No. 32

GMAG NEWSLETTER

November 2009

Topical Group on Magnetism and its Applications http://units.aps.org/units/gmag/

Note From the Chair

A good part of the 2010 March Meeting organization has already happened at this point thanks to the efforts of Berry Jonker the GMAG chair-elect and thus also GMAG program chair. Namely, the invitations for symposia and focus topic invited talks have been mailed out by now. As far as I am concerned this part of the program looks already extremely inviting and hopefully it will be complemented by many excellent contributions, which are due on November 20th.

In addition this newsletter will have information on the new GMAG student dissertation awardees (congratulations!) and how to become more involved in various GMAG activities. As in the past, if you have additional feedback on how GMAG can assist you or the magnetism community-at-large in their scientific endeavors, feel free to contact any member of the GMAG executive committee.

—Axel Hoffmann, GMAG Chair

Request for Magnetism Outreach Proposals

For several years GMAG has made funds available to its members to support outreach activities. Funds up to $2500 per project are available to cover supplies and expenses associated with activities, which aim to educate non-scientists about magnetism and its applications. Preference will be given to innovative activities that will be documented so that they can be reproduced elsewhere. The outcome of the activities are then disseminated to the GMAG membership through the GMAG Newsletter (for an example see the August 2008 GMAG Newsletter) and to the broader magnetism community through the GMAG website. Interested GMAG members should prepare a 1-2 page summary of the proposed activity (including expected duration and outcome) along with a 1 page CV and a list of anticipated expenses. These should be mailed as a single file in PDF format to the GMAG Chair, Axel Hoffmann (hoffmann@anl.gov). The GMAG Executive Board will review proposals on an ongoing basis.

Nominations for APS Fellowships and Prizes/Awards

It is never too early to think about nominating some of your well-deserving colleagues for fellowships and suitable prizes. GMAG nominates 3–5 people (0.5% of our membership) for APS Fellowship each year. The next deadline is June 1, 2010 and nominations should me made on-line at http://fellowship.aps.org/. APS prize descriptions and nomination deadlines are at http://www.aps.org/praw/.

GMAG Student Dissertation Awards

Each year GMAG will select dissertation awards that recognize students who have conducted outstanding research leading to their dissertation. These awards will be presented at the next APS March Meeting in Portland, OR during the GMAG business meeting and they consist of an invited talk in an appropriate session at the March Meeting, a $500 prize for the student and an award of up to $250 toward his or her travel expenses to the meeting.

The most recent winners selected from among many excellent nominations are Rajit Pal Chaudhury of the University of Houston for his dissertation on "Effects of high pressure, magnetic fields and substitutions on multiferroic system" and Jun Zhao of the University of Tennessee for his dissertation on "Magnetic structures and spin excitations of electron-doped cuprates and Fe Pnictides superconductors with the technique of neutron scattering."

Next year's new nominations will be due on September 1, 2010.

Nominations for GMAG Officers and members of the Executive Committee

The nomination committee, which is chaired by Mike Fitzsimmons, recently selected a slate of candidates for new positions within the GMAG Executive Committee. Early next year GMAG members will be able to elect a new Vice-Chair (who will become subsequently the Chair-Elect, Chair, and Past Chair) and two new at-large members for the Executive Committee. The two candidates for the new Vice-Chair will be Matthias Bode (Argonne National Laboratory) and Paul Crowell (University of Minnesota). For member-at-large the four new candidates will be Olav Hellwig (Hitachi GST), Ale Lukaszew (College of William and Mary), Patti Sparks (Harvey Mudd College), Shufeng Zhang (University of Arizona), and Igor Žutić (State University of New York at Buffalo).

According to the GMAG bylaws, the GMAG membership may recommend additional candidates to be included in the election. To be included, a candidate must be nominated by 5% of the GMAG membership (thus requiring at least 42 supporters) as of December 31st, 2009. Any such additional candidate nominations should be sent to Maria Varela (mvarela@ornl.gov), Secretary/Treasurer, before December 31, 2009.

March Meeting 2010, Portland, OR

The APS March Meting will be held next year in Portland, OR during March 15–19, 2010. As in the past we expect that sorting category 6 (magnetism) will be one of the biggest topics of the meeting. Any contributed talks must be submitted directly to APS at http://abs.aps.org/ until November 20, 2009. Below are the magnetism sorting categories and a description of the GMAG sponsored focus topics.

Sorting Categories

06. Magnetism (Experiment, Theory, Applications)
06.1 Cooperative Phenomena (incl. spin structures, spin waves, phase transitions)
06.2 Magnetic Domains and Domain Walls
06.3 Magnetic Field Phenomena: Dynamic & Static
06.4 Correlated Electrons (incl. heavy fermions & oxides)
06.5 Spin Dependent Transport
06.6 Magnetization and Spin Dynamics
06.7 Magnetic Anisotropy: Hard & Soft Materials
06.8 Artificially Structured or Self-Assembled Magnetic Materials (incl. multilayers, patterned films, and nanoparticles)
06.9 Low Dimensional Magnetism (incl. molecules and surfaces)
06.10 Disordered Magnetic Materials
06.11 Magnetic Devices & Applications
06.12 Magnetic Materials & Phenomena for Information Technologies
06.13 Magnetic Characterization and Imaging

Special Focus Topics

06.14.1 Magnetic Nanostructures: Materials and Phenomena
06.14.2 Bulk Properties of Complex Oxides
06.14.3 Complex Oxide Thin Films
06.14.4 Spin Transport & Magnetization Dynamics in Metal Based Systems
06.14.5 Spin Dependent Phenomena in Semiconductors
06.14.6 Frustrated and Low Dimensional Magnetism
06.14.7 Spin Dependent Physics in Organic-based Materials
06.14.8 Novel Magnetic Devices

Focus Topics – Descriptions

6.14.1 Magnetic Nanostructures: Materials and Phenomena (DMP/GMAG)

This topic focuses on magnetic nanostructures, including thin films, multilayers, nanoparticles, nanowires, nanorings, nanocomposites, core-shell structures, hybrid structures, molecular magnets, magnetic point contacts and self-assembled as well as patterned magnetic arrays. The sessions will cover both experimental and theoretical advances in investigating these materials. Phenomena include the following: hysteresis, proximity and structural disorder effects, AC and DC spin torque, current- and field-induced domain wall motion, microwave resonance and microwave assisted reversal, magnetic quantum confinement, interlayer magnetic coupling, exchange spring, exchange bias, magnetic anisotropy, inter-particle interactions, relaxation dynamics, thermal and quantum fluctuations, and other unusual phenomena unique to the nanoscale. Of special interest is the fabrication or characterization of nanostructures with atomic-scale precision.

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6.14.2 Bulk Properties of Complex Oxides (DMP/GMAG)

Transition metal oxides exhibit a wide range of novel phenomena, which originate from the complexity induced by competing interactions and the presence of multiple ground states. Associated with this complexity is a tendency for short range order such as the formation of stripes, ladders, checkerboards, or phase separation, and an enhanced response to external fields that gives rise to giant and colossal effects with potential for applications. This Focus Topic explores the nature of the various ground states observed in bulk specimens of complex oxides and their competing interactions, the ways in which the spin, lattice, charge and orbital degrees of freedom respond on a variety of length scales, and how they interact and compete with each other to produce novel phenomena. It provides a forum to discuss recent developments and results covering basic aspects (new materials synthesis, experiment, theory and simulation) of bulk systems, including 3-, 4-, and 5-d transition metal complex oxides.

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6.14.3 Complex Oxide Thin Films (DMP/GMAG)

A rich variety of intriguing behaviors has been observed in complex oxides, many of which remain far from understood. High Tc superconductivity, ferroelectricity, metal-insulator transitions, or colossal magnetoresistance are just a few of them. When grown in the form of thin films, heterostructures, or nanostructured systems, they often exhibit additional effects resulting from epitaxial strain, reduced dimensionality, charge transfer, proximity effects or phase competition across interfaces. New effects can emergence at such interfaces including two-dimensional electron gases or ferromagnetism. This Focus Topic is dedicated to fundamental advances in the growth, characterization, and experimental as well as theoretical understanding of the physical properties of complex oxides in thin-film, superlattice, and nanostructured forms, paying special attention to the role of interfaces. It also will focus on understanding the impact of defects on their properties, growth conditions on film microstructure, and the mechanisms by which the macroscopic properties are affected, which may include strain, electronic phase separation, charge transfer or localization, etc. These mechanisms often play an important role in the interaction between spin, charge, lattice, and orbital degrees of freedom in thin films of these complex oxides.

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6.14.4 Spin Transport & Magnetization Dynamics in Metal Based Systems (GMAG/DMP/FIAP)

Spin-related effects in metals and in (ferromagnetic) heterostructures are generally robust and readily observed at room temperature. Fundamental discoveries such as the Giant and

Tunnel Magnetoresistance and the current-induced spin-transfer torque have moved from discovery to applications in remarkably short times, and this whole field of research is rapidly expanding. This Focus Topic covers the new developments in this field, including experimental and theoretical aspects of spin transport and magnetization dynamics in metal-based systems, such as ultrathin films, lateral nanostructures, perpendicular nanopillars, and tunnel junctions.

In particular, contributions describing new results in the following areas are solicited:

- The interplay between spin currents and magnetization dynamics in magnetic nanostructures; spin-transfer, spin pumping and related phenomena, including current-induced magnetization dynamics in heterostructures and domain wall motion in magnetic wires.
- Effects of the spin-orbit interaction on steady-state and dynamical properties of nanostructures; intrinsic and extrinsic spin orbit interactions causing the (inverse) spin and anomalous Hall effects; microscopic mechanisms of magnetization (Gilbert) damping; out-of-plane spin-transfer torques in magnetization textures.
- Ultrafast magnetization response to (and reversal by) intense laser pulses.
- Thermoelectric spin phenomena such as giant-magneto thermopower and Peltier effects, spin-Seebeck effect, spin and anomalous Nernst and Ettingshausen effects (spin caloritronics).
- Magnetization dynamics in (composite) nanostructures including spin wave excitation, propagation, and detection (magnonics), as well as vortices.
- Coupling between magnetic and elastic degrees of freedom, such as the spin-current induced Einstein-de Haas effect in nanoscale mechanical systems.

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6.14.5 Spin Dependent Phenomena in Semiconductors (GMAG/DMP/FIAP)

The field of spin-dependent phenomena in semiconductors is developing rapidly, with significant advances and challenges in a widening range of material systems (e.g., pnictides, oxides, silicon, diamond, carbon nanotubes, graphene), in semiconductor nanostructures (e.g., self-assembled and lithographically-defined quantum dots), and in hybrid ferromagnetic/semi conductor device structures. This series of Focus Sessions solicits contributions aimed at understanding spin-dependent processes in magnetic and non-magnetic structures incorporating semiconducting materials. Topics include: (i) growth, characterization, electrical, optical and magnetic properties of (ferro-)magnetic semiconductors, nanocomposite and hybrid ferromagnet-semiconductor structures including quantum dots, nanocrystals, and nano wires; (ii) high temperature ferromagnetism in semiconductors and semiconductor oxides (iii) transport and dynamical effects in semiconductors with or without spin-orbit interactions; (iv) electrical and optical spin injection, spin Hall effects, spin interference, spin filtering, spin lifetime effects, spin dependent scattering, and spin torque; (v) manipulation, detection, and entanglement of electrical and nuclear spins in quantum systems such as dots, impurities and point defects; and (vi) spin-dependent devices and device proposals involving ferromagnets and semiconductors.

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6.14.6 Frustrated & Low-Dimensional Magnetism (GMAG/DMP)

There is a robust framework for describing the low temperature structures, phase transitions, and excitations of conventional three dimensional magnetic materials. However, when fluctuations are enhanced by low dimensionality or competing interactions, qualitatively new behavior can emerge. This is well established in one and two dimensions where controlled theory and experiment have uncovered phases lacking long-range magnetic order but exhibiting novel statistical and quantum phenomena. Such phenomena include valence bond solids and various forms of spin liquid and spin ice phases. This Focus Topic solicits abstracts for presentations that explore both theoretical and experimental aspects of the field. Topics of interest include: one dimensional quantum magnetism, geometrical frustration and associated effects of quantum spin liquid and spin ice, magnetism in frustrated or low dimensional artificial structures, order by disorder, the role of magnetoelastic coupling, quantum critical two dimensional spin systems and magnon Bose condensation. Also of interest are the effects of strongly fluctuating spins on properties beyond magnetism including transport, thermal transport and ferroelectricity.

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6.14.7 Spin Dependent Physics in Organic-based Materials (GMAG/DMP)

This focus topic is on spin transport and exchange in organic- and molecular solids including all-carbon systems, transition-metal with and without organic radical systems, as well as π-conjugated polymeric systems. Research at the intersection of several forefront areas in condensed matter and material physics are of interest: spin injection at the inorganic to organic interface, the degree of spin polarization attainable by organic-based solids, understanding and demonstrating the low Z attributes to spin transport including hyperfine interaction between the electronic spin and nuclear magnetic moments, and novel forms of magnetic exchange that may be adapted to inorganic dilute magnetic semiconductors. Phenomena and materials of interest include hybrid ferromagnetic/organic structures, spin transport in graphene, Kondo effect, spin qbits in diamond, quantum tunneling, triplet states and coherence in molecular nanomagnetics, organic magnetoresistance and magnetic field effects and all related topics.

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6.14.8 Novel Magnetic Devices (DMP/GMAG)

This topic focuses on novel magnetic devices of all kinds, with a special interest in devices that make use of the spin torque effect. Of particular interest are spin torque switching of magnetic nanobits — which could be used in an advanced magnetoresistive random access memory (MRAM) — and spin torque nano-oscillators, both theoretically and experimentally. Other devices of interest include magnetic tunnel junctions, or spin valves with special properties that can enable advanced magnetic technologies such as thermal assisted MRAM, toggle MRAM, high density magnetic recording, or magnetic sensors for field detection and biological sensing. Less mature devices are also of interest, including semiconductor devices that make use of electron spin or that use magnetic semiconductors, as well as negative resistance magnetic devices to achieve power gain. Also of interest are the results of novel metrology techniques that have been applied to examine the underlying physics of the above devices. Examples of interest include high frequency/high speed electrical or optical measurements to examine magnetodynamics, and imaging techniques such as XMCD.

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GMAG Sponsored Symposia

From the many excellent submissions this year, the GMAG executive committee selected the following five symposia for the APS March Meeting in Portland, OR next year. The exact list of invitees will be published in the February GMAG Newsletter.

- Electric Voltages generated by Magnetization Dynamics
- Microscopic Physics of Magnetization Damping
- Magnonics: Spin Waves Processes in Magnetic Materials
- Room Temperature Semiconductor Spintronic
- Spin Transport in Carbon-based Materials

Magnetism-Related Tutorials

The tutorials at the APS March Meeting are not directly organized by GMAG (although many GMAG members are involved in their organization). Nevertheless, there are many magnetism-related tutorials that should be of interest to the GMAG membership. Specifically note:

Tutorial #1: Complex Oxide Thin Films and Superlattices

ORGANIZER: MARIA VARELA, OAK RIDGE NATIONAL LABORATORY

A rich variety of exciting, intriguing behaviors has been observed in complex oxides, many of which remain still far from understood. High Tc superconductivity, ferroelectricity or colossal magnetoresistance are just a few of them. When grown in the form of thin films, heterostructures or superlattices they may exhibit additional effects such as those of epitaxial strain, reduced dimensionality, 2D electron gases, proximity effects or interplay across interfaces.

Since all this phenomenology can deeply alter the macroscopic physical properties, their understanding acquires an special relevance.This tutorial will explore the physical properties of thin complex oxide films, heterostructures and superlattices, paying special attention to the role of interfaces. It also will focus on the mechanisms by which the macroscopic properties are affected, which may include strain, electronic phase separation, charge transfer or localization, structural defects, etc. All of them have an important role in the interaction between spin, charge and orbital degrees of freedom in films.

The lectures in this tutorial will provide a forum to discuss recent developments in these issues, ranging from growth, characterization, physical properties of complex oxide films and heterostructures based on oxides such as manganites, cuprates, titanates, multiferroics, etc.

Tutorial #2: Topological Insulators

ORGANIZER: SHOUCHENG ZHANG, STANFORD UNIVERSITY

Search for new states of matter has become the central focus of condensed matter physics. Most states known to date are characterized by the symmetries they break, for example, a crystal breaks the translational symmetry, a magnet breaks the rotational symmetry and a superconductor breaks gauge symmetry.

More recently, it has been recognized that topological insulators are new states of quantum matter distinct from conventional insulators. A topological insulator has a full energy gap in the bulk, and contains gapless surface states which can not be destroyed by any non-magnetic impurities. Three topological insulator materials have been theoretically predicted and experimentally discovered so far, the HgTe quantum well, the BiSb alloy and the Bi2Te3/BiSe3 compounds.

Topological insulators have unusual physical properties. Because of the time reversal symmetry, the surface states can not be scattered back by non-magnetic impurities and can conduct without dissipation. Therefore, these materials are promising candidates for low power electronic devices for logical processing. The spin and the charge degrees of freedom are intimately coupled in the surface states, such coupling can be used for electrical manipulation of the spin degrees of freedom — a central goal of spintronics. BiSb alloy and Bi2Te3/BiSe3 compounds are also excellent thermal electric materials.

Deeper understanding of these materials could lead to better design of thermal electric devices, for example by optimizing the surface to volume properties. When a thin magnetic layer is applied on the surface, a full insulating gap is opened on the surface. In this case, an electric charge close to the surface is predicted to induce an image magnetic monopole. Such an effect could be used to electrically read and write magnetic storage bits. When a thin superconducting layer is applied on top of the surface, elementary excitations are predicted to be Majorana fermions which can be used for topological quantum computing. History has taught us repeatedly that fundamental breakthroughs in science often lead to many useful applications.

Beyond potential applications, topological insulators extended into deepest realm of fundamental science. One deeply mysterious fact of quantum mechanics is the sign change of the electron wave function when its spin is rotated by 2pi. It is exactly this mysterious fact that protects the surface states of topological insulators. Therefore, investigation of topological insulators can help us understanding the mysteries of the quantum world, and use them to our advantage. Many exotic particles, such as the fractionally charge, spinon, holon, magnetic monopole, axion and Majorana fermion are predicted to appear as elementary excitations of topological insulators. Table top observation of these exotic particles reveals the deeper mysteries of the universe.

Tutorial #5: Emergent Phenomena in Bulk Complex Oxides

ORGANIZER: JOHN MITCHELL, ARGONNE NATIONAL LAB, ARGONNE, IL

Few materials classes enjoy the remarkable diversity of physical properties of the solid oxides. Transition metal oxides in particular have proven to be a fertile area for modern condensed matter physics research, supporting striking phenomena such as high temperature superconductivity, colossal magnetoresistance, and multiferroicity. The multifunctional nature of these materials opens up many possibilities for basic research as well as exciting potential applications, e.g. in oxide electronics. This situation has sparked great interest in the field of complex oxides, with many areas advancing at an impressive pace.

In this tutorial we aim to provide an introduction to some of the most rapidly evolving areas of current research in this area, with an emphasis on correlated electron oxides such as manganites, cobaltitites, etc. We will begin with an introduction to the complex oxide materials, focusing in particular on the all-important structural aspects and how function is intimately linked to the atomic arrangement. Magnetic and electronic transport properties will then be reviewed, covering aspects such as mechanisms of conduction and magnetic ordering, charge and orbital ordering, and phase separation.

Additionally, we will discuss issues of relevance to energy such as thermoelectric behavior. Recent advances in the theory of transition metal oxides will be the topic of the third talk, with links to heterostructures and thin film geometries. Finally, we will provide a view of correlated electron physics in transition metal oxides with an emphasis on how spectroscopies reveal the underlying electronic structure and descriptions beyond the one electron model.

Tutorial #8: Spintronics

ORGANIZER: DR. STUART PARKIN, IBM ALMADEN RESEARCH CENTER, SAN JOSE, CALIFORNIA

"Spintronics" comprises the field of research which has emerged over the past decade that refers to nano-materials and nano-devices which have novel properties that arise from the manipulation and control of spin-polarized electrons and especially spin-polarized currents. This tutorial will discuss recent developments in this field, notably: (1) thermoelectric effects resulting from spin currents induced by temperature gradients, (2) the manipulation of magnetic moments by the transfer of spin angular momentum from photons and from spin-polarized currents and (3) the recent discovery of magnetoelectric effects in topological insulators, a new state of matter. Although many of these effects have potential important technological applications in magnetic memory, storage and logic, this course will emphasize the fundamental science underlying these spin-based phenomena.

Ask your colleagues to Join GMAG

For $7 additional dues APS members can become GMAG members with these benefits (students are free for one year):

- Quarterly GMAG newsletter.
- Eligibility for GMAG graduate student awards and sponsorship.
- Potential to increase the number of APS Fellows sponsored by GMAG.
- Potential to increase the number of invited talks on Magnetism at the March Meeting.
- Opportunity to help shape the voice and future of the Magnetism community (your community) in the US.

See the GMAG website: http://www.aps.org/units/gmag. TO JOIN: Go to the APS page for "Membership Units" (http://www.aps.org/membership/units/join-unit.cfm) and follow instructions for adding a unit to your membership. Or call the APS at 301-209-3280 and tell a Membership Rep that you want to join topical group GMAG.

Important Deadlines

Thanks for being involved with GMAG and please get actively involved in the many activities described above.

November 20, 2009

APS MARCH MEETING, CONTRIBUTED ABSTRACT SUBMISSION

abs.aps.org

December 31, 2009

ADDITIONAL NOMINATIONS FOR GMAG ELECTIONS

Maria Varela, mvarela@ornl.gov

June 1, 2010

FELLOWSHIP NOMINATION

fellowship.aps.org

Ongoing

OUTREACH PROPOSALS

Axel Hoffmann, hoffmann@anl.gov

Upcoming Conferences

COMPUMAG 2009 | NOVEMBER 22–26, 2009 | FLORIANÓPOLIS, BRAZIL
WWW.COMPUMAG2009.COM/

MATERIALS RESEARCH SOCIETY (MRS) 2009 FALL MEETING | NOVEMBER 30–DECEMBER 4, 2009 | BOSTON, MA
WWW.MRS.ORG

SPIN MANIPULATION IN COLD ATOMS AND CONDENSED MATTER | JANUARY 6–9, 2010 | UTRECHT, THE NETHERLANDS
WWW.ICAM-I2CAM.ORG/?P=451

JOINT MMM/INTERMAG CONFERENCE | JANUARY 18–22, 2010 | WASHINGTON, DC
WWW.MAGNETISM.ORG/

APS MARCH MEETING 2010 | MARCH 15–19, 2010 | PORTLAND, OR
WWW.APS.ORG/MEETINGS/MARCH/INDEX.CFM

INTERNATIONAL CONFERENCE ON SUPERCONDUCTIVITY AND MAGNETISM 2010 | APRIL 25–30, 2010 | ANTALAYA, TURKEY
WWW.ICSM2010.ORG/

CORRELATED ELECTRON SYSTEMS | JUNE 13–18, 2010 | MOUNT HOLYOKE COLLEGE, SOUTH HADLEY, MA
WWW.GRC.ORG/PROGRAMS.ASPX?YEAR=2010&PROGRAM=CORRELEC

INTERNATIONAL CONFERENCE ON STRONGLY CORRELATED ELECTRON SYSTEMS | JUNE 27–JULY 2, 2010 | SANTA FE, NM
SCES.NEWMEXICOCONSORTIUM.ORG/

INTERNATIONAL SYMPOSIUM ON ADVANCED MAGNETIC MATERIALS AND APPLICATIONS | JULY 12–16, 2010 | SENDAI, JAPAN
WWW.ECEI.TOHOKU.AC.JP/ISAMMA2010/

INTERNATIONAL CONFERENCE ON HIGHLY FRUSTRATED MAGNETISM 2010 | AUGUST 1–6, 2010 | BALTIMORE, MD
PHYSICS-ASTRONOMY.JHU.EDU/HFM2010

MAGNETIC NANOSTRUCTURES | AUGUST 8–13, 2010 | LEWISTON, ME
WWW.GRC.ORG/PROGRAMS.ASPX?YEAR=2010&PROGRAM=MAGNANO

XXXIVTH INTERNATIONALO CONFERENCE ON MAGNETIC RESONANCE IN BIOLOGICAL SYSTEMS | AUGUST 22–27, 2010 | CAIRNS, AUSTRALIA
WWW.ICMRBS2010.ORG/

2010 IEEE 7TH INTERNATIONAL SYMPOSIUM ON METALLIC MULTILAYERS | SEPTEMBER 19–24, 2010 | BERKELEY, CA
MML2010.LBL.GOV/

A more detailed list of magnetism related conferences can be found on the GMAG website:
WWW.APS.ORG/UNITS/GMAG/MEETINGS/INDEX.CFM

Topical Group on Magnetism and its Applications
American Physical Society
One Physics Ellipse
College Park, MD 20740
http://units.aps.org/units/gmag/