	NHMFL		
Arcon, D.	U. of Sussex	NHMFL	Magnetic Instabilities in $Na_2Rb_{1-x}Cs_xC_{60}$
Prassides, K.	U. of Sussex		
Maniero, A.L.	NHMFL		
Brunel, L.-C.	NHMFL		
Bratt, P.J.+	UF	NHMFL	Photosynthesis (K)
Angerhofer, A.	UF		
Heathcote, P.	U. of London		
Hassan, A., +	NHMFL		
Maniero, A.-L.	NHMFL		
Brunel, L.-C.	NHMFL		
Bratt, P.J. +	UF	NHMFL	The Secondary Acceptors in Photosystem II (K)
Angerhofer, A.	UF		
Smith, P.J. +	U. College London		
Nugent, J.H.A.	U. College London		
Krzystek, J.	NHMFL		
Hassan, A.	NHMFL		
Brustolon, M.	U. of Padova	NHMFL	Radical Anions of C_{60} Derivatives
Maniero, A.L.	NHMFL		
Zoleo, A. *	U. of Padova		
Agostini, G. *	U. of Padova		
Prato, M. *	U. of Padova		
Brunel, L.-C.	NHMFL		
Cornia, A.	U of Modena	NHMFL	Iron(III) Clusters (K)
Segre, U.	U of Modena		
Feola, V. *	U of Modena		
Maniero, A.L.	NHMFL		
Van Tol, J.	NHMFL		
Saylor, C. +	NHMFL		
Dalal, N.S.	FSU	NHMFL	Heisenberg Antiferromagnet
Cage, B. *	FSU		
Brunel, L.-C.	NHMFL		
Dalal, N.S.	FSU	NHMFL	Standard for HF EPR
Cage, B. *	FSU		
Weekley, A. *	FSU		
Brunel, L.-C.	NHMFL		

*+ Postdoc * Student ^ Private Sector (K) Experiment used the Keck magnet in the DC Field Facility*

NHMFL - Geochemistry Facility

USER	INSTITUTION	FUNDING	PROJECT
Choppin, G.	FSU	DOE	Stability of Uranium-Thorium Complexes in Aqueous Solutions
Hickey, R.	Florida Interntl. U.	NSF	Isotopic Investigation of Island-Arc Basalts
Jacob, D.	U. Göttingen	DFG, Germany	Studies of the Hafnium Isotopic Composition of Eclogites in Diamondiferous Kimberlite
Landing, W.	FSU		Trace Elements in Atmospheric Dust
Macfarlane, A.	Florida Interntl. U.	NSF	Pb-Isotope Investigations of Ore Deposits
Marcantontio, F.	Tulane U.	Louisiana	Pb Isotopes in Tree Rings: Chronology of Pollution in Bayou Trepagnier, Louisiana
Martin, E.	UF	NSF	Sr and Nd Isotopes in Fossil Fish Teeth for Paleoceanography
Mia, K.	FAMU		Trace Elements in Atmospheric Dust
Mitchell, S. Odom, R. Zindler, A.	FSU FSU FSU		Investigations Into the Natural Variations in Mercury Isotopic Composition
Odom, R.	FSU	Metro Water District of Southern CA	Age Dating of Alluvial Materials
Pomares, M.	Havana U.	Cuba	Comparison of Matrix Effects Between ICPMS and ICPES
Salters, V. Landing, W. Cooper, W. Proctor, L. Wang, Y. Hsieh, Y.	NHMFL FSU FSU FSU FSU FAMU	South Florida Water Mgmt. District	Phosphorus Sources and Speciation in the Everglades
Salters, V.	NHMFL	NSF	A Hf-Isotope Study of Mantle Materials
Salters, V. Longhi, J.	NHMFL LDEO	NSF	Experimental Determination of Trace Element Distributions Between Melts and Mantle Phases at P, T, and X Relevant to MORB Genesis
Salters, V. Zindler, A.	NHMFL FSU	NSF	Determining the Mineralogy of the MORB-Source Through Nd-Isotopes in Abyssal Peridotites
Salters, V. Brunel, L.-C. Landing, W. Cooper, W.	NHMFL NHMFL FSU FSU		Metal Speciation in Natural Waters
Srimal, N.	Florida Interntl. U.	India	Age Dating of Himalayean Orogenesis
Uddin, A. Odom, R. Zindler, A. Salters, V.	FSU FSU FSU NHMFL	Enron Oil	Isotopic, Thermochronologic, Petrologic, and Magnetostratigraphic Analyses of Cenozoic Sandstones, Bengal Basin, Bangladesh
Xie, J. Odom, R.	NHMFL FSU		Experimental and Theoretical Investigation of Radiation and Heat Effect on Electron Paramagnetic Resonance-Detected Point Defects and Quartz: Implications for Quartz Geochronometry
Zindler, A.	FSU	NSF	U-Th Systematics of Primitive Icelandic Basalts: Building a Foundation for Interpreting U-Th Disequilibrium in MORBs
Zou, H. Zindler, A.	FSU	NSF	Studies of Mantle Melting Process and Composition Using Major and Trace Elements, Neodymium-Strontium-Lead Isotopic Systematics, and Uranium Series Disequilibria:Mathematical Modeling and Experimental Analyses

+ *Postdoc* * *Student*

SEMINARS

APPENDIX B

Seminars sponsored by the NHMFL from July 1, 1998, through June 30, 1999, are listed below. Entries noted by an asterisk (*) were held at the University of Florida.

July 13, 1998
Steve Maple
Eli Lilly & Company; Research Laboratories
Coupled Liquid Chromatography/NMR Spectroscopy/Mass Spectroscopy: Recent Developments and Applications

July 13, 1998
Steve Maple
Eli Lilly & Company
Feasibility of Stop-Flow, High Resolution Solution State NMR at 19.6 T

July 13, 1998
Steve Maple and Piotr Starewicz
Eli Lilly & Company; Resonance Research
Future Development of Narrow Bore, Very High Field Superconducting Magnets

July 15, 1998
David Embury
Los Alamos National Laboratory
A Survey of Processing Methods for High Strength–High Conductivity Wires for Magnet Applications

July 17, 1998
Fei He
University of California at Davis
Characterization of Gas-Phase Non-Covalent Complexes by Electrospray Ionization (ESI) Fourier Transform Mass Spectrometry (FTMS)

July 23, 1998
Ed Reijerse
University of Nijmegen, Netherlands
Multifrequency EPR of Transition Metal Complexes

July 28, 1998
Andrew Webb
University of Illinois at Urbana-Champaign
NMR Microdetectors: Current and Future Applications

July 30, 1998
Didier Poilblanc
Universite Paul Sabatier
Effect of Impurities and Lattice Dynamics on Spin-Field Systems

August 6, 1998
Raz Jelinek
Ben Gurion University of the Negev, Israel
Solid State NMR Studies of fd Filamentous Bacteriophage and Phage-Displayed Peptides

August 7, 1998
Hakno Lee
California Institute of Technology
Development of a New Spectroscopy Method for Gas Phase Ions in R.F. and Microwave Frequencies

August 10, 1998
Warren Warren
Princeton University
Generating & Exploiting Intermolecular Zero-Quantum Coherences in Solution NMR: Why High Resolution Spectroscopy is Possible on the Keck Magnet

August 18, 1998
Richard Bowtell
University of Nottingham, United Kingdom
Dipolar Field Effects in Liquids at High Magnetic Field Strengths; Design & Construction of Multi-Layer Gradient Coils

August 19, 1998
Eva Meirovitch
Bar-Ilan University, Israel
Dynamics Structure & Function of Adenylate Kinase Studied by Multidimensional Heteronuclear NMR

August 28, 1998
Paul Erdos
University of Lausanne, Switzerland
Superconducting Micronets in a Magnetic Field

September 4, 1998
Ke Han
Los Alamos National Laboratory
Internal Stresses in Wires for High Field Magnets

September 8, 1998
Zhong G. Wei
Royal Institute of Technology
Field-Induced Phase Transformations in Shape Memory Materials

September 9, 1998
Alan Zindler
Florida State University
Mixing in the Mantle: Plum Pudding or Layer Cake?

September 11, 1998
Wei Bao
Los Alamos National Laboratory
From Double-Exchange to Super-Exchange in Charge-Ordinary Manganites

September 21, 1998
Marina Brustolon
University of Padua
EPR Studies on Functionalized Fullerenes

September 21, 1998
T. Kiyoshi
NRIM
Development of 1 GHz NMR Magnet and Uniform Force Field Magnet at TML/NRIM

September 21, 1998
T. Miyazaki
Kobe Steel
Development in the Bronze-Processed Nb_3Sn Conductors

September 21, 1998
Kazutomi Miyoshi
Furukawa Electric Co., Ltd.
Mechanical Strength and Current Distribution in HTS Power Cables

September 21, 1998
O. Ozaki
NRIM
Quench Simulation Code for Superfluid Helium Cooling Magnets; Quench Protection of 1 GHz NMR Magnet

September 21, 1998
T. Takeuchi
NRIM
Development Status of Transformed Nb_3Al Multifilamentary Wire

September 25, 1998
Taichi Terashima
NHMFL and NRIM
CeP: Low-Carrier-Density Semimetal Showing Complex Magnetic Phases and CMR-Like Transport Behavior

October 1, 1998
Arata Nishimura
National Institute for Fusion Science
The First Cool-Down of the Large Helical Device and Strain Measurement During Coil Excitation

October 9, 1998
Takeshi Egami
University of Pennsylvania
Electron-Lattice Coupling in Manganites and Cuprates

October 12, 1998
E.W. Collings
Ohio State University
Control of Coupling Loss in Advanced Accelerator Cables and the Processing of Nb_3Al Strand for Future High Field Cable Applications

October 13, 1998
B.L. Adams
Carnegie Mellon University
Observations of Lattice Curvature at Grain Boundaries in Deformed Columnar Polycrystals

October 16, 1998
Alexander J. Bohris
School of Physical Science; University of Surrey
Stray Field Diffusometry—Ways to Diffusion Weighted Imaging

October 19, 1998
W.J. Nellis
Lawrence Livermore National Laboratory
Flux-Compression Experiments on Hydrogen and D-Band Systems

October 19, 1998
Anne Ulrich
Friedrich Schiller University, Germany
Solid State 19F-NMR of Biomembranes

October 20, 1998
Sergei Zvyagin
University of Frankfurt
Single-Ion Bound States in S=1 Antiferromagnetic Chains with Planar Anisotropy and Subcritical Exchange Coupling

October 23, 1998
Richard G.S. Spencer
National Institute on Aging
Cartilage Formation and the Effects of Therapeutic Agents on Matrix Development in a NMR-Compatible Bioreactor

October 28, 1998
Chris Rey
DuPont Superconductivity and Carpco
HTS Reciprocating Magnetic Separation Unit

October 29, 1998
Cesar Luongo
Bechtel National, Inc.
A Case Study of Design-Driven Development: Quench in Cable-in-Conduit Conductors

November 5, 1998
Peiwen Wang
Massachusetts Institute of Technology
Conceptual Design of the KSTAR Superconducting Magnet System

November 9, 1998
B.D. Nageswara Rao
Indiana University-Purdue University Indianapolis
ATP Binding at Enzyme Active Site: Combining NMR and X-Ray Results

November 10, 1998
Eric Gouaux
Columbia University
Structure and Function of Channel-Forming Proteins

November 13, 1998
Noriyuki Hirota
The University of Tokyo, Kitazawa Laboratory
Magnetic Field Effect on Dia- and Para-Magnetic Materials and Magneto-Archimedes Levitation

November 17, 1998
Russ Mitchell and Mark Cola
Los Alamos National Laboratory
An Overview of the Design & Development Program for the Accelerator Production of Tritium Project

November 18, 1998
Maurice Guillot
Grenoble High Magnetic Field Laboratory
The Origin of Magneto Optic Effects in Magnetic Insulators

November 30, 1998
Hassane Mehaeurab
University of Wisconsin
Identification of Protein Folding Patterns Using Site-Directed Spin Labeling

December 2, 1998
Harden McConnell
Stanford University
Self and Non-Self Discrimination by the Immune System

December 3, 1998
Eric Munson
University of Michigan
Solid State NMR Studies of Polymers, Pharmaceuticals, and Heterogeneous Catalysts

December 8, 1998
Andrei Gavrilin
National Institute for Fusion Science
Computer Simulation of Quench and Normal Zone Propagation Analysis in Immersed Superconducting DC Magnets;Conventional and HTS Current Leads Optimizing

December 14, 1998
Raju Subramanian
University of Illinois at Urbana-Champaign
RF Probes for High Field NMR

January 8, 1999
T. Noh
Seoul National University
Role of Jahn-Teller Distortion on Optical Properties of Manganites

January 8, 1999
Tom Painter
NHMFL
Engineering Design of the 30 Tesla Split-Pair Repetitively Pulsed Coils for the Los Alamos Neutron Science Experiment (LANSCE)

January 11, 1999 *
Jim Sauls
Northwestern University
The Effects of Strong Magnetic Fields on Pairing Fluctuations in High T_c *Superconductors*

January 12, 1999
Richard D. James
University of Minnesota
Magnetostriction of Martensite: New Materials That Combine Shape-Memory and Ferromagnetism

January 13, 1999
Michael Bizimis
Florida State University
Geochemical Processes in the Upper Mantle: Evidence from Kimberlites and Carbonatites

January 14, 1999 *
Joe Orenstein
University of California-Berkeley
Electrodynamics of Thermal and Field-Induced Vortices in BSCCO

January 22, 1999
Murugesan Velayutham
North Carolina State University
Exchange Interactions in Some Low Dimensional Copper and Vanadium Complexes: EPR and X-Ray Crystal Structure Studies

January 25, 1999 *
Laura Greene
University of Illinois at Urbana-Champaign
Tunneling into Andreev Bound States of $YBa_2Cu_3O_7$*: Observation of Broken Time-Reversal Symmetry*

January 25, 1999
Sangkwon Jeong
Korea Advanced Institute of Science and Technology
Research Activities in the Cryogenic Engineering Laboratory of KAIST (Korea Advance Institute of Science and Technology) and Upcoming Ramp-Rate Limitation Experiment Using TACL Magnet

January 25, 1999
James Maxwell
Louisiana Tech
Superconducting Microcoils

January 25, 1999
Jos Perenboom & **Paul Frings**
University of Nijmegen, Netherlands
A New High Field Magnetic Laboratory at Nijmegen

January 28, 1999
Ross Mckenzie
University of New South Wales, Australia
The Spin-Peierls Instability with Real Phonons

January 29, 1999
Dung-Hai Lee
University of California at Berkeley
Is the Half-Filled Landau Level a Fermi Liquid of Composite Fermion?

February 1, 1999
Gregory S. Skalka
Computer Science & Applications, Inc.
Design and Calibration of the Eglin RF Simulator

February 2, 1999
Dmitriy Khokhlov
Moscow State University
DX-Like Impurity Centers in the IV-VI Narrow-Gap Semiconductors

February 4, 1999
Tom Painter
NHMFL
Transitioning to the Manufacturing Phase of the 30 T Split-Pair Project

February 5, 1999
Peter Gor'kov
University of Illinois at Urbana-Champaign
Construction of Instruments for MR Imaging:
1. Microscope Slide Probe for Histologically Prepared Samples
2. Miniature Permanent Magnet for MR Imaging

February 5, 1999
Yung Woo Park
Seoul National University
Magnetoresistance of the Metallic Polyacetylene

February 8, 1999
Chuck Swenson
NHMFL
NbTi Persistent Joint Technology

February 9, 1999
William W. Brey
Conductus, Inc.
Superconductive RF Coils for Magnetic Resonance Applications

February 12, 1999
Micheal Goshe
Case Western Reserve University
Hydroxyl Radical Catalyzed H/D Exchange: Identification of Amino Acid Residues Involved in Peptide-Protein Interactions

February 12, 1999
Thomas E. Mason
University of Toronto
Quantum Critical Behavior in the Normal State of $La_{2-x}Sr_xCuO_4$

February 16, 1999
Vladimir Mineev
Russian Academy of Sciences
Phase Transition into Superconducting Mixed State and de Haas-van Alphen Effect

February 19, 1999 *
Junichiro Kono
Stanford University
Terahertz Dynamics in Semiconductor Nanostructures

February 22, 1999
Huub Weijers
NHMFL
3 T Class HTS Insert Coil Development

February 26, 1999
Pengcheng Dai
Oakridge National Laboratory
Spin Fluctuations in Bilayer and Single-Layer High-T_c *Cuprate Superconductors*

March 1, 1999 *
Daniel Agterberg
NHMFL
Odd Parity Superconductivity in Sr_2RuO_4

March 3, 1999
Andreas Stracke
Florida State University
Isotopic Constraints on Mantle Melting Beneath Iceland

March 5, 1999 *
Shuheng H. Pan
University of California-Berkeley
High Resolution Scanning Tunneling Microscopy of Magnetic Vortices in the High T_c *Superconductor* $Bi_2Sr_2CaCu_2O_{8+d}$

March 8, 1999
Sastry Pamidi
NHMFL
Hg-Based High Temperature Superconductors

March 17, 1999
Yang Wang
Florida State University
The Distribution and Carbon Isotopic Composition of Dissolved Organic Carbon in the Florida Everglades

March 18, 1999
Kazuto Hirata
NRIM
Observation of Vortices in YNi_2B_2C *by STM*

March 18, 1999
Michael Zhitomirsky
ETH-Honggerberg, Switzerland
Excitonic Ferromagnetism

March 19, 1999
Tadashi Shimizu
National Research Institute for Metals in Tsukuba, Japan
Systematics of Superexchange and Supertransferred Hyperfine Interactions in Cuprates

March 25, 1999
Yasuyki Takata
Kyushu University
Numerical Simulation of Thermal and Fluid Flow with Phase Change in Helium I

March 29, 1999
Dave Evans
Rutherford Laboratories, United Kingdom
Work of Fracture—A New Approach to Characterizing Resins for Low Temperature Applications

March 29, 1999
N. Furukawa
Aoyama Gakuin University, Japan
Truncation of a 2D Fermi Surface Due to Quasiparticle Gap Formation at the Saddle Points

March 29, 1999 *
Andrew Millis
Rutgers University
Dependent Optical Spectral Weights in the Manganites and Cuprates

March 30, 1999
M. Dodgson
ETH-Honggerberg, Switzerland
Topological Decoupling Transition in Layered Superconductors at Finite Fields

March 31, 1999
Vincent Salters
NHMFL
Melting Beneath Mid-Ocean Ridges

April 2, 1999
Isa Zharekeshev
Institut für Theoretische Physik, Germany
Level Statistics at the Anderson Transition

April 5, 1999
Mark Bird
NHMFL
A Year in the Life of Resistive Magnets:
33 T II
Keck
Large Bore
Hybrid Insert
Heat & Momentum Transfer in Very Rough Cooling Passages
The Road to 1 ppm

April 6, 1999
Paul Dawson and **Donald Boyce**
Cornell University
Intercrystalline Stresses in Metal Polycrystals: Comparing Simulation to Diffraction Experiments

April 12, 1999
Richard Thome
Massachusetts Institute of Technology
The ITER Central Solenoid and TF Model Coil Program-Status and Accomplishments

April 13, 1999
Brian E. Spencer
Spencer Composites Corporation
Composites and the Filament Winding Process

April 13, 1999
Dr. David Wemmer
University of California-Berkeley
Using NMR in the Design and Understanding of Sequence Specific DNA Ligands

April 16, 1999
Michael J. DeMarco
Buffalo State University
Mossbaurer Effect on Ruthenates

April 16, 1999
Alexi Efros
University of Utah
Are Interacting Electrons Never Localized

April 19, 1999
J. Brisson
Massachusetts Institute of Technology
Breaking Taboo's—Cold Moving Parts to Refrigerate Below 1K

April 19, 1999 *
Erwin Schuberth
Meissner Institute, Germany
Magnetization Studies on the Heavy Fermion Superconductor Upt_3

April 22, 1999
Louis Jansen
Grenoble High Magnetic Field Laboratory, Max-Planck-Institut für Festkoerperforschung
Magnetotransport Phenomena in 3D Metallic Systems

April 30, 1999
William M. Reiff
Northeastern University
Effects of Structural Condensation and Zero Point Vibrations on the Magnetic Properties of Ionic and Molecular Solids

May 7, 1999
A. Goldman
University of Minnesota
The Superconductor—Insulator Transition in 2D

May 14, 1999
Gergely Zarand
University of California-Davis
Staggered Superconductivity in UTH_xBe_{13-x}*?*

May 27, 1999
Shimon Reich
The Weizmann Institute of Science
Possible Nucleation of a 2D Superconducting Phase on WO3 Single Crystals Surface Doped with Na^+

May 31, 1999
Liang Li
NHMFL/MS&T
Irreversible Inductance Change and Plastic Deformation of High Field Pulsed Magnets

June 1, 1999
Jinghong Li
University of Florida
Application of Transmission Electron Microscopy in Advanced Materials

June 2, 1999
Jesus Rivas
LANL
Multi-Dimensional Materials Characterization; Some Case Examples

June 3, 1999
Yan Xin
University of Illinois
TEM/STEM Investigations of Semiconductor Materials

June 8, 1999
Masahiro Yamamoto and Masanori Yamaguchi
International Superconductivity Technology Center, Japan
Informal Report on SMES Activities in Japan

June 14, 1999
Bob Walsh
NHMFL
Low Temperature Mechanical Testing of Materials

June 28, 1999
David Hilton
NHMFL
High-Speed Thin-Film Thermometer and Heater Design for Second Sound Shock Waves

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The Research Program Committee is charged with promoting the NHMFL 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.

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Stan Tozer
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KEY PERSONNEL & COMMITTEES

APPENDIX C

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