NATIONAL HIGH MAGNETIC FIELD LABORATORY

REPORTS

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NHMFL REPORTS

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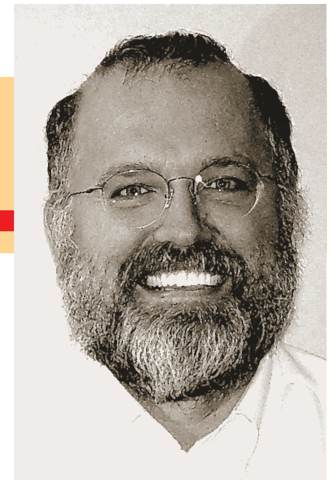
FROM THE DIRECTOR'S DESK



Greg Boebinger

Users Line Up for New World Record Magnet

The engineering team of the laboratory achieved another major milestone in early April when it completed and turned over to the user community its **newest world record powered magnet: a 31 T system that has an experimental space of 50 millimeter**. This magnet is the highest field DC magnet with this bore size anywhere in the world and represents a 6-tesla—or 20 percent—upgrade over existing facilities at the NHMFL, as discussed in the R&D story by Mark Bird on page 10. The magnet has already hosted three research groups:

- First was James Valles of Brown University, who continued his studies of the effects of magnetic fields on single-cell, microscopic animals in pond water. The new magnet allowed greater optical access and resolution to study swimming mechanics and other macroscopic behavior phenomena in a magnetic-field tunable environment.
- After only one week idle, during which the femtosecond optical experiment was built, the magnet hosted David Reitze from the University of Florida, who used the new environment for spatial, temporal, and spectral investigations of superfluorescence from quantum dots, which requires strong magnetic fields to adequately compress the electron and hole wavefunctions to reach the threshold for collective fluorescence to begin.
- Third in the queue was FSU Professor James Brooks, who is continuing his studies into the properties of organic magnetic materials. As a member of the local NHMFL Condensed Matter Science program, Jim has a record of being one of the first users in new NHMFL magnets, but, alas, he was bumped to third in line this time around !

We certainly hope these three experiments are published in the near future to add to the impressive publication record of the laboratory. **In 2004, NHMFL faculty and users reported 392 refereed publications, of which 118 appear in generally-recognized "prominent publications".** The 2004 publications include:

5 *Science* magazine articles
3 *Nature* magazine articles
1 *Nature Structural and Molecular Biology*
29 *Physical Review Letters*
46 *Physical Review B*
10 *Journal of Magnetic Resonance*
7 *Journal of the American Chemical Society*, and
1 *Proceedings of the National Academy of Sciences*

We hope that all NHMFL users send us information on their publications, including pdf files of their NHMFL-affiliated publications. The table on page 4 contains an example of the database we now keep online, a sampling that includes 10 *Physical Review Letters* already for 2005 . To search the NHMFL website publications database, see: http://www.magnet.fsu.edu/search/publications/ For listings of the (self-identified) "significant publications", see http://intranet.magnet.fsu.edu/

On the heels of the highly-successful NHMFL Open House (see page 18), the laboratory hosted a small group of eminent scientists and science communicators to develop "**Quantum Magic: The Story of Superconductivity**," another informal science education project in which the NHMFL is collaborating with, among others, the University of Illinois at Urbana-Champaign. The year 2007 will mark the fiftieth anniversary of the "BCS" theory of superconductivity which earned John Bardeen, Leon Cooper, and the NHMFL's Bob Schrieffer the 1972 Nobel Prize in Physics. To mark that occasion, "Quantum Magic" will explain to the general public the microscopic theory of superconductivity using generally accessible language, video, and interactive demonstrations. In early May, the NHMFL hosted leaders in the physical sciences and leaders in science communications, including, among others:

- David Pines, member of the National Academy of Science

A Sampling of 2005 NHMFL Significant Peer-Reviewed Publications

Bobkova, I.V.; Hirschfeld, P.J. and Barash, Y.S., *Spin-dependent quasiparticle reflection and bound states at interfaces with itinerant antiferromagnets,* **Phys. Rev. Lett.**, **94**, 037005 (2005)

Chekmenev, E.Y.; Hu, J.; Gor'kov, P.L.; Brey, W.W.; Cross, T.A.; Ruuge, A. and Smirnov, A.I., *^{15}N and ^{31}P solid-state NMR study of transmembrane domain alignment of M^2 protein of influenza A virus in hydrated cylindrical lipid bilayers confined to anodic alumin,* **J. Magn. Reson.**, **173** (2), 322-327 (2005)

Dagan, Y.; Barr, M.C.; Fisher, W.M.; Beck, R.; Dhakal, T.; Biswas, A. and Greene, R.L., *Origin of the Anomalous Low Temperature Upturn in the Resistivity of the Electron-Doped Cuprate Superconductors,* **Phys. Rev. Lett.**, **94**, 057005 (2005)

Dobrosavljevic, V. and Miranda, E., *Absence of Conventional Quantum Phase Transitions in Itinerant Systems with Disorder,* **Phys. Rev. Lett.**, **94**, 187203 (2005)

Du, X.; Tsai, S.W.; Maslov, D.L. and Hebard, A.F., *Metal-Insulator-Like Behavior in Semimetallic Bismuth and Graphite,* **Phys. Rev. Lett.**, **94**, 166601 (2005)

Farid, A.K.; Yu, Y.; Saxena, A. and Kumar, P., *Spatial Structures in a Generalized Ginzburg-Landau Free Energy,* **Phys. Rev. B**, **71** (10), 104509 (2005)

Gangadharaiah, S.; Maslov, D.L.; Chubukov, A.V. and Glazman, L.I., *Interacting Fermions in Two Dimensions: Beyond the Perturbation Theory,* **Phys. Rev. Lett.**, **94**, 156407 (2005)

Gao, X.P.A.; Boebinger, G.S.; Mills, A.P., Jr.; Ramirez, A.P.; Pfeiffer, L.N. and West, K.W., *Strongly Enhanced Hole-Phonon Coupling in the Metallic State of the Dilute Two-Dimensional Hole Gas,* **Phys. Rev. Lett.**, **94**, 086402-1-4 (2005)

Graf, D.; Choi, E.S.; Brooks, J.S.; Harrison, N.; Murata, K.; Konoike, T.; Mousdis, G.A. and Papavassiliou, G.C., *Magnetization, thermoelectric, and pressure studies of the magnetic-field-induced metal-insulator transition in tau-phase organic conductors,* **Phys. Rev. B**, **71**, 045117 (2005)

Hoch, M.J.R. and Holcomb, D.F., *^{31}P Knight shifts and spin dynamics in Si:P at temperatures comparable to the Fermi temperature,* **Phys. Rev. B**, **71**, 035115 (2005)

Jorge, G.A.; Stern, R.; Jaime, M.; Harrison, N.; Bona, J.; El Shawish, S.; Batista, C.D.; Dabkowska, H.A. and Gaulin, B.D., *Crystal symmetry and high-magnetic-field specific heat of $SrCu_2(BO_3)_2$,* **Phys. Rev. B**, **71** (9), 092403 (2005)

Koerting, V.; Yuan, Q.; Hirschfeld, P.J.; Kopp, T. and Mannhart, J., *Interface-mediated pairing in field effect devices,* **Phys. Rev. B**, **71**, 104510 (2005)

Pankov, S. and Dobrosavljevic, V., *Nonlinear screening theory of the Coulomb glass,* **Phys. Rev. Lett.**, **94**, 046402 (2005)

Sambandamurthy, G.; Engel, L.W.; Johansson, A.; Peled, E. and Shahar, D., *Experimental Evidence for a Collective Insulating State in Two-Dimensional Superconductors,* **Phys. Rev. Lett.**, **94**, 017003 (2005)

Uji, S.; Yasuzuka, S.; Konoike, T.; Enomoto, K.; Yamada, J.; Choi, E.S.; Graf, D. and Brooks, J.S., *Quantum oscillation of Hall resistance in the extreme quantum limit of an organic conductor $(TMTSF)_2ClO_4$,* **Phys. Rev. Lett.**, **94**, 077206 (2005)

Wu, J.; Tshepe, T.; Butler, J.E. and Hoch, M.J.R., *1/f Noise in semiconducting and just-metallic boron-implanted diamond,* **Phys. Rev. B**, **71**, 113108 (2005)

Zheng, G-q.; Kuhns, P.L.; Reyes, A.P.; Liang, B. and Lin, C.T., *Critical Point and the Nature of the Pseudogap in Single-Layered Copper-oxide Superconductors $Bi_2Sr_{2-x}La_xCuO_{6+\delta}$ Superconductors,* **Phys. Rev. Lett.**, **94**, 047006 (2005)

- Piers Coleman, Rutgers University professor and condensed matter many body theorist
- Barry Aprison, Ph.D., Director of Science and Technology, Museum of Science and Industry, in Chicago
- Linda Feferman, Guggenheim Fellow and Sundance award-winning producer, director, and writer
- Rob Semper, Ph.D., physicist, science educator, and Executive Associate Director of the Exploratorium in San Francisco

The meetings focused on developing plans for producing a major museum exhibit, a web site, a video, and other media in the years 2007-2009 to trumpet not only the 50th anniversary of BCS theory but also the 60th anniversary of the discovery of the transistor by John Bardeen and coworkers. Dr. Schrieffer's close friend and colleague—and one of the NHMFL's founding scientists—Lev P. Gor'kov will also be featured in the "Quantum Magic" project for his pioneering work on superconductivity. The laboratory is cheering Lev Gor'kov's recent election to the National Academy of Sciences (see page 21), a richly deserved honor for his distinguished career in superconductivity.

"Quantum Magic" is a project of the **Institute for Complex Adaptive Matter**—a distributed "institute without walls" for the exchange of scientific ideas that currently involves 47 institutions, including Florida State University. ICAM is co-directed by David Pines and myself, and the lead institution is one of the NHMFL partners, Los Alamos National Laboratory. Among its many goals, ICAM aims to translate complicated science concepts for the public and to engage students in a lifelong appreciation of science and technology. ICAM's efforts to bring together physics, chemistry, and biological research have been discussed in the *New York Times* "Science Times" section and in a recently-published book on the growing recognition of 'emergence' in physics, chemistry and biology, written by Nobel Laureate Robert B. Laughlin and titled "A Different Universe: Re-inventing Physics from the Bottom Down."

With the approach of summer, I offer my standard closing… *Rock & Roll*…but urge everyone to continue to rock gently and roll safely!

Greg Boebinger

FROM THE CHIEF SCIENTIST'S DESK

J. Robert Schrieffer

Our user program continues to attract not only new scientific projects, but also advances in instrumentation. In a recent visit by the Dresden and Vienna Team of Doerr and Rotter, a highly engineered capacitive dilatometer was employed to carry out magnetostriction studies of $SmCu_2$, where the commensurate and incommensurate antiferromagnetic phase boundaries were mapped out in the field range between 20 and 33 T. Doerr and Rotter plan to return to the NHMFL late this Fall to extend the range of the dilatometer studies into the 45 T hybrid magnet range.

How to Use a Miniature Capacitance Dilatometer to Measure Magnetostriction in High Magnetic Fields

M. Doerr, University of Technology Dresden, Germany, Physics
M. Rotter, University Vienna, Austria, Physics
B. Brandt, NHMFL
J. Brooks, NHMFL and FSU, Physics
E. Jobiliong, NHMFL
A. Lindbaum, University Vienna, Austria, Physics
R. Vasic, NHMFL
H. Müller, Technical University, Vienna, Physics

Magnetoelastic phenomena of solids are widely investigated because of the fundamental importance of the interactions between electronic and lattice degrees of freedom, for instance, in magnetic materials or superconductors. On one hand, such investigations allow us to prove microscopic models and theories, including crystal electric field and magnetic exchange interactions; on the other hand, aspects of technical application, such as giant-magnetostrictive devices, magnetic switches and sensors, substrates for magnetoresistive thin films etc., are of great interest. Most of the investigations are focused on ferromagnets. Recently antiferromagnets have attracted more interest because they show quantum critical points when a field is applied (i.e., at the transition to field induced ferri- or ferromagnetic states in the limit of zero temperature).

Capacitive dilatometers are extremely sensitive devices for measurements of the change in length $\varepsilon^{\mu}_{\nu} = dl(T,H)/l_0$, when an external magnetic field H or the temperature T is varied (the property in the first case is called forced magnetostriction, whereas the second type of measurement is the thermal expansion). The properties ε^{μ}_{ν} are the components of the magnetostriction tensor. The derivatives of the curves $\varepsilon^{\mu}_{\nu}(T,H_{\nu})$ with respect to T or H_{ν} give the expansion coefficients $\alpha^{\mu}_{T}(T,H_{\nu})$ and $\alpha^{\mu}_{H_{\nu}}(T,H_{\nu})$ (μ…direction of the measurement, ν …field direction). In such a capacitive dilatometer the

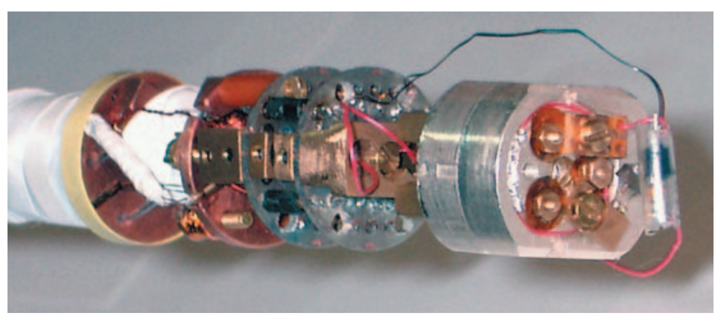


Figure 1a. The miniature dilatometer mounted at the 33 T magnet sample stick. The capacitor is surrounded by silver screening plates (right hand side). The slot marks the capacitor gap, which is in the order of 100 µm. The small plastic tube contains the sample thermometer.

change of length is transduced to the movable part of a capacitor and results in a capacitance change. This method is extremely sensitive (in practice between $dl/l_0 \cong 10^{-9}$ and 10^{-6}) using the high precision of modern capacitance bridges. The size of modern dilatometers could be reduced and a special miniature dilatometer (see Fig. 1a and b) was developed with a diameter of 22 mm.[1] Because the sample is housed inside the capacitor, the height of the dilatometer cell could be minimized so that the longitudinal as well as the transversal components of the strain tensor can be analyzed. The construction is based on the tilted plate technique so that the problem of holding the plates parallel to each other is overcome. The small size (which, in principle, could be reduced to a characteristic length less than 20 mm) allows us to mount the capacitor cell into the free sample space of cryostats, furnaces, or strong magnets, especially in the 33 T or 45 T magnets at the NHMFL.

Before starting the measurements it is necessary to take care of the following: The noise due to electrical influences and mechanical vibrations can result in a remarkable reduction of the resolution. It is very important to isolate the sample stick and all measuring devices galvanically from the power line and the ground of the cryostat (especially to avoid ground loops). This can be done using isolation tape and special plastic spacers in the vacuum line. By taking these precautions, a resolution of about 10^{-6} in dl/l_0 was realized. The influence of mechanical vibrations was rather small; the given resolution value got worse by a factor of 3, approximately, after starting the cooling water flow. It should be possible to minimize this effect by further miniaturization of the capacitance cell so that it is not touching the cryostat. Last, we want to mention that the experiments were done with field ramp rates of 1 T/min or 2 T/min. Higher rates can result in eddy currents, which heat up the cell during the scan. Because the magnetostriction often is much smaller than the thermal expansion of a solid, temperature instabilities may lead to magnetostriction artifacts.

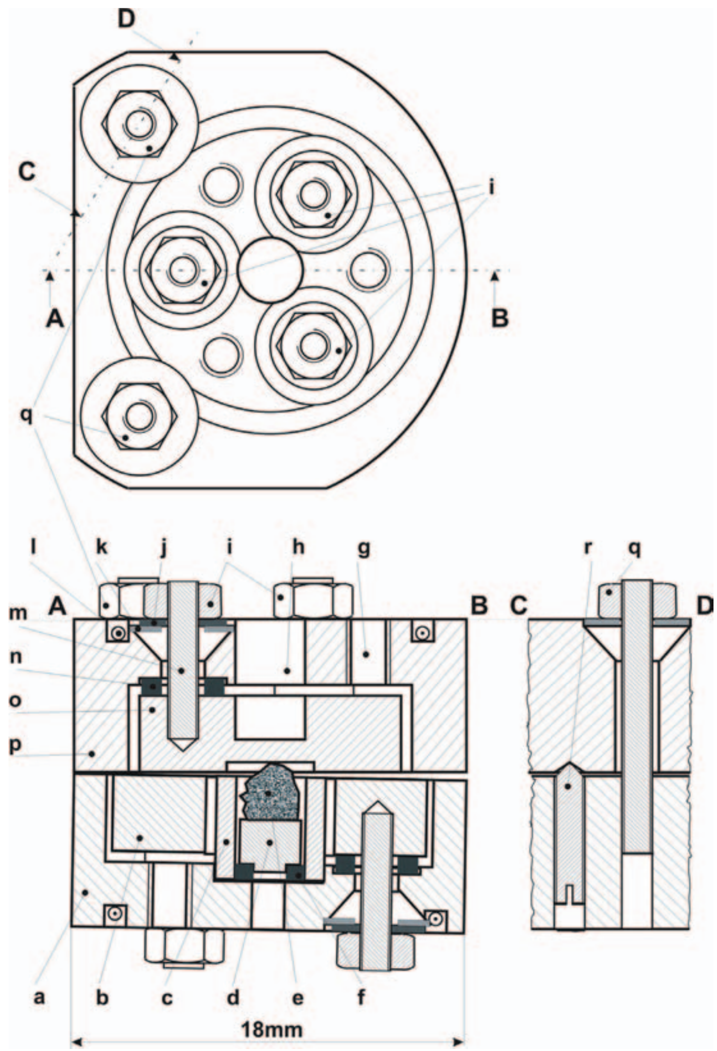


Figure 1b. Drawing of the tilted plate miniature dilatometer.[1] The sample is mounted inside the capacitor. The parts are in detail: (a) and (p) capacitance plate holder (Ag), (b) and (o) upper and lower capacitance plate (Ag), (c) electrical shielding of sample space (brass), (d) sample support (Ag), (e) sample, (f) and (n) isolation washer for electrical sample isolation (sapphire), (g) and (h) mounting holes, (i) plate holder nuts, (j) electrical isolation (capton), (k) disk spring (Cu-Be), (l) groove for temperature stabilization of the wires, (m) thread bolt (brass), (q) adjustment nuts, (r) needle bearings.

The experimental team
M. Doerr (University of Technology, Germany, left) and
M. Rotter (Vienna University, Austria, right) after the
preparation of the experiment.

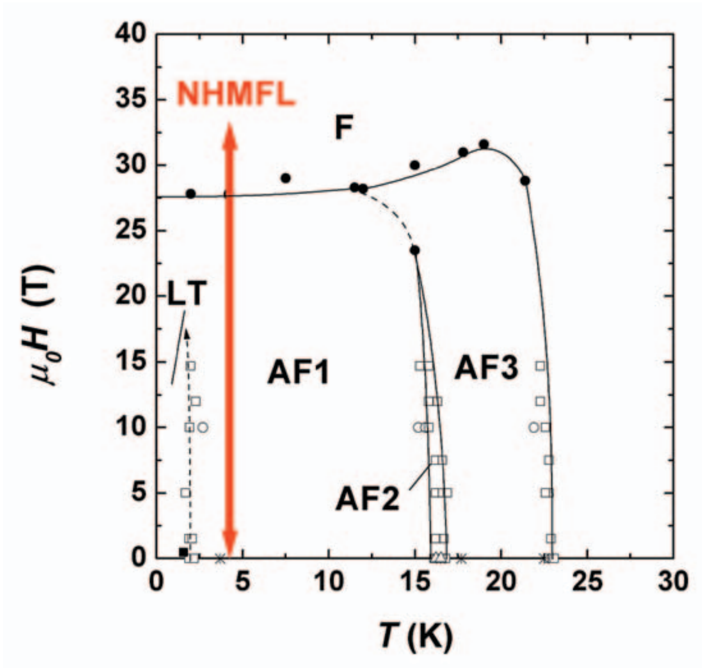


Figure 2. Magnetic phase diagram of $SmCu_2$.[2] AF1, AF2 and AF3 denote commensurate and incommensurate antiferromagnetic phases, LT is a low-temperature modification of AF1 and F is the induced ferromagnetic state. The closed symbols are the results of magnetization measurements in pulsed fields and the open symbols are from lab measurements of magnetization or magnetostriction.

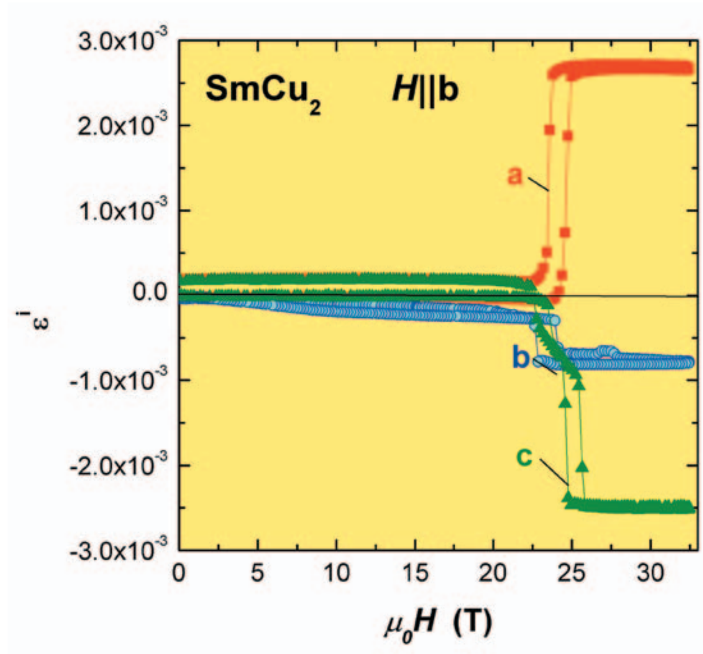


Figure 3. Magnetostriction of $SmCu_2$ in steady high fields along the (easy) b-axis measured in the 33 T magnet at the NHMFL in Tallahassee.

We performed experiments in the 33 T magnet of the NHMFL on some of the orthorhombic RCu_2 (R = Sm, Gd, Tm) compounds, which are examples for rare earth-based antiferromagnets. Among these, $SmCu_2$ has attracted the most interest because of the sign reversal of the anisotropic part of the two ion interaction.[2] The magnetic moment is only 0.5 μ_B/f.u. due to a partial compensation of the orbital and spin moment. The magnetic phase diagram (see Fig. 2) contains an unconventionally shaped line for the transition into the induced ferromagnetic state with a critical field of about 27 T at 4.2 K. Our magnetostriction results, taken at the same temperature, offer steady high field data of $SmCu_2$ for the first time. They confirm the antiferromagnetic-ferromagnetic transition and show that the lattice is remarkably influenced by this magnetic ordering process. The magnetostriction in fields along the (easy) b direction (see Fig. 3) is characterized by an expansion of the a axis of $\varepsilon^a = +2.7\text{x}10^{-3}$ at 24 T, the b and c axes contract by $\varepsilon^b = -0.8\text{x}10^{-3}$, $\varepsilon^c = -2.5\text{x}10^{-3}$. In contrast to these large values, the magnetostriction in fields along the a or c axis is rather small and does not exceed 10^{-4} up to 33 T.

Moreover, basic magnetoelastic investigations were done at the pure rare elements Sm and Tm, because for both elements no magnetostriction data are available.[3] It can be concluded that the capacitive method is a very sensitive tool, also at the highest steady fields and extended the pool of interesting experimental methods at the NHMFL. It can be applied to a large number of systems and promises many deep and new insights into the nature of magnetism and superconductivity.

1 Rotter, M., *et al.*, *Rev. Sci. Instr.*, **69**, 2742-2748 (1998).
2 Rotter, M., *et al., Phys. Rev. B*, **64**, 134405-134412 (2001).
3 Doerr, M., *et al.*, *Adv. in Physics,* **54**,1 (2005).

Attention Users
Your Committee Convenes, Reviews & Recommends

Bruce Brandt, Director DC Field Facilities

The NHMFL Users' Committee represents users of all of the NHMFL Facilities. The Users' Committee meets at least annually with teleconference meetings bimonthly. (More information about the Users' Committee is at http://www.magnet.fsu.edu/users/committees/.) Condensed versions of the Report of the 2004 meeting and notes from the February, 2005 teleconference are provided below. Additional information, including PowerPoint slides and the full text of the Users' Committee reports and teleconference notes, can be found by pointing a browser to *http://opserver.magnet.fsu.edu/Users_Committee/*.

<u>Condensed</u> Report of the Users' Committee Meeting November 12 and 13, 2004, at the National High Magnetic Field Laboratory in Tallahassee

Voting Committee Members Attending: Charles Agosta, James Brooks, W. Gilbert Clark, Roy Goodrich, Lowell Kispert, Lia Krusin-Elbaum, Charles Sanders, Thomas Timus, James Valles (2005 Chair), and Richard Wittebort.
Non-voting members elected for 2005-2007 present: Junichiro Kono, Stephen Julian, and Ulrich Welp.

Introduction
The Users' Committee (UC) began by recognizing that Jack Crow, the first director of the NHMFL, had built it into the finest high magnet field lab in the world. Committee members then expressed their strong support for Greg Boebinger's new leadership and his vision for the future of the lab. The UC elected its new officers for 2005. The Chair is James Valles and the Secretary is Ulrich Welp. The UC's recommendations and comments on NHMFL projects and programs were as follows:

Recent Progress and Developments
1. The UC was happy to see the **900 MHz wide bore NMR magnet system** and probes operating successfully and look forward to high profile results soon.
2. **The Magnet Science and Technology** (MS&T) group has restructured and taken on a number of outside projects. Since decisions about the priorities given to different MS&T projects affect the timing of projects that can directly affect NHMFL users, we recommend that the project priority lists be made available to the UC for comment.
3. **The Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS)** facility at Gainesville is doing outstanding science that can lead to major medical advances and is well supported. We approve the recent additional financial support for this facility and the decision to hire a staff scientist who will enhance the linkage between AMRIS staff and the NHMFL.

New Facilities Development
1. The users committee views the **Series Connected Hybrid (SCH)** as the next generation workhorse for high field magnets. It will allow more user hours and higher continuous fields. The first version will provide a high homogeneity field (10 MW and 35 T) for NMR research. To meet the needs of other users, we encourage the lab to produce a high field version (10 MW and 40 T, 32 mm bore) as well.
2. **Split Magnet Design** – There is user support for both vertical field and horizontal field radial access (split coil) magnets. The UC will recommend during the second quarter of 2005 which geometry to fabricate first.
3. The UC sees the development of a **Free Electron Laser (FEL)** capability as a potentially important new direction for the NHMFL that will appeal to users in many different fields. It will require additional staff to run it and to support users.
4. **Tallahassee Short Pulse Facility** – Needs further review by the NHMFL and the UC.
5. A significant issue regarding the **combined LTS and HTS magnet for NMR** is whether it should be a stepping stone to 1.1 GHz moderately high homogeneity NMR or a unique advanced resource. A narrow bore 1.1 GHz instrument may be too conservative in this regard. The balance between cost, technological possibilities, and the objective of creating exciting new resources needs further consideration and analysis.
6. We recommend to the NHMFL that Phase I planning for a **21 Tesla magnet for FT Mass Spectrometry** be supported by matching NSF - Chemistry funds allocated by Alan Marshall. We propose a 67%/33% (MS&T/ICR) matching structure to cover the $500 K costs for MS&T to do the preliminary design and evaluation.
7. **Smaller Facilities** - We support the:
   a. Rebuilding of the 60 T long pulse magnet
   b. Permanent installation of a top loader dilution refrigerator in a 33 T magnet
   c. Acquisition of a 20 T superconducting solenoid based dilution refrigerator system for NMR.

User Support Issues

1. Users could benefit from visitor housing within walking distance to the NHMFL.
2. The UC supports efforts to provide more user travel funds and more transparent policies for their assignment to users.
3. We continue to support item 14 of the 2003 UC report for additional support for EMR users.

Notes of Users' Committee Conference Call
February 24, 2005

Users' Committee members present: James Valles (chair), Ulrich Welp, Stephen Julian, Chuck Agosta, Lia Krusin-Elbaum, James Brooks. [J. Kono and L. Kispert had classes to teach and G. Clark was in Bangalore, India and tried unsuccessfully to call in.]

NHMFL Staff present: Alex Lacerda, Bruce Brandt, Tim Cross, John Miller, Mark Bird, Chris Hendricksen, Yasu Takano, Scott Hannahs

Additional information, including PowerPoint slides and the full text of the Users Committee reports and teleconference notes, can be found by pointing a browser to *http://opserver.magnet.fsu.edu/Users_Committee/*.

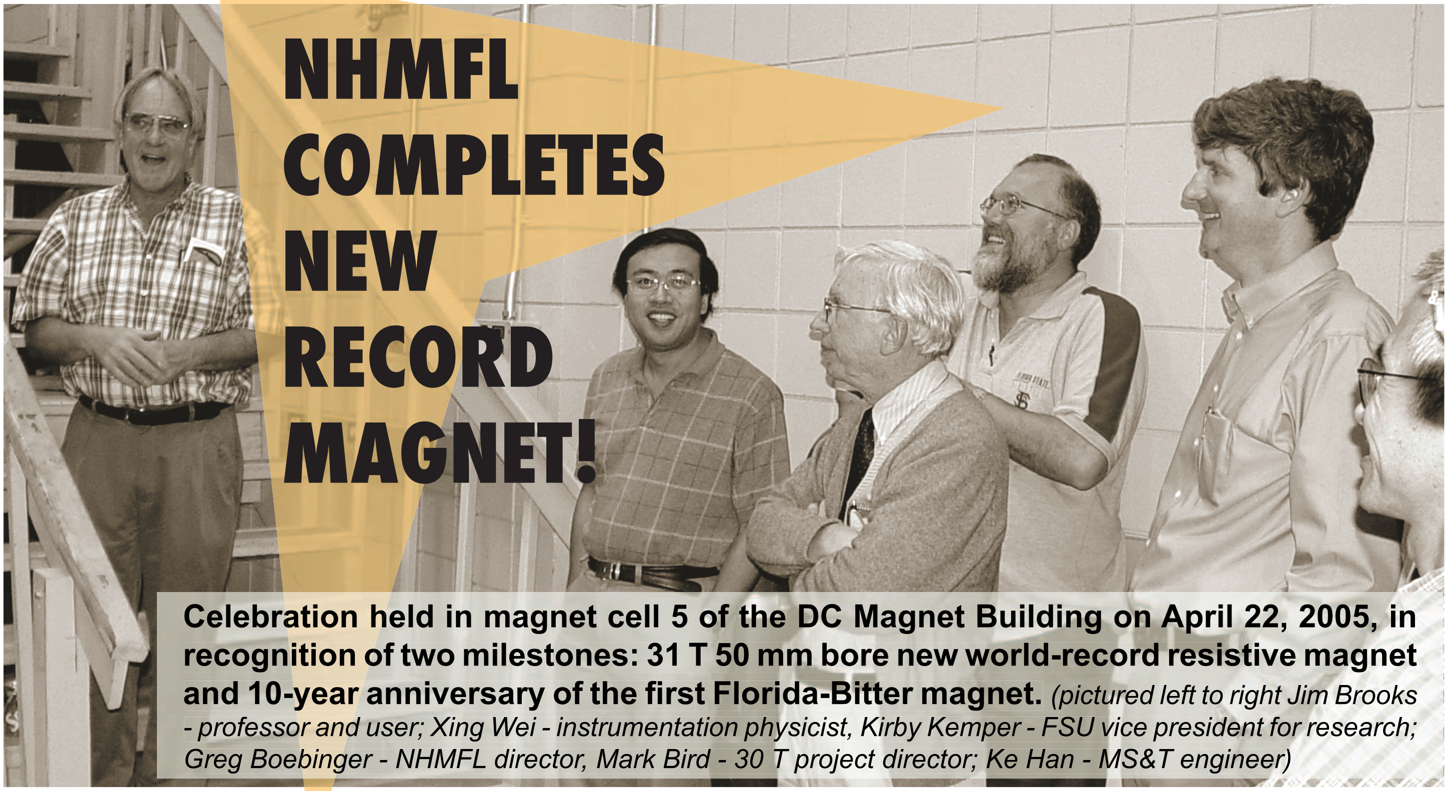
1. Magnet and Technology Projects Status
   - **a. Series Connected Hybrid (SCH) – John Miller** described plans for the SCH for NMR, which is the first magnet to be built of this sort. The SCH program has funds for the Conceptual & Engineering Design phase from 7/04 – 7/06. That will result in a proposal to build the first magnet. See the file named SCHOptionsB.ppt.
   - **b. Split Magnet Design – Mark Bird** described the design for the split that is currently being worked on. It includes two versions of the highly stressed inner coils – one for photon scattering experiments and one for sample rotation work. The outer coils and housing would be dual-use. The dual-use approach requires that the housing be rotatable. See the file, Split 05_02_21.pdf.
   - **c. LTS/HTS NMR Magnet – Tim Cross** said that the report of the NRC study committee on high magnetic field research (COHMAG) confirms our vision of NMR in high field, non-ideal magnets such as the SCH. The COHMAG report also strongly advocates the development of a 30 T LTS/HTS superconducting magnet for solution and solid state NMR. Such a magnet has now been accepted by the NHMFL as a goal, and we hope to bring NIH in as a partner to help support the costs for its development.
   - **d. 21 Tesla ICR Magnet** – **John Miller** described the concept being developed, the organization of the cooperation with the Korea Basic Science Institute (KBSI), and tentative schedule. The Conceptual Design Phase has begun with funding from all the partners (NSF ICR grant, NSF Core grant, and KBSI).
   - **e. Other MS&T projects** not related to NHMFL facilities – **John Miller** showed two tables of all the projects that MS&T has on its list for attention of some kind during 2005. One table listed each project's value or cost; the other showed the priority label. Priority One projects are those that are necessary for the NHMFL's core mission, like resistive magnet maintenance and the 32 mm bore magnet upgrades. Priority Two projects include projects that have funds and deadlines, such as the SCH conceptual design work, 100 T pulse magnet materials testing, and the JPL levitation magnet. Most work for others has priority Two. Priority Three projects include individual staff research projects, such as IHRP projects, and have funding and deadlines. Priority Four projects have no funding and no deadlines.
   - **f. Tallahassee Short Pulse Facility – Alex Lacerda** reported that a 50 T, 0.5 MJ class short-pulse magnet facility (including magnet, instrumentation, staff support, and footprint) would cost $300 K - $500 K for the initial cost of the magnet and power supply. Specialized instruments and staff support, would add to the cost. It is presently on the wish list, not in the budget. It will be considered for inclusion in the renewal proposal.

2. **Free Electron Laser (FEL) Development** – **Hans Van Tol** A proposal seeking funding for conceptual design of an FEL for long wavelength measurements in high fields has been submitted by the NHMFL with partners from Jefferson Lab and the Center for Terahertz Science and Technology at UCSB. A decision is expected in June or July. The summary is 050124 FEL Project.pdf.

3. **Pulse Field Facility at Los Alamos** –**Alex Lacerda** reported that the 60 T long pulse magnet rebuild is going smoothly. He was also pleased to announce that funding is now available for a new user magnet capacitance bank. It will take a year or two to bring it on line. *NHMFL@LANL* is responding to user requests for less expensive, more convenient housing in Los Alamos by investigating the possibility of renting a house with several bedrooms for users, similar to the user condo in Tallahassee.

4. **DC High Field Facility in Tallahassee – Bruce Brandt** reported that a top-loading dilution refrigerator permanently installed in a 33 T magnet would cost about $525 K for the magnet and $900 K for the dil fridge, vibration isolation stand, etc. This item is not in the budget now, but will be considered for inclusion in the renewal proposal.

NHMFL COMPLETES NEW RECORD MAGNET!



Celebration held in magnet cell 5 of the DC Magnet Building on April 22, 2005, in recognition of two milestones: 31 T 50 mm bore new world-record resistive magnet and 10-year anniversary of the first Florida-Bitter magnet. *(pictured left to right Jim Brooks - professor and user; Xing Wei - instrumentation physicist, Kirby Kemper - FSU vice president for research; Greg Boebinger - NHMFL director, Mark Bird - 30 T project director; Ke Han - MS&T engineer)*

M. Bird, NHMFL

At approximately 5 p.m. EDT on April 7, 2005, the NHMFL completed testing of a new 50-mm bore Florida-Bitter magnet. The new magnet reached 31.3 +/- 0.2 T using 18.7 MW of power. The field was measured with a hall probe previously calibrated against NMR up to 30 T. NMR field calibrations will be performed in the near future. Fig. 1 shows a CAD model of a section of the new magnet.

This magnet constitutes a 6 T upgrade at the NHMFL in this bore and, as far as we know, is the highest field 5 cm bore DC magnet available to users worldwide. It surpasses the 28 T, 18 MW resistive magnets in Grenoble, and the 30 T, 15 MW hybrid in Tsukuba. The magnet is conceptually very similar to the successful and reliable 33 T magnets. Both consist of four nested coils made from the same materials and operating at the same temperature and stress limits. Fig. 2 is a plot of the computed temperature distribution at the mid-plane of the inner two coils of the new magnet.

The primary innovation in this magnet compared with the older 32 mm bore magnets is the introduction of current-density grading to the coils. By using lower current-density at the ends of the coils than at the mid-plane, greater efficiency can be attained. DC resistive magnet "efficiency" is defined $E = B(a_1/P)^{1/2}$ where B is the flux density, a_1 is the inner radius, and P is the power, as shown in Table I.[1] We see that the new 50 mm bore magnet is more "efficient" than the older 32 mm bore magnet once we adjust for the differences in bore and power consumption.

Table 1. Parameters of 32 mm and 50 mm high field magnets at the NHMFL.

Magnet	32 mm	50 mm
Field [T]	33.1	31.3
Inner Radius [mm]	19	28
Power [MW]	17.5	18.7
Field/Power [T/MW]	1.89	1.67
Efficiency [T(mm/MW)$^{1/2}$]	34.5	38.3

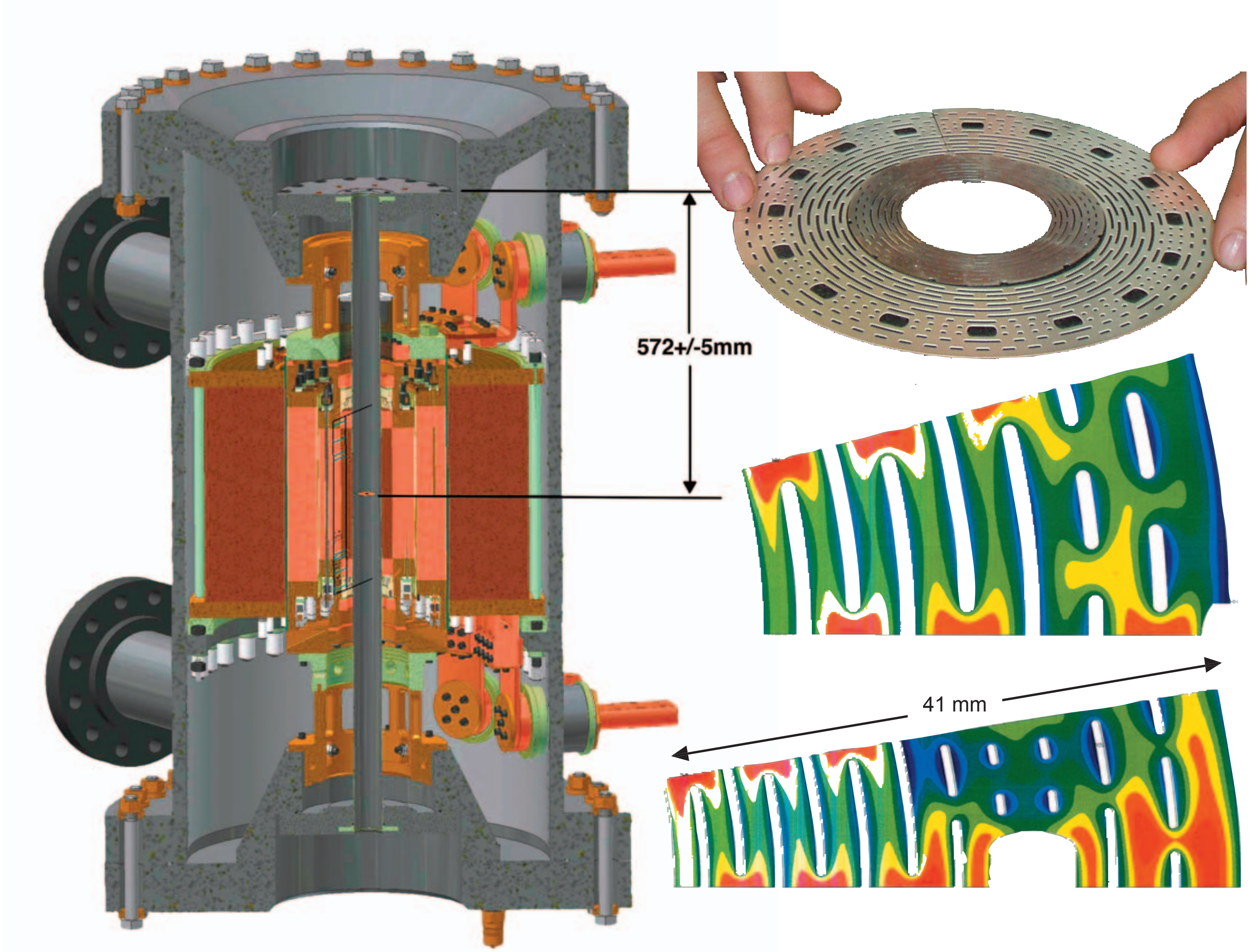


Figure 1. Section of new 31 T Florida-Bitter magnet at the NHMFL.

Figure 2. Florida-Bitter disks from the inner two coils of the 50 mm, 31 T magnet along with temperature plots.

For more than a decade, the NHMFL has operated both 32 mm and 50 mm high field magnets. For most of that time, the difference in field between the two bore sizes was 7 T or more. Hence, the smaller bore magnets were much more popular. With this new 50 mm magnet, the difference in field has been reduced to only 2 T. Thus, various activities become more attractive in the larger bore such as: conducting multiple experiments in parallel, performing 2-angle rotation, particularly in conjunction with high-pressure cells, etc. In particular, insert coils have been designed and fabricated that will provide AC modulation and gradient on top of the 31 T DC field. They will be tested and provided to users in the near future.

In the 3rd quarter of this year we expect to commission a new version of the 32 mm magnets that will employ the same outer two coils as the new 50 mm magnet. The new magnet should provide 35 T reliably and will constitute a 2 T increase in field at that bore size.

In addition, we are building another 32 mm bore magnet using the same conductors as the new 35 T magnet but assembling them to attain higher homogeneity. The new magnet should be completed in the 4th quarter of 2005 and attain 28 T with inhomogeneity of about 50 ppm over a 1-cm-diameter spherical volume. This magnet will represent a 4.5 T increase in field at this level of homogeneity compared with the existing magnet in cell 7.

[1] Picoche, J.C.; Rub, P. and Schneider-Muntau, H.-J., *J. of Magnetism & Magnetic Materials*, **11**, 308-316 (1979).

Attention Users
Pulsed Field Users Program

C.H. Mielke, Head of the NHMFL/Los Alamos Users Program

The de Haas-van Alphen Effect: *Old Dog, New Tricks*

Paul Goddard, NHMFL/LANL
Neil Harrison, NHMFL/LANL

Although the measurement of the de Haas-van Alphen (dHvA) effect in pulsed magnetic fields is by no means new, the technique continues to be a powerful tool in condensed matter physics fifty years after Shoenberg's pioneering work.[1] Today, the pulsed-field team at the NHMFL, Los Alamos, has taken this technique far beyond its original elemental objectives, with very strong magnetic fields enabling the Fermi surface to be explored in hitherto unmeasurable materials.

As many of you are aware, the magnetization and dHvA techniques are readily available to users at LANL. As the field is pulsed, the e.m.f. induced in a pick-up coil that surrounds the sample is recorded and can be integrated to obtain the magnetization. The coils themselves are of order a millimeter in diameter and consist of around 1000 turns, being tediously wound and compensated by hand. Further stages of compensation take place *in-situ*, including performing two magnetic field pulses with identical control settings, one with

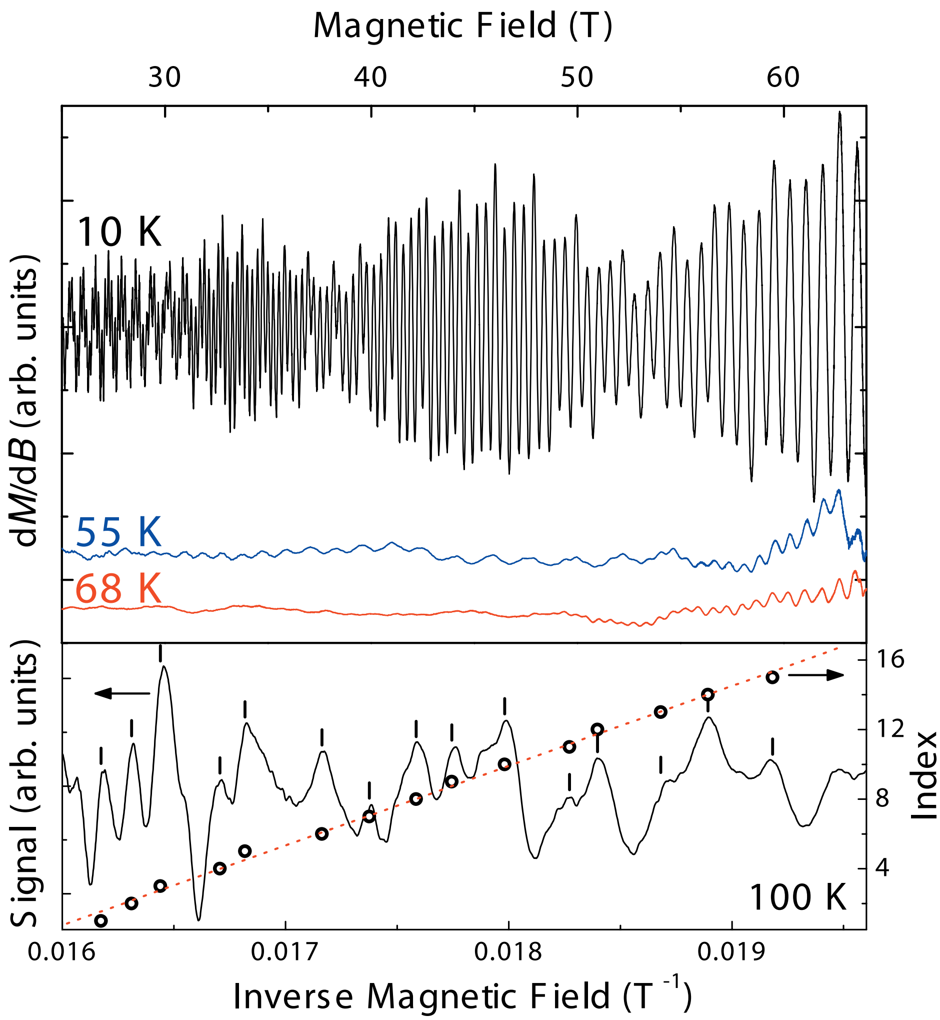


Figure 1. Top: dHvA oscillations observed in the magnetic susceptibility of AuZn at 10 K (upper), 55 K (middle) and 68 K (lower); curves are offset for clarity. Bottom: the measured signal ($\propto dM/dB \times dB/dt$) at 100 K. The positions of the marked dHvA oscillations are also shown as index vs. 1/B (points); the straight line fitted to these points reveals a dHvA frequency of 4590 ± 80 T.

the sample inserted, one with it extracted and subsequently subtracting them. This method yields an accurate and consistent measurement of the magnetization in fields as high as 65 T and temperatures as low as 500 mK. In the case of the dHvA effect, a knowledge of the absolute magnetic

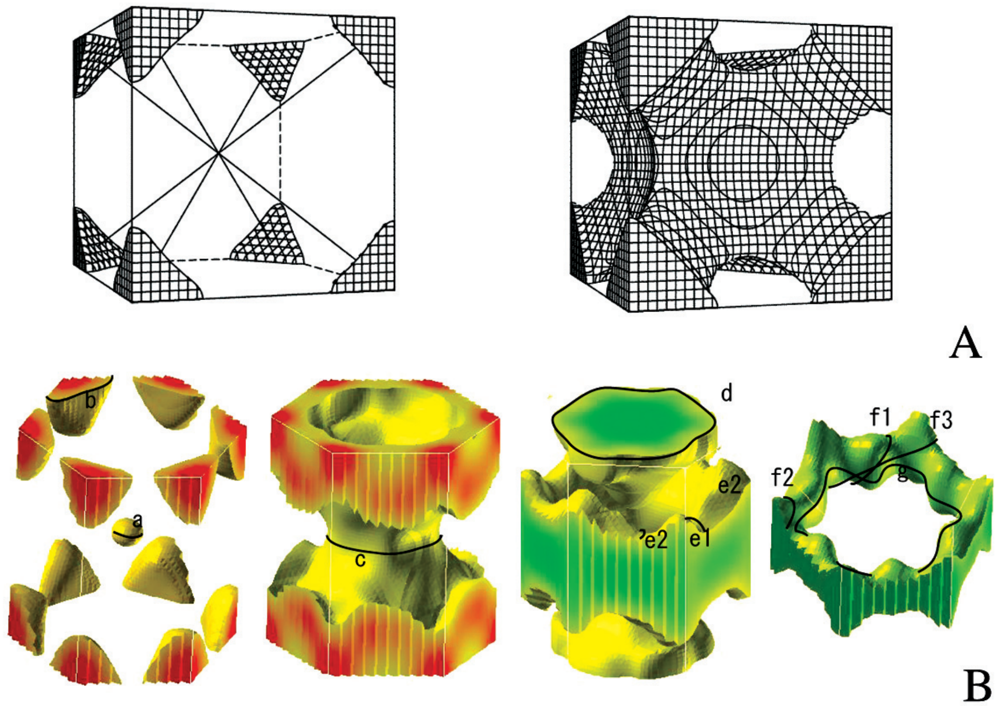


Figure 2. The calculated Fermi surface sections in AuZn in the high (A) and low (B) temperature phases.

moment is not necessary and the extraction stage is abandoned in favor of a greatly increased filling factor, overall miniaturization and hence improved sensitivity.

A very recent example highlighting the versatility of the technique is that of AuZn, where workers at Los Alamos succeeded in measuring the dHvA effect at an unprecedented temperature of 100 K.[2] This feat would have been not so remarkable except for the fact that it allowed the observation of a Fermi surface reconstruction through a structural phase transition.

AuZn is a shape memory material similar to the Nitinol alloy that is used to make the indestructible eyeglass frames that some of you may be wearing in order to read this article. (Warning: unless you are certain of the composition of your spectacles please do not attempt to test their indestructibility.) In contrast to Nitinol, whose transition takes place at room temperature, AuZn has its transition at 67 K, allowing the link between the Fermi surface and the shape memory effect to be investigated without the phonons obscuring the view. It was suggested in an earlier paper[3] that the shape memory transition in this material is driven by a Peierls-like instability and the dHvA measurements were able to show that there is indeed a major upheaval of the Fermi surface at the transition temperature that is in keeping with this hypothesis. In addition, the oscillations revealed the coexistence of both phases at low temperatures as well as illuminating the nature of the microstructure in the bulk of the sample.

Of course, it should be noted that dHvA is generally a low temperature effect and the observation of oscillations up to 100 K is extremely unusual. The amplitude of the oscillations depend not only on the sensitivity of the pick-up coil and the size of the magnetic field, but most significantly on the effective mass of the quasiparticles: the fact that the masses in AuZn are so small (0.05 to 0.35 m_e) is the primary reason that these experiments were so successful.

1 Shoenberg, D., *Nature*, **170**, 569, (1952) and Shoenberg, D., *Phil. Trans. Roy. Soc. Lond. A,* **255**, 85 (1962).
2 Goddard, P., *et al., Phys. Rev. Lett.*, **94**, 116401, (2005).
3 McDonald, R.D., *et al*., *J. Phys. C.M.*, **17**, L69, (2005).

1.3 GHz High Resolution NMR:
Potential and Prospects

W.D. Markiewicz, NHMFL
J. Schwartz, NHMFL
T.A. Cross, NHMFL

The recent Committee on Opportunities in High Magnetic Field Science was charged with a number of tasks including, to paraphrase the executive summary of the circulated draft copy of the COHMAG report, an assessment of high field magnet science and technology in the United States, and an identification of possible major new initiatives for future high-field magnets.[1] Regarding nuclear magnetic resonance (NMR) science and magnet technology, the COHMAG report identifies NMR spectrometers of 30 T/1.3 GHz as having great interest for a number of scientific areas, including an increase in accessible protein size for structure determination, enhanced macromolecular alignment at high fields, improved ability for membrane protein structure studies, and improvements in solid state NMR. As a result of these identified opportunities, the science justification for a 1.3 GHz NMR spectrometer is strong. The COHMAG report also recognizes the large technical challenge associated with making such spectrometer magnets available.

The NHMFL is in a unique position to initiate the significant advance in magnet technology that 1.3 GHz NMR will represent. Recently, two major programs were completed that are the foundation (or perhaps pillars would be a better analogy) for the future advancement of NMR magnet technology, namely the 900 MHz ultra wide bore NMR magnet and the 5 T high temperature superconductor (HTS) insert coil.[2,3] The success of these programs, with the demonstration of technology developed at the NHMFL, provides confidence in the capabilities and engineering approach of the NHMFL as a basis for a 30 T initiative.

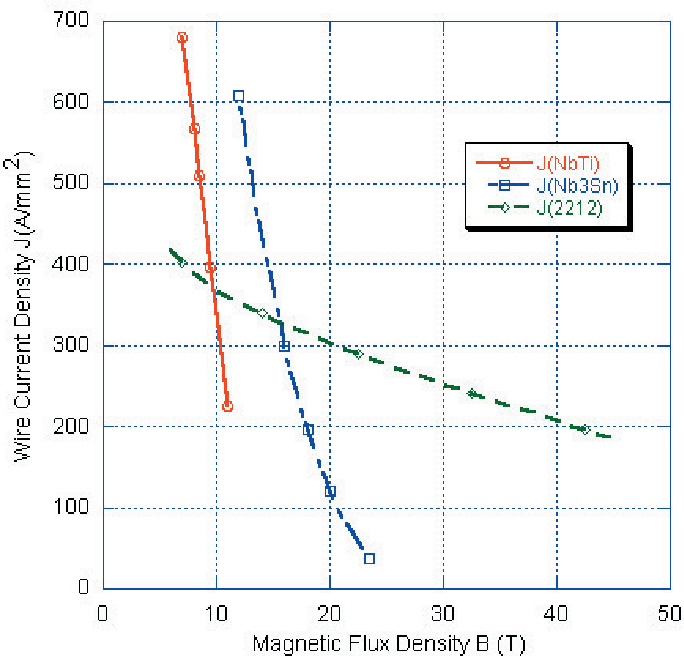


Figure 1: Representative current densities versus applied magnetic field in superconducting composite wires containing NbTi, Nb_3Sn, and BSCCO 2212 for high field magnet applications.

The objective of the NMR magnet program at the NHMFL has been, since its inception, to push the technology to the highest field values possible. With this general objective, there have been some outstanding and noteworthy achievements. NMR has been demonstrated to be possible at the highest steady state field of 45 T produced at the lab, which is obtained in a superconducting and resistive hybrid magnet. NMR has also been demonstrated with useful results in the purely resistive Keck magnet, funded by the Keck Foundation, operating with a steady state field of 25 T, permitting many solid state NMR

Figure 2: Cross-section of BSCCO 2223 tape conductor (*Courtesy of American Superconductor Corporation).*

and some solution NMR experiments. For the advancement of high resolution NMR, the NHMFL instituted a program of superconducting magnet technology with a field objective of 25 T and above. The two components of the previous 25 T objective were the ultra wide bore 900 MHz magnet, to develop the technology of the required large outer magnet utilizing low temperature superconductors (LTS), and the development of an HTS insert magnet technology that is represented by the 5 T HTS insert coil.

The ultra wide bore magnet was not simply a 900 MHz NMR magnet, but a very large bore 900 MHz magnet, with an inner bore large enough to fit an insert coil for significantly higher fields. By accepting the challenge of a 900 MHz large bore magnet, the NHMFL thereby commissioned a program to address and solve the magnet engineering problems that are inherent in obtaining yet higher fields. The 900 MHz program was used to address a host of magnet technology issues, including the protection of high current density magnets with very large stored energy, reinforcement for the stress in the windings, leads for the brittle superconductor Nb_3Sn, and even a tough new epoxy for the impregnation of the coils. The manufacturing technology for such large coils required new processes. The technology development activities and the technology contained in the 900 MHz magnet is demonstrated by the results now being generated. Unique spectral results have been obtained in the solution NMR of membrane proteins, ^{17}O solid state NMR spectroscopy of an ion channel, and images of a mouse brain.

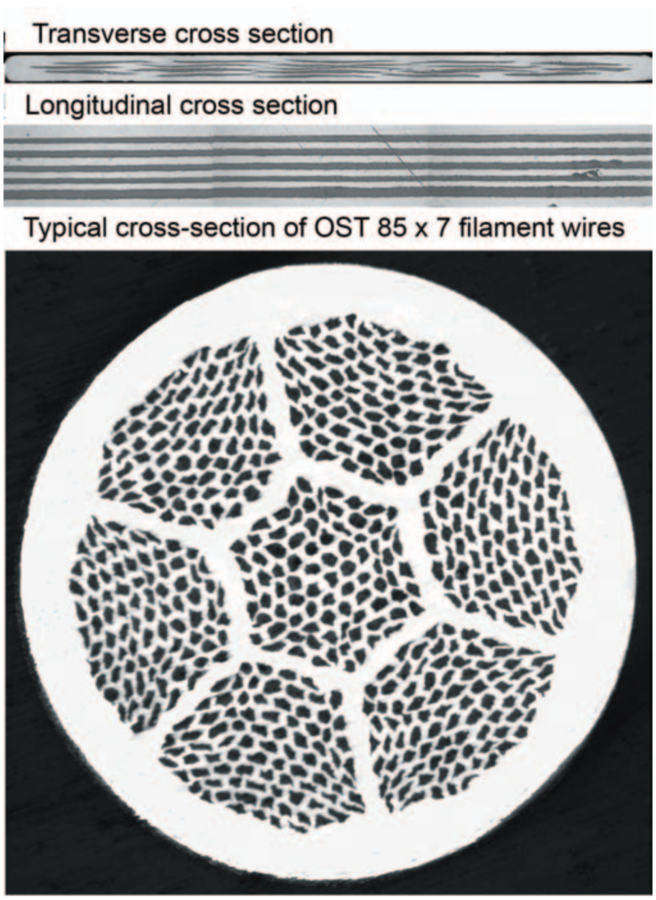


Figure 3: Cross-sections of BSCCO 2212 wire and tape conductors (*Courtesy of Oxford Superconducting Technology).*

The enabling technology for the 1.3 GHz/30 T magnet is contained in the inner high field coils, which will be wound from high temperature superconductors (HTS). The field range of applicability of LTS and HTS conductors can be seen in Fig. 1. The critical current density for the LTS conductors NbTi and Nb_3Sn, as used in the 900 MHz magnet for example, are seen to decrease rapidly beyond 10 T and 20 T, respectively. With additional developments, LTS conductors are estimated to be capable of extension to possibly 1 GHz/23.5 T. In contrast, as seen in Fig. 1, the critical current density of $Bi_2Sr_2CaCu_2O_x$ HTS conductor remains high and relatively flat to 30 T and much higher. A goal of 25 T or 30 T marks a clear requirement and commitment to HTS superconductor technology.

The technology of HTS superconductors—the making of practical wires and tapes that can be handled and processed for the making of high field magnets—is well underway but still a work in progress. HTS conductors have been plagued by fundamental problems of high sensitivity to heat treatment processing conditions, by the anisotropy of the superconducting critical current to the field direction, strain sensitivity, and oxygen compatibility of other necessary magnet materials, resulting in greatly reduced properties in applications. These issues are being addressed in a number of candidate HTS conductors including reinforced $Bi_2Sr_2Ca_2Cu_3O_x$ multifilamentary tape in Fig. 2, multifilamentary $Bi_2Sr_2CaCu_2O_x$ wire and tape in Fig. 3, $YBa_2Cu_3O_x$ tape in Fig. 4, and an emerging conductor MgB_2 shown in Fig. 5.

In order for the promise of HTS conductors to be realized in a new generation of high field magnets, not only are further advances in conductor technology required, but technological advances in other aspects of magnet engineering are essential. A primary characteristic of high field magnets is the high mechanical stress that is developed in the windings

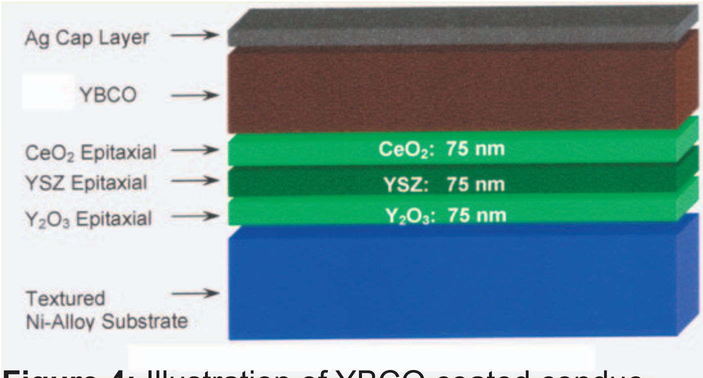


Figure 4: Illustration of YBCO coated conductor architecture (*Courtesy of American Superconductor Corporation).*

as a result of the Lorentz force interaction of the current and the generated magnetic field. The size of high field magnets, and indeed the very practicality of such magnets, is directly related to the science of high strength materials and the successful application of such materials in magnet technology. Increasingly, use is made of high strength fibers in the reinforcement layers of windings, and the results of nanotechnology in strengthening the non-superconducting metallic components of composite superconductors may prove to be important in achieving the potential for high field magnets.

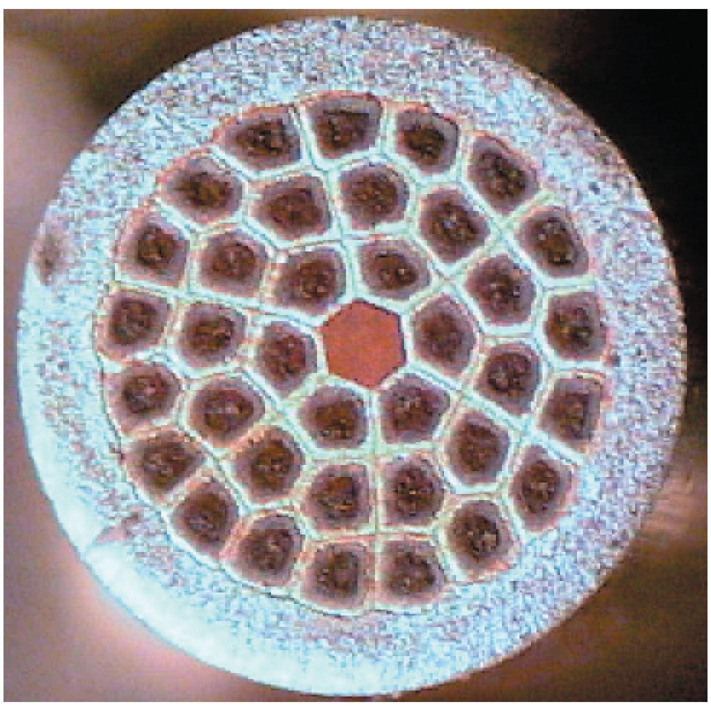


Figure 5: Cross-section of MgB_2 wire (*Courtesy of Hyper Tech Research).*

It should be appreciated that the highest field and strain sensitive HTS coils of a very high field magnet require reinforcement. The largest part of the magnet, and the location of the highest mechanical stress, is in the large LTS coils surrounding the smaller HTS inner coils. Once the proper operation of the HTS inner coils is assured by conductor technology, coil processing, sufficient reinforcement and the like, the greatest reduction in magnet size, and the greatest increase in the practicality of high field magnets is to be anticipated from improvements in the properties of the superconductors and structural materials that constitute the large outer coils in such magnets.

The goal of 30 T, as identified in the COHMAG report, is a field value that is exciting in its science potential and exciting in the challenge it poses to the technology. On the basis of our knowledge of HTS, and LTS, conductor properties, both superconducting and mechanical, and present practices in magnet technology, one may make initial estimates of the size and challenge of a 30 T high resolution NMR magnet. These initial estimates reinforce the perception that 30 T is an effective goal for motivating progress for two important reasons, in that it sets an inspiring challenge while being close enough within reach to be taken up as a real objective. At the same time, the scale of the device places a high priority on achieving improvements in a wide range of NMR magnet technology that will impact the size, the reliability, and the cost of such a magnet. This realization places emphasis on a program that considers many aspects of NMR magnet technology, including the further development of HTS superconductors into practical and reliable conductors for application to a device of the size of the 30 T magnet, and the further development of reinforcement materials and coil construction methods for both HTS and LTS technology. The overall capability in magnet technology and materials science at the NHMFL is well suited to the pursuit of the 30 T goal.

1 Report of the Committee on Opportunities in High Magnetic Field Science (Draft), National Research Council of the National Academies, The National Academies Press, Washington D.C. (2004).

2 Dixon, I.R., *et al*., *IEEE Trans. Appl. Supercond*., in press (2005).

3 Weijers, H.W., *et al*., *Supercond. Sci. Technol*. **17**, 636 (2004).

Korea Basic Science Institute Partners with NHMFL To Advance Technology

The NHMFL has developed strong interactions with major magnet-related research facilities in Japan, Germany, France, The Netherlands, Russia, and elsewhere. On February 28, the laboratory extended international interactions again when the Korea Basic Science Institute, located in Daejeon, South Korea, and the NHMFL opened the doors to the KBSI-NHMFL Research Collaboration Center during a ceremony at the NHMFL in Tallahassee. The new Center will promote basic scientific research, create knowledge and new opportunities for revolutionary technologies, and undertake development of new magnet systems for chemistry, biology, and other fields of science and engineering.

Chief Technology Officer Hans Schneider-Muntau presided over the event that included the signing of official documents, a ribbon-cutting ceremony, the exchange of presents, and a press conference. The Korean delegation included **Dr. Sang Dai Park**, Chairman of the Korea Research Council of Fundamental Science and Technology that provides funding to the KBSI; **Dr. Jung Soon Lee**, President of KBSI; **Dr. Jong Shin Yoo**, Vice President of KBSI; and **Dr. Yoo-Seung Kim**, President of the Korea Institute of Science and Technology. **Dr. Kirby Kemper**, President of the Florida State University Research Foundation and Vice President for Research and **Dr. Greg Boebinger**, Director of the NHMFL represented the NHMFL and FSU.

"The opening of the KBSI-NHMFL Research Collaboration Center expands and formalizes previous collaborative efforts between the NHMFL Ion Cyclotron Resonance Program and KBSI and demonstrates our mutual commitment to future scientific and engineering collaborations," said Boebinger.

KBSI President Lee concurs, and adds that "the KBSI has a long-term goal of establishing several user facilities for research in high magnetic fields, and the globally recognized credentials of the NHMFL, the premier magnet laboratory in the world, will ensure that the development of these facilities at the cutting edge of modern science will be successful." The KBSI-NHMFL Research Collaboration Center will be co-located with the NHMFL Magnet Science & Technology Program, and engineers and technologists from both groups will work closely with scientists in other programs at the laboratory toward common goals.

The first major initiative, already underway, is for a next-generation 21 T ICR superconducting magnet system that would provide a 45 percent increase in magnetic field over the current world-record 14.5 T Fourier transform ICR instrument at the NHMFL. ICR mass spectrometry is an extremely useful tool for analyzing complex chemical mixtures, such as crude oil, and molecular structures, such as proteins. The KBSI-NHMFL collaboration on the 21 T ICR magnet system includes both engineering design and construction phases, and its total cost is estimated to be approximately $10 million. The first system will be located at the NHMFL; the KBSI will get the second.

Future projects include the development of an unprecedented 1.1 to 1.3 GHz (approximately 25 T to 30 T) Nuclear Magnetic Resonance superconducting magnet system. This effort, along with the 21 T ICR project, will build on the NHMFL's successful development, construction, and operation of its 900 MHz (21.1 T) ultra-wide bore, NMR spectrometer completed in July 2004. This very complex research facility for NMR and MRI is an engineering feat: it stands 16 feet tall, weighs over 30,000 pounds, and has a stored energy of 40 megajoules. After seven months of operation, it continues to perform exceptionally well and is supporting a wide range of novel biological and chemical research projects.

In 2004, nearly 900 researchers (including over 200 scientists from outside the United States) used NHMFL facilities to advance their scientific efforts. The KBSI-NHMFL Research Collaboration Center aims to push the development of new magnet-related technologies, build new state-of-the-art research facilities, and offer users expanded capabilities and science opportunities.

In the closing remarks, Boebinger summed up the reasons for this and other international collaborations: "First, it's enjoyable! Scientific interactions present great opportunities to learn and exchange both knowledge and cultures. ***Through science we can create a community of humanity.*** Second, it promotes ***progress***. And third, it's sheer ***economics***. The latest two large magnets developed and now operating at the Magnet Lab cost about $15 million each. International exchanges and collaborations simply make sense."

Magnet Lab Celebrates World Year of Physics 2005

On February 26, 2005, the NHMFL hosted a record number of visitors for the 11th Annual Open House. Over 4,200 people took part in hands-on activities and demonstrations designed to translate research conducted at the laboratory for the general public. Visitors viewed: a new introductory video describing research conducted at the NHMFL after which they walked throughout the lab to see the record-setting 45 tesla Hybrid magnet and the new 900 megahertz superconducting magnet. Activities for all ages entertained crowds that marveled at explanations of complex physics concepts. A new feature of this year's Open House was the Great Magnet Lab Search Party that was enjoyed by a large number of children and adults. The Search Party consisted of four puzzles that were placed throughout the lab. Figuring out the solution was difficult!

Many of the laboratory's Community Classroom Consortium partners participated with special events and activities: St. Marks Wildlife Refuge, the Tallahassee Museum of History and Natural Science, the Challenger Learning Center, the Mary Brogan Museum of Art and Science, Joe Budd Aquatic Center, Saturday at the Sea, FSU Science on the Move, Museum of Florida History, LeMoyne Art Center, City of Tallahassee, Department of Environmental Protection, and others.

with 11th Annual Open House and “Focus on Physics”

While the NHMFL boasts a national and international focus, it is very involved with local, regional, and state education efforts, including school group tours, outreach programs, and curriculum products in use throughout the state. In January, a month-long series of activities and events designed to showcase the World Year of Physics 2005 and Einstein’s “Miraculous Year” kicked off at the LeRoy Collins Public Library in Tallahassee. The library, the NHMFL, and the American Association of Physics Teachers offered students, parents, and teachers exciting new resources and opportunities to explore physics concepts, important men and women in the field, and literary connections that enhanced the understanding of physics. “Focus on Physics” is part of the World Year of Physics 2005, a worldwide celebration of physics and its importance in our everyday lives.

The kick-off event included interactive demonstrations, hands-on activities, and book talks targeted to grades 4 through 8. All children were invited to participate in the “Find Your Way to Physics – Library Quest” month-long physics treasure hunt, which could be completed as a class or independent project. Students who submitted a completed form were eligible to win a free book and participate in the grand prize drawing for a bicycle. “Beat the Science Fair Blues,” a program to help students and their parents plan and execute a science fair experiment was held at local library branches. Each registered participant received a free copy of *Guide to More of the Best Science Fair Projects* and handouts.

North Florida Company Develops Airplane Navigation Equipment with Help from the Magnet Lab!

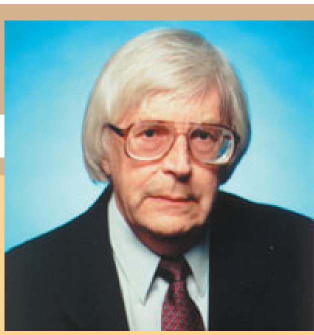
Utilizing the world-class research facilities of the National High Magnetic Field Laboratory, **Capital Avionics, Inc.** developed its latest product, the innovative **CA-320 Digital Compass System.** This equipment is used to calibrate compass components used in navigation systems on board aircraft. The current methods used by the industry rely on compass roses painted on surveyed taxiways. The airplane is parked on the compass rose and aligned with it as best as can be done by eye; then the navigational equipment on the airplane is calibrated. Problems arise because the compass roses may not exist at smaller airports, and because the local magnetic field changes over time. Capital Avionics' product does not depend on geographic points for magnetic reference. The actual magnetic field of the earth is detected and displayed relative to the airplane with unparalleled accuracy.

The CA-320 provides a much-needed solution to aircraft compass calibration problems. The Digital Compass transmitter and the receiver comprise the digital compass correction system. The transmitter attaches to the aircraft and a built-in laser pointer assists in the alignment of the unit with the longitudinal axis of the aircraft. Magnetic heading is transmitted to the receiver through a wireless link.

Capital Avionics, which is located at the Tallahassee Airport, worked with the NHMFL's DC Field Facility in collaboration with Jeff Owens, FSU Professor of Physics and small plane pilot, who assisted with the development of the CA-320. The NHMFL helped characterize the magnetic field generated in a Triaxial Helmholtz coil that Capital Avionics constructed to mimic the earth's field. The triaxial coil was then used to calibrate the CA-320.

The aviation community, military and civilian, are very interested in the CA-320 because compass systems can be aligned with it as an airplane taxis. New contracts include: General Dynamics, the Navy, and Cessna. Al Ingle, President of Capital Avionics, said that "working with the Magnet Lab was a truly pleasurable experience. The personnel were helpful and knowledgeable of magnetic fields. It was a joy." He also stated that they were really engaged in his project and did not act like he was just "some guy in their way."

Ingle was so excited about working with the laboratory and prospects for the CA-320, that he volunteered to participate in the 11th Annual Open House (see page 18). His demonstrations were a huge draw, and the traffic at his location was non-stop. The community was obviously excited to see a local company teaming up with the national laboratory in its neighborhood.



LEV P.
GOR'KOV

PEOPLE IN THE NEWS

Lev P. Gor'kov, a distinguished researcher at the NHMFL and FSU physicist, has been elected to the National Academy of Sciences—one of the highest honors that can be accorded a U.S. scientist or engineer. Gor'kov, who is internationally known for his pioneering work in the field of superconductivity, is one of 72 new members and 18 foreign associates from 14 countries elected by the academy in recognition of their distinguished and continuing achievements in original research. The National Academy of Sciences announced the new members following its May 3 meeting. "This is spectacular news and well deserved," said Gregory S. Boebinger, director of the NHMFL. "Membership in the National Academy of Sciences is one of the greatest of scientific accolades, and Lev is one of the world's great scientists."

Gor'kov, the director of the Condensed Matter Theory Program at the NHMFL, is one of the Magnet Lab's founding scientists. Kirby W. Kemper, FSU's vice president for research, said Gor'kov's presence was an early key to the laboratory's success. "When the Magnet Lab was formed, we were able to hire Robert Schrieffer and Lev Gor'kov, two of the biggest names in theoretical materials science—and they really put us on the map, helping us bring in students and top-notch faculty," he said. "To have the National Academy of Sciences honor Dr. Gor'kov for his five decades of research is really giving him his due."

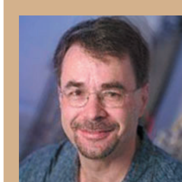
A native Russian, Gor'kov trained at the Moscow State University and eventually joined the theory group of the Landau Institute in Moscow. His work in superconductivity theory led to a number of conceptual breakthroughs, and he was awarded the Lenin Prize, Russia's highest award for scientific achievement, in 1966. He left Moscow for the United States and the NHMFL in 1992.

JAMES
BROOKS

James S. Brooks, FSU Professor of Physics and member of the NHMFL Condensed Matter/Experimental Science Group, was awarded the Distinguished Research Professor Award by Florida State University's Council on Research and Creativity for 2004-2005. He was recognized at the Faculty Awards Program and Research Recognition Dinner in April. He received $6,000 along with the title that is awarded to three professors annually in recognition of outstanding research or creative activity.

Brooks has worked in many areas of experimental low temperature and high magnetic field physics. International collaborations with Asian, Australian, and European research teams are a major component of his program. His main topic of interest in research is the Electronic and Magnetic Mechanisms in Low Dimensional and Novel Materials. This activity involves the investigation of the role of electronic anisotropy in molecular crystalline materials. The area of molecular crystals is an emerging area in the science and technology of electronic (conducting) materials. They link the realms of semiconductors, metals, and biological structures. The purpose of the research is to experimentally and computationally investigate the role of anisotropy in these materials. The methods include the use of electronic, magnetic, pressure, and optical probes to measure and manipulate their physical properties. Computational methods are also employed to predict trends in the changes in physical properties.

Brooks has a keen interest and dedication to K-12 and other outreach and research experience programs, where every summer his group expands to include teachers and students at all levels in his laboratory activities.



RAFAEL
BRÜSCHWEILER

Rafael P. Brüschweiler, George Matthew Edgar Professor of Chemistry and Biochemistry at FSU, has joined the NHMFL as Associate Director for Biophysics in CIMAR. Brüschweiler's research group studies the structure and dynamics of proteins by NMR spectroscopy and computer simulation and develops new methods for processing and analysis of multidimensional NMR data. He studied physics at ETH, where he graduated in solid-state physics and biophysics. After receiving his Ph.D. in 1991, which was awarded with the Medal of ETH, he moved with a fellowship from the Swiss National Science Foundation to The Scripps Research Institute in La Jolla, California. In 1996, he received the Werner Prize of the New Swiss Chemical Society.

DAVID
GRAF

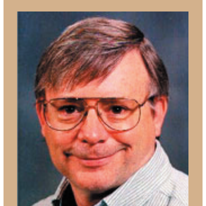
David E. Graf, who has worked in the NHMFL Condensed Matter/Experimental Science Group since 1999, is the first recipient of the Jack E. Crow Postdoctoral Fellowship named for the founding director of the NHMFL. Crow's commitment to education and research at the Magnet Lab is a well-known legacy. Graf graduated from SUNY College at Buffalo in 1998 and received his M.S. in Physics in 2001 from the Florida State University. His research interest is in high B/T phenomenon in low-dimensional organic compounds and his previous professional experience includes a 1997-98 Research Internship in Mössbauer Spectroscopy and a Summer 1998 Research Internship at NIST (Gaithersburg, Maryland).

YOUNGJUNG JO

Younjung Jo, recent graduate of Ewha Womans University in Seoul, Korea, is the second recipient of the Schuler Postdoctoral Fellowship, named in honor of Mr. and Mrs. John N. Schuler of Longboat Key, Florida. Jo, who received her Ph.D. in physics, has three years visiting research experience at the NHMFL experimenting with the 33 T and 25 T magnets and the ^{3}He refrigerator, as well as user experiences with the National Institute for Material Science in Tsukua, Japan, and the Technical University Dresden in Germany. Her skills include cryogenic techniques under very high magnetic fields and high pressure measurements through the use of piston-cylinders-clamp-like pressure cells applied to organic superconductors. She has published more than fifteen scientific papers. At the NHMFL, she will work with Luis Balicas in a variety of topics, such as pressure effects on the metamagnetic quantum critical point of $CeAuSb_2$, Hall-effect studies in the same compound, fermiology in exotic materials such as the cobaltites, ruthenates and cuprates, high-field and high pressure studies in an iridate based new spin liquid system (in collaboration with the University of Kyoto), among others, as well as projects of her own.

MASASHI KOSAKA

Masashi Kosaka, an Assistant Professor at Saitama University under N. Mori (retired Director of Extreme Conditions Laboratory, ISSP, U. Tokyo), is visiting the NHMFL Instrumentation Group for ten months to learn how to perform high pressure electrical transport measurements in a diamond anvil cell. He will study the effect of pressure and magnetic fields on $YbAl_3C_3$ an intermetallic compound that shows a quadrupolar ordering at 80 K. A second material of interest is Ce_3PbC that undergoes a transition to an antiferromagnetic state at $T_N = 8.4$ K and shows a second transition at $T_t = 6.0$ K. He is working with Stan Tozer and may be contacted via e-mail at *kosaka@magnet.fsu.edu*.

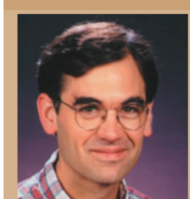


DAVID TANNER

David Tanner, UF Distinguished Professor of Physics, was honored with a three-day symposium for his 60th birthday. *Tannerfest 2005* included talks in the many areas of science where Tanner has made lasting contributions, a reception at the Harn Art Museum, a poster session, and a lab tour. David Reitze, one of the conference organizers, said "the breadth of presentations spanning from 'The Gap in High-Tc' to 'David Tanner and the Search for Dark Matter' is a testament to the impact David has over a wide range of physics." Jan Musfeldt, another organizer, said, "We expect to see you all back in ten years to celebrate David's 70th birthday!"

Grants

Art Edison Awarded Human Frontier Science Program Grant



ART EDISON

Art Edison was recently awarded a major grant from the Human Frontier Science Program. HFSP is an international agency that funds large projects at the interface of biology and physical sciences with collaborating investigators from different participating countries. Edison's grant includes collaborators from Cal Tech/HHMI (Paul Sternberg), the MRC in Cambridge (Mario de Bono), and the USDA laboratory (Peter Teal).

Edison, an NHMFL faculty member at the University of Florida, acknowledged the importance of the NHMFL-UF connection: "The incredible resources and people in the NHMFL have helped make this project possible, especially new microcoil and HTS probe development at the Advanced Magnetic Resonance Imaging and Spectroscopy facility at the University of Florida's McKnight Brain Institute (with Andrew Webb and Bill Brey and their teams) that allow very small amounts of materials to be studied using NMR."

Caenorhabditis elegans

The project, "Discovery of *Caenorhabditis elegans* Chemical Ecology," involves the isolation, identification, and biological characterization of chemicals secreted by *C. elegans*, one of the best studied animals on earth. *C. elegans* was the first metazoan to have its genome sequenced. Its entire cell lineage from a single fertilized egg to an adult is known and has been related to the animal's anatomy, and its anatomy has been comprehensively described by ultra high resolution electron microscopy. *C. elegans* is particularly tractable for genetic studies, and as a result many complicated genetic pathways have been identified. The importance of these studies was recently recognized by the 2002 Nobel Prize in Medicine to three pioneers in the field: Sydney Brenner, Robert Horvitz, and John Sulston. Despite this wealth of genetic, cellular, and anatomical information, almost nothing is known about the chemistry that *C. elegans* uses to communicate between individuals and its environment. The goal of the project is to identify several different molecules produced by the worm in order to begin to decipher its chemical language. This information will not only add to the extensive scientific knowledge of *C. elegans* but may provide important new clues for the biological control of other nematode parasites of plants or animals.

Ira Flatow Tours Magnet Lab

The host of National Public Radio's popular weekly science program, *Talk of the Nation – Science Friday*, took a break from program preparations to visit the NHMFL on Thursday, April 7. The tour included stops at Optical Microscopy, the state-of-the-art ICR facilities, and the newly commissioned wide bore, 900 MHz NMR magnet. Flatow was particularly impressed by the applications of the 900 MHz instrument, such as the protein sequencing research currently underway and investigations into tuberculosis and possibly the bird flu.

In the DC Field Facility, Bruce Brandt explained the range of research conducted in the world-class 45 T Hybrid magnet. One example cited involves the effect of magnetic fields on frog eggs—and whether the position of the sample in the magnetic field, nearer the top or the bottom—would make a difference. Flatow asked, "why would you do that?" The answer was simple and exceedingly well received as it speaks to the heart of basic research—"to see what happens!" Flatow was also introduced to one of the laboratory's newest postdoctoral fellows, David Graf (see page 21). Graf is an outstanding science communicator who is actively involved in educational outreach at the NHMFL. While a graduate student at FSU, Graf was supported by the NSF-funded GK12 program, which encourages graduate students to engage with students in K12 classrooms. Graf is also the first recipient of the Jack E. Crow Fellowship, named for the founding director.

At the end of the fast-paced hour, Flatow remarked, "I was already familiar with the Magnet Lab and am delighted that I had this opportunity to visit. I've picked-up several ideas for future shows (*Science Friday*)." Flatow was at Florida State University to broadcast his live two-hour show on Friday, April 8. The show focused on end-of-life care issues and the sociological aspects of aging and how technology can be used to assist an aging population—both very contemporary issues, particularly in Florida. FSU experts in these fields were included in the discussions. The event marked the first time that the Washington-D.C.-based program, launched in 1991, has broadcast from the campus of a Florida university.

Relay for Life

The Magnet Lab entered ***four*** teams in the Relay For Life event held at FSU on April 1-2. Mrs. Joan Crow (standing, left of poster), wife of NHMFL founding director Jack Crow, was the Honorary Chairman for the university-wide campaign that attracted 76 teams and collected more than $123,000. Relay For Life at FSU was a student-run, overnight event designed to celebrate survivorship and raise money for research, advocacy, education, and patient services programs of the American Cancer Society. The Magnet Lab teams collected over $15,500 and had participants on the track throughout the night.

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CONFERENCES & WORKSHOPS

Electronic Properties of Two-Dimensional Systems and Modulated Semiconductor Structures (EP2DS-16)
http://ep2ds-16.sandia.gov/
July 10-15, 2005
Albuquerque, New Mexico
Contact: Diane Gaylord
ep2ds-16@sandia.gov
505-284-2092

Complex Behavior in Correlated Electron Systems
http://www.lc.leidenuniv.nl/lc/web/2005/20050801/info.php3?wsid=127
August 1-18, 2005
Leiden, The Netherlands
Contact: Vlad Dobrosavljevic
vlad@magnet.fsu.edu
850-644-5693

Physical Phenomena at High Magnetic Fields-V (PPHMF-V)
http://pphmf5.magnet.fsu.edu
August 5-9, 2005
Tallahassee, Florida
Contact: Diane Nakasone/Alice Hobbs
pphmf5@magnet.fsu.edu
850-644-9186/644-3665

24th International Conference on Low Temperature Physics (LT24)
http://www.phys.ufl.edu/~lt24/
August 10-17, 2005
Orlando, Florida
Contact: Gary Ihas
lt24@phys.ufl.edu
352-392-9244

International Conference on Ultra-Low Temperature Physics (ULT2005)
http://www.clas.ufl.edu/ULT2005/
August 11-17, 2005
University of Florida, Gainesville
Contact: Carol Binello
cbinello@clas.ufl.edu
352-392-0780

Sixth International Symposium on Crystalline Organic Metals, Superconductors, and Ferromagnets (ISCOM 2005)
http://iscom.magnet.fsu.edu
September 11-16, 2005
Key West, Florida
Contact: Jim Brooks
850-644-2836
iscom2005@magnet.fsu.edu
or Diane Nakasone
850-644-9186

8th International Symposium on Magnetic Suspension Technology
http://www.ifw-dresden.de/imw/ISMST8/
September 26-28, 2005
Dresden, Germany
Contact: Hans Schneider-Muntau
smuntau@magnet.fsu.edu
850-644-0863