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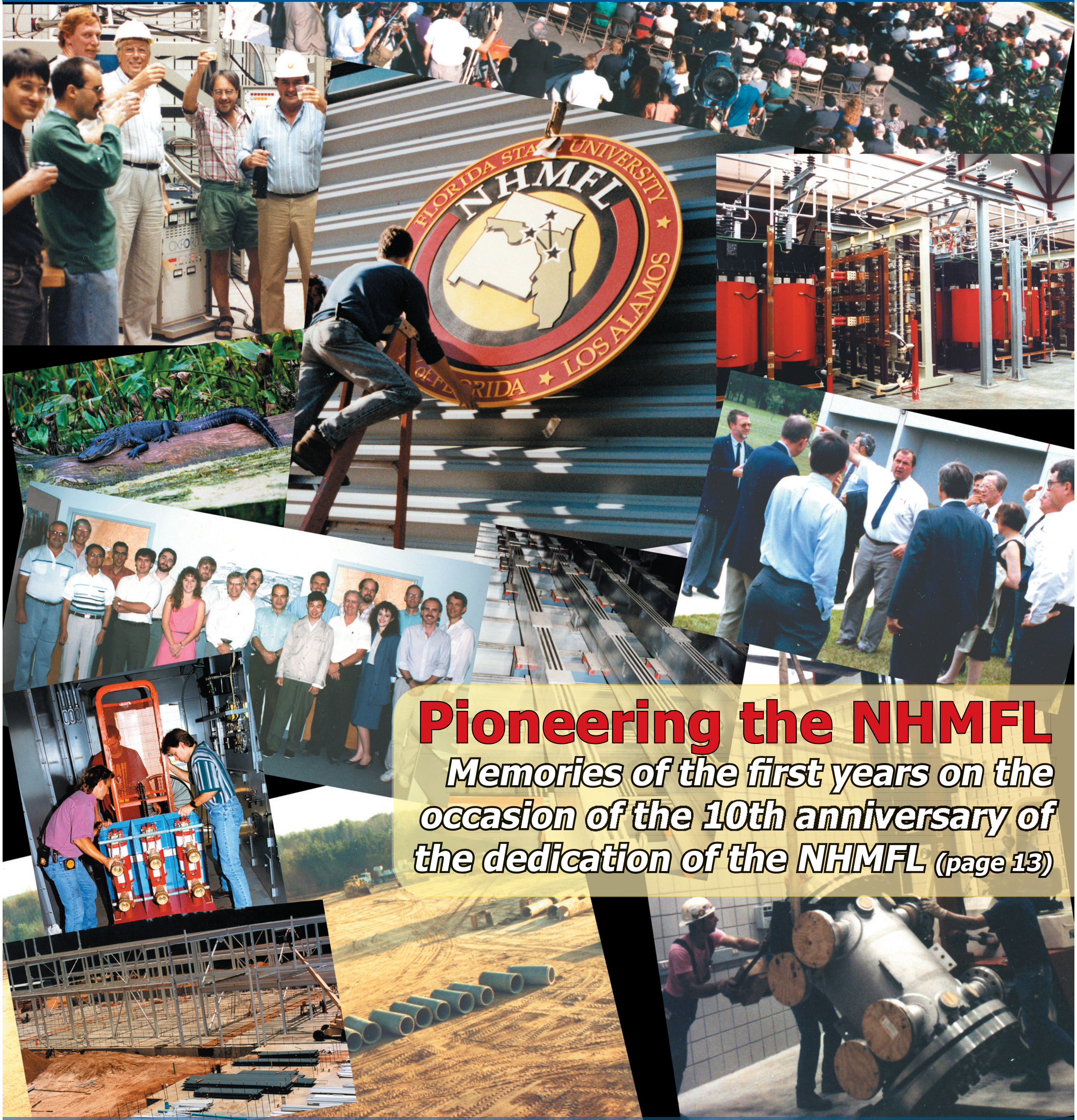

Pioneering the NHMFL

Memories of the first years on the occasion of the 10th anniversary of the dedication of the NHMFL *(page 13)*

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NHMFL REPORTS

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FROM THE DIRECTOR'S DESK

Greg Boebinger

Thankfully, the Atlantic hurricane season is coming to an end, and I am pleased to report that the NHMFL staff kept user operations going nearly uninterrupted throughout each of the four fierce storms—Charlie, Francis, Ivan, and Jeanne—that toppled trees and flooded communities in the Tallahassee and Gainesville regions. As for the laboratory, our Director of Facilities and Safety, John Kynoch, reports the most serious damage as a tattered flag at the entrance to our building.

The next big event is the NHMFL Users' Committee in Tallahassee on November 12-13. This committee is charged with providing broad representation of the NHMFL users community and we rely on their input and guidance in managing the laboratory. It is also an opportunity for the NHMFL to present a snapshot of the "State of the Laboratory." Viewgraphs of the presentations will be posted on the NHMFL Web site (*www.magnet.fsu.edu*) shortly after the meeting.

In addition to the NHMFL Users' Committee, which addresses NHMFL-wide issues, the NMR and ICR user facilities at the NHMFL each have their own advisory Users' Committees. We will be exploring the establishment of other specialized Users' Committees at the NHMFL to further increase user involvement in laboratory planning. I would like to thank members of all of these committees for their service on behalf of the NHMFL. Newly elected members of these committees will be announced in an upcoming issue of *NHMFL Reports*.

A few new initiatives to be discussed at the NHMFL Users' meeting are: (1) NHMFL organizational changes; (2) NHMFL funding priorities for fiscal year 2005; (3) a roadmap for future magnet science and technology development; (3) a "Big Light" initiative to propose the design and construction of an IR-FIR-THz Free Electron Laser (FEL) to couple to our suite of DC magnets; and (4) developing NHMFL collaborations with the Advanced Photon Source at Argonne National Laboratory and the Spallation Neutron Source at Oak Ridge National Laboratory to bring "Big Magnets" together with "Bright X-rays" and "Bright Neutrons."

Turning attention to this issue of *NHMFL Reports*, we find an article by Professor Andrew Rinzler and colleagues at the University of Florida on *Nanotube Films as Transparent Conducting Materials* (page 4). This research, first published in the August 27 issue of *Science*, finds very interesting transport and optical properties of nanotubes films that have revolutionary implications for flexible opto-electronics. To learn about other recent publications resulting from NHMFL research, please see our Web site (*www.magnet.fsu.edu*) and click "***New*** Pubs & Talks" in the right-hand menu.

This issue also contains a report on the NHMFL In-House Research Program (IHRP), a competitive program to stimulate cutting-edge research that advances the NHMFL user programs. The 2004 solicitation resulted in seven funded projects (see page 9) from "the strongest set of proposals received in the history of the IHRP program" in the opinion of NHMFL Chief Scientist Bob Schrieffer. John Eyler at the NHMFL/UF has directed the IHRP for three years and I would like to thank him—most sincerely—for his service. Directing this program requires a significant commitment of time and effort, and we are pleased that Lloyd Engel at the NHMFL/FSU has "volunteered" to direct IHRP for the next two years.

Finally, please note in the schedule of upcoming NHMFL conferences (see back cover) that *Physical Phenomena at High Magnetic Fields – V* will be held in Tallahassee on August 5-9, 2005. Since 1991, Bob Schrieffer has been instrumental in organizing these flagship NHMFL conferences that have become an important venue for discussing condensed matter physics relevant to magnetic field research. With PPHMF-V, we are seeking to broaden the scope to include a more complete representation of the range of NHMFL research activities. We anticipate setting aside one day for parallel Resonance and Condensed Matter sessions, followed by forums that encourage interdisciplinary discussions. Please plan to join us at PPHMF-V next summer!

Rock and Roll,

FROM THE CHIEF SCIENTIST'S DESK

J. Robert Schrieffer

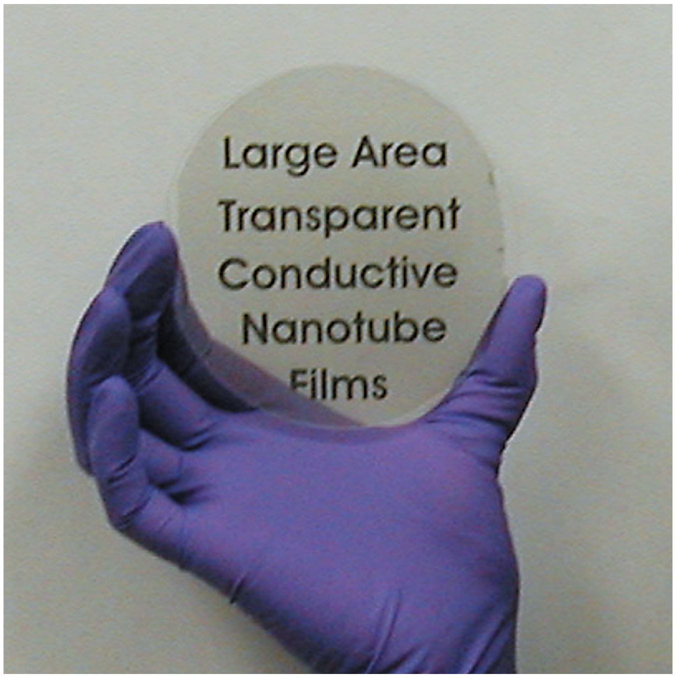
High quality nanotube films that are both electrically conductive and transparent have been developed. In addition, because they are flexible and able to be doped as either p-type or n-type conductors, nanotube films might someday replace existing transparent conducting oxides in a rapidly growing array of technologies. This very interesting work by a group at the University of Florida was recently featured in *Science*.[3]

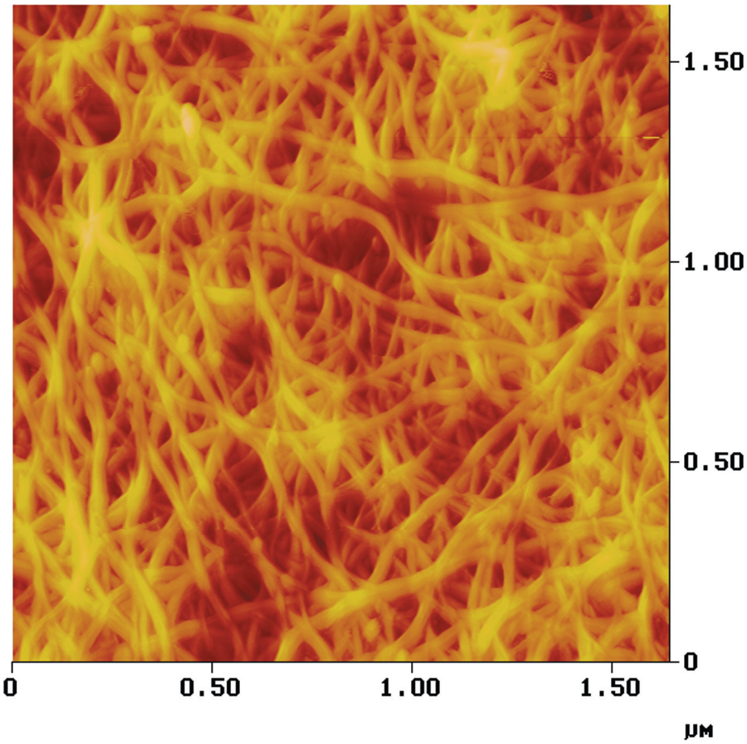
Nanotube Films as Transparent Conducting Materials

A.G. Rinzler, UF, Department of Physics

If not for a handful of materials, the properties of optical transparency and good electrical conductivity would be mutually exclusive. Glasses and plastics are nicely transparent, but they are generally electrically insulating. Metals, on the other hand, while being good electrical conductors, tend to be opaque. They can be made very thin and thereby transparent, but most metals oxidize the depth of the film making for poor conductors and the precious metals, which don't oxidize, don't like to form contiguous films, so their conductivity when thin enough to be transparent, is also poor. This leaves a handful of semiconductors: the transparent conducting oxides (TCOs), like indium tin oxide, to carry the burden. And a big burden it is because modern technology depends heavily on the use of transparent conducting films and the need keeps growing. Where? Well, in computer laptop displays, in infrared light emitting diodes (LEDs) like in TV remotes and their photodiode receivers, in the visible LEDs you see in traffic lights and commercial signs, in each of the megapixels of digital cameras, in photocopiers, in solar cells, and in digital watch displays. The list goes on. Given this ubiquity the TCOs are obviously very successful. Nevertheless there remains considerable room for improvement. The conductivity of the TCOs depends critically on their oxygen doping, which is finicky to control, and limits their temperature tolerance during device fabrication. The TCOs are brittle, limiting their use to rigid devices. Finally, most TCOs are n-type conductors, which limits the range of materials to which they can electrically couple without the formation of significant contact barriers.

Now a group of researchers at the University of Florida has demonstrated that thin films of pure single walled carbon nanotubes (SWNTs) can provide transparent conductors having properties complimentary to if not outright competitive with the TCOs. Fabrication of the films and application to GaN based light emitting diodes were first reported in the *Journal Nano Letters*.[1,2] Elaboration of the film fabrication process and optical and electronic characterization appeared in the August 27th issue of *Science*.[3] The nanotube films are distinguished by having higher electrical conductivity, for equal transparency in the mid-IR compared to other known materials; they are highly flexible, with no degradation in their opto-electronic properties after repeated flexing; and the semiconducting nanotubes in





Figures. A transparent nanotube films (text lies behind the film) and its microstructure (AFM image, right).

the mixture of ~1/3 metallic, 2/3 semiconducting, tend to be p-type conductors, although by simple chemical charge transfer doping (effected by exposure to vapors of the appropriate chemicals) their carrier concentration can be modulated all the way to n-type. This means that the nanotube films should permit the coupling of current into a broad range of materials.

How do the nanotubes achieve a simultaneous high transparency in the mid IR and good electrical conductivity? Part of the high transparency is explained by the low nanotube carrier density, which limits their free carrier absorption. Low carrier density usually spells poor conductivity, however, the remarkably high mobility of the itinerant carriers in the nanotube atomic lattice makes for a good electrical conductivity, despite the low carrier density. One further feature contributes to the high transparency. Optical absorption is suppressed in the nanotubes for components of the incident radiation polarized perpendicular to the nanotube axis. This was first inferred several years ago by the UF researchers from polarized Raman spectroscopic data on fibers of aligned nanotubes[4] and subsequently confirmed by reflectance measurements on such fibers.[5]

High magnetic fields will soon be of relevance in this research. In 2001, Rick Smalley's group from Rice University used the high field facilities of the NHMFL to produce optically dense films of aligned nanotubes. This magnetic field induced alignment is consistent with the present method for forming the transparent films. Aligned, transparent nanotube films will be useful both for further scientific exploration of the one-dimensional character of the nanotubes themselves and for exploration of the technical limits of the film transparency to polarized light.

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1. Z. Chen, *et al.*, *Nano Letters*, **3**, 1245 (2003).
2. K. Lee, *et al.*, *Nano Lett.*, **4**, 911 (2004).
3. Z. Wu, *et al.*, *Science*, **305**, 1273 (2004).
4. H. H. Gommans, *et al.*, *J. Appl. Phys.*, **88**, 2509 (2000).
5. J. Hwang, *et al.*, *Phys. Rev. B*, **62**, R13310 (2000).
6. D. A. Walters, *et al.*, *Chemical Physics Letters*, **338**, 14-20 (2001).

Bruce Brandt, Director, DC Field Facilities

The instrumentation available to users is always being improved, sometimes in small ways, sometimes by the addition of completely new capabilities. The demand for the Sub-Millimeter Wave Spectroscopy facility for experiments in biology, chemistry, and physics has increased steadily since it was first described in this newsletter about two years ago (*NHMFL Reports, Summer 2002*). Papers describing the results have appeared in *JACS, Phys. Rev., Phys Rev. Letters*, and other journals. Sergei Zvyagin wrote the article below about one of those projects, which exploits some very old ideas to understand a very new problem. The results, just published in the *Physical Review Letters*, suggest that copper pyrimidine dinitrate, a new molecular magnet, is the best candidate to date for studying solitary wave dynamics on the quantum level.

Solitary Waves in Quantum Spin Chains

S.A. Zvyagin, NHMFL
J. Krzystek, NHMFL
R.L. Desilets, NHMFL
A.K. Kolezhuk, Institute of Magnetism, Ukraine and University of Hannover, Germany
R. Feyerherm, Hahn-Meitner-Institute, Germany

The term "soliton" was introduced in the 1960's; however, the scientific research of solitons started in the 19th century when a Scottish engineer and scientist John Scott Russell (1808-1882) observed a large solitary wave while watching wave propagation in shallow water on Union Canal at Hermiston near Edinburgh. Following this discovery, Russell built a 30 ft. wave tank in his backyard and made further important observations on properties of solitary waves that he called Waves of Translation. In the days of Russell, there was much debate concerning the very existence of this kind of solitary wave.

Nowadays, many differential nonlinear equations are known to possess soliton solutions. The sine-Gordon equation

$$\left(\frac{\partial^2}{\partial t^2}\phi(x,t)\right)-\left(\frac{\partial^2}{\partial x^2}\phi(x,t)\right)+\sin(\phi(x,t))=0$$

is one of the most famous "soliton" equations, which is used for a description of a broad class of nonlinear phenomena (see for instance, Ref. 1 and references therein): self-focusing refraction in atom and molecular lasers, magnetic-flux dynamics in Josephson junctions, light propagation in ultrafast fiber-optical intercontinental communication systems, formation of black holes, and even energy transport in biomolecules. The availability of the exact solutions for the sine-Gordon model (soliton, antisoliton, and multiple soliton-antisoliton bound states called breathers) allows a very precise theoretical description of many observable properties and physical parameters of sine-Gordon systems.

On the quantum level the sine-Gordon model is one of the paradigms of the quantum field theory. One of the most basic quantum-mechanical systems is a uniform chain of antiferromagnetically (AFM) coupled S=1/2 spins. Since the S=1/2 AFM chain is critical, even small perturbations can considerably change fundamental properties of the system. One of the most prominent examples is an S=1/2 AFM chain perturbed by an alternating g-tensor and/or the Dzyaloshinskii-Moriya interaction; this situation is realized experimentally in several spin chain systems.[2] In the presence of such interactions, application of a uniform external field H induces an effective transverse staggered field $h \sim H$, which leads to the opening of an energy gap $\Delta \sim H^{2/3}$. The gapped phase can be effectively described by the quantum sine-Gordon field theory recently developed by Oshikawa and Affleck.[3] They predicted a rich solitary wave excitation spectrum consisting of solitons and breathers.

Our study was a detailed investigation of the elementary excitation spectrum in the molecular magnet copper pyrimidine dinitrate (Cu-PM). It has been recently identified as an S=1/2 antiferromagnetic chain system with a field-induced spin gap, and appears to be the best realization of the quantum sine-Gordon spin chain model known to date. The excitation spectrum was studied using a

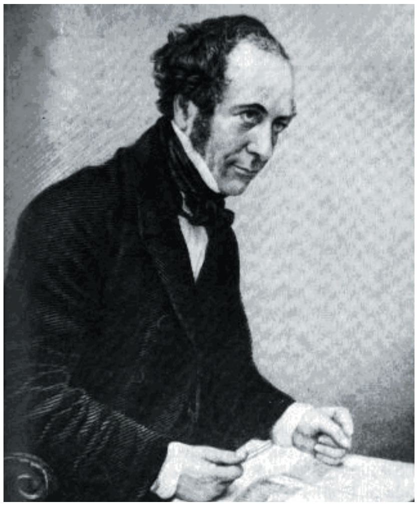

Figure 1. John Scott Russell, a Scottish engineer and scientist, who discovered solitary waves.

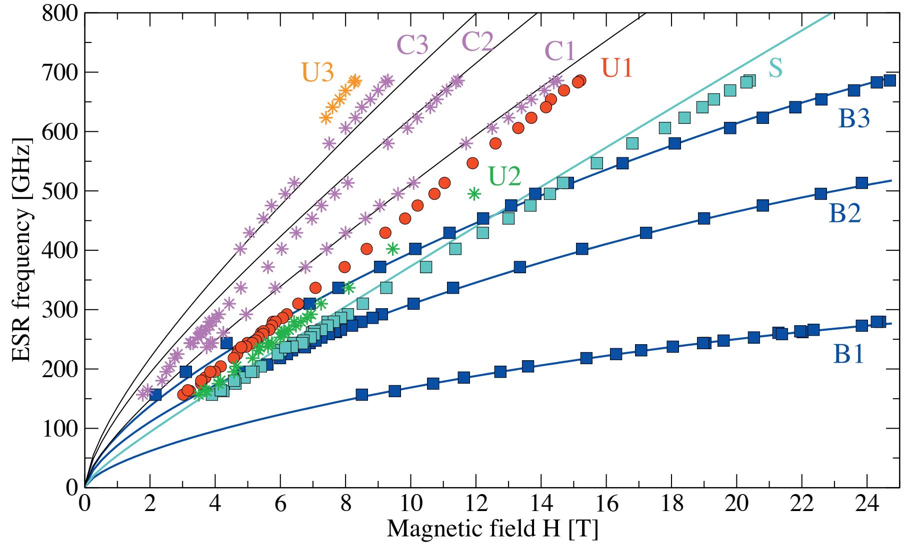

Figure 2. The frequency-field diagram of the ESR modes in Cu-PM. Symbols denote experimental results and lines corresponds to contributions from specific excitations as predicted by the sine-Gordon quantum field theory: the mode S corresponds to soliton excitations, the modes B1-B3 correspond to breather excitations.

high-field tunable-frequency submillimeter wave electron spin resonance (ESR) spectrometer, recently developed at the National High Magnetic Field Laboratory, Tallahassee.[4]

The complete frequency-field diagram of magnetic excitations in Cu-PM is presented in Fig. 2. *Ten* ESR modes were resolved in the low-temperature spectrum, and their excitation diagram was systematically studied in a broad frequency-field range. For the first time, the field-induced gap in Cu-PM has been observed *directly*. We showed that the size of the gap was determined by excitation energy of the first breather (mode B1, Fig. 2). By comparing the entire set of data with theoretical predictions,[3] we have provided clear experimental evidence for a number of excitations: one soliton (S), three breathers (B1-B3), and several soliton-breather bound excitations (C1-C3) have been observed. The origin of the modes U1-U3 still remains unexplained. Thus, for the first time a complete set of excitations predicted by the sine-Gordon quantum field theory in a quantum spin chain has been confirmed experimentally. It is amazing that waves in shallow water and in quantum spin chains have so much common in their behavior . . .

For more information see S.A. Zvyagin, *et al.*, *Phys. Rev. Lett.*, **93**, 027201 (2004).

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[1] D.K. Cambell, *et al.*, *Physics Today*, **57**, 43 (2004).
[2] D.C. Dender, *et al.*, *Phys. Rev. Lett.*, **79**, 1750 (1997); R. Feyerherm, *et al.*, *J. Phys.: Condens. Matter*, **12**, 8495 (2000); M. Kenzelmann, *et al.*, *Phys. Rev. Lett.*, **93**, 017204 (2004).
[3] M. Oshikawa and I. Affleck, *Phys. Rev. Lett.*, **79**, 2883 (1997); I. Affleck and M. Oshikawa, *Phys. Rev. B*, **60**, 1038 (1999), *ibid.* **62**, 9200 (2000).
[4] S.A. Zvyagin, *et al.*, *Phys. B: Condens. Matter*, **346**, 1 (2004).

2004 NHMFL Annual Reporting

Users of NHMFL facilities and faculty supported by the laboratory are required to report their research and publication activities each year. This information—research reports and an accounting of all NHMFL-related publications, presentations, and related activities—is provided to the National Science Foundation, our principal funding agency, and to critical review and advisory committees.

Annual reporting is conducted online: *http://reporting.magnet.fsu.edu*.

Reports Submission Deadline: Wednesday, December 15, 2004

Important change for 2004: Researchers and users who have submitted reports in the past will recall that the production process included a final proof review/corrections stage. In an effort to expedite production, to conserve resources, and to take advantage of information management technologies, the proof review stage has been eliminated. Research reports must be submitted this year in final, camera-ready format. They will be published on the Web site essentially as submitted.

Please refer to the Web site for complete instructions.

Questions? Contact Kathy Hedick, 850-644-6392, hedick@magnet.fsu.edu

Tim Cross, NMR Program Director

900 MHz Commissioning Phase Update

W.W. Brey, NMR Program

The Commissioning Phase of the 900 ultra-wide bore magnet is proceeding on schedule. Although the priority is on tuning up and demonstrating the instrument, there has been significant time for preliminary science activities that are particularly appropriate for this unique instrument and can make use of the capabilities that are presently available. Both solid state and solution activities are progressing, while imaging waits for probes and gradients that have been promised for delivery by Bruker in late 2004. The in-house static HX probe is being used for ^{17}O applications where its high sensitivity on the X channel is helpful, while we improve the ^{1}H B1 (see figure). The Bruker 3.2 mm HCN probe has been used for double and triple resonance biological spectra, but we are continuing to work with Bruker to demonstrate the appropriate sensitivity. We have also run ^{27}Al and other quadrupole nuclei close to ^{13}C in double-resonance mode with enhanced sensitivity. As expected, solution NMR is proceeding more slowly, but the drift correction system is working quite well and we are starting to look at water suppression and 2D spectroscopy. We encourage any potential users who feel their applications may benefit from the high field and wide bore of this system to contact NMR Director Timothy Cross.

Unique Cation Binding Studies at 900 MHz

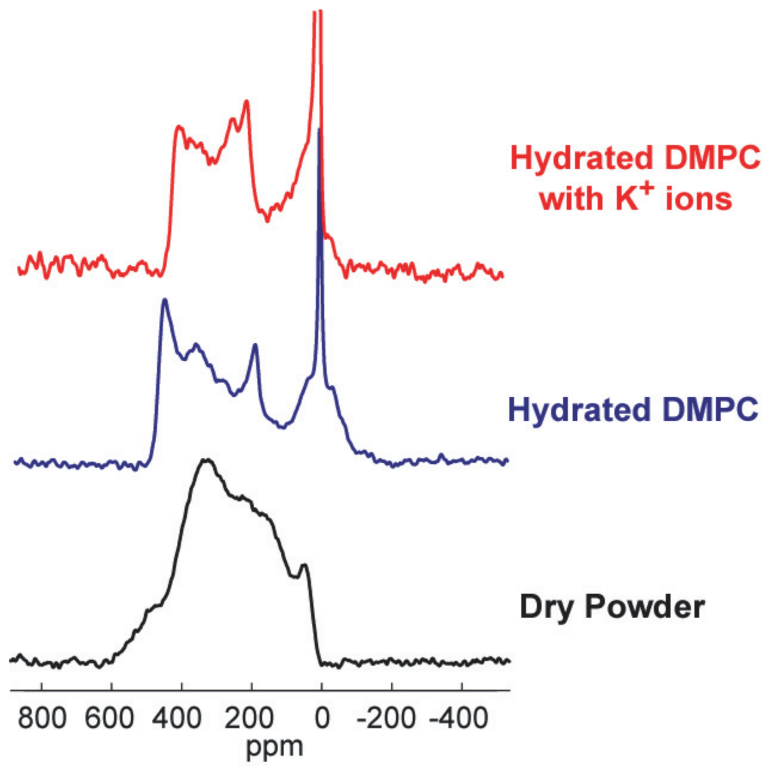

Figure. ^{17}O wideline NMR spectra of randomly oriented Leu_{10}-^{17}O gramicidin A at various sample conditions. The spectra show dramatic changes with hydration and cation binding allowing us to characterize ion-protein interactions. (J. Hu, B. Brey, P. Gorkov, E. Chekmenev, T.A. Cross, NHMFL/Tallahassee)

For more information, please contact William Brey at 850-645-3293 or wbrey@magnet.fsu.edu

In-House Research Program Funds Seven Projects

The NHMFL In-House Research Program was established in 1996 to stimulate magnet and facility development and to provide intellectual leadership for experimental and theoretical research in magnetic materials and phenomena. The ninth solicitation was conducted this year and attracted 22 pre-proposals representing FSU, UF, and the NHMFL at LANL. Of the 22 proposals, 13 were selected to advance to the full-proposal stage, and 7 were ultimately funded (see table).

John Eyler at the University of Florida has directed the program for three years for Bob Schrieffer, the Chief Scientist of the laboratory. As is tradition, the directorship now rotates to FSU; Lloyd Engel of the Condensed Matter Science Program will begin his term with the 2005 solicitation.

2004 IHRP Awards

Principal Investigator, Institution & Project Title	Amount Funded (k$) Over 2 yrs
PI: Yong-Jie Wang (NHMFL-FSU) **Project:** Study of Submillimeter Wave and Infrared Radiation - Induced Resistance Oscillations in Ultra High Mobility 2D Electron Systems in High Magnetic Fields	**$174.0**
PI: Randolph Duran (UF) **Project:** High Magnetic Gradient Studies of Multi-Component Core-Shell Particle Dynamics	**$176.0**
PI: David Reitze (UF) **Project:** Ultrafast Coherent Control in High Magnetic Fields	**$161.0**
PI: Yan Xin (NHMFL-FSU) **Project:** High Strength-High Modulus Reinforcement Materials for Magnets	**$206.0**
PI: Alexander Angerhofer (UF) **Project:** New EPR Techniques Applied to Oxalate Decarboxylase and Model Systems	**$165.0**
PI: Dmitry Smirnov (NHMFL-FSU) **Project:** Magneto spectroscopy of and with IR and THz quantum cascade lasers	**$181.5**
PI: Marcelo Jaime (LANL) **Project:** Detection of a Coherent Spin Fluid in Quantum Magnets	**$182.0**

PULSED FIELD USERS PROGRAM
ATTENTION USERS

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

R.D. McDonald and collaborators have recently demonstrated the sensitivity of their GHz-frequency conductivity technique by measuring quantum oscillations in a 50 T short pulse magnet. These GHz-frequency techniques are not only an exciting addition to the User Program's pulsed field capabilities, but also mark an important milestone in the development of instrumentation for dynamic ultra high magnetic field environments such as the single-turn magnet facility currently under construction at the NHMFL in Los Alamos.

Pulsed-Magnetic Field GHz-Frequency Conductivity Measurements

R.D. McDonald, NHMFL/Los Alamos
P.A. Goddard, NHMFL/Los Alamos
N. Harrison, NHMFL/Los Alamos
C.H. Mielke, NHMFL/Los Alamos
J. Singleton, NHMFL/ Los Alamos

Probing the excitations and ground state properties of correlated electron systems in high magnetic fields provides invaluable insight into their behavior. In many highly correlated systems of interest, the energy scale of these excitations and interactions corresponds to light with a frequency of tens of GHz: 60 GHz ≈ 3 K ≈ $^1/_4$ meV. It is therefore desirable to extend GHz-frequency conductivity measurements to fields that at present are only accessible by the use of pulsed magnets. Here we focus upon the recent observation of quantum oscillations in the GHz conductivity of an organic superconductor, as a beautiful example of the sensitivity of our new microwave resonator system for use in pulsed-magnetic fields. As well as measuring the sample conductivity to probe "orbital physics" in metallic systems, this technique probes the sample permittivity and permeability allowing measurement of insulating systems and "spin physics." The demonstration of these techniques in the User Program short pulse magnets is an important stage in the development of instrumentation for more extreme dynamic environments, such as the 60 and 100 T controlled pulse magnets and single-turn magnets currently under construction at the NHMFL in Los Alamos.

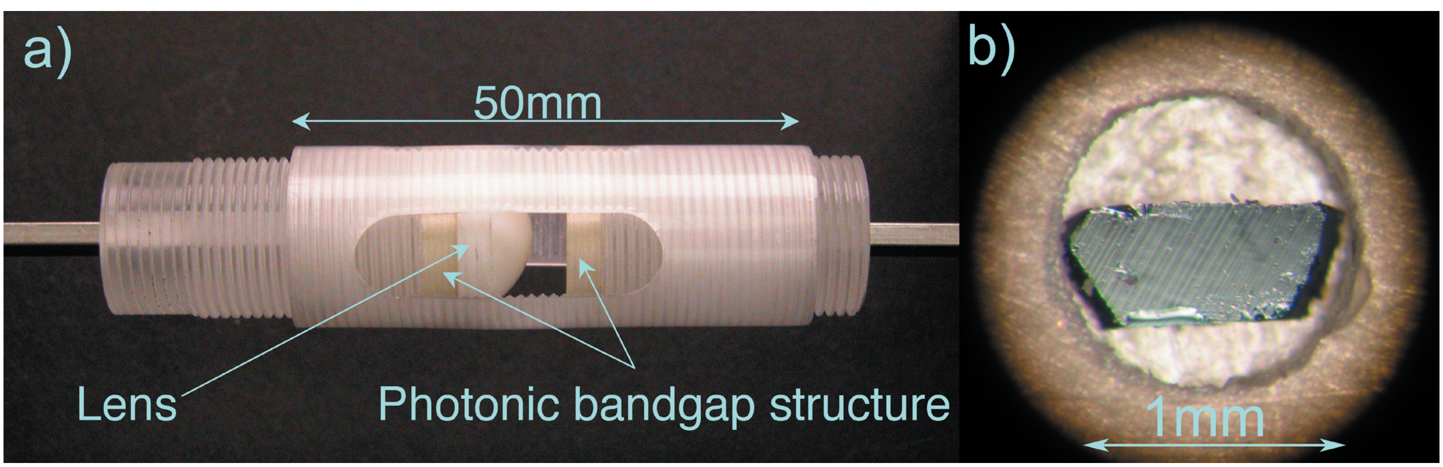

Figure 1. a. Waveguide-coupled photonic-band-gap resonator. b. A κ-(BEDT-TTF)$_2$Cu(SCN)$_2$ sample loaded in the dielectric resonator

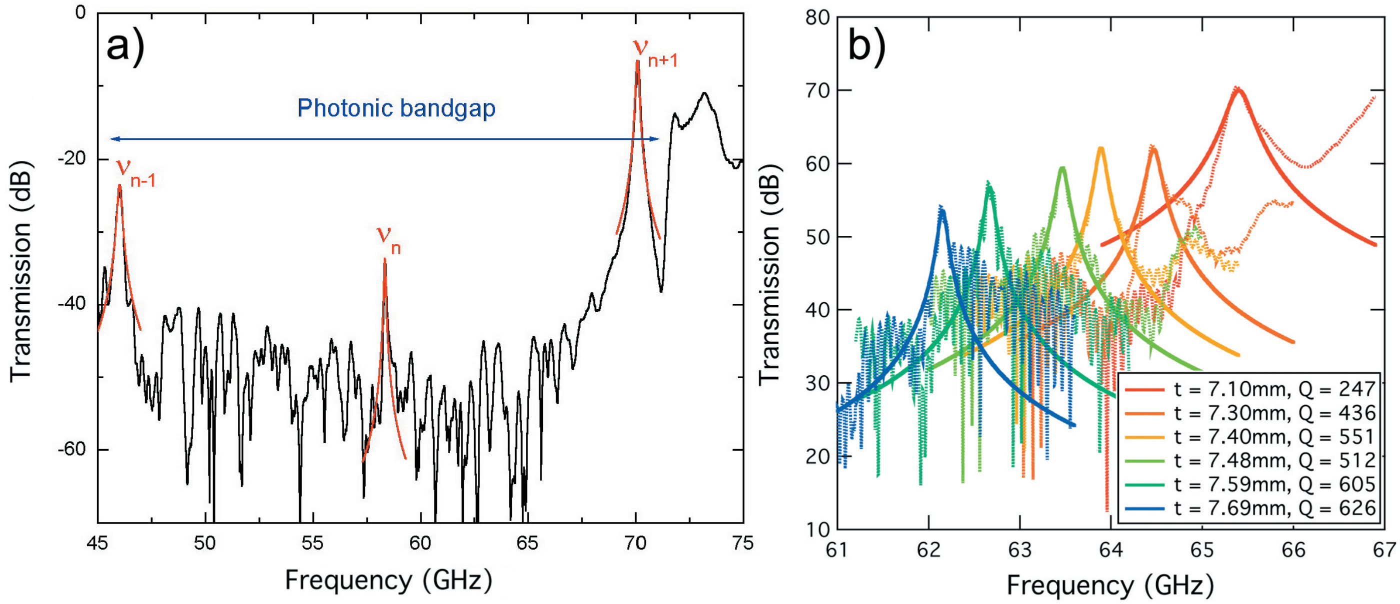

Figure 2. a. The room temperature transmission spectrum illustrating the photonic band gap region and well separated resonant modes. b. Tuning the resonance in the region of the band edge, note that the increased coupling is accompanied by an increase in the width of the resonance, a degradation of the Q-factor.

Conventional DC-magnetic-field GHz-frequency conductivity apparatus relies largely upon the use of metal components to both guide the radiation and provide a resonant environment in which to measure a sample. Both of these aspects are critical. The use of a resonator greatly improves measurement resolution compared to a simple reflection or transmission geometry. A resonator, with waveguide coupling, also facilitates the measurement of samples with dimensions that are small compared to the wavelength and in environments (cryostats that fit into a magnet bore) that are of comparable size to the wavelength without the obvious diffraction problems encountered with free space propagation. This aspect is particularly important at the frequencies in question (60 GHz has a wavelength of approximately 5 mm in free space). A pulsed-field environment places more stringent criteria upon the design of GHz apparatus: firstly the apparatus must be smaller so as to fit in the bore of a pulsed magnet, typically < 24 mm, and secondly the use of metallic components must be reduced to an acceptable level both from the point of view of eddy current heating and magnetic forces and torques.

Our solution to this problem is an entirely non-metallic microwave resonator. The resonator relies upon photonic-band-gap structures to longitudinally confine the radiation and a dielectric lens to provide lateral confinement (see Fig. 1). The photonic-band-gap structure consists of a periodic array of dielectrics: essentially a stack of quarter wave plates with sufficient refractive index contrast to possess a high reflectivity for a large range of frequencies and almost all angles of incidence. Coupling the microwave power via mono-moded rectangular waveguide and the single surface spherical lens generates resonant modes that are transverse polarized with a Gaussian intensity profile. The standing wave pattern is such that there is an integer number of half wavelengths between the multilayers with an electric field node and magnetic field anti-node at the multilayer surface. The mono-moded rectangular waveguide maintains better than 99% polarization of the E and H fields within the resonator. This is an ideal geometry for many microwave applications such as electron spin resonance and bulk conductivity measurements of layered materials, where it is desirable to orientate the microwave magnetic field perpendicular to the applied magnetic field.

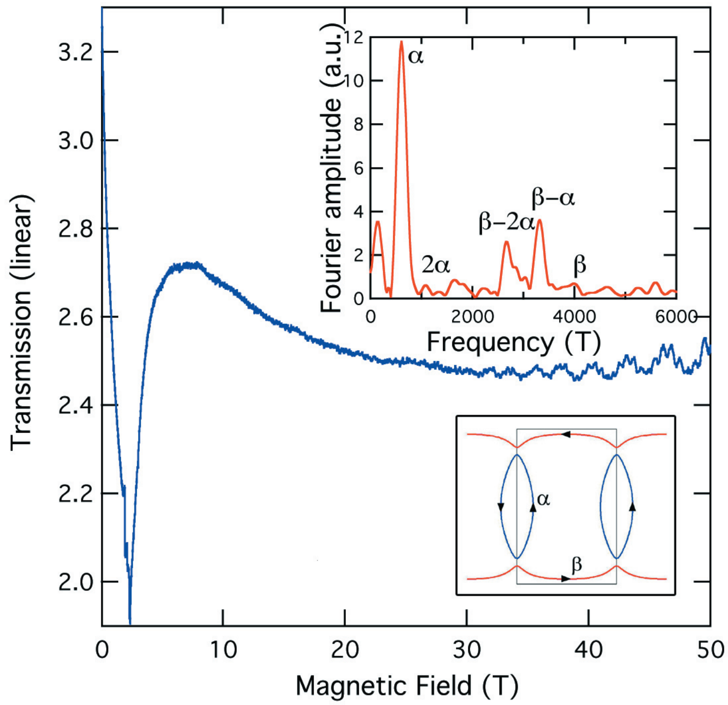

Figure 3. The GHz-frequency magneto-conductivity of κ-$(BEDT\text{-}TTF)_2Cu(SCN)_2$ measured at a temperature of 2.1 Kelvin and a frequency of 64 GHz. Note the Josephson plasma resonance at low field and the quantum oscillations at higher fields. The insets show the Fourier spectrum of the quantum oscillations and the associated Fermi-surface orbits.

It is desirable to measure the resonator in transmission such that a resonance appears as a sharp peak in intensity orders of magnitude larger than the background signal, as opposed to vice versa for reflection coupling (see Fig. 2a). Coupling the microwave power to the resonator by terminating the waveguide with the resonator's multilayer structure has the advantages over aperture coupling that it is relatively frequency independent: within the frequency range of the photonic-band-gap only a decaying wave penetrates the resonator and critical coupling can be obtained by varying the number of dielectric layers or tuning the resonant frequency in the region of the band edge (see Fig. 2b). In practice it is usually preferable to slightly over couple the resonator, at the expense of the Q-factor, so as to maximize the difference between transmission at resonance and the background microwave leak signal. Note from Fig. 2a that at room temperature the transmission is of the order of -50 dB down mid band gap and that the resonant modes are of the order of 20 dB above this. At low temperature both the Q-factor and ratio of resonant amplitude to background transmission improve (Q → 1500).

Loading the resonator with a sample perturbs the resonant frequency and Q-factor. Thus, measuring the change in transmitted amplitude at resonance provides a very sensitive probe of the sample properties. The fast data acquisition at the frequencies in question is provided by a Millimeter Vector Network Analyzer manufactured by AB Millimetre. Ideally the sample provides a small perturbation to the resonator. The size of this perturbation, and hence the sensitivity to the change in sample properties, can be controlled via the sample's location in the resonator. For low-loss or small samples the perturbation is optimal for the sample located centrally. This is achieved mounting the sample in a thin disk of the lens material clamped between the lens and one of the dielectric mirrors (see Fig. 1b).

The apparatus is currently designed to run in a 24 mm bore, 50 T short pulse magnet equipped with a flow cryostat providing temperature control between room temperature and 2 K. Fig. 3 shows the magneto-conductivity of κ-$(BEDT\text{-}TTF)_2Cu(SCN)_2$ measured in a pulsed magnetic field with a rise time of 8 ms at a frequency of 64 GHz and a temperature of 2.1 K. Under these conditions the quantum oscillations corresponding to the alpha and beta-orbits, plus Stark quantum interference between the two are clearly visible (see the upper inset of Fig. 3). It should be noted that the effective mass of the alpha orbit is $\approx 3.5m_e$ and that of the beta orbit $\approx 7.1m_e$ such that their observation at this temperature is only possible at these high fields. The dip in transmission at low field is a Josephson plasma resonance, which occurs close to the superconducting upper critical field.

PIONEERING THE NHMFL

Memories of the First Years on the Occasion of the 10th Anniversary of the Dedication of the NHMFL

Hans J. Schneider-Muntau, Chief Technology Officer

Looking back, it seems completely natural that the magnet lab has become what it is today: the leading facility worldwide in providing unparalleled research opportunities to the international science community in the highest magnetic fields possible. When we started 13 years ago, a handful of enthusiastic people under the leadership of Jack Crow, we wanted to create the best laboratory in the world. We were thankful for this unique opportunity. We worked day and night to make our dreams and ideas become reality.

Building an entirely new laboratory requires a special set of people. They can best be described as pioneers. It requires courage to come to an unknown place, leave defined and safe working conditions behind, persuade spouse and children to abandon friends and established relationships, and confront an unknown educational, fiscal, contractual, and climatic environment. We were from different states and countries, and we felt like immigrants in this small and unknown town Tallahassee, which we wanted to put on the world map of research in magnetic fields.

There were enormous challenges ahead of us. We had to transform an abandoned administrative building into a facility in which highly sophisticated scientific instrumentation could be operated. We had to define the specifications of the main technical equipment, such as power supply and cooling circuit, and find the vendors that could reliably provide this cutting edge equipment and the needed infrastructure. We had to design building extensions for the very specific needs of the NMR/ICR program, the resistive magnets, and the hybrid magnet. We had to start a magnet development program to provide the basis for successful design and construction of a large variety of next generation magnets, far beyond what existed at that time. We had to build a new laboratory from scratch with a sophisticated

The team of the first hour: Neil Sullivan, Bob Schrieffer, Hans Schneider-Muntau, an unidentified representative of Marshall Contractors Inc., Larry Campbell, Dwight Rickel, Jack Crow, Don Parkin, Tim Cross, John Miller, Steve Van Sciver, Bill Moulton, Denis Markiewicz, and Jim Ferner.

The vacant building before it became the National High Magnetic Field Facility. Two extensions were added, the NMR/ICR wing to the left, and the user facility for resistive and hybrid magnets, housing 16 magnet stations. The 26 MW cooling towers and the 4000 m^3 reservoir for chilled cooling water are at the far end.

infrastructure under an enormous pressure of time and budget constraints, and most important, make it operational within four years.

The Chancellor of the Board of Regents at that time, Charlie Reed, had been decisive in obtaining the laboratory for Tallahassee. He persuaded governmental leaders to provide the necessary budget to outbid our competitor, the MIT. In addition, he had identified a building for the future magnet lab in the Innovation Park, an industrial park south of Tallahassee. It had originally been built for administrative and training purposes, but had never been used. We had to adapt it to its new function. We proposed to build additional, specially designed wings on both ends of the existing building to match the research requirements and to reduce interference between the magnets themselves and the building structure. We modified the building, removed several walls and floors to create high-bay areas, and added additional reinforcements to make the building hurricane safe. Space at the ground floor was reserved for vibration sensitive instruments, such as SEMs and TEMs. The chemical laboratories were set up in the 3rd floor because of the simplified installation of fume hoods. A conceptual design of the NMR wing was established in cooperation with scientists of the NMR community, assuming a future need for four major very-high-field magnets, and a series of smaller NMR magnets. We were concerned about their interactions and the impact of ferromagnetic materials near ultra-high resolution spectrometers up to 1 GHz. This is the reason why the building has four long arms in wooden construction extending out perpendicular to each other. We even thought about the acceptable distance to moving ferromagnetic objects, such as cars. One should not forget that 600 MHz was the highest spectrometer frequency commercially available at that time (1990), and nobody knew if a 1 GHz magnet was technically possible and even less its environmental requirements.

It was our ambition to create the potential for the generation of magnetic fields of the highest quality, in not only strength, but also concerning field stability and especially vibrations. The experience gained in Grenoble was very helpful and guided us in the layout of the cooling water circuit. The cooling pumps were put on vibration absorbers mounted on solid and heavy concrete blocks, which were isolated from the rest of the floor, which itself was isolated from the main building. This reduced the transmission of vibrations through the floor and ground. The cooling water pipes were suspended elastically from the ceiling to avoid vibration transmission through the building, and the elbows were arranged in such a way that vibration transmission within the pipes was damped as much as possible. The magnet housings were designed for a symmetrical feed of the cooling water to reduce any remaining vibrations even further. It was a great satisfaction when we made the first comparison of the vibration level of the magnets of the Francis Bitter lab at MIT with the NHMFL magnets. The set-up with an antivibration device at MIT showed the same vibration level as the NHMFL magnet without any antivibration device. Measurements of hitherto unknown sensitivity were made possible, confirming that we had created new research opportunities and set new standards.

In parallel with designing the building, we pursued the technical installations. The first task was the definition of the parameters, such as voltage, current, current ripple, power level, water pressure, water flow rate. The original plan of NSF requested a 45 T Hybrid magnet and a 20 MW power supply. First calculations indicated that 20 MW would not be sufficient for generating 45 T and that at least 24 MW would be required. The fact that the installed electrical power level determines the achievable magnetic field, and especially our ambition to create the best and strongest facility in the world, convinced Jack that it would be worthwhile to obtain the highest power within the available budget. In addition, it was our goal to improve the field quality of the resistive magnets to approach it as much as possible to that of superconducting magnets. A very low field ripple would open a new dimension for sensitive measurements, similar to ones done in superconducting magnets, but at much higher fields. In multiple discussions with different potential suppliers, power level, power module size, current stability and ripple, and overload capability were explored. We decided that, within our budget, the optimum compromise would be a power supply consisting of four units of 8.5 MW with an overload capability for the rectifiers of 100%, and for the transformers of up to 10 MW for one hour. We had thus succeeded in doubling the power level compared to the original NSF solicitation opening the possibility of generating magnetic fields with resistive magnets at levels that were reserved at that time to hybrid magnets only. It was our choice to adopt the same electrical and hydraulic parameters as those of the magnet laboratory in Grenoble for two reasons: they represent an optimum compromise between different requirements, and they opened the possibility of cooperation. We wanted to establish and maintain a strong cooperation with the second largest magnet laboratory so that magnets could

The foundation of the wing housing the user facility with the resistive and hybrid magnets had been designed for maximum stability and low vibrations. The casting of the 1 m thick slab took several days and nights. It was the largest amount of concrete ever poured in Northern Florida.

Jack Crow with our first “baby,” a 64 T pulsed magnet, built in cooperation with K.U. Leuven and tested successfully at Eglin Air Force Base in 1992.

At the dedication, the speakers honored the achievements and confirmed that a world leading facility for research in magnetic fields had been successfully installed. The Governor of Florida, Lawton Chiles, at the dedication ceremony on October 1, 1994. From left to right: Congressman Pete Peterson, Lt. Governor Buddy MacKay, Vice President Al Gore, Senator Bob Graham, and Director of NSF, Neil Lane.

be built together and even swapped if necessary or in case of major problems. In fact, the very first magnet operated in Tallahassee was a magnet built together in Grenoble, and we had a successful and cost saving partnership arrangement later with the design and construction of the 20 T large bore magnet.

The greatest challenge, however, was the task of delivering the magnet systems NSF had charged us to build. The Seitz-Richardson report had defined a wide variety of magnets the new national facility should develop and eventually offer to the scientific user community. One of my first tasks was, therefore, to establish a program and vision for the future efforts and to head a department that should take care of the magnet science and technology activities. The program presented to NSF required an enormous progress in the generation of magnetic fields far beyond the start-of-the-art of that time (1990); from 20 T to 25 T for superconducting magnets, from 600 MHz to 1 GHz for NMR magnets, from 25 T to 35 T for resistive magnets, from 30 T to 45 T and 50 T for hybrid magnets, and from 50 T to 75 T in pulsed magnets. To this impressive list we added two new pulsed magnet systems enabled through the cooperation with the Los Alamos National Laboratory and the availability of a 600 MJ generator; a 60 T magnet with a flat top of 100 ms, and a 100 T system. The new generation of magnets we wanted to build covered an enormous range of very diverse technologies, materials, and design and construction approaches. New technologies and a precise understanding of the physics and mechanics of magnets had to be developed. We were fortunate to have recruited a sizeable group of outstanding engineers who were intrigued by the challenge of building magnets no one had ever built before.

This dynamic group, aided by the efforts of outstanding technicians, pioneered many new ideas and technologies. I mention just a few examples to illustrate some important innovations. The use of cable-in-conduit technology and superfluid helium for the hybrid magnet, the development of a new epoxy system and reinforcement scheme for the 900 MHz, the new computer codes that added a new dimension to analyze and optimize magnets, the sol gel insulation for HTS pancakes, and the invention of the Florida-Bitter magnet. An article in this newsletter next spring will expand on the numerous world records and achievements by MS&T that confirmed the courageous and far-sighted vision established in the beginning that enabled the NHMFL to become *the* leader in magnet technology worldwide.

In parallel to the creation of the facility, the technical infrastructure, and providing the first magnets, Jack Crow also pursued with vigor to establish the scientific credibility of the NHMFL. His efforts were crowned by winning Bob Schrieffer to join the team in April 1991, followed by many other renowned scientists. A future article will describe this equally exciting part of our

Editor's Note: Dr. Schneider-Muntau was Director of Magnet Science and Technology from 1992-1997 and served as Deputy Director of the NHMFL from 1992-2002. Prior to joining the NHMFL, he led the magnet development program at the Grenoble High Magnetic Field Laboratory for 20 years.

MR Microscopy of Neurodegeneration in an ALS-PDC Mouse Model at 17.6 T

S.C. Grant, UF, Neuroscience
J.M.B. Wilson, University of British Columbia, Canada, Neuroscience
M.S. Petrik, University of British Columbia, Ophthalmology
J. Lai, University of British Columbia, Ophthalmology
S.J. Blackband, UF, Neuroscience
C.A. Shaw, University of British Columbia, Neuroscience, Ophthalmology, Physiology, and Experimental Medicine

The development of higher magnetic fields improves the sensitivity of the magnetic resonance experiment, which can be traded for improved spatial resolution or acquisition times in magnetic resonance imaging (MRI). The recent commissioning of the 900 MHz (21 T) superwide (105 mm) bore magnet at the NHMFL is therefore particularly exciting, promising improvements in MR microscopy (MRI at resolutions < 100 microns). Before the 900 MHz magnet's successful installation, the highest field wide bore (89 mm) systems were the few 750 MHz (17.6 T) magnets around the world, one of which is housed in the AMRIS facility at UF and is operated as a user facility with the NHMFL. This system has been used in collaboration with external researchers to provide high spatial resolution, three dimensional data sets of isolated tissues, for example with Dr. Helene Benveniste (Brookhaven National Laboratory) for the development of a mouse brain atlas.[1] Here, we summarize recently published results with collaborators at the University of British Columbia.[2] These studies utilize the 750 MHz instrument to examine neuro-anatomical alterations in a mouse model of Amyotrophic Lateral Sclerosis-Parkinsonism-Dementia Complex (ALS-PDC), further demonstrating the utility of high field high MR microscopy.

ALS-PDC is a progressive human neurological disease linked to the consumption of seeds from the cycad palm tree (*Cycas micronesica K.D. Hill*), particularly in the populace of Guam.[3] Recently, Wilson *et al*.[4] developed an animal model of ALS-PDC through cycad feeding, in which specific cortical and subcortical cell losses were measured with histologically stained, two-dimensional sections and were correlated with behavioral testing. We implemented the non-destructive technique of MR microscopy on intact, excised brains and spinal cords at resolutions of at least 50 microns through the use of optimally constructed RF coils and the 17.6 T system. MR microscopy was chosen for three primary reasons: (1) MR microscopy provides a truly 3D picture of the tissue under investigation at relatively high resolution. (2) MR microscopy has various contrast mechanisms that can be brought to bear upon the investigation of the disease. (3) Unlike histological sectioning, MR microscopy can provide gross and fine volumetrics that do not suffer from shrinkage and section distortions. Additionally, further staining and/or immunohistology can be performed on tissue following MR microscopy analysis to provide additional and correlative information.

Mice were fed washed cycad for two months and showed progressive motor deficits resembling human ALS-PDC. After sacrifice, CNS tissues (brain and lumbar-sacral spinal cords) were extracted and fixed. Using a homebuilt split ring resonator, samples were imaged at 17.6 T using a three-dimensional gradient-echo pulse sequence (2 averages; TE = 12.5 ms; TR = 140 ms) to develop T2*-weighted contrast. A 512x256x256 matrix was acquired over a 2.1x1.05x1.05-cm field of view (41-micron isotropic resolution) in approximately 5.5 hours.

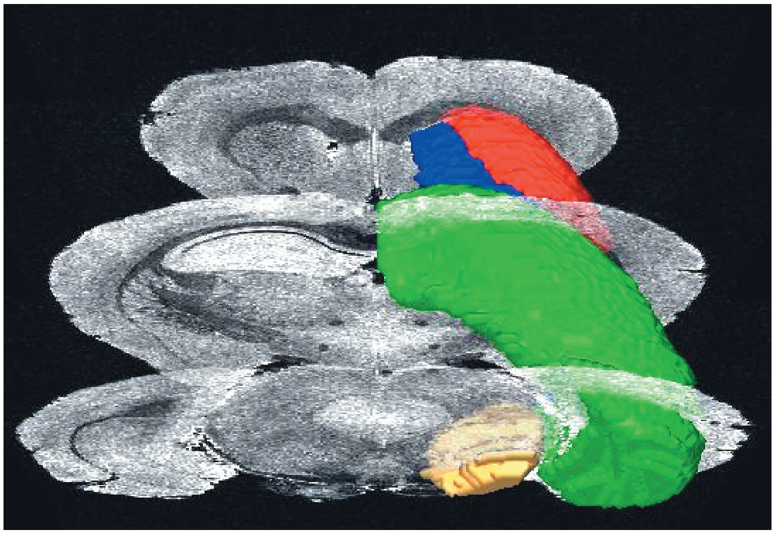

Figure 1. Three coronal sections of a 3D data set with rendered isosurfaces of the hippocampus (green), striatum (red), lateral ventricle (blue), and substantia nigra (gold).

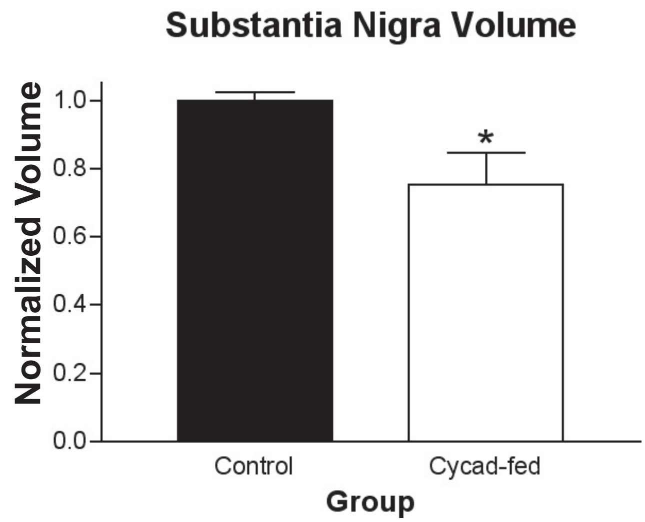

Figure 2. Comparison of volume differences in the substantia nigra between control and cycad groups *(*p<0.001).*

Fig. 1 shows an example of segmented brain regions from the MR microimages. The high resolution images facilitate accurate segmentation of these structures. Cycad-fed mice showed significantly decreased volumes in lumbar spinal cord gray matter, substantia nigra (example data shown in Fig. 2), striatum, basal nucleus/internal capsule and olfactory bulbs compared to flour-fed controls. In fact, MR microscopy was successful in identifying changes in the basal nucleus/internal capsule that were previously unseen in histological studies. Additionally, these alterations in MR neuro-anatomy correlated well with behavioral deficits and with the expected areas of neurodegeneration related to the ALS-PDC pathology.

These results show that MR microscopy is sensitive enough to measure degeneration in this early stage model of a progressive neurological disease. Current efforts are focused on (a) comparing cycad-induced ALS-PDC with genetic models of ALS (e.g., SOD1 knockouts) and (b) assessing ALS-PDC neuronal alterations through diffusion tensor imaging. Because of the non-invasive nature of MRI, in vivo investigations of this mouse model also are planned to track the entire progression of the disease. Ideally, similar analysis may be used in the future as a diagnostic aid in tracking the early progression of neurological disorders in pre-clinical human subjects. It is expected that the 900 MHz instrument and higher fields will facilitate improved spatial resolutions to bolster these types of microstructural investigations.

Acknowledgements. This work was supported by the ALS Association, Scottish Rite Charitable Foundation of Canada, Natural Science and Engineering Research Council of Canada, and the U.S. Army Medical Research and Materiel Command (#DAMD17-02-1-0678) (to CS). MR studies were supported by the National High Magnetic Field Laboratory (NSF-0084173) and the NCRR/NIH (P41-RR016105) (to SB). Cycad seeds were provided by Drs. U. Craig, T. Marler, and J. Steele.

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1 H. Benveniste, *et al.*, "Anatomical Studies in the Rodent Brain and Spinal Cord: Applications of Magnetic Resonance Microscopy". P. 211-235. Series: Methods and New Frontiers in Neuroscience. (Editor: Sidney Simon), Book: Techniques of Biomedical Imaging in Neuroscience. Editors: Nick van Bruggen. Tim Roberts. CRC Press (2003).

2 J.M. Wilson, *et al*., *NeuroImage*., **23**, 1, 336-43 (2004).

3 L.T. Kurland, *Trends Neurosci.*, **11**, 51-53 (1988).

4 J.M.B. Wilson, *et al., NeuroMolecular Med.*, **1**, 207-221 (2002).

NHMFL Educators Engage in National Issues

As schools open around the nation, Center for Integrating Research and Learning educators return to a full schedule of outreach, professional development, curriculum development, and research. We continue to find new ways to reach students and translate the excitement of research being conducted at the NHMFL. The Federal *No Child Left Behind Act* provides the structure around which schools are currently designing their science education efforts. The Center recognizes this as a jumping off point from which to provide quality experiences for K12 students and teachers. Center educators also recognize that this requires exploring both traditional and nontraditional venues for educational outreach such as partnerships with area educational consortia that reach rural counties, partnerships with local "front porch initiatives," and partnerships with groups that provide opportunities for typically underrepresented groups in science.

In an effort to get the message out to a national audience, Center educators participated in a number of conferences this Fall. Carlos Villa, Outreach Coordinator, presented to 35 teachers at the Florida Association for Science Teachers in Orlando, Florida, focusing on activities that deal with magnets, magnetism, and related concepts. In addition, the session showcased educational opportunities at the NHMFL for teachers and students. Not only does this type of activity take the Center out of the local area, but it also provides a chance for Center educators to learn more about what teachers and students are facing each day and what schools are doing to accommodate high stakes testing.

Villa and fellow educator, Gina LaFrazza, also participated in, and conducted special sessions at, the *Project Superconductivity* workshop at the recent Applied Superconductivity Conference. See page 27 for more information and to learn about plans to expand this outreach to other venues.

Pat Dixon, Director of the Center, presented at the School Science and Mathematics Association national conference in Atlanta, Georgia. The talk centered on the Research Experiences for Teachers program and preliminary research results. A study started in August 2002 has yielded exciting data about students' attitudes toward science as a result of being in a class taught by an RET participant. Preliminary data also suggests that teachers make significant changes when they return to their classrooms. These changes may translate to others as teachers return as science education leaders. In addition to the research being conducted on the NHMFL RET program, the Center continues its valuable partnership with the RET Network and will begin program evaluation in early 2005.

Students from the NHMFL Research Experiences for Undergraduates program and teachers from the NHMFL Research Experiences for Teachers program participated in a Poster Session at the University of Florida in Gainesville. Christy Amwake, an REU participant in 2003 and 2004 and currently conducting graduate research at UF; Julia Giblin, REU class of 2004 and currently conducting research with the Geochemistry group at the NHMFL; Pat Cramer, a sixth grade science teacher in Leon County, and Rich McHenry, a chemistry teacher in Leon County, presented posters of the research they conducted at the NHMFL. The collaboration with UF continues as REU, RET, and other educational activities conducted by both universities are strengthened by joint efforts.

Planning for the next Open House—to be held on Saturday, February 26, 2005—has already begun with new exhibits, demonstrations, and hands-on activities being developed. As research efforts at the laboratory evolve, so do the ways to translate those activities. We are looking forward to a new viewing area for the Hybrid magnet, an updated introductory video, and new educational activities for children of all ages.

The Web site, http://education.magnet.fsu.edu, continues expanding and is being used for the first time for teachers to receive in-service credit through the Teacher Network. A statewide initiative in Florida follows a national trend for teachers to conduct follow-up activities in their classrooms and document student outcomes in order to receive recertification credit. Online submission of documentation of classroom implementation is already available through the NHMFL to support its workshops and institutes.

For more information about education at the laboratory, contact Pat Dixon, pdixon@magnet.fsu.edu, 850-644-4707.

Correction

In the last issue of this newsletter, Figure 2 in **"Probing Excitonic Spin States in CdSe Nanocrystal Quantum Dots by Polarized Resonant Photoluminescence Spectroscopy,"** by Madalina Furis *et al.*, page 7-8, appeared incorrectly. We regret this production error and are pleased to publish the correct figure here.

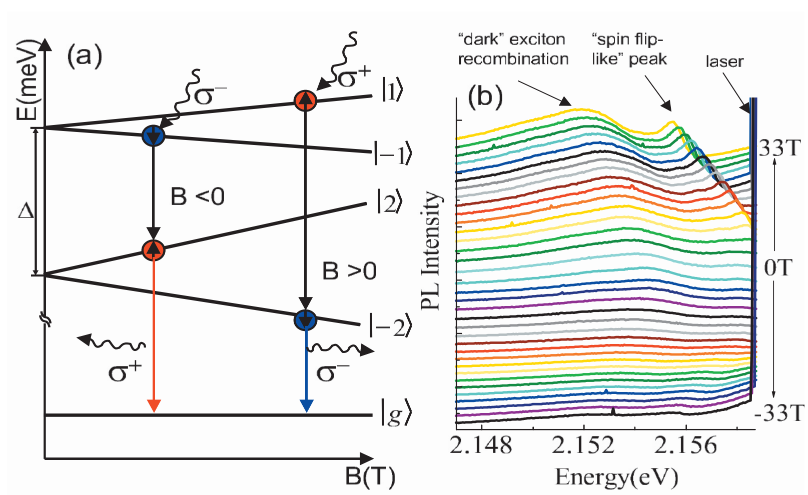


Figure 2. (a) Principles of the spin-polarized fluorescence line narrowing (FLN) experiments in high magnetic fields. Spin-up or spin-down "bright" excitons are selectively and resonantly pumped using circularly polarized light from a narrowband dye laser, and the nearly-resonant photoluminescence associated with spin-up or spin-down "dark" excitons is analyzed.

Spacecraft Missions and the NHMFL

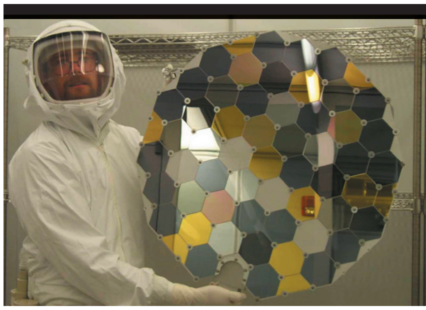
M. Humayun, Geochemistry Program

Asteroids and comets make up the largest number of bodies in our solar system. Although they represent only a small mass fraction of the planetary system, they represent the chemical diversity present in the early solar system. Both asteroids and comets undergo collisions that send debris spiraling in towards the Sun, a fraction of which is encountered by Earth. Chemical and isotopic measurements performed on this material, meteorites and interplanetary dust particles (IDPs), are an important source of information on how our solar system formed (indeed on star and planet formation, in general). These measurements are mainly done by mass spectrometry, a key strength of the facilities at the NHMFL. One limitation to the free gifts of the heaven, meteorites and IDPs, is that their sources are not known. For example, some IDPs are inferred to originate from comets by their morphology and the presence of large isotopic anomalies in D/H ratio, but this is not easy to establish in the absence of bona fide comet samples.

Not since the U.S. Apollo and Soviet Luna missions (1969-1972) have extraterrestrial samples been returned for analysis. That is about to change with three sample return missions underway. The GENESIS mission collected solar wind ions implanted in high-purity substrates, and returned to Earth September 2004. The STARDUST mission collected cometary dust from Comet Wild2, which will be returned to Earth, January 2006. The Japanese HYABUSA Mission will collect and return samples from Asteroid Itokawa in 2007. The quality of analysis that can be performed in ground-based laboratories is many orders of magnitude better than measurements that can be performed by spacecraft-borne instrumentation. Spacecraft instruments are restricted in their capabilities by payload requirements, i.e. instruments must be small and limited in their power requirements. Ground-based laboratories can analyze radioisotope ages of rocks and soils that cannot be performed by remote instruments. Sample return from bodies lacking large gravitational fields is technically feasible and places comets and asteroids within reach.

The principal challenge facing ground-based laboratories that have worked with rock and soil samples from Earth, Moon, and meteorites is that the amount of material returned by the three spacecraft missions is significantly smaller than previous endeavors. The Apollo missions returned nearly 400 kilograms of rock and soil from the Moon. By comparison, STARDUST collected about 1,000 particles 15 to 100 microns in diameter. Evidently microanalytical methods will need to be used to get the most information from these tiny samples. Among the techniques available to the space science community are scanning electron microscopy (SEM), transmission electron microscopy (TEM), secondary ion mass spectrometry (SIMS), and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS).

Each technique provides a different type of information. Electron microscopy provides chemical composition of major elements and morphology; SIMS provides elemental and isotopic analyses of low FIP (First Ionization Potential, FIP<7 eV) elements; LA-ICP-MS analyzes elements of FIP<12, but occupies a unique niche for elements with FIP~7-12. Laser ablation ICP-MS is a new tool at the NHMFL Geochemistry labs, however, the technique is presently limited to >10 μm scale, providing only bulk analysis of the largest cometary grains. This is due to a low duty cycle for magnetic sector mass spectrometers due to magnetic hysteresis. It is this aspect



Leading page: an artist's conception of the STARDUST spacecraft. **On Left**: a GENESIS Mission collector array prior to flight. Eight different collector materials are represented among the hexagons, including Si wafers (dark gray) and Si-on-sapphire wafers (yellow). Images courtesy of NASA.

of laser ablation microanalysis that new initiatives at the NHMFL Geochemistry program seek to advance.

In laser ablation, a burst of UV laser light (266 nm, 213 nm or 193 nm) is focused on the specimen. This produces a pulse of aerosol from the ablated specimen that is swept by a continuous stream of argon (Ar) gas into an Ar plasma where it is ionized. The innovation we are developing is to split the aerosol and then send it to two mass spectrometers (MS), simultaneously. Nature has provided us with the convenience that low mass elements are generally much more abundant in the cosmos than high mass elements. Thus, one MS scans the abundant peaks in the low mass range (e.g., ^{7}Li to ^{60}Ni), while the other, a multicollector ICP-MS equipped with multi-ion counters, statically collects a single portion of the high mass range. By carefully choosing the elements of interest, the Dual-MS technique increases the information return on small grains by nearly 40-fold. One mass range of interest is that of Hf-Pb. For nuclei heavier than ^{56}Fe, two nucleosynthetic processes manufacture most of the isotopes: slow neutron capture (s-process) which takes place in red giant stars, and rapid neutron capture (r-process) which takes place in supernovae. The solar system has a unique and relatively homogeneous mixture of the two. In the Hf-Pb mass range of the solar mix some elements are produced dominantly by the s-process (Pb), others by the r-process (e.g., Pt, Au). Interstellar grains need not have the solar s/r mixture, and comets are believed to have preserved many interstellar grains in their ices.

Dual-MS detection results in a very significant improvement in the detection limits of high-mass elements over single-MS detection, so that lasers with spatial resolution of 4 microns can be used for elemental analysis. At 4 µm spatial resolution, a cometary grain of 15 microns or larger can now be analyzed in different parts to determine compositional variability in the grain. Such variability is expected on the basis of recent studies of "cometary IDPs." The IDPs (interplanetary dust particles) are cosmic dust grains originating from asteroids, and possibly comets, that fall to Earth and are collected by NASA U-2 aircraft from the stratosphere. These particles include some so small they are slowed to terminal velocity in the atmosphere before heating up significantly enough to melt, preserving delicate structures. Some are interpreted to be cometary dust. One of these particles is the GEMS (**G**lass with **E**mbedded **M**etal and **S**ulfides). The individual Fe-metal and FeS grains are interpreted to be stellar condensates and are nano-metre scale particles embedded in a silicate glass. Analysis of individual nm-size grains is not feasible, but analysis of clumps of Fe-metal within Fe-bearing silicates will enable identification of distinct stellar chemical or isotopic signatures to be resolved.

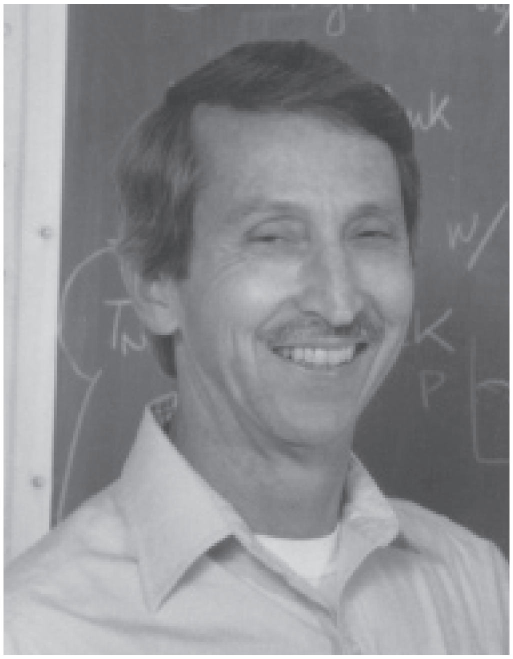
Another mystery observed in "cometary" IDPs is the presence of optically clear silicate mineral grains (particularly, enstatite $MgSiO_3$). Grains that have resided in the interstellar medium accumulate UV irradiation damage, so these grains were either radially transported from the inner solar system or were introduced into the interstellar medium shortly before incorporation into the solar system by a nearby star. Such a star may also introduce the "extinct" radionuclides observed in meteorites.

New developments in microanalysis and inorganic mass spectrometry at the NHMFL contribute to solution to these mysteries. In the process, we will develop a deeper understanding of the formation of asteroids and comets, unprecedented by previous work on IDPs. A thousand grains of authentic cometary material will undoubtably reveal new insights into the events surrounding the birth of our solar system.

Notes:
The sample container of the GENESIS Mission was released and re-entered the Earth's atmosphere. It was intended that parachutes would deploy, and the sample capsule then captured in mid-air by helicopters. The parachutes failed to deploy and the capsule struck the ground at about 200 mph, shattering many of the collectors. Despite that, fragments of the high-purity substrates will soon be made available for distribution to the space science community.

The STARDUST mission is due to return interstellar and cometary dust samples to Earth by January 2006. The spacecraft encountered the dust tail of Comet Wild2 and dust particles from the tail were collected in aerogel (silica foam) collectors. The encounter velocity was low enough that the particles would have experienced minimum impact heating, preserving intact grains for analysis.

PEOPLE IN THE NEWS



Dwight Adams, UF professor of physics, received the 2005 Keithley Award of the American Physical Society. The Keithley Award recognizes physicists who have been instrumental in the development of measurement techniques or equipment that have had an impact on the physics community by providing better measurements. The award is endowed by Keithley Instruments, Inc. and the Instrument and Measurement Science Topical Group of the APS. The prize consists of $5,000 and a certificate citing Adams' contributions, both of which will be presented at the 2005 March Meeting of the APS, to be held in Los Angeles. His citation reads: "for the pioneering development of the capacitive pressure transducer, its application to the He melting pressure thermometry, and other scientific uses." The famous Straty-Adams Strain Gauge is the workhorse for thermometry at very low temperatures and played a critical role in many milestone experiments.

TuKiet T. Lam completed his Ph.D. on "Protein Applications of Fourier Transform Ion Cyclotron Resonance Mass Spectrometry" in 2003 at FSU, and has stayed on in Tallahassee for several months to help with the NHMFL ICR User Program. Dr. Lam accepted an Associate Research

A Celebration of the Life of Jack E. Crow

The founding director of the NHMFL, Jack Crow, died on September 3 at the age of 65. Jack faced all of life's challenges with the greatest of enthusiasm and promise. He continued to embrace this philosophy even during his yearlong battle with cancer and fought it with the same conviction and determination with which he lived his life.

A memorial service was held at the NHMFL on September 20. Family and hundreds of colleagues and admirers crowded the laboratory to pay their respects. Jack's life was devoted to his family, education, and science and he treasured every moment of it. On any given day you could find him talking to a group of school children about the importance of science and

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Scientist permanent position starting in September, 2004 in the W.M. Keck Biotechnology Resource at Yale University, where he will be applying FT-ICR mass spectrometry to various proteomics problems.

UF/AMRIS Welcomes John Forder, the Latest Faculty Hire in the Department of Radiology

Forder was trained in cardiovascular pharmacology at the University of Michigan in Ann Arbor—his thesis was a study of the alterations in the purine salvage pathway following myocardial ischemia. He spent a year and a half in a postdoctoral fellowship studying the *in vivo* application of NMR at Johns Hopkins University School of Medicine in the laboratories of Dr. Jerry Glickson. He was on the faculty at Johns Hopkins for seven years, first as an instructor, then as an assistant professor of radiology. He left Hopkins for the University of Alabama at Birmingham, where he was an associate professor of Medicine, and the director of the 4.7 T NMR facility. Three years later, he was recruited to the University of Southern California as the director of Cardiovascular NMR Science, and (along with Dr. Gerald Pohost) the co-director of the Cardiovascular Magnetic Resonance core lab for the STICH (surgical treatment for ischemic cardiomyopathy) clinical trial.

His research interests remain cardiovascular in nature, centering around three main areas: (1) development of novel magnetic resonance techniques for imaging regional myocardial oxygen consumption (combining BOLD and spin-label perfusion imaging), (2) diffusion of water in the heart (diffusion tensor imaging), and (3) investigations into myocardial intermediary energy metabolism using ^{13}C-NMR spectroscopy. His work ranges from cellular extracts and isolated organ preparations all the way to the intact animal and clinical applications. The environment at UF is unique in terms of its available facilities and resources, and he looks forward to the opportunity to develop worthwhile collaborations.

Dr. Forder and his wife have three Pomeranian dogs and two parrots that share their home. Leisure activities include photography, bicycling, and sailing. They brought a 41 ft sailboat "Galadriel" with them from California, and currently keep it in Jacksonville Beach. They are looking forward to sailing again on the east coast.

cont. from page 23

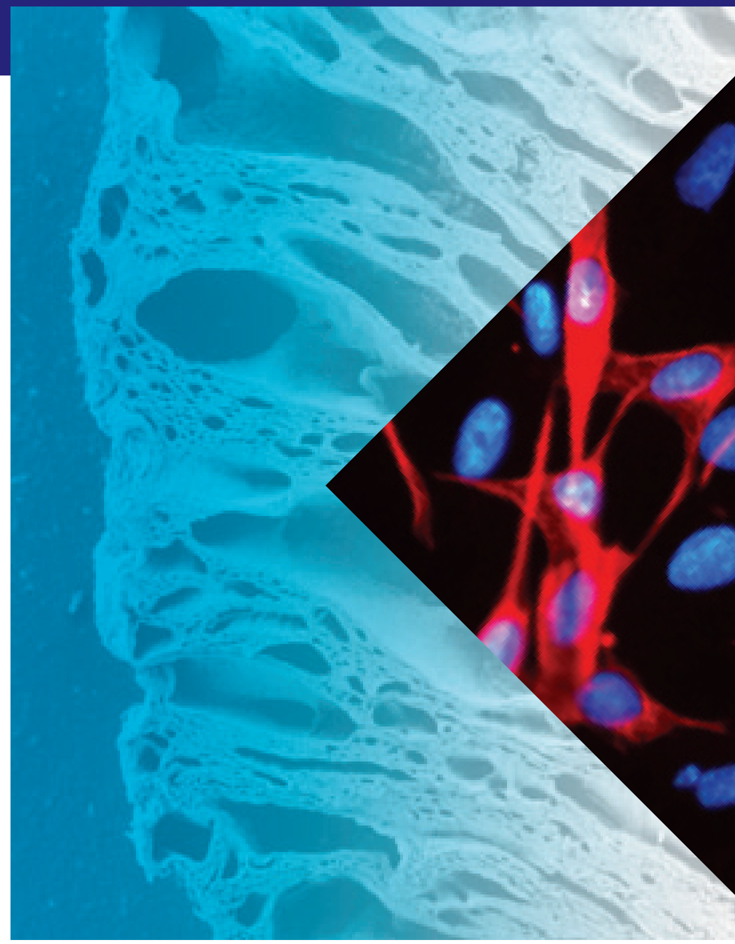
discovery in their lives, or instructing his graduate students about their latest data.

Jack had the uncanny ability to communicate with all types of people in all walks of life. "He could talk in molecules and he could talk in dollars and cents and make it understandable to a politician like myself," said Florida State University President T.K. Wetherell, who was the Speaker of the state House in the early 1990s when lawmakers were lobbied for the funding needed to make the new laboratory a reality for the State of Florida. "But for his vision, but for his hard work . . . I can assure you this facility would not be here," added President Wetherell.

Jack felt a strong commitment to give back to his community and encouraged faculty and staff to do the same. He was instrumental in establishing a Science Center in downtown Tallahassee. He was a long-time member of the Board of Directors for Tallahassee Memorial Hospital and Sun Trust Bank of Northwest Florida.

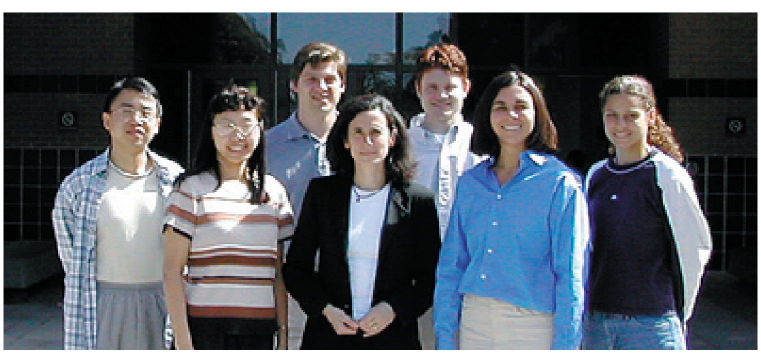
Jack was most proud of his family and especially his wife Joan of 44 years who is an innovative and popular science teacher in Tallahassee. She earned her college degree after raising one daughter and two sons. He adored his seven grandchildren and shared in their robust lives. He is also survived by two brothers and a sister.

Jack was born and raised in upstate New York and educated at the University of Rochester and Cleveland State University. Following work experiences at Brookhaven National Laboratory, Temple University, and NSF, he joined Florida State University in 1989 filled with ideas, enthusiasm, and drive. He was a fellow of the American Physical Society and American Association for the Advancement of Science.



New Grant in Noninvasive Monitoring and Tracking of Muscle Stem Cells at UF

Glenn Walter, UF Assistant Professor of Physiology and Functional Genomics and NHMFL/UF McKnight Brain Institute affiliated faculty, has been awarded a 4-year NIH grant. The overall objective of this proposal is to develop high-resolution imaging methods to noninvasively evaluate cell-based therapies in skeletal- and cardiac myopathies. Current methods for the analysis of cell-based therapies are largely restricted to invasive measurements in animal models.



Walter Laboratory

In this proposal, emphasis is placed on the development of noninvasive magnetic resonance (MR) assays to monitor *in vivo* stem cell migration, viability, and engraftment following cell delivery to cardiac and skeletal muscle. An immediate application of this technology is the monitoring of cell therapies to mitigate the devastating effects of muscular dystrophy.

Looking Back . . .

The 2004 Applied Superconductivity Conference was held from October 3-8 at the Adam's Mark Hotel in Jacksonville, Florida. Despite the hurricanes that battered Florida in the weeks before, the conference was a tremendous success. In total, there were 1,435 registered attendees, representing 36 countries from around the world. 40% of the attendees were from the U.S.; Japan was the second largest population with 24% of attendees. The conference included oral and poster sessions in Electronics, Materials and Large Scale. In total, 1,345 presentations were made and 965 manuscripts were submitted to the *IEEE Transactions on Applied Superconductivity* for publication. These manuscripts will go through a peer-review process to determine if they will be accepted for publication. The conference offered three short-courses before the technical sessions began, and these were also very successful—attracting 58 regular and 29 student participants. There was also a large exhibit with 53 booths representing companies from around the world.

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

The ASC also expanded beyond its historic mission of being the premiere conference in applied superconductivity by playing host to the first-ever *Project Superconductivity* Teacher-Scientist Workshop. This exciting event, developed and organized by G. LaFrazza (NHMFL), gave ASC attendees the opportunity to work directly with high school teachers, educating the teachers on superconductivity so that they can bring it to their classrooms, and educating scientists on more effective ways of reaching younger audiences. More details on this workshop can be found in the accompanying article.

The success of the conference was due to the efforts of many hard-working members of the NHMFL and Applied Superconductivity communities. In particular, Cesar Luongo (NHMFL) and Cathy Foley (CSIRO-Australia) served as Co-Chairs of the Technical Content Committee, Ysonde Jensen (NHMFL) served as the Local Chair, Sastry Pamidi (CAPS) served as the Short Course Chair, Jim Maguire (American Superconductor Corporation) served as the Exhibits Chair, and Gina LaFrazza (NHMFL) served as the Teacher-Scientist Workshop Chair.

Project Superconductivity

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

Throughout the week, LaFrazza met with ASC attendees to plan *Project Superconductivity* workshops at future scientific conferences. At present there is support to host workshops at the Particle Accelerator Conference in Knoxville, Tennessee in May 2005 and at the Applied Superconductivity Conference in Seattle, Washington in 2006. Currently, the leaders of the European Conference on Applied Superconductivity (EUCAS) and the Magnet Technology Conference (MT-19) are securing funds for teacher workshops at the fall 2005 conferences as well. For the European conferences, collaborators have already begun translating the teacher guidebook into Italian and German.

For more information about Project Superconductivity, please contact Gina LaFrazza at *lafrazza@magnet.fsu.edu* or 850-645-0033.

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CONFERENCES & WORKSHOPS

2005

Aspen Winter Conference 2005 in Condensed Matter Physics: High-Temperature Superconductivity
http://home.physics.ucla.edu/calendar/conferences/cmsc-2005/
January 9-15, 2005
Aspen, Colorado
Contact:
aspen2005@physics.ucla.edu

5th North American FT-ICR MS Conference
http://www.magnet.fsu.edu/FT-ICR
April 17-20, 2005
Key West, Florida
Contact: Mark Emmett
emmett@magnet.fsu.edu
850-644-0648
or Karol Bickett
bickett@magnet.fsu.edu
850-644-0535

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 Workshop
August 1-18, 2005
Lorentz Center
Leiden, The Netherlands
Contact: Vladimir Dobrosavljević
vlad@magnet.fsu.edu
850-644-5693

Physical Phenomena at High Magnetic Fields-V (PPHMF-V)
http://PPHMF.magnet.fsu.edu
August 5-9, 2005
Tallahassee, Florida
Contact: Alice Hobbs
aclark@magnet.fsu.edu
850-644-3203

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

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
September 2005
Dresden, Germany
Contact: Hans Schneider-Muntau
smuntau@magnet.fsu.edu
850-644-0863