NATIONAL HIGH MAGNETIC FIELD LABORATORY

REPORTS

WINTER EDITION

VOLUME 13 • NO. 5 • 2006

INFRASTRUCTURE UPGRADES RAMP UP LAB'S POWER, COOLING CAPACITY

Page 14

INOVATIVE HYBRIDS TO OPEN NEW FRONTIERS IN HIGH-FIELD RESEARCH

Page 20

80 T AND BEYOND: MULTI-SHOT MAGNET COMMISSIONED FOR USER OPERATIONS

Page 23

SUPPORTED BY: THE NATIONAL SCIENCE FOUNDATION and THE STATE OF FLORIDA
OPERATED BY: FLORIDA STATE UNIVERSITY • UNIVERSITY OF FLORIDA • LOS ALAMOS NATIONAL LABORATORY

NHMFL REPORTS

CONTENTS

Front cover photo by Larry Gordon.
Back cover photo by Amy Winters.

PUBLISHED BY:
NATIONAL HIGH MAGNETIC FIELD LABORATORY
1800 EAST PAUL DIRAC DRIVE
TALLAHASSEE, FLORIDA 32310-3706

DIRECTOR:
GREG BOEBINGER

DIRECTOR, PUBLIC AFFAIRS:
SUSAN RAY

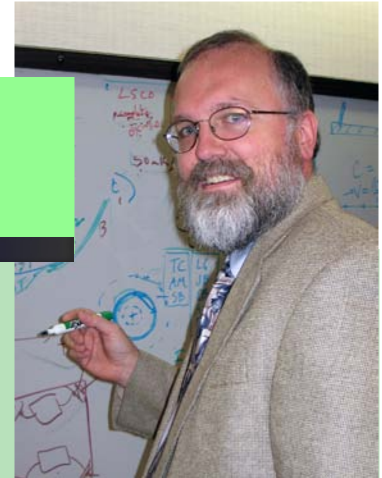
EDITING AND WRITING:
AMY WINTERS, SUSAN RAY

ART DIRECTION AND PRODUCTION:
WALTER THORNER

www.magnet.fsu.edu

This document is available in alternate formats upon request. Contact Amy Winters for assistance. If you would like to be added to our mailing list please write us at the address shown at left, call 850-644-1933, or e-mail *winters@magnet.fsu.edu.*

FROM THE DIRECTOR'S DESK



Greg Boebinger

The National Science Foundation recently released its Strategic Plan for 2006-2011. The document, online at www.nsf.gov, states four major goals: discovery, learning, research infrastructure, and stewardship. The vision strongly reiterates the need for basic research, recognizing the need for both large research facilities and single investigator grants. Both are clearly necessary for the health of the Magnet Lab's user programs.

Of course, the NSF isn't printing the money, so all scientists must work to ensure that the NSF's vision is equally embraced by the rest of the Federal Government and, ultimately, the American taxpayer. The Magnet Lab's educational and outreach programs help to establish an increasingly informed national discussion. To that end, I am pleased to announce that our Web site is being restructured to facilitate navigation and build a substantial educational component on electricity and magnetism (go to www.education.magnet.fsu.edu). The educational material is being rolled out now and is modeled after the incredible microscopy site developed by the Magnet Lab's Optical Microscopy group headed by Mike Davidson (www.microscopy.fsu.edu or simply Google "microscope" or "microscopy").

September 2006 marked the commissioning of the 100 T Multi-shot Magnet at the lab's Pulsed Field Facility in Los Alamos (see page 22). The system achieved its planned-for 85 T pulses, and even a few 88 T pulses. The peak field is designed to be incremented up to 100 T as operating experience is gained. This achievement is the culmination of more than 10 years of planning, materials testing, engineering and construction, and marks the highest magnetic field ever produced non-destructively. Destructive magnets can go much higher, but only for microseconds … and then there's that pesky *destructive* component of each pulse. This magnet is the fourth of the "Honkin' Big" Magnet Lab magnets, joining the 60 T Long-Pulse, the 45 T Hybrid, and ultra-wide-bore 900 MHz NMR as unique facilities. I continue to be amazed by the talents of the MagLab's engineers, technicians and scientists involved in these projects … to pull off such stunning success with so few individuals.

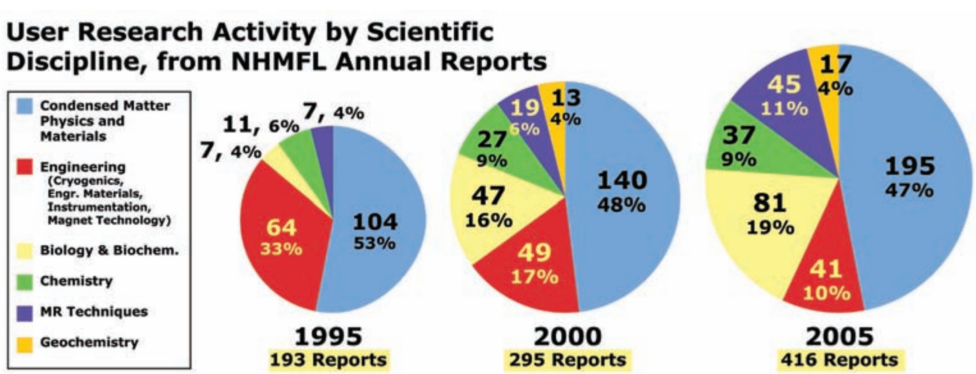
Research Infrastructure

"…Identify and support the next generation of large research facilities. NSF will work with the science and engineering community to identify the next generation of major equipment and facilities to enable transformational research. We will also fund the development of new capabilities, technologies, and instrumentation that could lead to the establishment of next-generation facilities."

– *Investing in America's Future, p. 9; NSF Strategic Plan*

The next of the unique magnets will be the >25 T Split Gap magnet (in 2009), followed by the Series Connected Hybrid – the fifth "Honkin' Big" – for which construction funds have now been awarded (see page 14). The first incarnation of the SCH, the 36 T/1ppm homogeneity "resonance" magnet, is expected for 2011, with the 40 T "high field" version to roll out two years later. Because of its novel engineering design, the SCH will likely likely become our next-generation "workhorse", offering 40T using only half the power of our current 35 T workhorse magnets.

Most importantly, September featured the completion and submission of the MagLab's NSF renewal proposal. This effort started in 2002 with the proposal for the National Academy of Sciences to convene a *Committee on Opportunities in High Magnetic Field Science*, followed by the COHMAG report, an NSF Blue Ribbon Panel review of the MagLab in 2005, and the February 2006 decision of the National Science Board to renew, rather than compete, the MagLab's grant. Since 2000, the MagLab's user program has greatly expanded, and roughly 40% lies within the traditional scope of the NSF's chemistry and biology divisions. The interdisciplinary nature of the MagLab's user program receives strong expressions of support throughout the NSF, from our program manager, Guebre X. Tessema, to the NSF Director, Arden Bement.

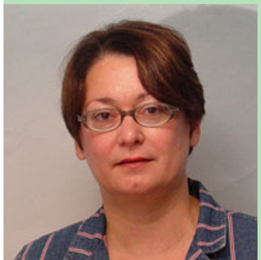


Rock 'n' roll,

Greg

Greg Boebinger

from the MagnetLab Science Council


Carol Nilsson

The first step in understanding the action of biological macromolecules is determination of their static structure, typically by X-ray diffraction and/or nuclear magnetic resonance spectroscopy. The next step is to find out how that structure changes as the molecule acts.

In collaboration with Professor Roman Tuma of the University of Helsinki in Finland, the Magnet Lab's Ion Cyclotron Resonance group has recently illuminated the mechanism of action of a viral "motor" in dsRNA bacteriophage ϕ8. The virus is activated by an ATP-driven "motor," namely, a pore constructed from six identical 34 kDa subunits, through which single-stranded RNA must be "threaded" to enter the virus and make it active.

Hydrogen/deuterium exchange monitored by FT-ICR mass spectrometry (HDX MS) revealed solvent-exposed segments in the pore on addition of RNA or ATP or both. Surprisingly, the pore does not simply widen in aperture to admit the RNA; rather, adjacent pore protein monomers are pried apart so that RNA slips between them.

The research report was featured on the July 20, 2006 cover of *Virology* (Lisal, J. *et al.*, *Virology* 2006, 351, 73-79). HDX MS is a prioritized area in the ICR group at the NHMFL. Recently, a four-year RO1 grant in the amount of $760,000 was awarded by the National Institutes of Health for the project "Structural Mapping of Protein Complexes by Hydrogen-Deuterium Exchange Mass Spectrometry," Alan G. Marshall, P.I.; Mark R. Emmett and Christopher L. Hendrickson, co-P.I.s; Carol L. Nilsson and Gregory Blakney, co-Investigators.

Solution-Phase Hydrogen/Deuterium Exchange With High Resolution Mass Spectrometric Analysis: Application to the Interaction of Packaging Motor with the Polymerase Complex of dsRNA Bacteriophage

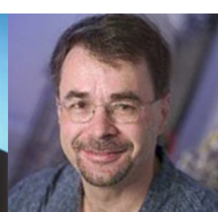
Mark R. Emmett[2], Jirí Lísal[1], Denis E. Kainov[1,4], TuKiet T. Lam[2,5], Hui Wei[3], Paul Gottlieb[3], Alan G. Marshall[2] and Roman Tuma[1]

Hydrogen/Deuterium Exchange with High Resolution Mass Analysis

Determination of protein-protein interaction is best accomplished by x-ray crystal diffraction and NMR[1] because both methods provide the highest spatial resolution at the sites of interaction. However, both methods require large (milligram) quantities

SCIENCE COUNCIL


Lev Gor'kov *Chairman*


Rafael Brüschweiler


James Brooks


David Larbalestier


Albert Migliori


Glenn Walter

of protein. Often crystals are difficult or impossible to obtain. NMR requires high sample concentration (limited by solubility) and analysis is difficult as molecular weight increases (~50 kDa and above). Other techniques rely on chemical or photo-induced reactions to reveal functional groups that are exposed to the solvent. These methods can suffer from limited availability of specific solvent available residues[2]. Additionally, covalent cross-linking has the potential to alter conformation. Hydroxyl radical reactions with alkyl C-H bonds are fast (108 M-1s-1, i.e., within a factor of 100 of diffusion-limited) and thus the OH radical tends to react mainly with surface-exposed residues providing a good footprint of the solvent exposed surface of the protein(s). The modification is covalent and thus irreversible, but each such modification can potentially change the conformation of the protein, so that one is never sure that the inferred properties are those of the native protein.

Exchange of labile hydrogen for deuterium (HDX) with mass analysis as a probe of protein surface accessibility[3,4] does not change the conformation of the protein. The experiment is initiated by dilution of the protein solution into a biological buffer made with D_2O. Solvent-accessible hydrogens exchange with deuterium. The exchange is quenched by dropping the pH to ~2.3 and lowering the temperature to 0-4 ˚C. During subsequent analysis, a substantial back-exchange of deuterium to hydrogen occurs. The side chains

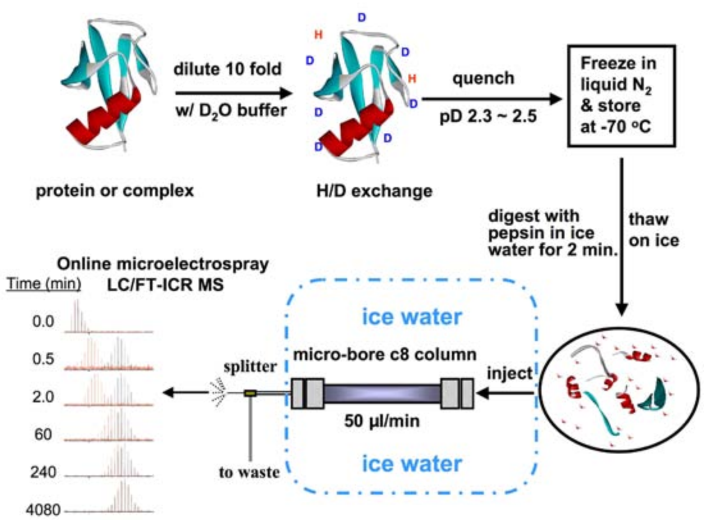


Figure 1. Schematic overview of the experimental steps in a typical H/D exchange experiment to generate partially deuterated peptides for MS analysis.

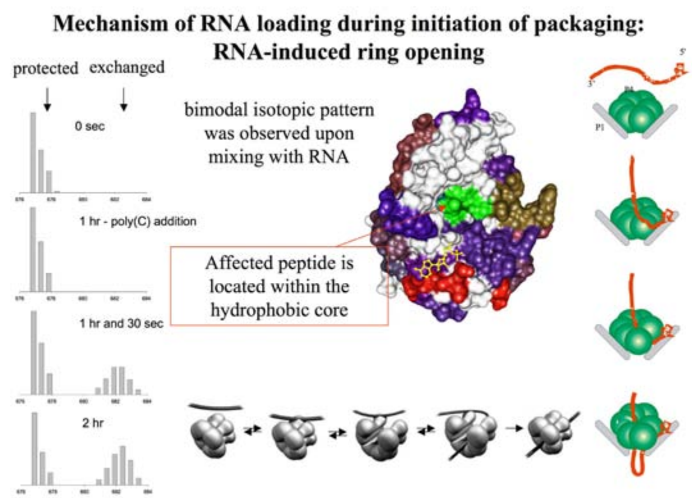


Figure 2. RNA induced ring opening of P4 protein. Far left panels (A-D) show representative spectra depicting bimodal deuterium incorporation in the P4 peptic peptide a.a.198-209 that is located within the hydrophobic core of the P4 motor in response to addition of poly riboCytosine (poly [rC]). Panel A & B show that no exchange occurs in peptide a.a.198-209 indicating that the peptide is protected from solvent accessibility. Panel C demonstrates that exchange begins almost immediately upon the addition of poly (rC) indicating that the protein has been exposed to solvent (i.e. the P4 ring protein was "opened"), Panel D shows a steady bimodal HDX distribution after 2hrs. Bottom Panels: Schematic of the proposed P4 ring opening by RNA. Right Panels: Model of RNA (red) loading into the packaging motor (green) within the context of the viral shell (one facet of protein P1, gray). From top to bottom: The packaging signal at 5' end of RNA is specifically recognized by capsid protein P1. RNA then binds to a putative primary binding site on P4 surface and ring opening commences. The captured RNA is processively translocated into the capsid.

[1]Institute of Biotechnology and Department of Biological and Environmental Sciences, University of Helsinki, 00014 Helsinki, Finland
[2]National High Magnetic Field Laboratory and Department of Chemistry and Biochemistry, 1800 E. Paul Dirac Dr., Florida State University, Tallahassee, FL 32310, USA
[3]Department of Microbiology and Immunology, The Sophie Davis School of Biomedical Education, The City College of New York, New York, NY 10031, USA
[4]Present address: IGBMC, CNRS, 1 rue Laurent Fries, BP 10142, 67404 Illkirch CEDEX, France
[5]Present address: WM Keck Foundation Biotechnology Resource Laboratory, 300 George St., Yale University, New Haven, CT 06511, USA

(e.g., arginine) typically exchange much faster than backbone amides, leaving only direct information about the backbone amide hydrogens. To limit back-exchange, a very fast elution gradient (at 0-4 ˚C) during the HPLC desalting/separation step limits the period that the sample is in contact with the aqueous mobile phase. Reversed-phase chromatographic resolution is thereby reduced, which results in increased complexity of the mass spectra. In this laboratory, the spectral complexity is efficiently analyzed by use of high resolution Fourier transform ion cyclotron resonance (FT-ICR) mass analysis (see schematic representation of the HDX experiment, Figure 1). Deuterium exchange is monitored by mass increase of the peptic fragments of the protein, which is directly related to the solvent accessibility of that portion of the protein. A full HDX time course with three replicates requires less than 750 μg of total protein.

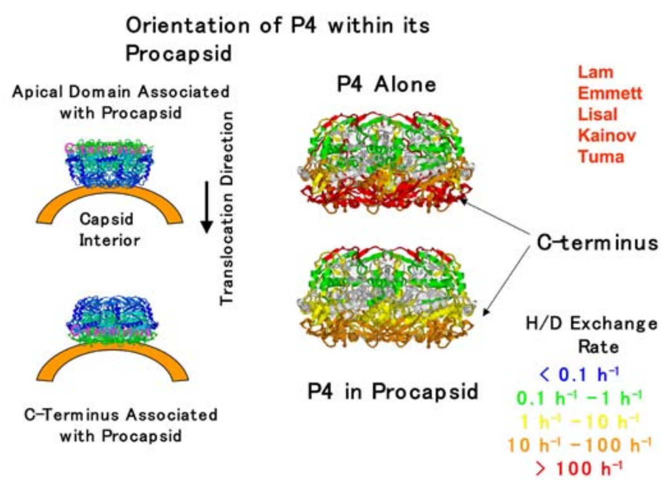


Figure 3. P4 orientation with procapsid. Figure depicts surface representations of ϕ12 P4 hexamer colored according to the weighted average HDX rates. Left panel shows the two possible conformations of P4 with the procapsid, either with the N-terminus or C-terminus associated with the procapsid. The right panel shows HDX rates for P4 either alone or complexed with procapsid. The legend at the bottom right is the color scale for rates (h^{-1}); segments for which no peptic fragments were available are shown in gray. When associated with the procapsid, the exchange rate for the C-terminus peptides are slowed in comparison to the uncomplexed P4 protein, which demonstrates orientation of the P4 with its C-terminal end associated with the procapsid.

Application of HDX to the Study of the Dynamics of a Viral Packaging Motor

Genome encapsidation is an essential step in viral morphogenesis. Viruses utilize different strategies that can be divided into two basic classes: (1) nucleic acid-coat protein co-assembly, or (2) genome packaging into a capsid precursor (procapsid, PC). While many ssRNA viruses adopt the first strategy the latter is common among dsDNA viruses and dsRNA bacteriophages. The second type of genome packaging requires a molecular motor that converts chemical energy into mechanical work in the form of translocation and condensation of the nucleic acid.

In comparison with dsDNA viruses, the packaging motor (protein P4) from dsRNA bacteriophages (ϕ6-ϕ14), Cystoviridae family, [5,6] is much simpler[7], and consists of a hexameric ring of identical ATPase subunits that encircle a central channel. Twelve hexamers are attached to the five-fold vertices of the procapsid (empty polymerase complex, as depicted on the cover of *Virology*)[8]. The polymerase complex is a large icosahedral molecular machine that constitutes the core of the bacteriophage[9]. The icosahedral framework of PC is built from 120 copies of major structural protein P1. The P1 framework also exposes specific RNA binding sites in a segment-specific manner on its surface during packaging. The close proximity of RNA may trigger hexamer opening and RNA loading into the central channel as observed for isolated hexamers from bacteriophage ϕ8[10]. After loading, ATP hydrolysis by P[4] powers unidirectional translocation of the enclosed RNA into PC (left figure on *Virology* cover). In addition to its roles in packaging, P4 hexamer is also required for nucleation of PC assembly[11,12] and for transcription[13] (Fig. 1C). Interestingly, ATPase activity of P4 is shut-off during transcription and consequently the hexamer may act as a passive pore for RNA exit[14] (right figure on *Virology* cover).

Here we take advantage of the high-resolution structure of P4 from bacteriophage ϕ12 and monitor the conformational change to the P4 motor in the presence of RNA and also characterize the procapsid bound structure of ϕ12 P4 by hydrogen-deuterium exchange (HDX) and high-resolution mass spectrometry (MS) [15]. Implications of the interactions for assembly and regulation are discussed. This contribution also demonstrates that HDX can be successfully applied to fairly complex virus capsids and complement the traditional techniques of structural virology.

Results

Deuterium incorporation into peptide fragments (i.e., amide hydrogen exchange) caused a progressive mass increase. The mass increment was converted to exchange kinetics. Because each peptide fragment contains multiple amide sites that often exchange with different rates, the kinetics are rather complex. Additional information was obtained by transforming the complex kinetics into exchange rate distributions[10].

RNA Loading: To distinguish whether the exchange was associated with RNA binding or release, P4 was pre-incubated in D_2O for one hour in the absence of both ATP and RNA. Subunit interfaces remained protected during this period (Figure 2A). The bimodal pattern appeared immediately after adding poly ribocytosine (poly[rC]) in D2O, Figure 2C). The bimodal distribution did not change appreciably for 2 hours after the initial burst, and consequently full deuteration was not reached (Figure 2D). The absence of full deuteration reflects the P4:RNA complex stability[17], which prevented additional ring openings, despite the excess of RNA. The number of fully exchanged sites was estimated from the isotopic envelope in Fig. 4D and is consistent with exposure of one or two interfaces per hexamer. The illustration at the bottom of Figure 2 depicts the cleft opening of the P4 motor and the illustration at the right of Figure 2 depicts the translocation of the RNA through the P4 viral motor and into the viral capsid.

P4 hexamer interacts with the procapsid via its C-terminal facet: On the bases of EM reconstruction for PC from the related phage ϕ6[8] and the doughnut structure of P4 hexamer,[16] the interactions between P4 and PC should be limited to either the N-terminal dome or the C-terminal facet of P4. Because the structure of P4 is compact, we assume that only regions exposed on the surface of P4 hexamer will interact with PC (left portion of Figure 3). The data reveals that certain peptides are more protected in the PC-associated than in the isolated P4, showing that HDX reveals changes associated with interactions between P4 and PC. HDX kinetics were obtained for 29 peptic fragments which together cover 68% of P4 structure. The surface representation of exchange rates is shown in Fig. 3. In the isolated hexamer, C-terminus (CT) fragment exhibits exchange rates that is in excess of 10 h^{-1} and suggests the CT is fully exposed to solvent and unfolded. When complexed with PC, the fragments lining the bottom facet of the hexamer (CT and fragments within the adjacent β-sheet) exhibited significantly decreased HDX rates. Taken together, the C-terminal facet, in particular the C-terminus, C-terminal helix and the adjacent β-strand, constitute the likely sites of direct PC-P4 interaction. Notably, this orientation is also consistent with the direction of RNA translocation proposed on the basis of the structure-based mechanism in which the RNA translocation direction is from the apical towards the C-terminal domain[16]. Furthermore, the C-terminal[13] residues of P4 from the related phage ϕ6 were essential for assembly[17]. We conclude that the C-terminal facet of P4 hexamer is proximal to and interacts with the procapsid.

Conclusions

In these studies we have demonstrated that hydrogen-deuterium exchange can be selectively determined for a selected subunit within a complex, multi-subunit, virus assembly. The exchange kinetics allowed comparison of the subunit solution and crystal structures with the structure of a large multisubunit assembly. This approach revealed the interactions of the packaging motor with RNA and with the viral core, and provided insight into roles of different regions in assembly, genome packaging and regulation of transcription. The approach holds promise for studying other packaging motors, especially those that are only transiently associated with the virus capsid (e.g. terminases or various non-structural proteins of dsRNA viruses) for which structural analysis by EM or X-ray crystallography is difficult or impossible. The technique shall be applicable to other molecular machines like ribosomes or replisomes and their transient states.

Acknowledgements

This work was supported by Academy of Finland grant 206926 (RT), the Finnish Centre of Excellence Program 2000-2005, The National Science Foundation Career Award MCB9984310, NSF DMR 00-84173, NHMFL, and Florida State University.

References

(1) Zuiderweg, E.R.P. *Biochemistry* 2002, **41**, 1.

(2) Leite, J.F., & Cascio, M. *Biochemistry* 2002, **41**, 6140.

(3) Molday, R.S., Englander, S.W., Kallen, R.G., *Biochemistry* 1972, **11**, 150.

(4) Mandell, J.G., Falick, A.M., Komives, E.A., *Proc. Natl. Acad. Sci.* USA, 1998, **95**, 14705.

(5) Mindich, L., and Bamford, D. H., In "*The Bacteriophages*" (R. Calendar, Ed.), 1988, Vol. **2**, pp. 475-519. Plenum Publishing Corporation, New York.

(6) Mindich, L., Qiao, X., Qiao, J., Onodera, S., Romantschuk, M., and Hoogstraten, D., J. *Bacteriol*. 1999, **181**, 4505-8.

(7) Kainov, D. E., Pirttimaa, M., Tuma, R., Butcher, S. J., Thomas, G. J., Jr., Bamford, D. H., and Makeyev, E. V., *J. Biol. Chem.* 2003, **278**, 48084-91.

(8) de Haas, F., Paatero, A. O., Mindich, L., Bamford, D. H., and Fuller, S. D., *J. Mol. Biol.* 1999, **294**, 357-72.

(9) Butcher, S. J., Dokland, T., Ojala, P. M., Bamford, D. H., and Fuller, S. D., *EMBO J.* 1997, **16**, 4477-87.

(10) Lisal, J., Lam, T., Kainov, D. E., Emmett, M. R., Marshall, A. G., and Tuma, R., *Nat. Struct. Mol. Biol.* 2005, **12**, 460-466.

(11) Poranen, M. M., Paatero, A. O., Tuma, R., and Bamford, D. H., *Mol. Cell* 2001, **7**, 845-54.

(12) Poranen, M. M., and Tuma, R., *Virus Res.* 2004, **101**, 93-100.

(13) Pirttimaa, M. J., Paatero, A. O.,Frilander, M. J.,and Bamford, D. H., *J. Virol.* 2002, **76**, 10122-7.

(14) Kainov, D. E., Lisal, J., Bamford, D. H., and Tuma, R., *Nucleic Acids Res.* 2004, **32**, 3515-21.

(15) Lanman, J., Lam, T. T., Emmett, M. R., Marshall, A. G., Sakalian, M., and Prevelige, P. E., Jr., *Nat. Struct. Mol. Biol*. 2004, **11**, 676-7.

(16) Mancini, E. J., Kainov, D. E., Grimes, J. M., Tuma, R., Bamford, D. H., and Stuart, D. I., *Cell* 2004, **118**, 744-755.

(17) Paatero, A. O., Mindich, L., and Bamford, D. H., *J. Virol.* 1998, **72**, 10058-65.

NEWS from the DC Field Facility

Data collected at the Mag Lab turns gravity on its head

Methods for studying biological responses to altered gravity have been hard to come by in Earth-based laboratories, and methods that do exist have proved troublesome.

Now, researchers Karine Guevorkian and James Valles have used the 31-tesla, 50-mm-bore magnet at the National High Magnetic Field Laboratory to increase, eliminate, and even decrease the effects of gravity on live paramecia in a vial of pond water. This new method will allow researchers to subject small biological systems to gravitational effects similar to those encountered in space.

“The Magnet Lab’s record-breaking DC magnet facilities allowed us to apply the largest possible range of forces; including forces strong enough to stall the forward progress of (the paramecia’s) swimming,” said Valles, a professor of physics at Brown University and chairman of the lab’s Users Committee. Guevorkian, who recently received her Ph.D. at Brown, is a postdoc at Institut Curie in Paris.

The findings of the NASA-funded study were first published online in the Aug. 17 edition of the prestigious *Proceedings of the National Academy of Sciences*.

The physicists created a topsy-turvy world for the single-celled paramecium by placing a vial with pond water and live paramecia inside the high-powered electromagnet. The organisms are less susceptible to a magnetic field than plain water is, so the magnetic field generated inside the vial “pulls” harder on the water than on the cells. If the field is pulling down, the cells float. If it’s pulling up, they sink.

Using water alone, Valles and Guevorkian were able to increase the effect of gravity by about 50 percent. To increase the effect even further, they added a compound called Gadolinium-diethylene-triamine-pentaacetate (Gd-DTPA) to the water. Gd-DPTA is highly susceptible to induced magnetic fields such as those generated in electromagnets. This allowed the researchers to make the water much “heavier” or “lighter,” relative to the paramecia, achieving an effect up to 10 times that of normal gravity. The magnetic field is continuously adjustable, so Valles and Guevorkian were also able to create conditions simulating zero-gravity and inverse-gravity.

By dialing the magnetic field up or down, the researchers could change the swimming behavior of the paramecia dramatically. In high gravity, the organisms swam upward mightily to maintain their place in the water column. In zero gravity, they swam up and down equally. And in reverse gravity, they dove for where the sediments ought to be.

“If you want to make something float more,” said Valles, “you put it in a fluid and you pull the fluid down harder than you pull the thing down. And that’s what we basically do with the magnet. That causes the cell to float more – and that turns gravity upside down for the cell.”

Cranking the field intensity even higher, Valles and Guevorkian could test the limits of protozoan endurance. At about eight times normal gravity, the little swimmers stalled, swimming upward, but making no progress. At this break-even point, the physicists could measure the force needed to counter the gravitational effect: 0.7 nano-Newtons. For comparison, the force required to press a key on a computer keyboard is about 22 Newtons or more than 3 billion times as strong.

Adapted and reprinted with permission of Marty Downs and Brown University.

Attention Users
User Support Scientists: EMR, Geochemistry, and ICR

In this issue, we present research faculty and scientists representing the EMR, Geochemistry, and ICR programs. This is the final installment in a series that profiles scientists and technicians who work closely with users.

EMR

EMR stands for Electron Magnetic Resonance and covers a variety of magnetic resonance techniques associated with the electron spin. The EMR program at the Magnet Lab in Tallahassee is truly interdisciplinary, covering a wide spectrum of scientific areas, from solid-state physics through materials and inorganic chemistry to biochemistry and biology. The professional background of our faculty and staff is correspondingly broad. Our scientists' job is not only to serve users, but also to engage in their own research, both individual and collaborative. Their level of expertise is highly recognized nationally *and* internationally, and documented by numerous publications in peer-reviewed professional journals and presentations at conferences (both contributed and invited). A complete listing of EMR publications, presentations, and personnel is online at *http://www.magnet.fsu.edu/science/cimar/emr/*. Users will also find information about EMR instruments and requesting magnet time.

-**Peter Fajer**, EMR program interim director ***fajer@magnet.fsu.edu***

Jurek Krzystek

Jurek Krzystek received his M.Sc. degree in chemistry from Warsaw University in Poland and his Ph.D. in physics from the Institute of Physics, Polish Academy of Sciences, then proceeded to a postdoctoral appointment at Stuttgart University in Germany. Since then, he has been developing expertise in electron paramagnetic/spin resonance (EPR/ESR) of various spin systems. After moving to the United States in 1989, he started his American career at the University of Washington in Seattle, where he participated in developing new EPR-related techniques, such as field-cycled EPR (which resulted in a U.S. patent) and force-detected EPR.

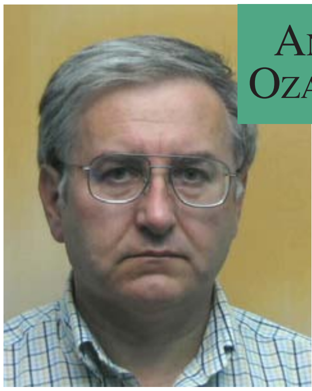
Krzystek joined the Magnet Lab in 1995 and has worked in the area of high-field EPR/ESR. He was instrumental in setting up the EMR facility using superconducting magnets and more recently the Mm and Sub-mm Wave Spectroscopy facility, which employs resistive magnets. His area of research covers the magnetism of transition metal ions coordination complexes as investigated by resonance techniques. More specifically, Krzystek is interested in high-spin paramagnets, and spin-correlated systems such as molecular ferro- and anti-ferromagnets, where he is looking for correlations between the geometric and electronic structure on one side, and magnetic properties on the other. For the purpose of investigating these spin systems, he developed a novel technique of tunable-frequency EPR/ESR.
krzystek@magnet.fsu.edu

Saritha Nellutla received her Ph.D. from Florida State University in physical chemistry. The focus of her study was several new spin-frustrated polyoxometalate (POM) lattices of increasing sizes and complexities. She employed experimental techniques such as magnetization, dc magnetic susceptibility and variable frequency EPR spectroscopy to understand the spin-frustration effects on the magnetic energy levels of metal clusters. She joined the Magnet Lab in 2006 as a postdoctoral associate. Apart from assisting the visiting scientists with their experimental needs, Nellutla collaborates with research groups led by Luis Balicas (NHMFL) and Naresh

Saritha Nellutla

S. Dalal (NHMFL and FSU professor of chemistry). Her research interests include dimensional (quasi 1D, 2D, 3D) magnetic lattices and Bose-Einstein condensation phenomena in spin s = ½ and s = 1 magnetic systems using torque magnetometry, specific heat, and EPR.

nellutla@magnet.fsu.edu



Andrew Ozarowski

Andrzej (Andrew) Ozarowski earned his Ph.D. in physical chemistry at the Wroclaw University in Poland. His specialty is EPR spectroscopy and magnetic properties of transition metal complex compounds. Before coming to the Magnet Lab, Ozarowski worked at universities in Marburg, Germany; Windsor, Canada; and Davis, California. In addition to the work in his area of specialty, he was also engaged in California in studies involving optically detected magnetic resonance (ODMR), as well as in teaching courses on various subjects in chemistry. At the Magnet Lab, Ozarowski runs and maintains the homodyne EPR instrument of the EMR facility and supports its users, both with actual measurements and with interpretation of the results. His own research activities concentrate on the high-field EPR applications to studies on exchange interactions in polynuclear transition metal complexes.

ozarowsk@magnet.fsu.edu

Hans van Tol

Johan (Hans) van Tol did his Ph.D. at Leiden University in the Netherlands, using optically detected magnetic resonance to study paramagnetic excited states. His postdoctoral work was done at the Grenoble High Magnetic Field Laboratory, where he developed new techniques for high field magnetic resonance and magnetization. In 1998, van Tol joined the Magnet Lab in the Electron Magnetic Resonance group. Here he developed a novel quasi-optical spectrometer for high-field transient EPR at (sub)millimeter frequencies with very high time-resolution. Currently he is involved in user support and the development of high-field pulsed EPR at the lab. Also, he is heavily involved in the design of a high power free electron laser for the Magnet Lab, in collaboration with Jefferson Laboratory and University of California, Santa Barbara. This powerful photon source will enable a range of new experiments especially focused of the field-dependent dynamics of excited states in materials.

vantol@magnet.fsu.edu

Geochemistry

Geochemistry, although not a user facility, accommodates scientists from Florida State University, as well as scientists outside FSU for use of the program's analytical instrumentation. Our group is specialized in high precision measurements of trace amounts of elements in a range of materials, natural as well as synthetic. To acquire these analyses reliably, the analytical method needs to be "matrix-matched", *i.e.* tailored to the material. The people who are highlighted in this article are experts in this area, and they advise visiting scientists before they come to the lab and during their visit. In addition to supporting users, they have their own research programs and teaching responsibilities.

-**Vincent Salters**, Geochemistry program director ***salters@magnet.fsu.edu***

Michael Bizimis

Michael Bizimis first joined the Geochemistry group at the Magnet Lab in 1995 as a graduate student, where he received his Ph.D. in isotope geochemistry in 2001. He then joined the department of earth sciences at Florida International University in Miami as a visiting research associate but continued to conduct his research from the Magnet Lab in Tallahassee. In 2004, he "returned" to the lab and the FSU Department of Geological Sciences as assistant scholar scientist. His research interests are in high temperature geochemistry and igneous petrology, with a focus on the isotope and trace element systematics of the Earth's mantle. Bizimis has extensive experience in mass spectrometry, as well as clean lab operation and chemical separations. He assists and advises users and students with instrumentation and method development suited for their particular research objectives.

His current NSF-funded research is focused on the detailed radiogenic isotope analyses of mantle material from Kauai and Oahu islands in order to constrain the mechanisms of plume-lithosphere interaction and the composition of the Hawaiian mantle plume.

bizimis@magnet.fsu.edu

Munir Humayun

Munir Humayun (Ph.D. 1994, University of Chicago) joined the Geochemistry group at the lab and the faculty of FSU Geological Sciences in 2004. His expertise is in inductively coupled plasma mass spectrometry (ICP-MS) and laser ablation microanalysis of solids. His research is focused on applications of ICP-MS to the analysis of trace elements and isotope compositions of tiny samples of meteorites and extraterrestrial materials, including samples returned by the NASA spacecraft missions *Genesis* and *Stardust*. He is currently developing enhanced laser ablation techniques using the new Plasma Analytical Facility for the analysis of micron-sized particles returned by the Stardust mission. The laser ablation system is used by researchers in cosmochemistry, but has applications to a much wider range of materials. Typical spot sizes are 4-100 microns with detection limits from the parts per million to parts per billion range.
humayun@magnet.fsu.edu

Yang Wang

Yang Wang received her Ph.D. from University of Utah in 1992 and worked as a postdoctoral researcher at University of California, Berkeley from 1992 to 1995. She joined the Magnet Lab and FSU as an assistant professor of geochemistry in 1995 and has been an associate professor since 2002. She is responsible for the light stable isotope facility specializing in analyses of stable isotopes of carbon, nitrogen, hydrogen and oxygen in a broad range of materials (*http://www.gly.fsu.edu/isotope.html*).

Wang's research interests include isotopic studies of hydrological problems, food webs in modern and fossil ecosystems, biogeochemical cycling of carbon and nutrients, and paleoclimate and paleoecology.
ywang@magnet.fsu.edu

ICR

The success of the Magnet Lab Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR) program is due in large part to its nonpareil staff, because the performance of our instruments is due not only to their high magnetic field, but also to a host of other advances in sample introduction, ion formation, capture, transmission, storage, excitation/detection, and fragmentation.

Scholar-Scientists are responsible for instrument design and development (Chris Hendrickson, Tanner Schaub), biological applications (Mark Emmett), environmental and petroleomic applications (Ryan Rodgers), computer systems to control the instruments, as well as processing and display of the data (Greg Blakney), and direction of the ICR user program (Carol Nilsson). Other essential personnel are John Quinn, a technician with wide-ranging expertise in mechanical, vacuum, optical, and electronics modules, and Dan McIntosh, a machinist who has fabricated numerous state-of-the-art ion optics, sample introduction, and other mechanical components. The staff also help in directing the research of graduate students (currently nine in Tallahassee), postdoctoral research associates (currently seven in Tallahassee), and sabbatical visitors (eight since the year 2000). In addition, they work with Professor John Eyler at the University of Florida, most recently in the design and construction of a complete FT-ICR mass spectrometer now available to users at the FELIX free electron laser facility in The Netherlands.

Magnet Lab FT-ICR instruments are homebuilt, for two reasons. First, if anything goes wrong, we can fix it ourselves. Second, any new development, whether originated here or elsewhere, can be implemented well before it becomes available commercially. Thus, our main attraction for external users is unique instrumentation and techniques. Several of those developments are now incorporated into all commercial FT-ICR instruments. Moreover, we have provided, at component cost only, ~20 modular ICR data systems ("MIDAS") to other FT-ICR MS laboratories around the world. Equipped with robotic sample introduction and automated control, our high-field FT-ICR instruments may now be operated remotely (so far, from as far away as Birmingham, England). We are proud of our instruments, and especially proud of our local family of experts who build and operate them, train new users, and keep coming up with new techniques and applications.

- **Alan Marshall**, FT-ICR program director
marshall@magnet.fsu.edu

Greg Blakney

Greg Blakney, ICR assistant scholar-scientist, director of Data System Development, received his doctorate in Professor David Laude's group at University of Texas at Austin combining FT-ICR MS with hydrogen/deuterium exchange of nucleotides. He joined the Magnet Lab in 2003, where his present research interests involve fundamental research in FT-ICR MS instrument development with an emphasis on improved instrument control and data acquisition methods. Much of his work focuses on the original MIDAS and current Predator ICR data stations and corresponding data analysis program. By developing the data station solution at the lab, the ICR group is able to design and implement experiments that would not be possible given the rigidity of commercially available ICR data acquisition systems. One such example involves the application of broadband phase correction that can improve resolution by a factor of two in a given ICR spectrum. MIDAS / Predator data stations currently control FT-ICR MS instruments at the Magnet Lab, as well as at universities around the world. A primary goal of the ICR program is to serve a national/international user community and, as such, it is important that external users have the ability to analyze the data collected here. The analysis software developed at the laboratory is available to the user community at *http://magnet.fsu.edu/~midas*. This free download operates under current Windows operating systems without the need for special hardware.

blakney@magnet.fsu.edu

Mark Emmett

Mark Emmett, ICR scholar-scientist, director of Biochemical/Biomedical Applications, earned his B.S. (1982) in biology and M.S. (1984) in molecular biology at Texas A&M University. He worked as a faculty member in the Department of Microbiology at Miami University (Ohio), until joining the CNC Disease Research Group at Ciba-Geigy Pharmaceuticals. Emmett later joined the neuroscience group at G. D. Searle Pharmaceutical, where he and co-workers discovered the strychnine-insensitive NMDA-associated glycine receptor. After transfer to the Analgesia Group at G.D. Searle, Emmett returned to complete his Ph.D. in biochemistry/neuropharmacology in 1995 at the University of Texas Health Science Center in Houston. Following a short postdoctoral period with Professor Marshall at FSU, Emmett joined the Magnet Lab ICR Program in 1997 to direct the external user program and applications to biological problems. He set up Magnet Lab ICR facilities for Bio-level II cell culture and protein production, as well as the extensive purification and cleanup capabilities essential to mass analysis of large biomolecules. Emmett has developed ultra-high sensitivity analysis of biological samples based on nano-scale liquid chromatography/microelectrospray mass spectrometry, which he originally introduced in his Ph.D. research. He is currently applying that technology to FT-ICR MS for the analysis of biological compounds (*e.g.*, peptides, proteins, lipids, and their glycoconjugates) at endogenous levels and low concentration, including robotic sample introduction and high-sensitivity MS and MS/MS techniques. Emmett is our local expert on hydrogen/deuterium exchange and heads up the experimental advancements to the technique (automation, reduction of back-exchange, etc.) and works with users who request this unique application to determine protein/protein interactions or conformations. He has served on advisory panels for mass spectrometry facilities in Scotland and Sweden. Nine of his 62 journal publications have been cited more than 50 times.

emmett@magnet.fsu.edu

Chris Hendrickson

Chris Hendrickson, ICR scholar-scientist, director of ICR Instrumentation, completed his B.A. in chemistry at the University of Northern Iowa in 1990, and Ph.D. with Professor David Laude at the University of Texas in Austin in 1995. Following postdoctoral research at the Magnet Lab with Professor Marshall, Hendrickson joined the staff in 1996. He had a major role in the design and construction of the laboratory's flagship 9.4 T FT-ICR mass spectrometer, and led the development of other FT-ICR instruments operating with unshielded 3.0 T, 5.6 T, and 6.0 T magnets, and actively-shielded 7 T, 9.4 T, and 14.5 T magnets; ionization sources including electron ionization, field desorption ionization, electrospray ionization, atmospheric pressure ionization, and laser ablation ionization; quadrupole, hexapole, and octopole ion storage and transmission optics; collision-activated, infrared multiphoton, and electron capture dissociation for MS/MS; and various ICR excitation/detection configurations. Eight of his 75 journal publications have been cited more than 50 times. He has chaired 10 symposia at national/international conferences, and just completed a term on the *Analytical Chemistry* Editorial Advisory Board.

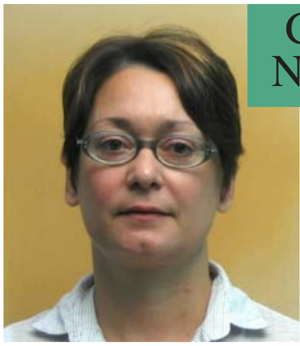
hendrick@magnet.fsu.edu

Daniel McIntosh

Daniel McIntosh, ICR machinist, joined the Magnet Lab in 1995. In less than a year, he helped to build up an array of custom instrumentation that became the backbone of our high field FT-ICR MS Facility. His subsequent instrument developments have kept us ahead of the competition, due in large part to his ability to construct quickly, with near perfection, a complex array of parts with precise dimensions and alignment, further complicated by the simultaneous need for ultrahigh-vacuum, non-magnetic components, and wide temperature range. Apart from his contributions to the ICR program, McIntosh has contributed

critically to other Magnet Lab projects, notably cryogenics, 900 MHz NMR, Hybrid magnet, Sweeper magnet, high pressure cells, and pulsed magnets.
mcintosh@magnet.fsu.edu

Carol Nilsson



Carol L. Nilsson, ICR assistant scholar-scientist, director of the ICR User Program, earned her M.D. and Ph.D. in clinical neuroscience from Göteborg University, Sweden. Her thesis work was titled "Analysis of Tissues that Reflect Central Nervous System Disease by Mass Spectrometry," and she was awarded a prize for that work from the Knut and Alice Wallenberg Foundation (Stockholm, Sweden) in 1998. She spent her postdoctoral years in the laboratory of the noted glycobiologist Karl-Anders Karlsson. In the year 2000, she established an independent research group at the Department of Medical Biochemistry at Göteborg University. During 2000-2003, she was a visiting scientist on several occasions at the FT-ICR facility in Tallahassee. She left Sweden in 2004 to become director of the FT-ICR MS User Program. Her interests include applications of FT-ICR MS and MS/MS in neuroscience and glycobiology. She has extensive experience in glycomics and proteomics, including the study of protein post-translational modifications.
nilsson@magnet.fsu.edu

John Quinn

John Quinn, ICR technician, earned his G.S. in chemistry at Doane College (Crete, Nebraska). After a postgraduate period at Cornell University, he worked as a research assistant at Analytica of Bradford and helped to develop some of the first commercial electrospray ionization sources. He joined the ICR Program in 1995, and has been an invaluable mainstay in instrument design, construction and troubleshooting. He has contributed essentially to virtually every instrumental ICR development at the lab, ranging from electrospray tip fabrication to ion sources, ion optics, external ion traps and mass filters, etc. A particularly good example is his ingenious angled-wire octopole ion trap, in which ions can be stored and then ejected with tenfold higher efficiency than previously possible. Quinn has co-authored ~25 refereed publications, and dozens of presentations at scientific conferences. He also serves as a consultant to other Magnet Lab units on high vacuum and other issues.
quinn@magnet.fsu.edu

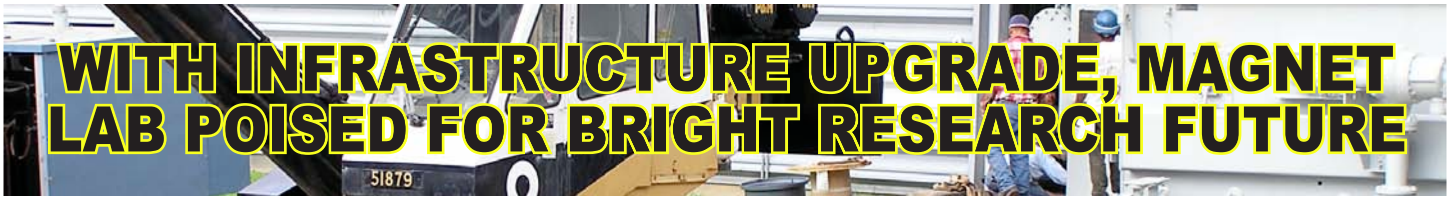
Ryan Rodgers

Ryan Rodgers, ICR associate scholar-scientist, director of Environmental and Petroleomic Applications, earned his B.S. in chemistry at the University of Florida in 1995, and Ph.D. in analytical chemistry at Florida State University in 1999, working with Professor Marshall. Following a postdoctoral year at Oak Ridge National Laboratory with Dr. Michael Ramsey, Rodgers returned to Tallahassee in 2001 to direct a new "petroleomics" program that he initiated during his graduate and postdoctoral research. Petroleomics is the correlation and ultimately prediction of the properties and behavior of petroleum and its derivatives based on detailed chemical composition derived from ultrahigh-resolution FT-ICR mass spectrometry. Rodgers leads that field in detailed chemical analysis of the "heavy" oils that are becoming increasingly prevalent as the world's supplies of "light" crude oils are depleted. He was recently named to the editorial board of the *Journal of Dispersion Science and Technology*. He currently co-directs six Ph.D. students and four postdoctoral researchers.
rodgers@magnet.fsu.edu

Tanner Schaub

Tanner Schaub, ICR visiting assistant scholar-scientist, Instrumentation, completed his B.S. in chemistry at New Mexico State University in 2000, and his Ph.D. from Florida State University in 2004 with research that consisted of the design, construction, and application of a novel FT-ICR mass spectrometer for petroleum analysis. Since then he has worked with the ICR group in instrumentation and technique development primarily with the 14.5 T hybrid linear ion trap FT-ICR mass spectrometer (the highest field FT-ICR system in the world). In addition to improving instrument performance through modification and characterization, Schaub has successfully configured the 14.5 T system to meet the instrumentation needs for a variety of internal and external users. Current and future projects include improvement of ion source transmission, instrumentation upgrades/modifications, and collaboration with external users in proteomics and petroleum analysis.
schaub@magnet.fsu.edu

WITH INFRASTRUCTURE UPGRADE, MAGNET LAB POISED FOR BRIGHT RESEARCH FUTURE



After six months of implementation and several years of planning, the Magnet Lab is putting the finishing touches on its most important infrastructure improvements since the lab's 1991 inception. The improvements add much-needed muscle to the power behind the lab's state-of-the-art magnet technology.

With electrical and cooling improvements at its center, the upgrade positions the lab well ahead of the facility's current energy demands. This new excess energy enables users and in-house researchers to ask more from the magnets – more in terms of field strength, magnet time, and overall reliability.

"Users are always looking for more field and more time at that field," said DC Field Facility Director Bruce Brandt. "It may not seem like a huge bump in power, but if you've been exploring something that happens at 30.9 T and your limit has been 31 T, then suddenly it's up to 35 T, you're going to be pretty happy."

User Mitrovic Vesna, an assistant professor of physics at Brown University, conducts research that requires stable high magnetic fields for a long period of time – often a time-consuming endeavor before the upgrade.

"The upgrades to the power supplies will mean that users like myself will be able to sit at full field for NMR measurements in the resistive magnets," said Vesna. "We will not have to take data for an hour and then reduce the field for an hour to allow the transformers to recover."

Brandt says that while beneficial to all the lab's users, the upgrade is a particular boon to nuclear magnetic resonance (NMR) scientists, who need strong, sustained fields to conduct their research.

Taking Action

After years of observing the weak links and bottlenecks that have blocked optimal operation of the magnets, Mag Lab Facilities and Operations personnel mapped needed improvements, then consulted with experts in cooling systems and power supplies to refine design requirements and write the bid documents.

To design one portion of the upgrade, the lab turned to one of the men responsible for its original system: Heinrich Boenig. A retired electrical engineer from the lab's Los Alamos branch, Boenig helped to plan the lab's approach to its increased power needs. Explained Facilities Department Head John Kyonch, "He figured out how much power we needed and he wrote the specs for this equipment."

Knoych himself, along with an outside contractor, was the brains behind the cooling system upgrade.

The upgrade, he noted, opens up all kinds of possibilities. "We can build more powerful series connected hybrids that only use one power supply, or redesign the hybrid to run on three power supplies – it needs all four now. Or we can build more powerful two-power-supply resistive magnets. All of this means more users and higher fields."

Four and a half million dollars of the $7.5 million allotted by the Florida Legislature for the upgrade went toward the lab's power boost; the remainder went toward the increased cooling needed to support it.

Transformers

At the heart of the upgrade are eight newly installed transformers. The transformers weigh 56,000 pounds each – carrying twice the weight and twice the power rating of the old set. In contrast to the older, dry type transformers, these are filled with a high flashpoint, environmentally friendly soybean oil that is cooled by water circulating in pipes. Though the new transformers are located in the same rooms the old ones were, the size difference was such that sections of the doorway had to be knocked out to accommodate the new additions. Two transformers deliver AC power to each power supply, which converts the power to the DC power required by the magnets.

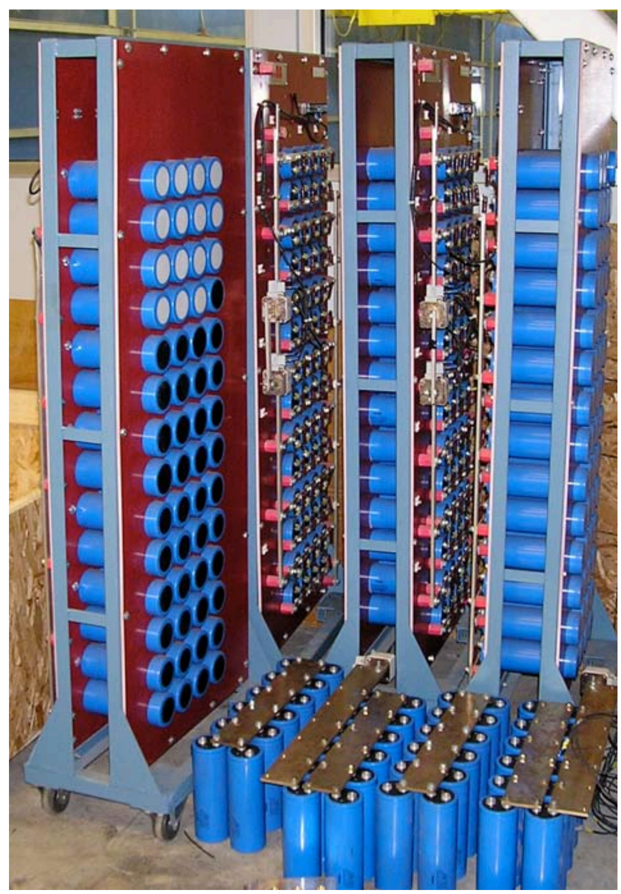
With an expected lifespan of two decades or more, a current undergrad may be sending his or her children off to college before the lab needs to replace the new transformers.

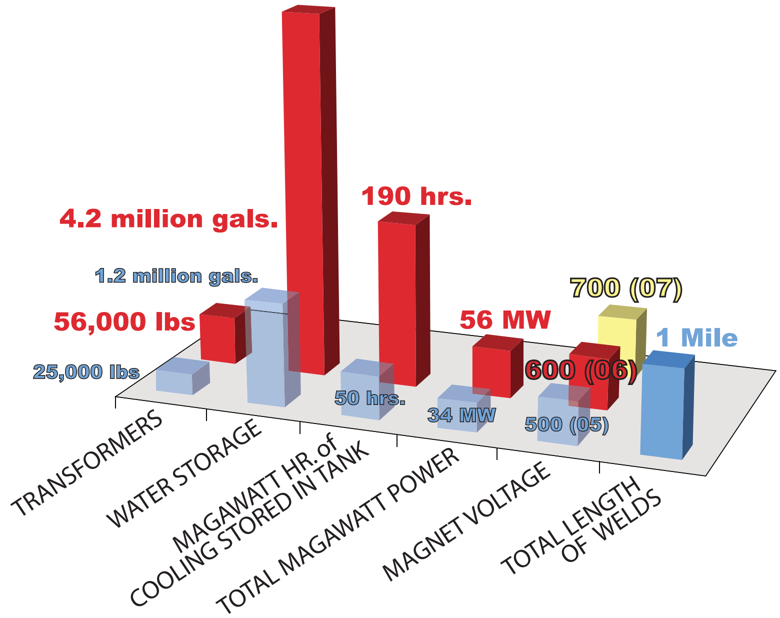
The transformers were designed to be adaptable to further improvements, allowing the lab flexibility for further upgrades, explained Electronics Engineer Andy Powell.

They also add punch for researchers working at the limit of the old system's capability. "A 10 megawatt power supply was a tease for some of our researchers," said Powell. "With the increased supply, we'll be able to double the number of users in some cases. Once everything's in place, we'll be able to run up to 14 megawatts from each of the four power supplies."

Bit and Pieces

Improvements to the lab's infrastructure wouldn't be possible without improvements at the Levy Avenue power substation. In the spring of 2007, larger cables will connect the substation to the lab.





The upgrade required replacing hundreds of components in the power supplies and installing a new rectifier control system. The transformers have two settings that will increase the voltage to the magnet from the current 500V to either 600V DC or 700V DC. All of the components such as the thyristors, which switch on and off to turn the AC current into DC, had to be replaced to handle the higher voltage.

Wes Morris, with materials testing help from Vince Topoloski, designed a fixture that accurately measured the critical clamping force on the 192 thyristors. This innovation made a big improvement on the speed and accuracy of this tedious job.

After the transformers reduce the voltage from 12,470V to 520V, copper piping conducts 4000 amps to the power rectifiers on the floor above. The low-voltage, water-cooled pipes coming from the transformer were custom bent in-house; every pipe was cut and bent differently, and each copper connector was milled, by the lab's machine shop.

"We hired two welders to help with some assembly, but other than that, all this work was in-house," said Maintenance and Construction Superintendent Richard Brooks of the pipes that made up each connection unit.

There was no margin for error; with a tight physical space in which to fit the components and a limited window of time to complete the project, every piece had to be perfect. Brooks' team worked longer hours than usual for more than a month to complete this portion of the project.

Rectifier Control System

The new rectifier control system replaces an existing system that was designed with late 1980's technology; soon finding parts for the existing rectifiers would have been impossible. With the existing system, settings were difficult to access. With the modern control system, improved fine tuning of the control of the rectifier will be possible.

"We didn't have as much control over the old rectifier control system as we needed," said Powell. "We figured out other ways to compensate; but with the new system, we will have far better control over the current."

The final result of the new rectifier control and new capacitors, explained Brandt, will be better control and purer DC current. "This will result in lower noise in the users' experiments and maybe measurements that have never before been possible in high field, high power magnets," he added.

Capacitors

Complementing the new transformers and rectifier control system, new capacitors and capacitor racks were installed on the floor above. The capacitors were purchased because the old ones were unable to handle the higher voltage

of the new transformers. From the capacitor, power moves to the active filter, further smoothing the current, and then into the magnets. As with the transformers, configuring the capacitors required substantial custom in-house work and cooperation; the capacitor racks were designed with help from Scott Bole, Todd Adkins and Steve Kenney from the lab's Magnet Science & Technology team.

Rebuilding the capacitors and replacing the accompanying rectifier control system has served to steady the current traveling to the magnets. This increases the uniformity of the magnetic field and the reliability of researchers' data.

Water

If the transformers are the heart of the lab's energy supply, the chilled water system functions as its circulatory system, supplying cool water throughout the massive and varied sources of energy throughout the lab.

In September, independent contractors connected the new 3 million gallon chilled water tank to the building with a new system of pipes that run underneath the service road behind the lab.

"The tanks store and stratify hot and cold water," said Kynoch. When the magnets run at high power, the system can draw on the cold water at the bottom of the tank and send the hot water to the top of the tank. When the magnets ramp down, it cools the hot water at the top of the tank and sends it back to the bottom.

Said Kyonch, "It is a very simple system that gives the lab much more cooling capacity than the chillers that are installed. It is also a very efficient method that matches our rapidly changing cooling demand."

The cooling upgrades will allow the lab to keep the more powerful magnets – and more magnets at once – cool and operating. Three additional cooling pumps, larger magnet heat exchangers, and wider pipes throughout the plant also are necessary to accommodate the larger power supply.

A team effort

Integrating the myriad small projects that completed the upgrade was a feat of cooperation, said Brandt. In addition to the considerable in-house engineering and fabrication required to make the upgrade work, Jim Reynolds, with Florida State University Major Projects and Dan Bull of FSU Purchasing, lent project management and purchasing assistance to the effort.

"We've been working up to this for three or four years, and this has really been a combined effort of people in facilities, instrumentation, and operations," said Brandt. "I've been very impressed with the hard work and the knowledge that has gone into this effort."

Photos contributed by: Larry Gordon, Wes Morris, Amy Winters and Walter Thorner.

NMR of Walkingstick Insects: New NHMFL Capabilities in Natural Products

Written by Art Edison on behalf of the Florida walkingstick group:

Aaron T. Dossey[1], Spencer S. Walse[2], James R. Rocca[3], & Arthur S. Edison[1,3,4]

Last spring we reported the successful completion of a 1-mm high-temperature superconducting (HTS) NMR probe [1]. This 1-mm HTS probe project was described in a recent *NHMFL Reports* (Vol. 13, No. 2) and was the result of a collaboration between Bill Brey's RF group in Tallahassee, Rich Withers and Rob Nast at Bruker-Biospin, and my group at UF. Our initial tests of the probe suggested that it would have very high sensitivity: as much as six-times greater signal-to-noise (S/N) (per mass of sample) than commercial cryoprobes. In contrast to conventional 5-mm NMR probes with 500-600 µL sample volumes, the new 1-mm HTS probe holds just 8 µL (Figure 1), so the perfect applications for the probe are samples with very limited amounts of material.

About the same time the 1-mm HTS probe was being installed and tested, my student Aaron Dossey was collecting a species of walkingstick insect, *Anisomorpha buprestoides*, at a gas station in Gulf Hammock, Florida. Aaron recently completed his Ph.D. but at the time was a graduate student in the Interdisciplinary Program in Biomedical Sciences (IDP) at UF, and his major emphasis was Biochemistry & Molecular Biology. Aaron worked in my laboratory on NMR studies of neuropeptides. However, Aaron's true love is entomology. His passion for entomology started in high school when Aaron collected insects for Honors Biology and Zoology. He joined the Young Entomologists Society and began making contacts for trading specimens from all over the world. As an undergraduate student at Oklahoma State University, Aaron donated many specimens to the OSU Entomology Museum and helped the OSU Insectary collect and rear beetles and walkingsticks.

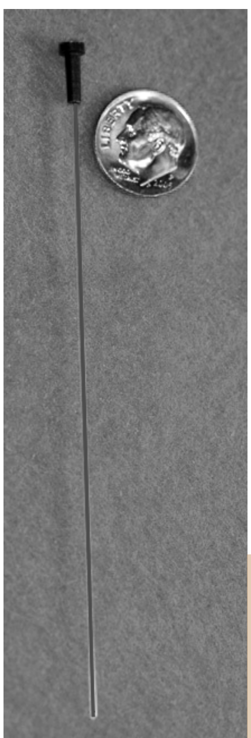


Figure 1) Sample tube used for the 1-mm HTS probe. 8-10 µL sample is loaded by a syringe. The sample is loaded vertically like 5-mm tubes are loaded into conventional probes. Photograph by Dr. Chris Williams.

Figure 2) Male *A. buprestoides* reared and photographed by Aaron T. Dossey in Gainesville, FL.

Aaron had been rearing *A. buprestoides* and, while feeding the insects, often noticed the defensive spray for which this species is well known. He was curious, looked into the literature, and found that Tom Eisner and Jerry Meinwald, the great chemical biology team at Cornell, had characterized the venomous defensive spray of *A. buprestoides* over 40 years ago[2, 3]. The initial study required several hundred insects and over 1000 "milkings" of walkingstick venom. Significantly, the Eisner and Meinwald found that walkingstick secretions were nearly pure "anisomorphal", a monoterpene (10 carbon) dialdehyde.

Despite fact that Aaron was working on a completely different project for his Ph.D. studies, he initially pooled together 10 milkings from the *A. buprestoides* that he raised and worked with Jim Rocca, our AMRIS expert in NMR spectroscopy applications. Jim is a very talented natural products chemist and analytical NMR spectroscopist, so he was a perfect person to help Aaron with his little "weekend" project. We often swap the 1-mm HTS probe and a commercial Bruker 5-mm cryoprobe in the same 600 MHz instrument, and when Aaron and Jim were ready to first analyze the pooled 10 milkings, the 5-mm cryoprobe was installed. The spectra they collected were impressive, and that is when Aaron showed me the results and introduced me to *Anisomorpha buprestoides* (Figure 2). We realized that it should possible to get nice NMR data from a single insect with the 1-mm HTS probe, so I encouraged Aaron and Jim to move forward with the project with the 1-mm probe.

Eisner and Meinwald extracted the *A. buprestoides* milkings with methylene chloride, and Aaron initially followed their lead by extracting milkings with chloroform. These important initial experiments showed us that a single milking from a mid-sized animal (Figure 3) produced enough material for very nice NMR spectra on the 1-mm HTS probe. However, Aaron and Jim noticed that they lost an initial milky-colored material after extraction by chloroform, so we decided to just try dissolving the secreted drop directly into D_2O. With no purification and within 10 minutes of milking from the animal, Aaron and Jim were able to collect the 1D NMR spectrum shown in Figure 4. We immediately saw that there were too many peaks in the NMR spectrum for a single 10

1) Department of Biochemistry & Molecular Biology, University of Florida, Gainesville FL 32610-0245
2) Center for Medical, Agricultural and Veterinary Entomology, USDA-ARS, Gainesville, Florida 32604
3) McKnight Brain Institute, University of Florida, Gainesville FL 32610
4) National High Magnetic Field Laboratory, University of Florida

Figure 3) Venom sample collection for mid-sized male *A. buprestoides*. The glass pipette tip was placed on the insect's defensive glands and caused the insect to spray into the tube. This drop is added to 10 µL D_2O for NMR analysis. Photograph by Dr. Aaron T. Dossey.

carbon compound. Jim recognized the extra peaks as a sugar and correctly guessed they were glucose.

One of the biggest pleasures I get in directing AMRIS is the diversity of users we support and the research that I get to hear about. When I learned that glucose is likely being produced with the anisomorphal venom, I was reminded of one of our users, Spencer Walse. Spencer works with Peter Teal in the Center for Medical, Agricultural and Veterinary Entomology in the U.S. Department of Agriculture in Gainesville. The USDA group specializes in insect natural product chemistry, and Spencer's project focuses on compounds that are glycosylated. In fact, much of Spencer's research focus is on the relevance of aqueous chemistry in organic natural products, an area that is seriously underappreciated by many natural products chemists. I described our initial walkingstick findings to Spencer and invited him to join the new walkingstick team.

Spencer is an expert in chromatography and mass spectrometry, and in a short time we had HPLC-MS (high pressure liquid chromatography-mass spec) and GC-MS (gas chromatography-mass spec) data that verified both glucose and anisomorphal in the venom. At this point, we all realized that in addition to the glucose, there were more components of the mixture, and these were found by NMR and GC-MS to be different stereoisomers of the 10 carbon anisomorphal. Three of the 10 carbons are chiral, and thus there are theoretically 4 pairs of enantiomers of anisomorphal. By NMR we easily identified 2 different forms from *A. buprestoides*, and

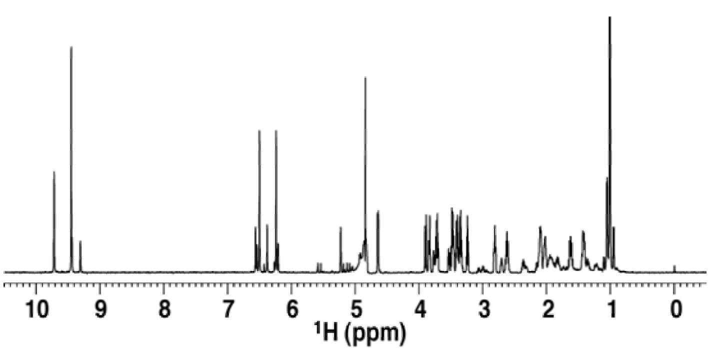


Figure 4) 1D 1H NMR spectrum from the 1-mm HTS probe of a single walkingstick milking as shown in Figure 3. The spectrum was collected in less than 1 minute with 8 scans and less than 10 minutes after the milking.

Spencer saw those two as well as a third minor form by GC-MS. In other words, *A. buprestoides* makes right handed, left handed, and a third handed form of anisomorphal. This was surprising to us, because nature normally has great specificity in the handedness of biological chemicals.

Aaron's extensive contacts in the world entomology community include Oskar V. Conle of Bolsterlang, Germany, one of the top Phasmatodea experts in the world. Oskar and his collaborator Frank H. Hennemann recently described a new species of walkingstick insect from Peru called *Peruphasmal schultei* (4). Oskar sent Aaron *P. shultei* milkings that were pooled from 3 animals, and in contrast to *A. buprestoides* we found by NMR and GC-MS that this insect only produces one isomer of anisomorphal. We also could not find any other report of this isomer, and we named it "peruphasmal".

The presence of 3 forms of anisomorphal in *A. buprestoides* made us wonder how this composition varied between individual animals and over time. Aaron had grown several animals, so he separated 4 and put them into individual plastic containers. They had all been reared from the same initial collection of insects and they were raised in identical conditions and fed the same plant leaves. Aaron collected data from these 4 animals on three different days (day 1, day 2, and day 8). To our great surprise, the individual insects produced different mixtures of anisomorphal isomers, and the composition varied between individuals over time. Full details of our findings have published (5).

The 1-mm HTS probe has allowed us to look at compounds from a single insect and thus allowed us to address questions that were not possible without the very high sensitivity that it affords. I think even more importantly, this work demonstrates the importance of simple curiosity in scientific research, because it all started when Aaron became interested in the venom produced by insects he had been keeping as a hobby. This probe clearly has great potential for natural products and many other areas of research where sample quantity is limited. The 1-mm HTS probe is part of the Magnet Lab external user program, and interested (and especially curious!) investigators are invited to contact Art Edison (art@mbi.ufl.edu) to discuss new collaborations.

References

(1) Brey, W. W., Edison, A. S., Nast, R. E., Rocca, J. R., Saha, S., and Withers, R. S. (2006) Design, construction, and validation of a 1-mm triple-resonance high-temperature-superconducting probe for NMR. *J Magn Reson* **179**, 290-3.

(2) Meinwald, J., Chadha, M. S., Hurst, J. J., and Eisner, T. (1962) *Defense Mechanisms of Arthropods* .**9**. Anisomorphal, the Secretion of a Phasmid Insect. *Tetrahedron Letters*, 29-33.

(3) Eisner, T. (1965) Defensive Spray of a Phasmid Insect. *Science* **148**, 966.

(4) Conle, O. V., and Hennemann, F. H. (2005) Studies on neotropical Phasmatodea I: A remarkable new species of Peruphasma Conle & Hennemann, 2002 from northern Peru (Phasmatodea : Pseudophasmatidae : Pseudophasmatinae). *Zootaxa*, 59-68.

(5) Dossey, A. T., Walse, S. S., Rocca, J. R., and Edison, A. S. (2006) Single Insect NMR: A New Tool to Probe Chemical Biodiversity. *ACS Chemical Biology* **1**, 511-514.

New hybrid magnets to enable research in a currently unavailable regime

The Magnet Lab has embarked on innovative projects to develop unique hybrid magnet systems. Novel because a set of Florida-Bitter resistive coils (insert) and a set of superconducting cable-in-conduit conductor (CICC) coils (outsert) are driven in series with the same power supply rather than independently.

The National Science Foundation has awarded the lab an $11.7 million grant for construction of a cylindrical-bore Series-Connected Hybrid (SCH), for high field nuclear magnetic resonance (NMR), condensed matter physics, biology, and chemistry, to be located at the Magnet Lab's Tallahassee location.

In addition, the NSF is funding a conceptual and engineering study for a similar SCH that would be used for neutron scattering experiments at Oak Ridge National Laboratory's Spallation Neutron Source (SNS).

Figure 1 shows a vertical section of the SCH that will be housed in cell 14 of the lab's high field DC facility. This system will provide high magnetic field for one-third the power consumption of traditional powered magnets. The general parameters of the SCH are listed in Table 1. The SCH will allow scientific exploration into a region of high-field and high-homogeneity parameter space unavailable anywhere else in the world, as illustrated in Figure 2. At 36 T, the design field of the SCH presently exceeds the available all-superconducting fields by 62% and fields in existing all-resistive magnets with similar bore and uniformity by 44%.

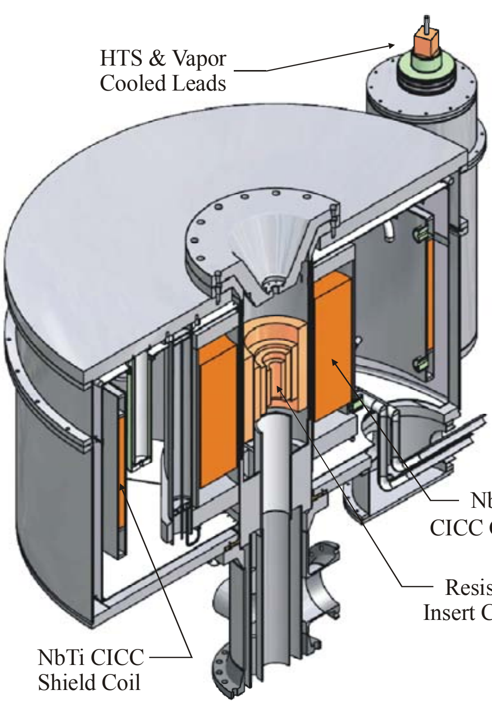


Figure 1. Vertical Section of the Series Connected Hybrid Magnet for the NHMFL.

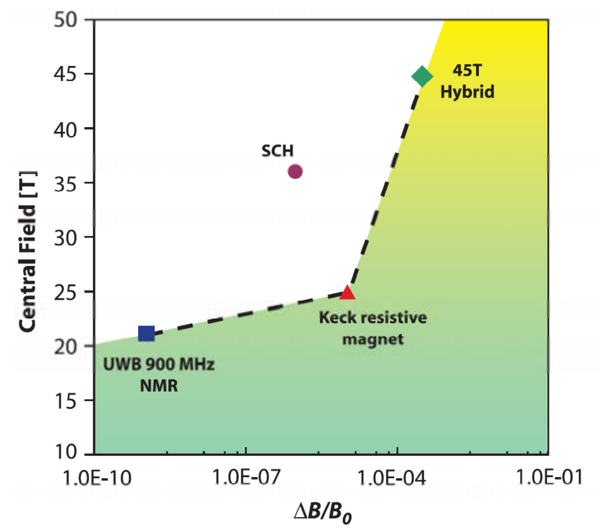


Figure 2. Uniformity and central field of the series-connected hybrid magnet in relation to the 45 T and 900 MHz magnets. The region above the curve represents a regime that is presently unavailable.

Table 1. General Parameters of the Series Connected Hybrid Magnet

Central Field	36 T
Warm Bore	40 mm
Operating Current	20 kA
Uniformity Over 10 mm DSV	1 ppm

Because of its naturally higher inductance/resistance ratio, this magnet configuration will have greater temporal stability than present all-resistive or hybrid magnets. Importantly, the amplitude of the high-frequency fluctuations will be preferentially suppressed, and new flux-stabilization techniques that will be developed in collaboration with researchers at Penn State University will further enhance the field stability. Homogeneity in the SCH will be improved by an order of magnitude over the world's highest-homogeneity resistive magnet, the Magnet Lab's 25 T Keck magnet, through the use of improved resistive magnet current grading and water-cooled resistive shims. The SCH will consume about one half the power of the existing high-uniformity, 25 T Keck magnet, resulting in lower operating costs than any magnet in its class.

Many of the technological achievements developed for the 45 T Hybrid will be applied to the SCH. However, the SCH will also contain several new enhancements, such as HTS leads, improved cryogenic support columns, improved superconductor, and higher strength conduit for the CICC that also has thermal properties similar to Nb_3Sn.

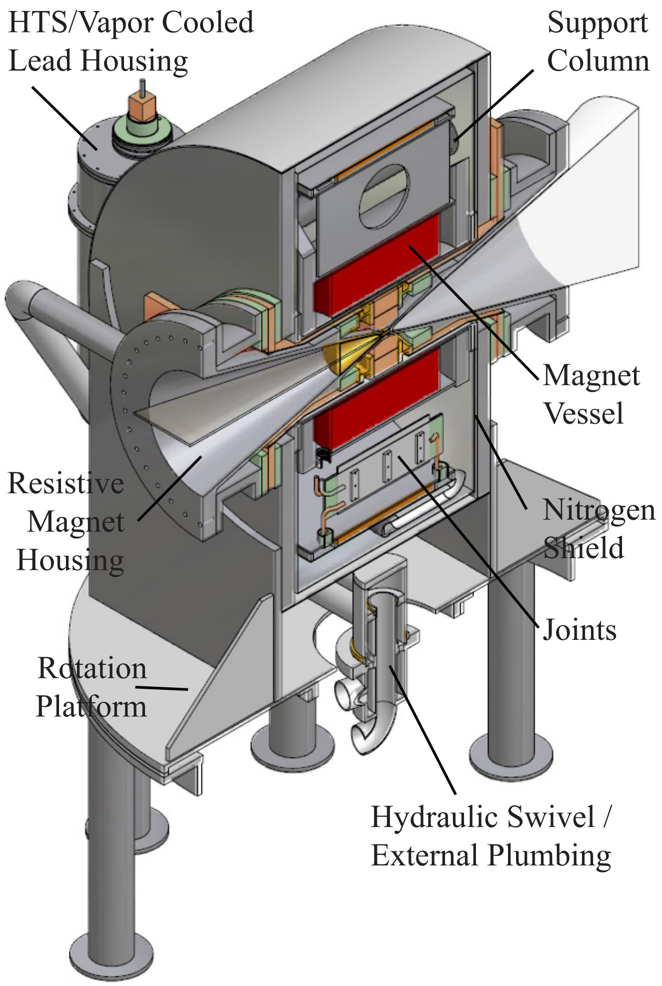


Figure 3. Vertical Section of the Series Connected Hybrid Magnet and Cryostat for the SNS

The SCH for SNS is a collaborative effort with Johns Hopkins University, Massachusetts Institute of Technology and the SNS with the objective to develop technical specifications for the magnet, beam-line, and sample environment. Over a two-year period, the engineering design of the magnet system will be performed at the NHMFL and development of the user facility plan, science program, and beam-line activities at Johns Hopkins, MIT, and SNS respectively.

This magnet system is similar in many respects to the SCH for the Magnet Lab with the exception that the system is oriented horizontally for alignment with the beam-line and the warm bore is conical. The external helium refrigeration, superconducting outsert coil, quench protection, power system, and cooling water system are all comparable or scaleable to the power demands of the insert.

With a conical bore, much less space is allotted for the resistive insert magnet. It will consist of two or three nested 20 kA coils that utilize a conical Florida-Bitter magnet technology to take advantage of the additional space at the mid-plane. A concept of this technology is shown in Figure 4. Included in this project is the prototyping of a conical Florida-Bitter coil that will be operated with a high background field.

The technology developed for the lab's 45 T Hybrid magnet has set the framework for the SCHs. Now an evolution of that design and the development of new features are allowing the creation of new instruments for high field NMR, chemical, and biological research and neutron scattering experiments.

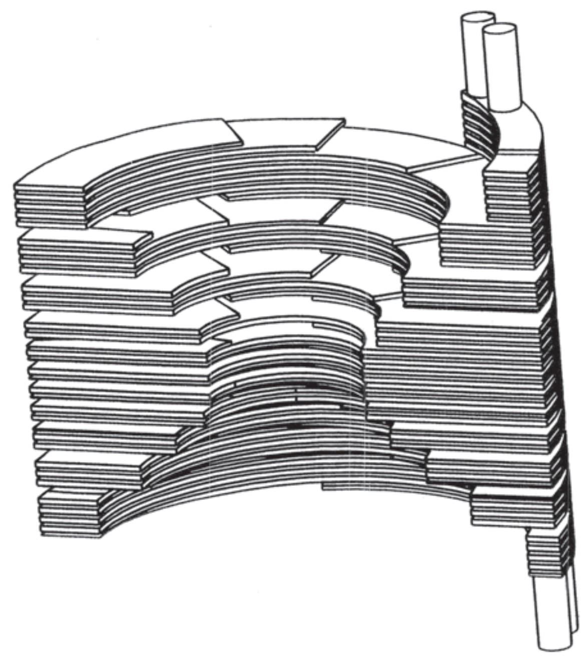


Figure 4. Conical Florida-Bitter Coil

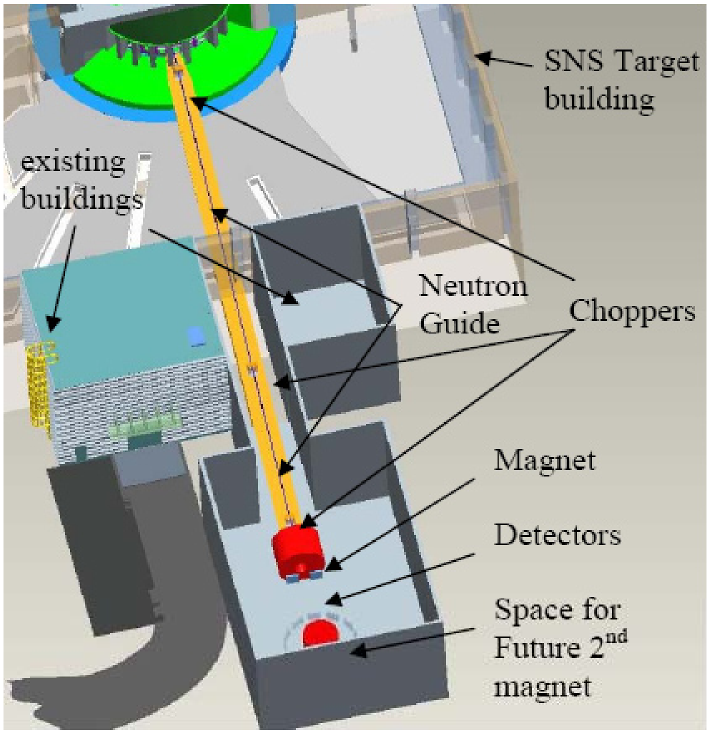


Figure 5. Layout of the Series-Connected Hybrid Magnet on Beam-line 14A at the SNS

New crystal growth program to enhance FSU's materials research efforts

Florida State University already has an excellent reputation for its various efforts to design, prepare and characterize new materials for research and commercial uses. Now that reputation is about to be burnished even further as scientists at the National High Magnetic Field Laboratory ramp up a program for growing exotic crystals that possess special properties.

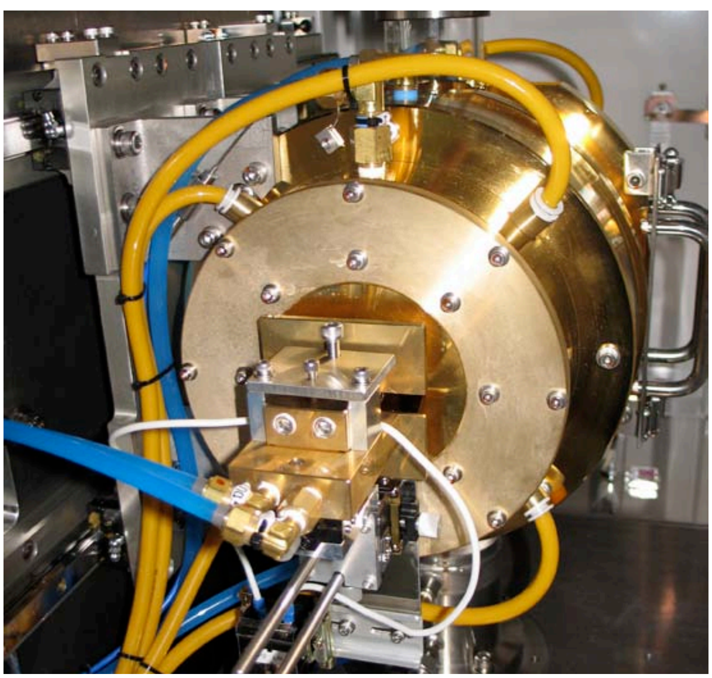
Chris Wiebe heads up the magnet lab's Quantum Materials Group, the centerpiece of which is a new, state-of-the-art image furnace capable of growing crystals such as magnetic oxides and high-temperature superconductors.

Access to these samples — the demand for which currently far outstrips the supply — and the ability to create completely new ones will give the lab and its research partners a distinct advantage.

"Crystal growth programs in North America typically have lagged behind those of other countries," said Wiebe, an assistant professor of physics at FSU. "We can't get enough good samples because the Japanese are so far ahead of us."

Wiebe said purchasing the image furnace is part of the magnet lab's commitment to getting the samples needed to push the U.S. back to the forefront of sample development.

The image furnace looks a bit like a refrigerator with the housing for a car engine inside. At the core of the furnace, two rods meet, spinning slowly in opposite directions. These rods are created from scratch at the magnet lab, and different combinations rods and materials yield different crystals. In the furnace, the rods are superheated with refracted light, and that heat acts as the catalyst for the reaction that forms crystals with special properties.



The "car engine" appearance of the furnace is lent by the water-cooled shell that, even with the furnace operating, is cool enough to touch. This shell enables researchers to place a video camera directly in front of the action, so that as the rods meet and crystals are formed, the success or failure of each effort can be monitored in real time.

Creating sophisticated crystals isn't as easy as following a recipe and putting in the right ingredients; mastery of techniques is paramount. Combining the different materials and techniques is creative, demanding work, and the group already has met with success, reproducing a difficult-to-make superconducting crystal first developed by Japanese researchers. Interest in the crystal has spawned collaboration between the magnet lab and chemists in FSU's Center for Materials Research & Technology (MARTECH, www.martech.fsu.edu).

The image furnace also will benefit the lab's magnet development program, because the crystals, such as the high-temperature superconductors, are materials that can be used to create the powerful magnets for which the lab is best known.

Wiebe said he expects that the furnace eventually will be incorporated into the lab's user program, leading to collaborations with physicists, chemists and engineers at other labs and universities around the world.

Said User Committee Chair Jim Valles of the eventual push toward tailoring the furnace in part for user needs, "Already at the Magnet Lab, materials scientists and their collaborators can call on a wide range of instrumentation for characterizing the magnetic properties and phases of the newest compounds. The development of this furnace system substantially expands the range of materials that can be created in the highest magnetic fields available in the world. I anticipate it will attract future users working at the forefront of novel materials synthesis methods."

With the addition of the image furnace, the magnet lab becomes one of only a few science facilities in the world capable of providing high-quality samples to eagerly awaiting experimental physicists.

"We're joining an elite club," Wiebe said.

The $180,000, Japanese-built furnace is funded jointly through start-up funds contributed by Wiebe and scholar scientist Luis Balicas, as well as through the National Science Foundation and the FSU Office of Research. Wiebe's team is rounded out by postdoc Haidong Zhou, and students John Janik, Ben Conner, and Brandon Vogt.

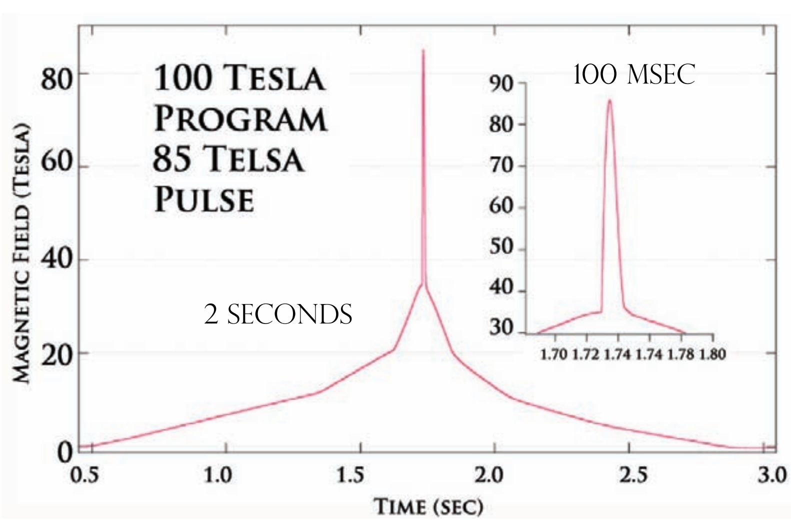
Commissioning of 100 Tesla Multi-Shot pushes boundaries of science beyond 80 tesla

Dwight Rickel of the National High Magnetic Field Laboratory's Pulsed Field Facility at Los Alamos National checks the 100 Tesla Multi-shot Magnet. Recently commissioned for user operation at 85 tesla, the magnet opens up new frontiers for scientific research.

The National High Magnetic Field Laboratory's eagerly awaited 100 Tesla Multi-Shot magnet is now commissioned for user operation at 85 tesla. Located at the Magnet Lab's Pulsed Field Facility at Los Alamos National Laboratory, the magnet opens up new frontiers for scientific research.

Achieving fields above 85 tesla repetitively marks a major milestone in magnet design and materials engineering, as man-made fields of this strength have never before been produced without the use of highly destructive, explosives-driven, magnetic field-generating technologies. This is the culmination of 10 years of major instrument development and construction, jointly supported by the U.S. Department of Energy's Office of Basic Energy Sciences and the National Science Foundation's 100 Tesla Multi-Shot magnet program.

The magnet is now part of the Magnet Lab science user program supported by the NSF. Scientists and engineers from academia, government laboratories and industry will have access on a competitive basis to the highest magnetic fields ever produced non-destructively on a repetitive basis.



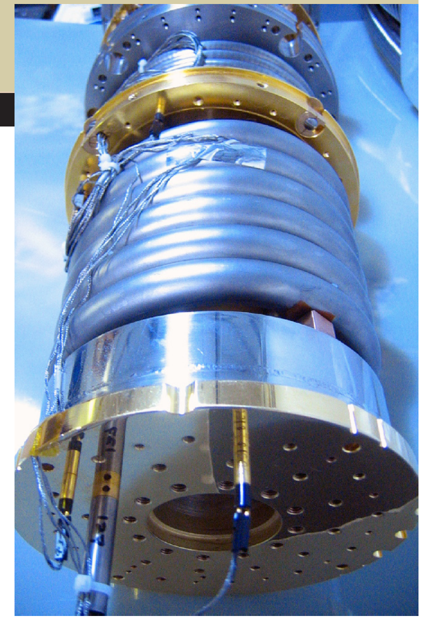
With this new Magnet Lab capability, researchers can explore uncharted regimes of low temperature and high magnetic field, central to understanding the mechanism of superconductivity, magnetic-field-induced phase transitions, and so-called quantum critical points, in which small changes in materials properties at very low temperature have dramatic effects on physical behavior.

Continuous improvements in the magnet's performance are underway, and peak field will be gradually increased up to 100 tesla as materials development and operating experience is gained.

"The NHMFL 100-T project is an excellent example of teamwork among scientists, engineers and government agencies," said Alex Lacerda, associate director for user operations at all three sites of the Magnet Lab and director of the Magnet Lab Pulsed Field Facility. "Achieving 100 T non-destructively has been a goal for many years world-wide.

"The scientific environment at Los Alamos was of paramount importance in positioning the NHMFL to achieve that goal. I'm particularly pleased by the continuing support from DOE-BES and NSF to this long and exciting project," Lacerda added.

Cooling power of new dilution refrigerator is world class



A new dilution refrigerator at the Magnet Lab's Tallahassee facility ranks among the top three in the world in cooling power. The system allows samples and devices to be cooled to temperatures near absolute zero, thereby revealing new phenomena not accessible or even possible at normal temperatures. The refrigerator was built by Giorgio Frossati of Leiden Cryogenics in the Netherlands. Frossati traveled to the Magnet Lab in October to assist in commissioning the system.

During the first round of testing, the new dilution refrigerator – one of four at the lab – has reached its demanding specifications. Irinel Chiorescu, head of the lab's Quantum Spin Dynamics group and assistant professor in physics at Florida State University, has found that over a two-week cooling period, the refrigerator has now reached 3 milliKelvin, or three-thousandths of a degree above absolute zero. This corresponds to -459.665 degrees Fahrenheit.

To achieve such low temperatures, the refrigerator mixes two fluids, actually, quantum fluids that do not freeze at low temperatures, namely, 3He and 4He. At the heart of the process, liquid helium 3 is "diluted" (hence the name) into liquid helium 4 and this quantum form of evaporation produces the cooling. Such low temperatures are not easy to reach, and literally a ton of sophisticated machinery, cryogenic liquids, and electrical power are necessary to produce 3 mK in only a small sample holder the size of a thimble, buried deep in complex refrigeration platforms, tubing, surrounding magnet, and deep cement pit in the floor. Moreover, the everyday vibrations due to the machinery and activity at the Lab, radio stations, and even cell phones, can affect the experiments. Shielding and vibration isolation are necessary for the temperature to reach its nadir. Chiorescu is grateful for the contribution of the Magnet Lab's "impressive technical support" teams in eliminating these problems.

Irinel Chiorescu (left), Giorgio Frossati of Leiden Cryogenics, and graduate students Nickolas Groll and Lei Chen stand with the Magnet Lab's newest and most powerful dilution refrigerator.

Such low temperatures are not the goal, but a means to the environment where Chiorescu and his group will explore the nature of very low temperature quantum phenomena in molecular magnets and superconducting devices, all with an eye to understanding how to control information at the quantum level. Two other very special features of this new effort are the vector magnet and microwave electronics that will allow studies of magnetic samples in complex electro-magnetic field configurations. This research is essential to provide a basic understanding of how quantum computers may ultimately be constructed and perform.

Start-up funding for the Chiorescu's new laboratory has come from both FSU and the Magnet Lab, and he has been successful in obtaining a Sloan fellowship and In-House Research funding through the Lab and NSF to aid in this research. Chiorescu said two of his graduate students, Nickolas Groll and Lei Chen, were instrumental in the success of the refrigerator's tests. "They have participated actively and have done an excellent job," said Chiorescu. "This of course means working weekends and late nights too!" The first experiment in the new system involving superconducting thin films, part of Chen's Ph.D. project, was running at press time, in the first and successful cool-down of the system.

New Web Site, grants, *will enhance educational outreach*

Pat Dixon, director of the NHMFL Center for Integrating Research and Learning (CIRL)

Educators at the Center for Integrating Research and Learning (CIRL) welcomed the start of the new academic year by developing and enhancing programs for students and teachers, and by stepping up outreach efforts.

In just the first few weeks of school, Carlos Villa, outreach coordinator for CIRL, conducted outreach for more than 900 elementary students in Thomasville, Ga., and Tallahassee, Fla. The outreach schedule is full through December, which points to teachers' increased focus on science. The No Child Left Behind mandate has created a need for quality resources for classroom teachers and the record number of children that we reach each year is testament to the role organizations such as CIRL can play.

To bring the resources of CIRL and the Magnet Lab to a wider audience, we have been working with Susan Ray, director of Public Affairs, and Mike Davidson, researcher in Optical Microscopy, to create a more user-friendly Web site that attracts students, teachers, parents and the general public. Kristen Coyne, a technical writer with extensive journalism experience, has worked with Jose Sanchez, assistant director CIRL, to update and enhance Web-based resources and to create new features such as the Magnet Academy.

The Magnet Academy translates complex science concepts such as superconductivity in a compelling and entertaining way that makes the science more accessible to a broader audience. Look for additional Academy topics in 2007. Wally Thorner, also in the Public Affairs group, has created bookmarks of pioneering scientists electricity and magnetism that will be distributed to teachers and students.

CIRL's research agenda is expanding with the addition of a 5-year research project that is being directed by Sherry Southerland, associate professor in Science Education at Florida State University. Two Research Experiences for Teachers programs, one at the Magnet Lab and one directed by Ellen Granger in the Office of Science Teaching Activities at FSU, will serve as laboratories for research on how features of RET programs influence teacher behavior.

Funded by the National Science Foundation, this study will provide a model of best practices and programs that result in teachers conducting inquiry-based science activities in their classrooms. Two graduate students will be assigned to the Magnet Lab program and Director Pat Dixon, co-PI on the grant, will oversee

Check us out online: education.magnet.fsu.edu

the research component for CIRL. In addition, the study begun in spring 2006 by Crissie Grove, a graduate research assistant, and Pat Dixon, will be presented at the Association for Science Teacher Education International Conference in January 2007 and the National Association for Research in Science Teaching annual conference in April 2007. The 2005 RET study resulted in an article titled, "The Influence of a Teacher Research Experience on Elementary Teachers' Thinking and Instruction," which will be published in the spring 2007 edition of the *Journal of Elementary Science Education*.

Center sharpens focus on students, teachers

The success of SciGirls, a summer camp for middle school girls interested in science, energized partners from the Magnet Lab, the Tallahassee Museum, and WFSU-TV to commit to continuing and expanding the program for summer 2007. Work has already begun on making the program even better than before and several students are working with Center educators to develop science fair projects based on their summer experiences.

The Center debuts a program for elementary students that adapts the NASA-funded Student/Teacher Astronomy Resource (STAR) materials created in 2005-2006 for middle school teachers and students. Two school-based workshops are being conducted in the fall and the local school district will host a third workshop for additional K-5 teachers. Mabry Gaboardi, graduate student in Geochemistry, worked with Munir Humayun, associate professor of Geochemistry, to obtain funding to create materials that would translate the excitement of the NASA Stardust Mission. With additional NASA support, these materials will be disseminated to middle school teachers and students in spring 2007.

PEOPLE IN THE NEWS

Maartje van Agthoven is a new postdoc in the ICR program. She completed master's degrees in engineering at the Ecole Superieure de Physique et Chimie in Paris and in spectroscopic methods at the Pierre and Marie Curie University in Paris, including an internship at Schlumberger-Doll Research, followed by a Ph.D. under Jean-Claude Tabet at U. Paris VI. Her prior and present research combines new ion optics development with applications to petroleum analysis.


Maartje van Agthoven

Kathy Hedick is the new chief of staff for User Programs, working directly with Associate Director for User Programs Alex Lacerda. Users know Hedick for her leadership of the annual reporting process and this newsletter. A jack-of-many-trades, Hedick also coordinated three successful open houses (1997-1999); orchestrated the 900 MHz commissioning ceremony in 2005; and helped to coordinate, develop, and edit the just-submitted renewal proposal. In 2000, Hedick was paired with systems designer/programmer Kirill Tchourioukanov to develop novel Web-based information management systems. Together, the team designed and fielded online systems to manage Magnet Lab personnel, user programs and reporting, the In-House Research and Visiting Scientist programs, and publications. For their innovations, Hedick and Tchourioukanov earned monetary Davis Productivity Awards (a major statewide recognition program). As chief of staff, Hedick will assist Lacerda with enhancement and promotion of the laboratory's user programs; continue to lead reporting activities; and focus on information systems and data integrity for a wide range of management needs.


Kathy Hedick

Frank Hunte is a new postdoc working with David Larbalestier at the Applied Superconductivity Center. Hunte is a graduate of Florida Agricultural and Mechanical University with bachelor's and master's degrees in physics. In 2004, he completed his Ph.D. in physics at the University of Minnesota on a study of exchange anisotropy in F/AF thin films by AMR and the planar Hall effect. Since earning his Ph.D., Hunte has taught physics and engineering at the River Falls campus of the University of Wisconsin and Rochester Institute of Technology. Most recently, he has been collaborating with the Superconductivity Technology Center and the lab's Pulsed Field Facility at Los Alamos. Hunte's current research interests include the study of high temperature superconductors by transport measurements, magnetometry, and magneto-optic imaging.


Frank Hunte

Priyanka Juyal is a new postdoc in the ICR program. She holds master's and doctoral degrees in Organic Chemistry from HNB Garhwal U (India). She carried out her doctoral studies as a research fellow in the "Specialties and Lubricants Group" at the Indian Institute of Petroleum (India.) Her work involved extensive synthesis, characterization, analysis and evaluation of ecofriendly fuel additives. She has been a research assistant professor for the Phase Equilibria and Separation Processes at the Technical University of Denmark where her research involved study of phase behavior of petroleum asphaltenes by structural alteration and microcalorimetry. Her research at Magnet Lab will begin with chemical derivatization to facilitate selective characterization of compound classes in petroleum.


Priyanka Juyal

Stephen A. McGill is a new assistant scholar/scientist at the Magnet Lab in Tallahassee. He received his Ph.D. in physics from the University of Pennsylvania in 2004, where he performed time-resolved optical measurements on manganites in Jay Kikkawa's research group. His ultrafast Kerr measurements were the first to be performed on these materials and provided evidence for transient photoinduced magnetization in $La_{0.7}Ca_{0.3}MnO_3$. Prior to joining the lab, he was a postdoc with Peng Xiong and Stephan von Molnár at the Center for Materials Research and Technology (MARTECH) at Florida State University. While at MARTECH, he helped to develop high-performance carbon nanotube field-effect transistors (FETs) using a understand the dynamic interactions between charge, spin, and lattice systems in highly correlated materials.

Stephen A. McGill

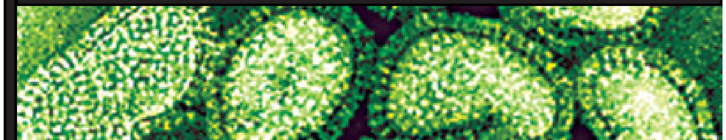
Kai Rankenburg is a new postdoc in the Magnet Lab Geochemistry group, working with Munir Humayun. Rankenburg received his diploma in geology from the University in Frankfurt, Germany, in 1997. In 2002 he completed his Ph.D. at the Max Planck Institute for Geochemistry in Mainz, Germany, studying magma genesis in the Cameroon Volcanic Line. Between 2002 and 2004, he was a postdoctoral fellow of the Max Planck Institute, and the University Louis Pasteur in Strasbourg, France. Between 2004 and 2006 he held fellowships from the National Research Council and Oak Ridge Associated Universities, and studied meteorites and lunar rocks at the NASA Johnson Space Center in Houston. At the Magnet Lab, he will study isotope anomalies in meteorites using the new Finnigan Neptune MC-ICP-MS in the new Plasma Analytical Facility.

Kai Rankenburg

Oskar Vafek has accepted an assistant professor position at FSU/Magnet Lab. He received his Ph.D. (2003) from Johns Hopkins University, where he studied various aspects of quasiparticles and their interactions with vortices in low dimensional superconductors. He moved to Stanford in 2003 to work as a postdoc at the Stanford Institute for Theoretical Physics where he worked on quantum phase transitions and superconductivity, such as disorder effects near a pair-breaking transition and magnetic field induced quantum phase transitions between spin (thermal) Hall plateaus in the mixed state of d-wave superconductors. He plans to study various equilibrium and non-equilibrium aspects of superconductivity and correlated electron systems.

Oskar Vafek

With BYU partner, Mag Lab researchers decipher flu virus



As the northern hemisphere braces for another flu season, researchers at Florida State University's High Magnetic Field Laboratory are making strides toward better understanding the mechanics of the virus that causes it – a virus that kills between a quarter and a half million people each year.

Tim Cross, director of the lab's Nuclear Magnetic Resonance (NMR) program, and collaborators from Brigham Young University are trying to understand the minute parts of the influenza A virus, a highly virulent agent. To do that, they are using all of the Magnet Lab's NMR resources including the lab's 15-ton, 900-megahertz magnet, to produce a detailed picture of the virus's skin.

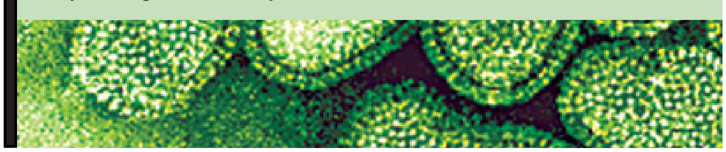
"Using the magnet helps us build a blueprint for a virus's mechanics of survival," said Cross, who also is a chemistry professor at FSU. "The more detailed the blueprint, the better our chances of developing drugs capable of destroying it." The only magnet of its kind in the world, the 900 is critical to this process. Otherwise, an image this complicated would be impossible to obtain.

Cross and David Busath, a biophysicist at Brigham Young University, recently discovered key components of the protein holes, or "channels," in the flu viral skin. These components lead to unique chemistry that is thought to be an important clue for understanding how the channel regulates whether the virus can distribute its genes into host cells and reproduce or not. These findings were published this summer in the *Proceedings of the National Academy of Sciences.*

"This is a viral structure we haven't seen before. And yet, through these tiny little doors acid must come in and DNA must come out if the virus is to survive," said Busath. "The idea is to block the door to prevent the normal function required for the virus to replicate."

Once researchers understand how these channels are selective for acid, they can use that knowledge to fashion novel drugs capable of more effectively killing the virus.

The work is funded by a five-year, multi-million dollar grant from the National Institutes of Health. Other authors on the PNAS paper include Jun Hu, Riqiang Fu, Katsuyuki Nishimura, Li Zhang, and Huan-Xiang Zhou of FSU, and Viksita Vijayvergiya, a former postdoctoral fellow at BYU.



National High Magnetic Field Laboratory

1800 East Paul Dirac Drive
Tallahassee, FL 32310-3706
Tel: 850 644-0311
Fax: 850 644-8350
www.magnet.fsu.edu

Non-Profit
Organization
U.S. Postage
PAID
Tallahassee, FL
Permit No. 55