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900 MHz Reaches Full Field

Sets New Dimensions!

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NHMFL REPORTS

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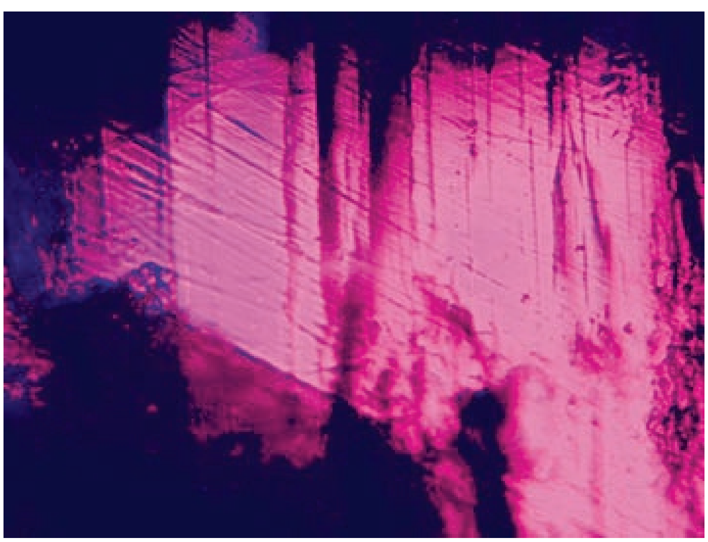
FROM THE DIRECTOR'S DESK

Greg Boebinger

The *extraordinary* news of this quarter is the achievement of yet another world record in magnet development…this time in superconducting magnets with the successful testing of the 21.1 T, 105 mm bore NMR magnet for chemical and biomedical research. This world-unique, ultra-wide bore magnet reached full field (900.25 MHz) without a single quench and continues to operate in persistent mode. As we put it through its commissioning paces, NHMFL scientists and engineers continue to fully characterize the high homogeneity and stability of this magnet. Tests to date strongly suggest that it will surpass homogeneity specifications and meet stability specifications through a novel drift correction technology. See page 9 for details about this engineering R&D success and the science opportunities it will bring to the NHMFL user programs.

The 900 MHz milestone demonstrates again the laboratory's world leadership in magnet science and technology, whether pulsed, powered, or persistent. The steady stream of NHMFL magnet achievements started with the world record 27 T resistive magnet in June 1994 and serves as a ten-year testimony to the talented and innovative engineers and technicians at the NHMFL. These individuals work across disciplinary boundaries and with industrial partners to advance magnet technology and develop state-of-the-art user systems.



Single crystal of $BaCuSi_2O_6$, a magnetic insulator, as seen through an optical microscope. About 2,000 years ago this compound, also known as Han Purple, was synthesized for use as a pigment by the Chinese. Its quasi-2D structure is important in the realization of Bose-Einstein condensation of spin-triplet excitations in an external magnetic field.

Of course, all of our world-class facilities exist to enable scientific research. As I write, NHMFL research once again graces the cover of *Physical Review Letters* (the 20 August 2004 issue), reporting an interesting quantum spin condensate in the same material used by China's Han dynasty as the purple dye for its famous terra cotta army. On page 4 of this issue of *NHMFL Reports*, Scott Crooker discusses research that establishes the efficacy of noise spectroscopy as a perturbation-free probe of spin dynamics and magnetic resonance. As devices shrink in size to the nanoscale regime, fewer atoms and spins dominate the device behavior and noise processes become more prominent. By drawing on the fluctuation-dissipation theorem, this work, soon to appear in *Nature* magazine, firmly establishes that one scientist's noise is another scientist's signal. Continuing with that theme, Dragana Popović of the NHMFL recently chaired the International Society for Optical Engineering's *Conference on Fluctuations and Noise in Materials* held in Maspalomas, Gran Canaria, Spain, in May. Other timely conferences supported by the NHMFL include the *16th International Conference on High Magnetic Fields in Semiconductor Physics*, that attracted 130 scientists from 18 countries to the NHMFL in Tallahassee in early August; the *2004 Applied Superconductivity Conference* (in Jacksonville) and the *15th Conference of the International Society of Magnetic Resonance* (in Ponte Vedra Beach) both in October 2004…when the Florida weather will be substantially cooler (or so they promise me).

Conferences, seminars, and publications are all excellent avenues to expand the scientific productivity of the NHMFL. As the new NHMFL director, one of my personal goals is to build on our strengths, to address any weaknesses, and to extend the scope of magnetic field research to include new scientific communities and new avenues for discovery.

Regards,

Greg Boebinger

FROM THE CHIEF SCIENTIST'S DESK

J. Robert Schrieffer

In this issue of *NHMFL Reports*, scientists at Los Alamos National Laboratory (S.A. Crooker, D.G. Rickel, A.V. Balatsky, and D.L. Smith) investigate the phenomena of magnetic random noise arising from the fluctuation of the spin. Employing the fluctuation-dissipation theorem, they used the noise spectrum to study the response of the spin orientation to a space and time varying magnetic field B(r, t). Using a linearly polarized laser which is detuned from any atomic absorption, they studied the noise spectrum in rubidium and potassium vapors.

Random magnetization fluctuations along the z axis impart small polarization (Faraday) rotation fluctuations on the laser. Applying a small transverse field B, all magnetization fluctuation precess about B. The detuned laser ensures a perturbation free probe of equilibrium spin noise, wherein the atoms are not optically pumped or excited in any way. The ensemble exhibits zero net magnetization, with equal population of spins within ground state sublevels.

Measuring Random Spin Fluctuations for Perturbation-Free Probes of Spin Dynamics and Magnetic Resonance

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Noise in experimental measurements is historically and generally disregarded as being an unwelcome background, or at best, a nuisance to be minimized. Certain types of noise, however, contain a wealth of information about the system itself—a classic example being the small, inherent fluctuations of electrical current (current shot noise), which both demonstrates the discrete nature of the current carriers, and also directly yields the electron charge. In magnetic systems, fundamental noise can exist in the form of random spin fluctuations. In his seminal 1946 paper on nuclear induction, Felix Bloch noted that random, statistical fluctuations of N paramagnetic spins should generate measurable noise of order $\sqrt{N}$ spins, even in zero magnetic field.[1,2] By the fluctuation-dissipation theorem, this "spin noise" alone contains detailed information about the spin system itself. (The fluctuation-dissipation theorem states that the response of a system to an external perturbation—*i.e.*, the susceptibility—can be described by its spectrum of fluctuations while in thermal equilibrium.)[3]

In this work,[4] we address precisely these same $\sqrt{N}$ spin fluctuations, using optical techniques to passively and sensitively "listen" to the magnetization noise in a classical equilibrium ensemble of paramagnetic alkali atoms. These random fluctuations generate spontaneous spin coherences, which precess and decay with the same characteristic energy and time scales as the macroscopic magnetization of an intentionally polarized or driven ensemble. Correlation spectra of the measured spin noise reveals the complete magnetic structure of the atomic $^2S_{1/2}$ ground state (g-factors, nuclear spin, isotope abundance ratios, hyperfine splittings, nuclear moments, and spin coherence lifetimes) without having to excite, optically pump, or otherwise drive the system away from thermal equilibrium. Historically, this information is obtained with conventional magnetic resonance techniques (optical pumping and/or radio-frequency excitation), which necessarily perturb the spin ensemble away from thermal equilibrium. These noise signatures scale inversely with interaction volume, suggesting routes towards non-perturbative, sourceless magnetic resonance of small systems.

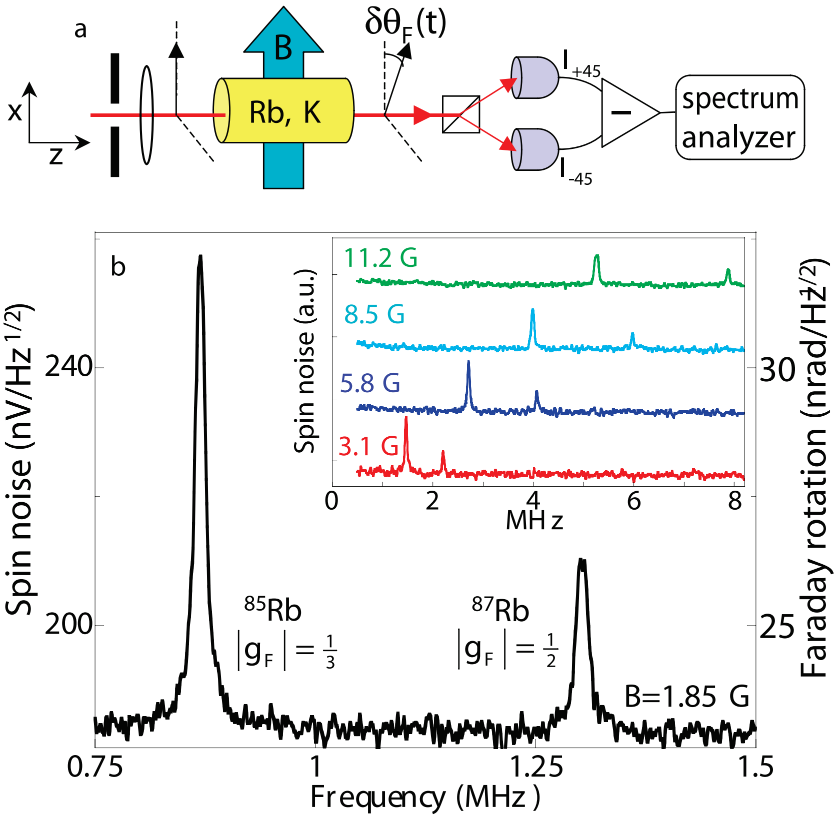

Figure 1. (a) Experimental schematic. Stochastic ground-state spin fluctuations $\delta M_z(t)$ impart polarization fluctuations $\delta\theta_F(t)$ on the detuned probe laser. **(b)** Measured spectrum of spin (Faraday rotation) noise in Rb vapor at T=369 K and B=1.85 G, showing spontaneous spin coherence peaks from ^{85}Rb and ^{87}Rb. The laser is detuned 25 GHz from the D1 transition (~794.8 nm), ensuring negligible absorption. Inset: The ^{85}Rb and ^{87}Rb spin noise peaks vs. magnetic field. Plots offset vertically for clarity.

Fig. 1a shows an experimental schematic. The linearly polarized laser, detuned from any atomic absorption, is focused through a cell containing rubidium or potassium vapor. Random magnetization fluctuations along **z** impart small polarization (Faraday) rotation fluctuations $\delta\theta_F(t)$ on the laser, which are sensitively measured with a balanced photodiode bridge. Helmholtz coils provide a small transverse magnetic field B along **x**, about which all magnetization fluctuations δM_z must precess. The detuned laser ensures a perturbation-free probe of equilibrium spin noise, wherein the atoms are not optically pumped or excited in any way. The ensemble exhibits zero net magnetization ($<M_z(t)>=0$), with nominally equal population of spins within ground state sublevels. The spin noise correlation function, $S(t)=<M_z(0)M_z(t)>$, has a Fourier transform $S(\omega)$ that is related simply to the power spectrum of $\delta\theta_F(t)$.

A typical noise spectrum from rubidium vapor is shown in Fig. 1b. The sharp peaks at frequencies Ω=869 and 1303 kHz are due to random spin fluctuations that are precessing in the small 1.85 G transverse magnetic field, effectively generating spontaneous spin coherences between ground-state Zeeman sublevels. These coherences precess with g-factors $g=h\Omega/\mu_B B\sim 1/3$ and 1/2, which are the ground-state g-factors of the stable isotopes ^{85}Rb and ^{87}Rb. Coupling of the nuclear spin I to the $J=½$ valence electron splits the $^2S_{1/2}$ atomic ground state into two hyperfine levels with total spin $F=I\pm J$ and g-factor $|g_F|\cong g_J/(2I+1)$, where $g_J\cong 2$ is the free electron g-factor. Thus, the nuclear spin of ^{85}Rb ($I=5/2$) and ^{87}Rb ($I=3/2$) may be directly measured from spin fluctuations in thermal equilibrium. The 13 kHz measured width of these noise peaks indicates an effective transverse spin dephasing time ~100 μs. The spectral density of the spin noise is small—the ^{87}Rb peak in Fig. 1b contributes only 3.1 nrad/$\sqrt{Hz}$ of Faraday rotation noise above the photon shot noise floor of 23 nrad/$\sqrt{Hz}$. Because spin noise arises, effectively, from N uncorrelated precessing spins, the integrated area under the noise peaks should scale with $\sqrt{N}$. This is conveniently confirmed by noting that the integrated spin noise of the ^{85}Rb and ^{87}Rb peaks is 24.7 and 15.4 μV respectively, whose

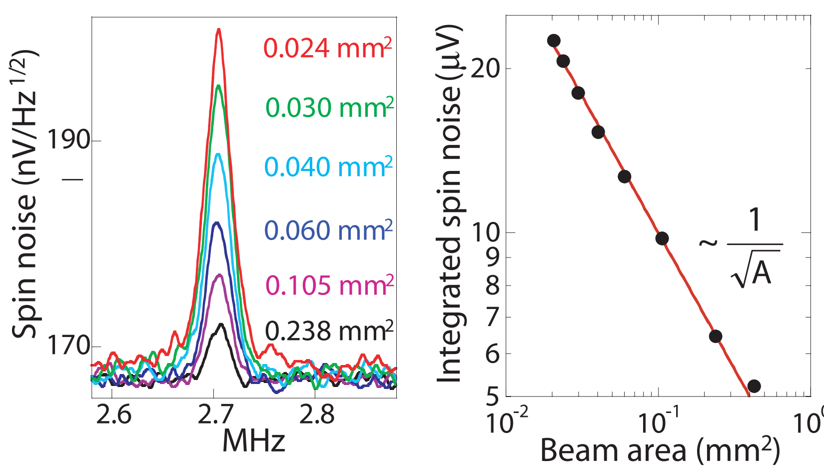

Figure 2. *Increasing* absolute spin noise with *decreasing* cross-sectional beam area. The spin density is fixed, with constant 145 μW laser power, and B=5.8 G. The integrated spin noise vs. beam area scales as $1/\sqrt{A}$.

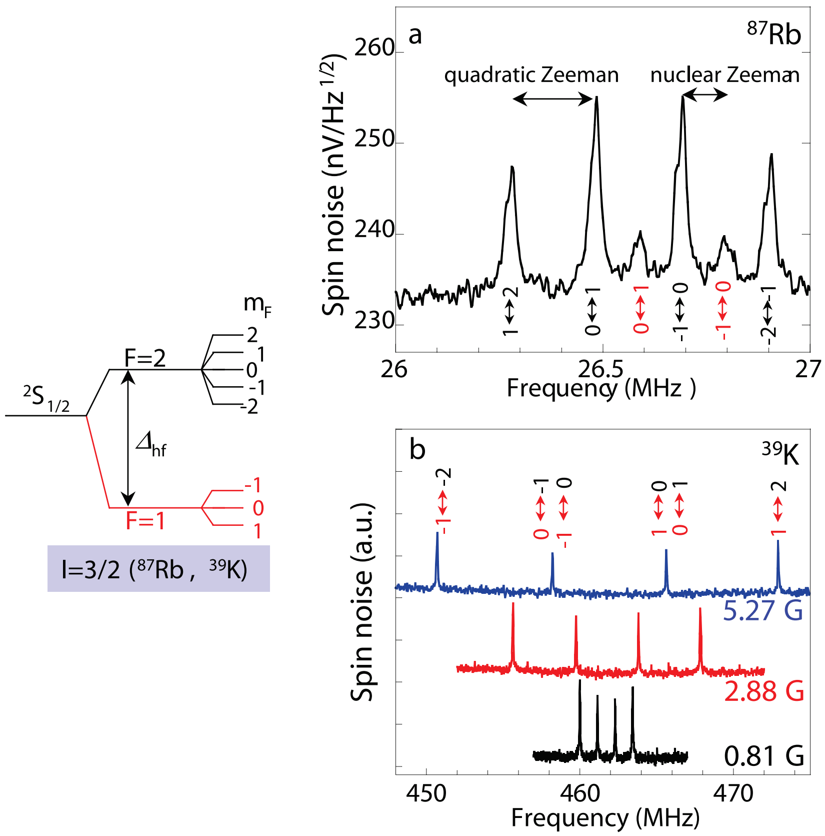

Figure 3. The ground-state hyperfine and Zeeman levels of ^{87}Rb (Δ_{hf} =6835 MHz) and ^{39}K (Δ_{hf} =461.7 MHz) which both have nuclear spin I=3/2. **(a)** Spin noise spectrum of ^{87}Rb at 38.1 G. Spontaneous coherences between all allowed ΔF=0, Δm_F ±1 Zeeman levels are resolved, from which hyperfine splitting and nuclear magnetic moment may be inferred. Coherences within the F=1 ground-state hyperfine level are labeled in red (refer to diagram). **(b)** *Inter*-hyperfine spin noise coherences (ΔF=1, Δm_F=±1) in ^{39}K at B=0.81, 2.88, and 5.27 G. T=456 K, and laser detuning is 220 GHz.

ratio—1.60—agrees quite well with the *square root* of the ^{85}Rb:^{87}Rb natural abundance ratio ($\sqrt{72.2\%/27.8\%}$=1.61).

In addition to scaling with $\sqrt{N}$, the measured spin noise actually *increases* when the diameter of the probe laser *shrinks,* as shown in Fig. 2. This result may be understood by considering that the Faraday rotation imposed on light passing through an intentionally-magnetized system is independent of beam area, so that the effective measurement sensitivity (rotation angle per unit polarized spin, θ_F/N) is larger for narrower beams. Therefore, fluctuations of order $\sqrt{N}$ spins induce correspondingly more signal. These data suggest the utility of noise spectroscopy for passive probes of small systems, where the absolute amplitude of measured fluctuations actually increases when probe size is reduced, as long as measurement sensitivity increases correspondingly. In magnetometry this situation can be realized, for example, through the use of smaller Hall bar magnetometers (since the Hall voltage is independent of area, for fixed current), or as is often the case for magneto-optical measurements, through a tighter focus.

Fig. 3 shows that spin fluctuations reveal detailed information about complex magnetic ground states arising from, *e.g.*, nuclear magnetism and hyperfine interactions. Fig. 3 shows the spin noise spectrum in ^{87}Rb at 38 G, where the single peak has split into six resolvable noise coherences, due to the effects of hyperfine coupling and nuclear magnetic moment. These peaks correspond to spontaneous coherence between the six allowed ΔF=0,Δm_F=±1 transitions. Lastly, spin fluctuations in thermal equilibrium also generate spontaneous spin coherence between *inter-hyperfine* Zeeman levels (ΔF=1,Δm_F=±1), as shown in Fig. 3b for ^{39}K. At low fields, these high-frequency noise coherences split away from the ^{39}K hyperfine frequency (Δ_{hf} = 461.7 MHz) with energy $h\Omega \cong \pm g_F \mu_B B$ and $\pm 3 g_F \mu_B B$, providing additional means of measuring Δ_{hf} from spin fluctuations alone.

We emphasize that these measurable ground-state spin coherences arise solely from random fluctuations while in thermal equilibrium, decidedly in contrast with normal methods for magnetic resonance. Nonetheless, the same detailed spectroscopic information is revealed, in accord with the fluctuation-dissipation theorem. The non-perturbative nature and inverse scaling of absolute noise with probe size portends favorably for local noise spectroscopy of small solid-state systems, where the planar geometry of many technologically-relevant structures is well-suited to high-spatial resolution studies. For example, in a semiconductor two-dimensional electron gas with electron density 10^{11}cm^{-2}, only ~1000 electrons are probed in a focused 1 micron laser spot. Thus, electron spin fluctuations (relative to the signal from a polarized system) are of order one part in $\sqrt{1000}$, as compared with only one part in ~ $\sqrt{10^9}$ in these studies.

1 F. Bloch, *Phys. Rev.*, **70**, 460 (1946).
2 T. Sleator, *et al*., *Phys. Rev. Lett*, **55**, 1742 (1985).
3 R. Kubo, *Rep. Prog. Phys.*, **29**, 255 (1966).
4 S.A. Crooker, *et al*., *Nature,* **431**, 49 (2004).

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

M. Furis, S.A. Crooker, T. Barrick, P.D. Robbins, and their collaborators have recently investigated the spin states of excitons in CdSe nanocrystal quantum dots using a fiber-coupled probe specially-designed for high resolution resonant photoluminescence and Raman spectroscopy. Their results, presented at the most recent SemiMag-16 conference hosted by NHMFL/FSU in Tallahassee, are an example of unveiling new physics of zero dimensional systems through high-resolution polarized optical spectroscopy in high magnetic fields.

Probing Excitonic Spin States in CdSe Nanocrystal Quantum Dots by Polarized Resonant Photoluminescence Spectroscopy

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P.D. Robbins, NHMFL and FSU
M. Petruska, LANL
V.I. Klimov, LANL
X. Wei, NHMFL
A.L. Efros, Naval Research Laboratory

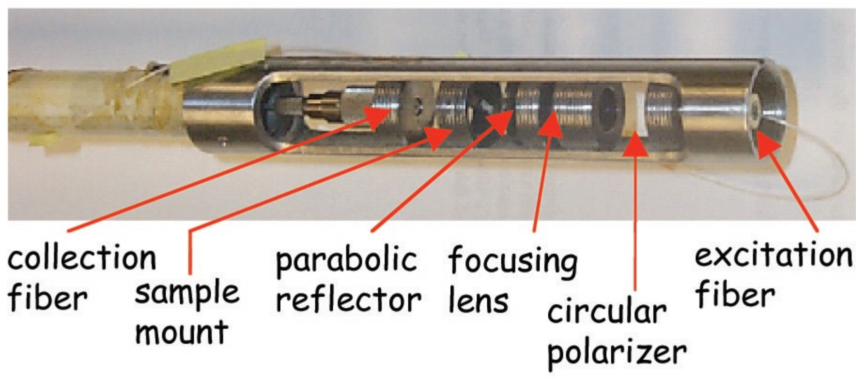


Figure 1. Fiber-coupled probe used for resonant photoluminescence and Raman spectroscopy in high magnetic fields. The telescope-like design avoids collection of specularly-scattered excitation light.

Colloidal nanocrystal quantum dots exhibit a very strong size-dependence of their optical properties due to the effects of quantum confinement. Their near-unity quantum yields and the possibility of tuning their emission wavelength over the visible spectrum, combined with the flexibility of functionalizing the nanocrystal surface, suggest that colloidal quantum dots are suitable for many optical applications that require an in-depth knowledge of the structure of excitonic energy levels. The ground state energy levels of an exciton in a quantum dot are strongly modified by the enhanced electron-hole exchange energy. In CdSe nanocrystals, the ground state exciton is characterized by a net spin $J=2$, and is therefore optically "dark" (*i.e.*, it cannot couple to light, photons having spin-1). The first excited state has net spin $J=1$, and is therefore optically allowed ("bright"). These fundamental exciton spin states can be investigated through fluorescence line narrowing (FLN), an optical spectroscopy wherein spin-1 "bright" excitons are resonantly pumped into the nanocrystals, and the photoluminescence (PL) associated with nearly-resonant exciton states is collected and analyzed.

The primary challenge of FLN experiments in high magnetic fields is to resolve features that are spectrally quite close (<1 nanometer) to the excitation wavelength. The authors at NHMFL/LANL developed a special fiber-coupled probe (Fig. 1) that minimizes the collection of the scattered excitation beam from the sample surface, while still collecting all the emitted PL. They were thus able to resolve emission features within 1 meV from the excitation energy using only a single-grating spectrometer. This probe fits the 32 mm bore of the 33 T DC field magnet in Tallahassee as well as the 20 T superconducting magnet in Los Alamos. Spin-up or spin-down "bright" excitons were selectively pumped in a CdSe nanocrystal sample mounted on this probe using circularly polarized light from a narrowband tunable dye laser. The PL from spin-up or spin-down "dark" excitons was analyzed as a function of magnetic field, as shown in Fig. 2a.

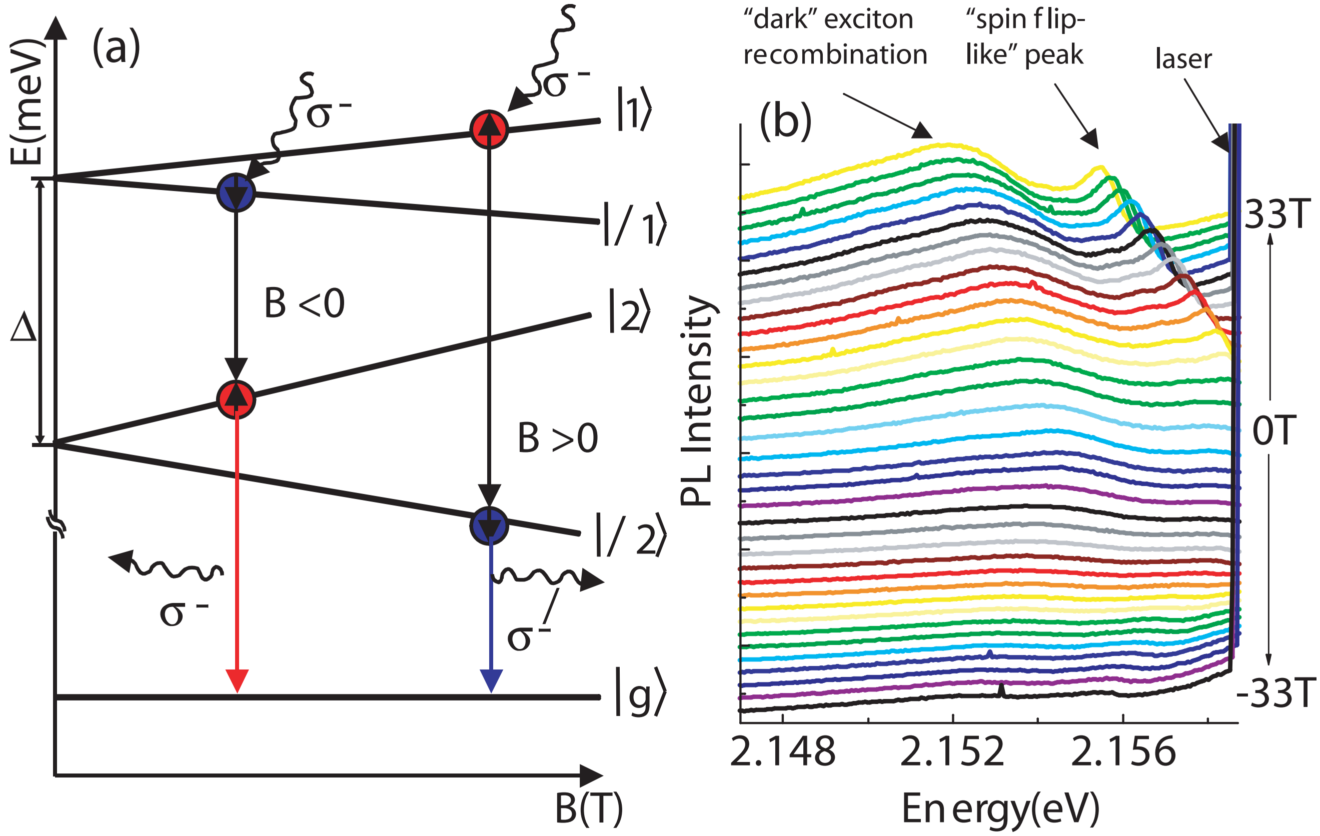
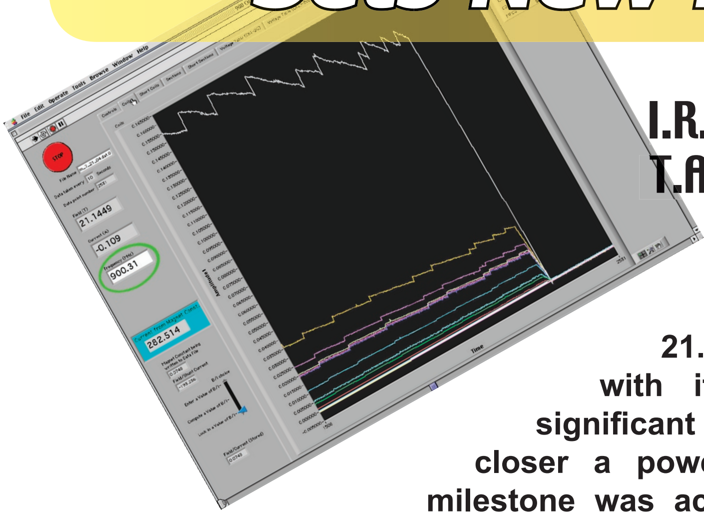


Figure 2. (a) Principles of the spin-polarized fluorescence line narrowing (FLN) experiments in high magnetic fields. Spin-up or spin-down "bright" excitons are selectively and resonantly pumped using circularly polarized light from a narrowband dye laser, and the nearly-resonant photoluminescence associated with spin-up or spin-down "dark" excitons is analyzed. (b) High resolution FLN spectra from CdSe nanocrystals as a function of magnetic field. A spin-flip feature associated with the splitting of the "bright" exciton state appears for B>10 T.

In addition to the features associated with exciton recombination, the spin-resolved FLN spectra from CdSe nanocrystals in high magnetic fields reveal the unexpected presence of a spin-flip-like feature, redshifted by only a few meV with respect to the excitation energy (Fig. 2b). This energy shift is associated with the splitting of the "bright" exciton state, and as can clearly be seen, the peak energy does *not* extrapolate back to zero energy at zero field. This offset, which depends on the size of the quantum dot, is directly related to the strain anisotropy, which splits the bright exciton levels even in zero applied field and is measured for the first time here in CdSe nanocrystals.

900 MHz Reaches Full Field . . .
Sets New Dimensions!



I.R. Dixon, 900 MHz NMR Magnet Project Leader
T.A. Cross, NMR Program Director

On July 21, 2004, the Ultra-Wide Bore 900 MHz NMR Magnet reached its full field of 21.1 T. Bringing the world's largest NMR magnet with its 105 mm warm bore operational marks a significant achievement in magnet technology and brings closer a powerful scientific instrument to the NHMFL. This milestone was achieved without incurring any training quenches.

The magnet, shown in Fig. 1, is a concentric assembly of ten superconducting coils, connected in series. Each coil is wound with a monolithic superconductor, composed of either niobium-tin (Nb_3Sn) or niobium-titanium (NbTi) filaments in a copper jacket. Many coils are overbanded with stainless steel wire and all are vacuum impregnated with cryogenically tough epoxy for structural support. The high current density coils produce a highly uniform field of 21.1 T in an extremely large region. Small adjustments to field homogeneity are achieved with a set of superconducting shim coils that fine tune the magnetic field. Fabrication of the NbTi and shim coils occurred in cooperation with an industrial partner, Intermagnetics General Corporation.

This past spring, fabrication of the cryostat around the magnet was completed, schematically shown in Fig. 2. The magnet resides within a vessel of the cryostat containing 2,400 liters of liquid helium at atmospheric pressure. This "magnet vessel" is conductively cooled to a temperature of 1.7 K by use of a closed loop heat exchanger. The pressure of the saturated helium in the heat exchanger is reduced to achieve the superfluid temperature. The level of helium in the heat exchanger is controlled by a Joule-Thompson (JT) valve that draws liquid in from the 1100 liter Helium-I reservoir. This liquid, prior to going through the JT-valve, is precooled to near the lambda point T_λ by the vapor that is being pumped off. The cryostat also contains a number of thermal shields and multi-layer insulation to suppress the radiative heat loads.

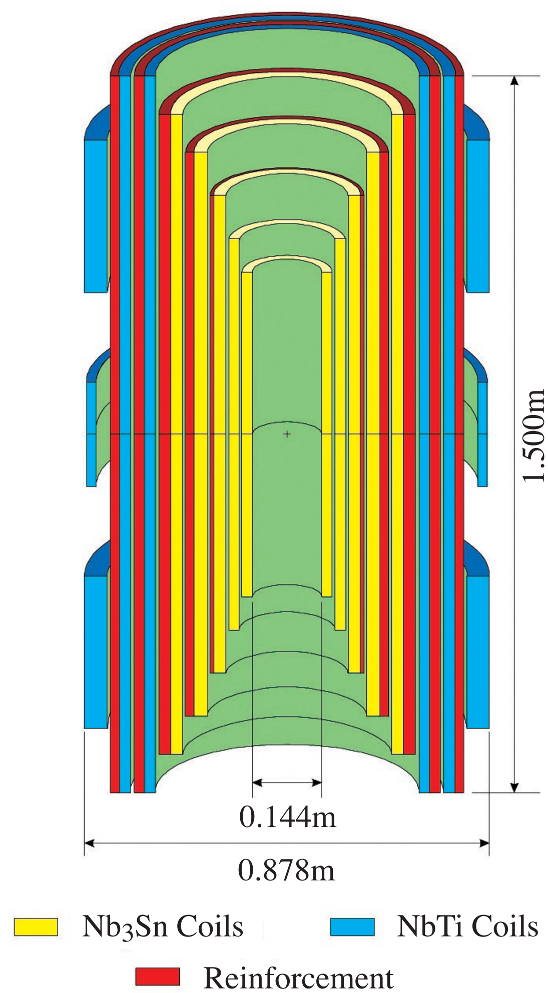


Figure 1. Sectional view of the 900 MHz NMR Magnet primary coils.

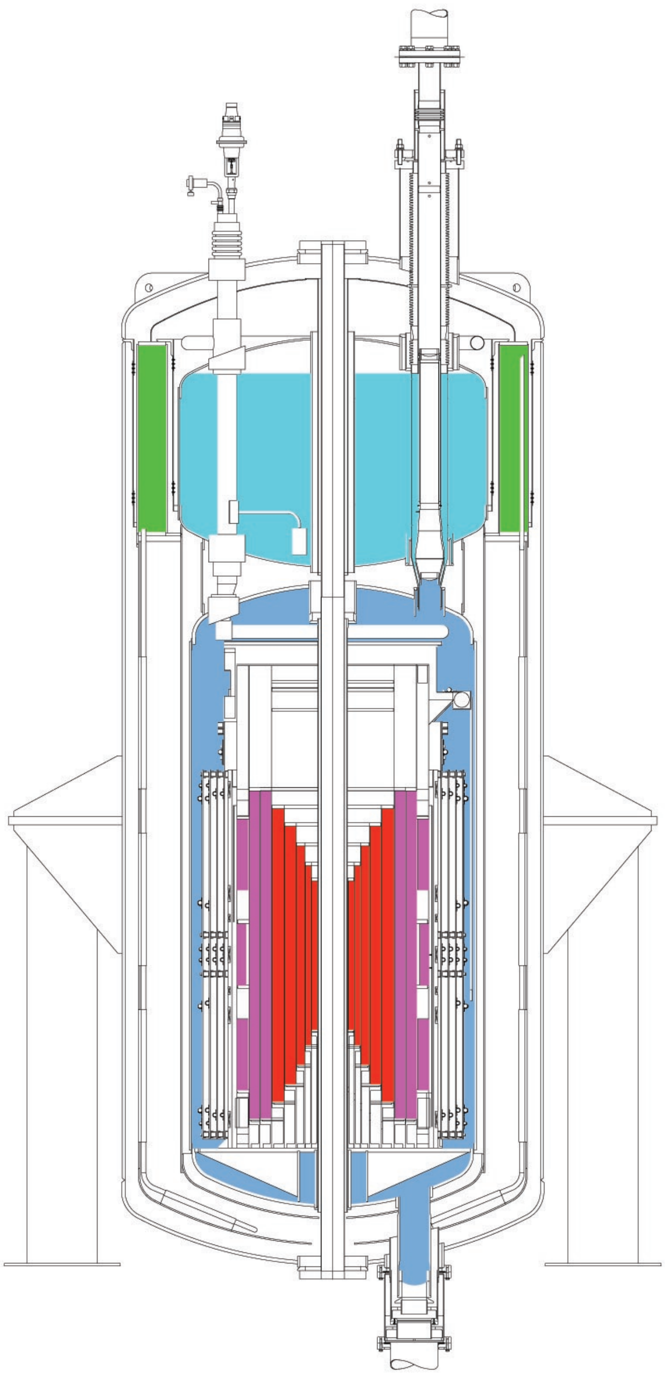


Figure 2. Schematic of the Ultra-Wide Bore 900 MHz Magnet within its cryostat.

The 900 MHz magnet has such a large bore (105 mm) in comparison to typical wide bores (89 mm) and standard bores (54 mm) because this magnet was originally conceived as a prototype to a standard bore 1.1 GHz (25 T) NMR magnet. The field produced by a 1.1 GHz magnet exceeds the operational limits of conventional low temperature superconductors (LTS), requiring the innermost coil to be constructed of high temperature superconductor (HTS). The HTS coil of a 1.1 GHz magnet would produce 5 T with the remaining LTS coils producing 20 T. The 900 MHz magnet is of the same scale as a 1.1 GHz magnet with the same outer LTS coils, but its innermost coil is constructed of LTS, adding an additional 1.1 T for a total central field of 21.1 T and a larger inner diameter. Thus the 900 MHz magnet has been an instrument for the development of skills, tools, and technology necessary to engineer and build state-of-the-art, higher field superconducting magnets.

The ultra-wide bore of the 900 MHz magnet, with its large uniformity zone, relieves many of the spatial constraints placed on scientific users. A number of probes are being developed and set up to optimize the useable space. The room temperature shim set reduces the clear bore to 89 mm, that of a typical wide bore magnet without shims. Some scientific applications, such as imaging, may not need the room temperature shims and may be able to utilize the entire volume.

Since reaching 21.1 T, an initial adjustment of the superconducting shims was performed to achieve a magnet homogeneity of approximately ±2 ppm over a 4 cm sphere. The room temperature (RT) shims, with an inner diameter of 89 mm, developed by Resonance Research Inc., will further improve the uniformity to ppb levels over this volume. A second standard bore RT shim set provided by Bruker Biospin will be used for high resolution solution and solid state NMR. Additional adjustment to the superconducting shims will be performed if necessary.

The magnet has a field decay of 525 Hz/hr. This is being compensated through a novel approach of injecting current through low loss leads into one of the main superconducting coils. The preliminary results of this field stabilization technique are very encouraging and it is expected that the drift will be reduced to less than 5 Hz/hr without significantly influencing the field homogeneity. This is a significant advance for high field NMR magnet technology.

Bruker Biospin is presently installing a four channel Avance 900 MHz console with capabilities for solution and solid state NMR as well as imaging. The console is equipped with ^{1}H/^{19}F solid state amplifiers (100 Watt output for solution NMR and 800 Watt output for solid state NMR), and one 1,000 Watt and two 500 Watt amplifiers for X nucleus irradiation. The console also has 60 Amp X, Y, and Z gradient amplifiers for imaging and diffusion NMR experiments.

For solution NMR, a 5 mm inverse triple resonance probe to observe ^{1}H while irradiating ^{13}C and ^{15}N with a ^{2}H lock is being installed by Bruker. This probe includes actively shielded X, Y, and Z gradient coils with variable temperature control.

For magic angle spinning spectroscopy, Bruker has provided an HCN probe utilizing 3.2 mm rotors with a maximum rotational rate of 23 kHz. Variable temperature capability extends between –100°C and +150°C. A second HX MAS probe with a considerable variable temperature range is under development. For uniformly aligned samples, a square coil HN probe has been designed and assembled in-house with high performance specifications and variable temperature capability.

For imaging and diffusion measurements, a Dodderell microimaging probe system has been obtained from Bruker Biospin. The NHMFL at the University of Florida Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) is working on developing a variety of additional imaging probes.

The science program (See *NHMFL Reports*, Fall, 2002) is designed to take advantage of both the high fields and ultra-wide bore of this magnet, for instance:

- Microimaging for ultrastructural characterization and for monitoring diffusional anisotropy.
- High resolution spectroscopy of quadrupolar nuclei for materials characterization and imaging of quadrupolar nuclei for ultrastructural characterization.
- ^{1}H and ^{19}F magic angle spinning solid state NMR of biological and inorganic materials.
- Structural and dynamic characterization of membrane proteins and other macromolecular structures through solid state and solution NMR.
- Characterization of nascent structure in weakly structured macromolecular systems.

Figure 3. Ultra-Wide Bore 900 MHz NMR Magnet System.

Once high performance capabilities are demonstrated in this Ultra-Wide Bore 900 MHz magnet, the NMR Spectroscopy and Imaging Program will be open for users. This program is focused on the development of technology, methodology, and protocols to enhance NMR spectroscopy and imaging at high fields AND to expand the range of scientific applications for NMR spectroscopy and imaging through the use of high magnetic fields. Additional information is available on the NMR Program Web site at *http://nmr.magnet.fsu.edu/*. Researchers interested in requesting time should e-mail Tim Cross (*cross@magnet.fsu.edu*) with a one to two page description of proposed experiments. Priority will be given to proposals that take the best advantage of the high field and wide bore aspects of this system.

Microcoil NMR Technology for Small Samples of Proteins

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X. Zhang, Univ. of Illinois at Urbana-Champaign, Electrical and Computer Engineering
T. Logan, NHMFL/FSU, Chemistry and Biochemistry
A. Webb, Univ. of Illinois at Urbana-Champaign, Electrical and Computer Engineering
A.S. Edison, AMRIS/UF, Biochemistry and Molecular Biology

NMR suffers from poor sensitivity, because the frequencies required for resonance are low and the ground and excited states are nearly equally populated at room temperature. This can be improved by increasing the frequency (e.g., making higher field magnets), lowering the temperature (e.g., high B/T), or improving the measurement efficiencies. The NHMFL has great strengths in all three areas, and this report summarizes recent developments in improvements in measurement efficiencies through the design of small radio frequency (RF) solenoidal microcoils.

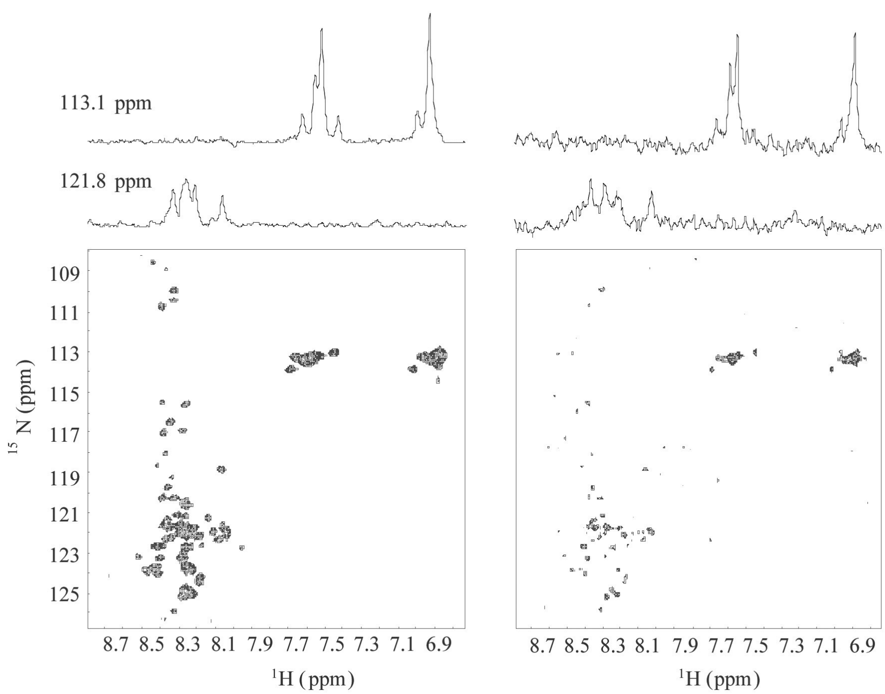

Figure 1. Comparison of the 2.5 mm solenoidal probe and a commercial 5 mm probe using equal amounts of ^{15}N-labeled IA-3: the data were acquired using a ^{1}H-{^{15}N} HSQC sequence. The solenoidal probe contained 60 μL of 1 mM ^{15}N-labeled IA-3, and the 5 mm probe contained 600 μL at a concentration of 0.1 mM. Two 1-D slices at 113.1 and 121.8 ppm in the ^{15}N dimension are shown on top of the 2D spectrum: spectra from the 5 mm probe are shown at a 10-times higher scale. The signal-to-noise ratios of the maximum peaks in these slices are 130:1 and 13:1 (113.1 ppm) and 60:1 and 6.5:1 (121.8 ppm). Complete details can be found in Li *et al.*, 2003.

The signal to noise (S/N) in an RF coil is approximately inversely proportional to the diameter of the coil. Thus, by decreasing the coil diameter, the S/N per nuclear spin increases. Of course, this increase in S/N is at a cost of sample volume. The optimal type of sample for microcoils is one that is mass-limited (e.g., hard to get) but soluble in relatively high concentrations. Microcoils have been widely used for small molecule, natural product NMR due to the difficulty in obtaining large quantities of material. Protein NMR has traditionally used larger 5 mm samples, because many proteins tend to aggregate at high concentrations. However, the high costs of fully labeling proteins with ^{13}C, ^{15}N, and sometimes ^{2}H, along with the difficulty often encountered in producing them make them, ideal candidates for microcoil NMR.

We started our work on protein solenoidal microcoils a few years ago with a relatively large coil of 2.5 mm and an active sample volume of about 15 μL (Li, *et al.*, 2003). This single coil was tuned to 4 frequencies, ^{1}H, ^{13}C, ^{15}N, and ^{2}H, allowing for standard protein triple resonance experiments to be collected. One significant benefit from the single microcoils tuned to multiple frequencies is that 90 degree pulse lengths are extremely short for all channels. Fig. 1 shows a comparison of two ^{15}N-HSQC spectra collected with the same total amount of material with 10x more concentration but 10x less volume in the microcoil. The S/N benefit in going smaller is apparent and suggests that this technology is appropriate for proteins.

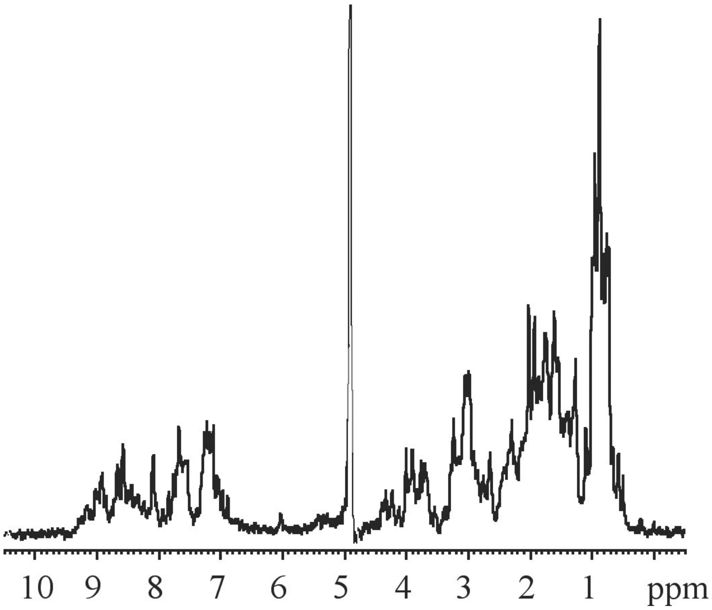

Figure 2. 1D 1H NMR spectrum of 1 µL active volume of 3 mM Target 2 protein. The spectrum was obtained at 750 MHz with 8 scans and used Watergate for water elimination.

Given our initial encouraging results from a 2.5 mm coil, we have recently decided to further push the limits with a 1 mm solenoid microcoil probe that has an active sample volume of about 1 µL and a total volume of about 4 µL. Both simulation and experimental methods have been utilized to optimize this coil. In order to improve the homogeneity of radio frequency field, a large length to diameter ratio of ~2.3 was used in the 1 mm solenoid microcoil design. We also found that the use of rectangular wires instead of round wires in the winding of such a coil can considerably reduce the coil loss and improve the sensitivity performance in NMR experiments. A 1D ^{1}H NMR 750 MHz spectrum of a protein demonstrating the high S/N using this coil is shown in Fig. 2.

In collaboration with Jim Prestegard's laboratory at the University of Georgia, we have collected several 3D triple resonance data sets of "Target-2" protein using the optimized 1 mm solenoid coil. Our immediate goal is to sequentially assign the protein using just 4 µL of sample, and we also will collect data to determine a low-resolution structure of the protein. The amount of the protein sample for these studies is below 10 nano-moles. The 3D NMR spectra have been acquired on a 750 MHz Bruker spectrometer in the AMRIS facility.

A significant advantage of microcoil technology is the ability to collect several datasets simultaneously because of the small size of the coils (Li *et al.*, 1999). This technique has been recently applied to 8 small molecules using a ^{1}H probe (Wang *et al.*, 2004). Simultaneous protein NMR is more challenging than small molecule studies, because the coils need to be larger and there are several additional frequencies that are required for protein NMR that need to be electrically isolated. Fig. 3 demonstrates the concept with two protein ^{15}N-HSQC spectra simultaneously collected with two 2.5 mm solenoid coils in the same probehead. By expanding this technique to more samples, this technology can easily be

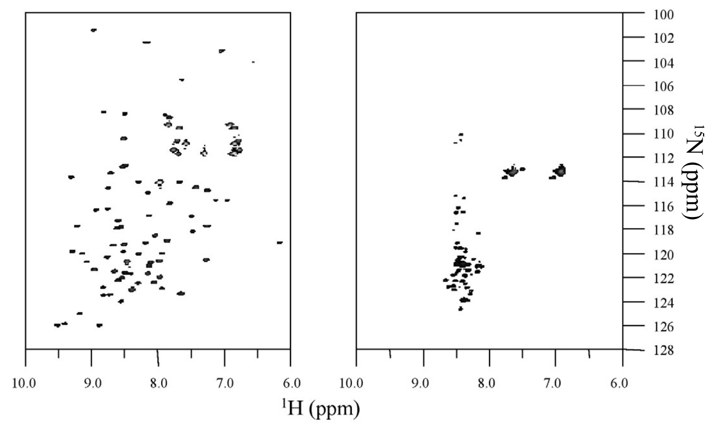

Figure 3. Simultaneous protein NMR detection using solenoids. (left) ^{15}N HSQC spectrum of 1.25 mM ^{15}N-labeled ubiquitin in 90% $H_2$0/10% D_2O, 50 mM phosphate buffer, pH 5.5. Data acquisition parameters: sw=4000 Hz, sw1=1600 Hz, 1024 complex data points, 192 t_1 increments acquired in States mode, 1 s water presaturation, 32 signal averages. Total data acquisition time 3.5 hours. (right) ^{15}N HSQC spectrum of 1 mM ^{15}N-labeled IA-3 in 90% $H_2$0/10% $D_2$0, 50 mM phosphate buffer, pH 5.5. Identical data acquisition parameters were used. Data were acquired in interleaved fashion with pulse transmission and data reception routed through an RF switch controlled from the console.

applied to high-throughput structural genomics, screening of large numbers of proteins for folding, and molecular library screening of molecules binding to proteins in drug discovery. This study is especially relevant to the ultra-wide bore 900 MHz magnet that will have room for larger arrays of microcoils than any other high-field magnet available today.

In summary, microcoils can provide very high quality data for proteins that are comparable in resolution to data collected on standard 5 mm commercial probes but that have much higher S/N per unit spin. These probes have exceptionally short pulse widths on all channels, making them ideal for protein NMR, especially using ^{13}C, at high magnetic field strengths. Their size allows the development of novel approaches to multiple sample detection, which has important applications in structural genomics and drug development. Finally, microcoil probes are relatively inexpensive and easy to construct and can be designed and constructed for particular sample needs.

1 Li, Y., *et al.*, *Anal. Chem.*, **71**, 4815-4820 (1999).
2 Li, Y., *et al.*, "Design and Optimization of High Sensitivity Small Volume Probes for Improved Limits of Detection in Protein NMR experiments" *Journal of Magnetic Resonance* **164**, 128-135 (2003).
3 Wang, H., *et al.*, *In Press, Journal of Magnetic Resonance* (2004).
4 Li, Y., *et al.*, ENC, Monterey CA, April 19-23 (2004).

This work was supported by "High Field Magnetic Resonance Research and Technology" 05/01/01 - 04/30/06 NIH/NCRR P41 RR16105-01 (PI: Blackband; Core PIs: Edison, Blackband, and Fitzsimmons).

As the 2004-2005 academic year begins, everyone at the Center for Integrating Research and Learning (CIRL) is busy working on various facets of educational outreach: school outreach, high school externships, teacher professional development, conference presentations, new programs development, partnerships, and existing programs support.

A multidisciplinary team from CIRL, Magnet Science & Technology, the Center for Advanced Power Systems, and the Research Experiences for Teachers program (Gina LaFrazza, Justin Schwartz, Sastry Pamidi, Ulf Trociewitz, Bianca Trociewitz, Doan Nguyen, Dave Sheaffer, Brandie Miklus, Stacy Vanderlaan, Ysonde Jensen, and two 2004 RETs—Linda Ford from Seven Hills School in Cincinnati, Ohio and Mark Johnson from Lake Weir High School in Ocala, Florida) have worked throughout the summer and fall of 2004 to create *Project Superconductivity*. This curriculum package brings the science of superconductivity and related concepts to students through hands-on, inquiry-based activities and materials designed for use in high school classrooms. Topics include critical temperature, the Meissner Effect, and calorimetry. LaFrazza and Schwartz continue efforts to expand the program to the national audience and adapt it for the undergraduate audience.

On October, 8, 2004, Gina LaFrazza, Carlos Villa, and Dave Sheaffer will debut *Project Superconductivity* at the first ever **Teacher-Scientist Workshop at the Applied Superconductivity Conference** (ASC) in Jacksonville, Florida. Teacher recruitment for the workshop has been an overwhelming success—all openings were filled in the first week. The workshop will provide a unique opportunity for seventeen high school teachers to learn side-by-side seventeen of the top scientists in the field of superconductivity. Teachers will receive all of the materials necessary to conduct the *Project Superconductivity* in their classrooms, as well as practice conducting the activities with expert scientists, curriculum developers, and fellow educators. The workshop will provide strategies to participating scientists for working with teachers and students in their local communities to further educate the public on the science of superconductivity. The workshop was made possible by funding from ASC, Inc., the Institute of Electrical and Electronics Engineers, the U.S. Department of Energy, and the Office of Naval Research.

Project MagLab Recertification was the direct result of the NHMFL's fledgling **Teacher in Residence** program. Rich McHenry, a chemistry teacher from Leon High School in Tallahassee, FL, and David Rodriguez, an earth/space science teacher from Raa Middle School in Tallahassee, FL, have developed a comprehensive manual of inquiry-based, hands-on science activities covering electricity and magnetism, molarity, electrical conductivity of solutions, and using chemical reactions to generate electricity. All activities are correlated to middle and high school Sunshine State Standards and the National Science Education Standards. The materials have been reviewed and accepted by Florida's Educational Consortia for use statewide.

In partnership with the local school district, and with funding provided by the **American Physical Society's Topical Group on Magnetism and its Applications**, the Center initiated its NHMFL Girls in Science Program. Up to 20 girls from grades 6-8 participate in the after-school science program designed to create enthusiasm for science and provide strategies for success. In addition to working with Pat Dixon from the Center, girls interact with guest speakers from community science and environmental groups, take field trips to the NHMFL and to other science facilities, and explore magnet-related science concepts.

Another new project was created in partnership with the LeRoy Collins Leon County Public Library System. Focus on Physics is a month-long promotion of the World Year of Physics 2005. Funded by the **American Association of Physics Teachers Bauder Fund Committee**, the events included displays, demonstrations, a parent-child night with hands-on activities, and a month-long "treasure hunt" of resources to find answers to physics questions. Students use print and Web-based materials to learn more about basic physics concepts and the people who have shaped the discipline.

A full schedule of classroom and community outreach provides new and exciting ways for students to learn about science concepts. Starting in kindergarten, students explore magnets, magnetism, and related concepts. Each year, new outreach materials are developed to engage students new to the experience as well as students who have participated each year. The Frenchtown After School Program serving two local after-school programs in neighborhood centers and the Boys and Girls Clubs programs continue this fall as part of our wide-ranging program. The outreach program continues to be an area of significant growth as teachers from a five-county area around the lab seek innovative ways to present science to their students. All materials to prepare students for their experience as well as materials to follow-up after the experience are provided in print and on-line.

The education Web site, *http://education.magnet.fsu.edu*, continues to be one of the most dynamic areas of the Center. In addition to providing on-line application/registration for the Superconductivity Workshop and for both the Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) programs, several unique features have recently been developed. The Teacher Network provides workshop and summer institute participants with the ability to submit follow-up documentation online. A dimension of the Web site that is important to the life of the program is the continuous online collection of data. An online outreach survey submitted by teachers after classroom outreach, counters that keep track of how many people are visiting the Web site and how the features are being used, and the REU and RET Networks that provides a means of keeping track of current and former participants. A "Calendar of Events" features notices of special outreach programs such as Science Night at Borders, upcoming workshops, and highlights CIRL presentations at upcoming educational conferences.

For more information, contact Pat Dixon (pdixon@magnet.fsu.edu)*, Gina LaFrazza* (lafrazza@magnet.fsu.edu) *or Carlos Villa* (villa@magnet.fsu.edu)*, who contributed this article.*

Sweeper Magnet Installation at the National Superconducting Cyclotron Laboratory

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D. Sanderson, NSCL
M. Thoennessen, NSCL
A. Zeller, NSCL
M.D. Bird, NHMFL

In September 1998, the NHMFL entered into a collaborative project with the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU) to develop a "Sweeper" magnet for use in nuclear physics experiments along the nuclear driplines. The NHMFL led the effort to design and build the magnet. The NSCL led the design and construction of detectors, systems integration, and will operate the magnet as a user facility. In March of this year, the magnet was completed and tested to 375 amps at the NHMFL with only one training quench (see *NHMFL Reports*, **11** (2), 2004). Since then, the magnet has been shipped to the NSCL, installed in the beamline of the N4 vault along with the Modular Neutron Array (MoNA) and focal plane detectors, and successfully operated in a test run. The installation is shown in Fig. 1, in the beamline beside the quadrupole triplet.

The first run consisted of observing neutrons detected by MoNA in coincidence with charged particles bent into the focal plane detectors by the Sweeper. A secondary beam of ^{8}Li from the Coupled Cyclotron Facility bombarded a beryllium target in front of the sweeper magnet. The single proton stripping reaction populates the ground state of ^{7}He which is unbound and decays immediately into a neutron and ^{6}He. The goal of the test run was to observe this decay and extract the ground state energy of ^{7}He.

Neutrons emitted near zero degrees through the large gap of the Sweeper were detected in MoNA located about 13 m behind the Sweeper. The Sweeper operated at 300 A corresponding to a rigidity required to bend the charged fragments into the detector system of the focal plane box located at 40°.

The upper left panel of Fig. 2 shows the ΔE-E plot recorded by detectors in the focal plane box following the Sweeper. Three distinctive groups identified as scattered ^{8}Li, and ^{6}He and ^{3}H reaction products (from top to bottom) can be seen. The other three spectra are time-of-flight spectra of neutrons recorded by MoNA relative to the fragments detected in the Sweeper detector setup. The three spectra are gated on ^{8}Li (bottom left), ^{6}He (bottom right), and ^{3}H (top right). The ^{8}Li gated spectrum shows only random coincidences from cosmic ray background as expected. The ^{6}He spectrum exhibits two distinct peaks corresponding to forward and backward emitted neutrons from the ground state of ^{7}He. The spectrum in coincidence with ^{3}H shows only one broad peak because ^{4}H does not have a sharp unbound resonance. The spectra shown in Fig. 2 were recorded online and are not calibrated. The fact that we were able to extract these distinct features already online shows that the Sweeper and all the detectors of MoNA and the Sweeper focal plane box worked great in this first test run.

After the test run, the magnet was operated at 350 A, without quenching. This first test run did not use the external trim coils shown in Fig. 3. The trim coils are designed to reduce the external magnetic field so that magnetic field-sensitive phototubes can be operated as close to the beam box as possible (for maximum solid angle). The next test run is scheduled for late August, 2004. After the run, the magnetic field will be mapped.

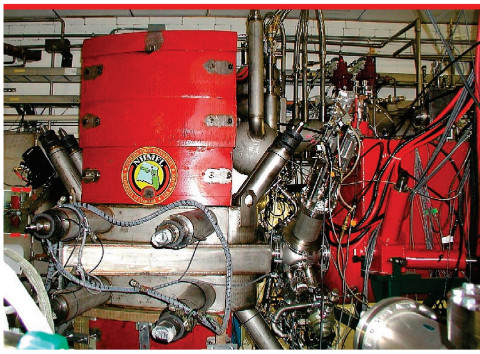

Figure 1. The Sweeper in the N4 vault at the NSCL. The quadrupole triplet is to the right and the focal plane detector is to the left. MoNA is not shown.

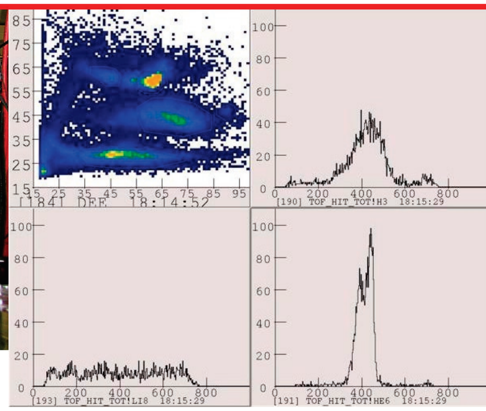

Figure 2. Online spectra from the first test run of the Sweeper Magnet in coincidence with the Modular Neutron Array MoNA. The top left figure shows the particle identification of fragments in the detector box following the sweeper. Bands of lithium, helium, and hydrogen (from top to bottom) can be clearly identified. The other three spectra are time-of-flight spectra of MoNA relative to the fragments in the Sweeper (see text).

Figure 3. Test fitting the trim coils on the Sweeper before installation in the vault.

PEOPLE IN THE NEWS

Gail E. Fanucci returned to the University of Florida in July—this time as an Assistant Professor in the Department of Chemistry. Dr. Fanucci earned her undergraduate degrees (Biochemistry and Biophysics) from the University of Scranton and her Ph.D. in Chemistry from UF in 1999 under the direction of Daniel Talham. Following UF, she was an NIH Postdoctoral Research Associate at the University of Pennsylvania with Stanley Opella and then held a similar position at the University of Virginia with David Cafiso.

Dr. Fanucci's work focuses on the interdisciplinary field of biophysical spectroscopy (such as EPR, fluorescence, infrared and circular dichroism), which has applications in chemical biology, protein science, structural biology, and membrane science. Her research program uses, among other tools, X-band EPR spectroscopy, for site-directed labeling and magnetic resonance approaches to study: conformational changes in mRNA and ribosome binding to mRNA; the association and translocation of peptides/proteins with membranes; orientations of protein on/at membrane surfaces; protein-protein interactions; and membrane protein structure, dynamics, and conformational changes. The NHMFL is extremely pleased to welcome Gail back to the University of Florida and to the extended NHMFL family.

Gail Fanucci

Arthur Hebard, UF Professor of Physics, has been selected as one of six University of Florida Research Foundation Professors. The three-year professorships recognize faculty who have established a distinguished record of research and scholarship that is expected to lead to continuing distinction in their field. Hebard specializes in condensed matter and his research focuses on the fabrication and characterization of thin-film structures and the unusual physical phenomena that occur within restricted dimensions. Hebard came to UF in 1996, after spending most of his professional career as a member of the technical staff at AT&T Laboratories. He received his B.A. from Yale University, and his M.A. and Ph.D. from Stanford University.

Arthur Hebard

Munir Humayun, associate professor in the FSU Department of Geological Sciences, is a new member of the NHMFL Geochemistry program. He received his Ph.D. in geochemistry from the University of Chicago (1994). Past honors and awards include a Carnegie Fellowship, a 1998 F. W. Clarke Medal of the Geochemical Society that is awarded to an early-career scientist for a single outstanding contribution to

Munir Humayun

Yoonseok Lee

Efstratios Manousakis

geochemistry or cosmochemistry, and the 2003 Quantrell Award for Excellence in Undergraduate Teaching from the University of Chicago. Humayun's research involves the measurement of chemical and isotopic abundances in natural materials by magnetic sector mass spectrometry. He is a co-principal investigator of the NASA GENESIS Mission, designed to return the first Solar Wind sample to Earth for analysis of the chemical composition of the Sun in ground-based laboratories using facilities at the NHMFL/Geochemistry program. Humayun also contributes to the acquisition of a new multicollector, magnetic sector inductively coupled plasma mass spectrometer (ICP-MS) that will be used for analysis of returned cometary and interstellar dust samples from NASA's Stardust Mission (2006), and in the Geochemistry program's new initiative in Biogeochemistry. He will build a new research group at the NHMFL applying mass spectrometry to the study of the origin and evolution of the Earth and Solar System.

The University of Florida chapter of the Society of Physics Students (SPS) was recently named "Outstanding SPS Chapter" for 2002-2003 by the American Institute of Physics. Less than 10 percent of SPS chapters are recognized annually. The group also recently received a Marsh W. White Award from the national SPS for its *Physics on Fire* outreach program that brings a series of shows to primary and secondary schools, illustrating the physics of heat-related topics with visually stunning demonstrations. **Yoonseok Lee**, UF assistant professor of physics, is the UF SPS faculty advisor. He received his B.A. and M.S. from Seoul National University and his Ph.D. from Northwestern University. In 2002, he was awarded the Association of Korean Physicists in America President's Awards for Outstanding Young Researcher, and in 2003 he received an NSF Career Award. In 2004, Yoonseok Lee was chosen as an Alfred P. Sloan Research Fellow for 2004 - 2006. He is the Director of the Microkelvin Laboratory at University of Florida, and his research interests include acoustic and magnetic properties of liquid and solid ^3He and low temperature properties of low dimensional conductors.

Efstratios Manousakis received a named professorship, the Donald Robson Professor of Physics, from FSU's Named Professorship Program, which was established by the President and Provost in 2000. The professorships honor outstanding tenured professors who exemplify standards of excellence in the performance of teaching, research, and service within their discipline and profession. Manousaki received his B.Sc. from the University of Athens in Greece, and his M.Sc. and Ph.D. from the University of Illinois at Urbana-Champaign. In 1998, he received the PAI Award for excellence in teaching and research at FSU. Manousakis's research interests include condensed matter theory, many-body theory, and statistical mechanics. His research group develops computational methods to study novel collective behavior in certain quantum many-body systems that arises because of strong correlations among the fundamental microscopic degrees of freedom.

Series-Connected Hybrid Gets Funding Support

Starting July 15, 2004, the NHMFL was granted $1.8 million for the conceptual and engineering design (CED) of a new, unique, hybrid magnet system. A primary objective of the CED study is to develop an accurate projection for the construction cost, but at present we think it will take another $6 million. This system will be composed of a large-bore superconducting outsert and a special high-homogeneity, resistive insert. Because these will be connected electrically in series and capable of being driven by a single 10-MW unit of the NHMFL DC power system, we refer to the proposed facility simply as the Series-Connected Hybrid (SCH). This grant, which is to be distributed essentially equally over the next two years until July 14, 2006, is the first to be supported by the NSF's newly established Instrumentation for Materials Research – Major Instrumentation Projects (IMR-MIP).

The SCH design will not represent an attempt to better the record of world's highest steady magnetic field held by the NHMFL's 45 T Hybrid. Instead, it will establish its own array of superlatives in areas of science that have typically been served either by all-superconducting or by all-resistive magnets. In particular:

- The field produced by the SCH will exceed presently available all-superconducting fields by 63% and fields in existing all-resistive magnets with similar bore and uniformity by 40%.
- The SCH will have greater temporal stability than present resistive-only or hybrid magnets. Resulting in part from a naturally higher inductance/resistance ratio, this will be especially helpful for suppressing high-frequency fluctuations, and flux stabilization will be applied to further enhance the field stability.
- The SCH will feature improved homogeneity over the world's highest-homogeneity resistive magnet (the NHMFL's 25-T Keck magnet) by an order of magnitude, allowing scientific exploration into the combined parameter space of high field and high homogeneity never before available anywhere in the world.
- The SCH will consume only about one half the power of the existing high-uniformity, 25-T Keck magnet and about one-third the power of an all-resistive magnet with similar specifications for field, bore, and uniformity, giving it lower operating and cooling costs than any magnet in its class.

The superconducting outsert magnet will be a reasoned and reasonable extrapolation of the technology successfully demonstrated in the NHMFL 45 T Hybrid, with significant advantages derived from the application of new-generation Nb_3Sn superconductors, more efficient and compact structural designs, new structural alloys, and a system configuration that results in less demanding fault scenarios.

The resistive insert magnet will also build on the experience gained from the design, manufacture, and operation of the "Keck" magnet and from the present insert for the 45 T Hybrid. The Keck magnet is a high-homogeneity, all-resistive magnet that typically uses three, 10 MW units of the NHMFL DC power system to deliver a 25 T, NMR-quality field in a 50-mm bore, and the 45 T resistive insert has demonstrated capability for contributing higher steady field than any resistive magnet in the world, whether alone or as part of a hybrid system.

As a combined system, the SCH will significantly advance the scientific capabilities at the NHMFL by increasing the magnetic homogeneity, stability, and field to levels not presently available anywhere in the world. Furthermore, it will introduce to the world advanced magnet technology with overall efficiency of design that simultaneously provides unequalled performance while allowing parallel operation of other NHMFL magnet systems, thereby increasing overall service to laboratory users.

Matching the SCH to user needs is another principal objective of the CED study, and a workshop is planned early in the project (mid-September 2004) to solicit input and to establish a clear set of requirements that will be addressed by the design team. A second workshop will be held midway through the project (around July 2005) to assess the system specifications developed up to that point; specifically, how well they address the requirements established earlier and the feasibility of their being achieved. A final workshop, held late in the grant period but leaving enough time to act effectively on its findings, will assess the design in terms of its suitability for construction and the credibility of its projections for cost and schedule to complete. Since their objectives are different, the constitution of these three workshops may vary, but an External Oversight Committee, assembled from scientists and engineers with expertise in the key technologies needed to construct the SCH and in the science it will be used to enhance, will serve throughout the project, hopefully providing continuity and consistency to the advice received from the community the SCH is being designed to serve.

The Principal Investigator for the SCH CED study is John Miller. Mark Bird, Bruce Brandt, Tim Cross, and Greg Boebinger are Co-PIs. This project is expected to be one of the NHMFL's more significant new facilities in the near future, and it is clear that its successful completion will depend on important contributions from most of Magnet Science and Technology as well from many others in every sector of the Lab.

This article was contributed by John Miller. For further information, he can be reached at 850-644-0929 or miller@magnet.fsu.edu.

Looking Ahead . . .

Applied Superconductivity Conference

Final touches are being put in place for ASC 2004, hosted by the NHMFL in Jacksonville, Florida, October 3-8, 2004. Over 1,400 oral and poster presentations are planned. Drs. Joe Minervini, Cathy Foley, Jiri Vrba, Shirabe Akita, Hasan Padamsee, and Chang-Beom Eom will give plenary talks.

NHMFL Director, Dr. Greg Boebinger, will open the conference with his talk, "The Abnormal Normal State of the High-Temperature Superconductors." Another conference highlight will be the talk by Dr. Bernard Kouchner, founding Director of Doctors without Borders, entitled "Globalization and New World Order: Are We Ready for 'Scientists Without Borders' ?"

A special memorial session honoring the late John Hulm, a key figure in the discovery of superconducting materials and their applications, and marking the 50th anniversary of the discovery of A15 superconductors is planned. In addition, sessions will be offered in cryo-packaging and integration of superconducting electronics, cryo-power electronics for large scale superconducting devices, and integration of superconducting devices to the utility grid.

Late conference registration is continuing. For additional information, please check the ASC Web site at www.ascinc.org or contact the Local Conference Chair, Ysonde Jensen, NHMFL (*ASC04LocalChair@magnet.fsu.edu*, 850-644-0807).

NEW WIDE RANGE DETECTOR

NHMFL users are always looking for ways to get more high field data. One way to get more data without staying up late or working weekends is to record data faster. Dr. Xing Wei, Visible Optics Instrumentation Physicist, has just completed the interface software for a new InGaAs Photodiode Array detector system that covers the same wavelength range (900 nm to 1600 nm) as our previous germinium detector, but 10 to 100 times faster. The Ge detector monitors a very narrow wavelength band as a spectrometer's wavelength setting is scanned. The InGaAs Photodiode Array covers the whole range in a single "snap-shot." Researchers seeking more details should contact Dr. Wei by email to *xwei@nhmfl.gov*.

2003 Annual Research Review
Available on the Web

The NHMFL *2003 Annual Research Review* presents abstracts of user experiments performed at the laboratory's three sites—Florida State University in Tallahassee, the University of Florida in Gainesville, and the Pulsed Field Facility at Los Alamos National Laboratory. It also includes reports of the scholarly activity of NHMFL-affiliated faculty in Magnet Science and Technology, Condensed Matter Theory, and other groups.

The *2003 Review* includes 372 research reports and is available on the Web at *http://www.magnet.fsu.edu/*.

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Fax: 850 644-8350
www.magnet.fsu.edu

CONFERENCES & WORKSHOPS

2004

Applied Superconductivity Conference (ASC04)
http://www.ASCinc.org
October 3-8, 2004
Jacksonville, Florida
Contact: Justin Schwartz
ASC04ConfChair@magnet.fsu.edu
850-644-0874

15th Conference of the International Society of Magnetic Resonance (ISMAR 2004)
http://www.ismar2004.org/
October 24-28, 2004
Ponte Vedra Beach, Florida
Contact: Tim Cross
mail@ismar.org
850-644-0917

2005

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 (EP2DS-16)
http://ep2ds-16.sandia.gov/
July 10-15, 2005
Albuquerque, NM
Contact: Jerry Simmons
ep2ds-16@sandia.gov
505-844-8402

Physical Phenomena at High Magnetic Fields-V (PPHMF-V)
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:ISCOM2005.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