Topical Group on Magnetism and its Applications

A Focused Group within The American Physical Society

N^0 15, February 2004

GMAG NEWSLETTER

A Note from the Chair

Dear GMAG members,

As current Chair of the Topical Group on Magnetism and its Applications (GMAG), I want to once again welcome you to GMAG and to provide you with an update on GMAG activities, including our student dissertation award winners, information on the upcoming deadline for nominating people for APS fellowships, and an insert showing the Magnetism sessions at the upcoming March meeting which we hope you will find useful in planning.

There are many ways to become involved with GMAG activities; please come to the annual business meeting and reception on Tues March 23 in Montreal (Room 513CD, Palais des Congres, 17:30) to learn more. At this meeting, the new GMAG-sponsored APS fellows will be recognized, GMAG activities and expenditures for the past year will be presented, and plans for next year will be discussed. GMAG wants and needs your participation to be a successful topical group representing the magnetism community both within APS and to the outside community.

We remind you that our annual elections are underway, and if you have not yet voted, please do so (information below). Also, this is the time of year to start thinking about nominations of people for the APS prizes and awards, as well as to begin thinking of topics for the next March meeting (2005). 2005 has been designated the World Year of Physics, commemorating Einstein's "year of miracles" in 1905. In the US, the theme will be "Einstein in the 21st Century," with the idea of not only celebrating Einstein's achievements but also looking to the future. Please be thinking about what role GMAG should play in this, and how you might be interested in participating.

—Frances Hellman

NOMINATIONS FOR APS FELLOWSHIPS AND PRIZES/AWARDS: GMAG is allowed to nominate 2-3 people for APS Fellowship each year from among our members (0.5% of our membership). This is an important task, and one for which we rely on the magnetism community for input. The nomination deadline for the upcoming year is **April 2, 2004**. Please consider nominating a worthy person from the magnetism community. A list of fellows from 1995-date can be found at the web site listed below, or you can look up an individual name in the APS directory to see if they are already a fellow or not; you may be surprised by some names that are not yet fellows. All nominations should be sent to:
Executive Officer, The American Physical Society
One Physics Ellipse
College Park, MD 20740
ATTN: Fellowship Program
Briefly, a nomination package includes a nomination form signed by two sponsors (both of whom must be APS members), and supporting letters. Complete information and the nomination form itself can be found at http://www.aps.org/fellowship/.

For 2003, GMAG sponsored the following APS fellows:
Gerald Francis Dionne, Massachusetts Institute of Technology
Roy William Chantrell, Seagate Research, Pennsylvania
Sungho Jin, University of California, San Diego

OUTSTANDING DISSERTATION IN MAGNETISM AWARDS: GMAG is pleased to announce the following three winners of our first GMAG dissertation awards:

Gonzalo Alvarez, a student at Florida State University working with Elbio Dagotto, "Computational Studies of Diluted Magnetic Semiconductors and Other Materials", March meeting invited talk A26 004, Monday 8:36

Xin Jiang, a student at Stanford University working with Stuart Parkin, "Tunnel spin injectors for semiconductor spintronics", S23 007, March meeting invited talk Wednesday 15:42

Owen Vajk, a student at Stanford University working with Martin Greven, "Quantum impurities in a two-dimensional antiferromagnet", March meeting invited talk P25 001, Wednesday 11:15

We received a relatively large number of outstanding applications for this award, and choosing among them was not an easy task. The criteria used by the committee included an assessment of originality and likely impact of work, publications by the student, recommendation letter from advisor, and speaking ability as assessed by advisor and as demonstrated by the written abstract by the student. The prize consists of an invited talk in one of the GMAG sessions at the March APS Meeting (session number listed above), a $500 prize to the student, and up to $250 towards travel or other costs of attending the Meeting. The prize will be awarded at the invited talk (session listed above); please be sure to attend these sessions.

STUDENT MEMBERSHIP SUPPORT: In an effort to encourage more students to participate in GMAG events, GMAG has implemented (on a trial basis) free student membership in GMAG. Students who are members of APS can join GMAG without paying additional dues (GMAG will pay student GMAG dues to the APS). Interested students should email a note to Jonathan Sun (jonsun@watson.ibm.com) with their name, APS membership#, mailing address, and email address (note that students can join the APS free for one trial year and $26 for each succeeding year).

GMAG ELECTIONS

By the time you receive this, the 2004 GMAG Elections will be well underway. We would like to thank both the members of the GMAG nominating committee for their efforts in putting together an outstanding slate of candidates and all the candidates (listed below) for agreeing to participate in this important process. This year, through the diligent efforts of APS and GMAG Exec Comm member Laura Lewis we have implemented a new APS Web balloting procedure. All members with an active email address should already have received an email directing

them to the Web address of the online voting system (which includes a user ID). One week later, members for whom this email bounced, or for whom no email address exists, should have been mailed a paper ballot. Paper ballots must be postmarked by 29 February 2004 in order to be counted. The APS will provide the GMAG Election Administrator (i.e., the Secretary/Treasurer, R. Bruce van Dover) with a list of members who have voted online (but not their choices, of course!) to ensure that there is no double-voting. Please contact Bruce at rbv2@cornell.edu if you did not receive a ballot.

Candidates for:
Vice-Chair
Thomas C. Schulthess
James J. Rhyne
Secretary-Treasurer
Caroline A. Ross
John E. Snyder
Member-at-Large
Jeffrey R. Childress
Seung-Hun Lee
Andrew Kent
John Mitchell
Diandra Leslie-Pelecky
Results will be announced at the Business Meeting in Montreal (Tues March 23, 17:30, Room 513CD).

NOMINATIONS FOR APS PRIZES/AWARDS: The nomination deadline for most of the APS prizes and awards will be approximately July 1, 2004 (exact date not yet listed). Please begin to consider worthy people from the magnetism community who you could nominate for the various awards, listed on the APS web site (http://www.aps.org/praw/). At this web site. you can find complete information on how to nominate someone, plus information on the prizes and on previous years' awardees.

APS UNITS CONVOCATION AND CONGRESSIONAL VISITS DAY:
Two GMAG officers (Jack Bass and Peter Schiffer) attended the APS units convocation and Washington Congressional visits day (January 22 and 23). The Congressional visits day seemed to be highly successful, with 28 APS officers of various units visiting 72 different Congressional offices to encourage support for increased funding for physical science research as the basis for future technological advances crucial to homeland security, national defense, and economic growth. All GMAG members are encouraged to participate in such political activity, since it seems to make a real impact on how individual members vote (as few as 5-10 letters to a representative or senator about an issue on which they don't normally receive mailings can be enough to stimulate action). Details on how to write to Congress are at http://www.aps.org/public_affairs/. Since the APS Office of Public Affairs provides pre-written letters and automatically determines the address from your zip code, the entire process can take less than five minutes!

The APS units convocation is the annual meeting of representatives from the various APS units (divisions, forums, topical groups, and sections). Among the many topics discussed, a major theme for the upcoming year will be preparation for the "World Year of Physics" in 2005 (http://www.physics2005.org/) declared by organizations such as IUPAP and UNESCO. The year commemorates the 100th anniversary of Einstein's seminal 1905 papers; the intent is to reach out to the public to generate enthusiasm about physics and basic science research. The meeting included 3 minute presentations by subunits, focusing partly on outreach. As background, we explained: (a) what GMAG is; (b) that it is now the 2nd largest topical group and the most rapidly growing (up 30% in membership since 2000); and (c) that its main task historically has been to organize focus sessions and symposia for the March meeting, where this year we sorted about 12% of the total abstracts. For outreach we have traditionally sponsored lunch with the experts tables (2) at the march meeting. We described our two new trial initiatives: the dissertation awards and free student membership in GMAG described above. For the future we

explained that we plan to try to encourage and strengthen interactions and collaborations between Universities and Industry in magnetism, and to examine whether we can provide useful supplementary information on job opportunities in magnetism beyond what is already provided by APS.

MARCH MEETING:

The 2004 APS March meeting will be held March 22-26 in Montreal. Information on the meeting, registration and hotels can be found at http://www.aps.org/meet/MAR04/. Please also note that the APS has gathered information concerning visas at this website as well, since the meeting is being held outside the United States.

Sorting of contributed talks was done Friday and Saturday, December 12-13, 2003. More than 6,000 abstracts were received, and more than 730 were in the magnetism category (6.n), up significantly from the 606 abstracts last year. These abstracts were sorted by Michelle Johannes, Berry Jonker, George Kioseoglou, Connie Li , Despina Louca, Jon Mallett, Art Ramirez , Dan Reich, Peter Schiffer (team leader), Mark Stiles, Olaf van t' Erve, Gang Xiao, and Igor Zutic. Everyone worked hard and did a great job.

Many of the magnetism sessions were part of focus topics. Many thanks to the organizers of these Focus Sessions for putting together an exciting program and getting the word out to all of you. The topics include:

6.11.1 Theory and Simulation of Magnetism and Spin Dependent Properties (DCOMP/DMP/GMAG)
6.11.2 Magnetic Nanostructures and Heterostructures (DMP/GMAG)
6.11.3 Magnetoresistance and Phase Complexity in Oxides (DMP/GMAG)
6.11.4 Spin Transport and Spin Dynamics in Metal-Based Systems (GMAG/DMP)
6.11.5 Spin-Dependent Phenomena in Semiconductors (DMP/GMAG)

There were in addition many sessions organized from the abstracts contributed to general sub-categories in category 6, as well as three invited symposia organized by GMAG and a number of magnetism-related symposia organized by the DCMP (DCMP is responsible for the large majority of symposia at the March meeting, with other divisions and topical groups directly allocated a few additional symposia). To help you in planning for the meeting, we attach a table showing magnetism-related sessions. **(See attached table!)**

GMAG is also sponsoring two tables at the APS-organized "Students Lunch with the Experts", which takes place on Wednesday, March 24 from 1:00pm - 2:30pm; the format is a round table accommodating 8 students and one volunteer expert (box lunch provided). Students sign up for the topic/table they are interested in. Jack Bass and Laura Lewis graciously agreed to be our experts for this year.

GMAG (thanks to Mark Stiles, Bob Camley, and Mark Johnson) also organized two Sunday tutorials which you should consider attending. The first is on the dynamics of magnetotransport (speakers Mark Stiles, Robert McMichael, Jonathon Sun, and Robert Buhrman, the second on spintronics (speakers Hiro Munekata,, David DiVincenzo, Nick Rizzo, and Daniel Reich). For more information including descriptions of these and how to register, please see http://www.aps.org/meet/MAR04/special.html#tutorials. Registration for the tutorials is $100 ($35 for students), and is done as part of the march meeting registration process.

We also want to alert you to the APS March Meeting Job Fair. This event, organized by APS, seeks to connect employers and job seekers from all the areas represented at the March meeting, including magnetism. Whether you are searching for a job or recruiting, check out the Job Fair. For more information, contact Greg Carfine at 301-209-3185 or e-mail gcarfine@aip.org.

BRIEF TUTORIAL: SINGLE MOLECULE MAGNETS: RECENT PROGRESS AND PERSPECTIVES

ANDREW D. KENT, **Department of Physics, New York University**

Single molecule magnets (SMMs) are magnetic nanostructures that consist of a core of strongly exchange-coupled transition metal ions with a large collective magnetic moment per molecule, thus far up to ~30 Bohr magnetons [1]. They have a strong uniaxial magnetic anisotropy that leads to an energy barrier to magnetization reversal. Importantly, they enable a bottom-up route to the assembly of magnetic structure from discrete chemical units. Their key advantage compared to conventional magnetic nanostructures, such as those produced lithographically, is their molecular nature; when assembled in crystals each molecule has the same atomic structure, spin, orientation and magnetic anisotropy. While magnetic hysteresis only occurs at low temperatures (<3 K), there are ideas to use SMMs as sub-millimeter wave sources [2] and for quantum information storage [3]. The main interest in these materials is fundamental: they enable the exploration of the ultimate limit to magnetic miniaturization. Indeed, provided that interactions between molecules are sufficiently weak, measurements of SMM single crystals provide information on the properties of individual magnetic molecules.

SMMs are leading to new insights into magnetism at the nanoscale and quantum effects, such as magnetic quantum tunneling (MQT). One of the key observations in this field was resonant MQT in Mn_{12}-acetate, an S=10 SMM with a 60 K anisotropy barrier [4]. At temperatures lower than a blocking temperature (~3 K) the magnetization relaxation rate increases dramatically at characteristic magnetic fields, as illustrated in Fig. 1. This arises from quantum transitions between magnetic states with opposite spin-projections on the easy axis when such states are degenerate. At sufficiently low temperature the relaxation rate and hysteresis curves become temperature independent, signifying a pure quantum relaxation process [5]. While this has been known for some time, the origin of MQT has been an open question. First, experiments showed that there was a distribution of tunneling rates in crystals that were thought to consist of identical molecules. Second, Mn_{12}-acetate has a high symmetry (tetragonal); however the magnetic properties did not reflect this symmetry, which leads, for instance, to only certain allowed tunneling transitions (much fewer than those seen in Fig. 1). Recently, x-ray studies showed that the local molecular environment was modulated by disorder in solvents around the magnetic core, with a small number of possible solvent configurations [6].

This appears to be the case. Magnetic studies at New York University in which the tunneling probability was measured as a function of the angle of an applied transverse magnetic field indicated a two fold-pattern of maxima for a subset of molecules in a crystal, illustrated in fig. 2. The maxima occur when the applied field is parallel to medium axes of the magnetic anisotropy. A four-fold pattern is expected for molecules with tetragonal symmetry. Studies of a complementary set of molecules produce the same pattern but phase shifted by 90 degrees. There is thus an overall 4-fold pattern of maxima but only when averaging over all molecules in a crystal [7]. Solvent disorder also leads to tilts of the magnetic easy axis of the molecules that is central to understanding the tunneling. Since experiments are performed in the presence of large longitudinal fields, tilts lead to fields transverse to the easy anisotropy axis, breaking the axial symmetry [8]. High field EPR experiments have come to these same conclusions: an intrinsic tetragonal anisotropy is modulated by solvent disorder [9] and there are tilts of the easy axes [10]. These results illustrate how subtle changes in molecule environment can affect magnetic anisotropy and MQT.

These complexities have been a boon for both experiment and theory. The presence of a disorder induced anisotropy leads to a non-monotonic dependence of the tunneling probability on transverse field [7], reminiscent of the oscillations in the tunneling probability first seen in SMM Fe_8 (another major advance in this field in which there is insufficient space to discuss here [11].) Further, density functional theory has been employed to compute the intrinsic and disorder induced transverse magnetic anisotropes in Mn_{12}-acetate [12]. The results capture many of the features observed in experiments, including the magnitude of the transverse anisotropy and easy axis tilts.

While there has been substantial progress in understanding MQT in SMMs, many fundamental questions remain and new research directions are opening up. Synthesis techniques have advanced considerably and many key characteristics of the molecules can be varied. For example, integer spin molecules can be reduced to half-

integer, molecule site symmetries modified and SMMs crystallized with different solvents. Further, magnetic interactions between molecules can be engineered to produce exchange coupled SMM dimmers [13-15] as well as structures with extended exchange networks [16]. An important goal remains the exploration and manipulation of coherent quantum phenomena in nanomagnets. (MQT studied thus far involves incoherent tunneling processes.) Another very interesting direction is the study of individual molecules. A number of groups are working to realize SMM transistors, that is, devices to study electronic transport through one SMM. Scanning tunneling microscopy should also be able to probe single molecules. Given the growing interest in this area, the years ahead should be marked by significant progress on these fronts. It will certainly be fascinating to compare the properties of individual molecules to ensembles of molecules and to ultimately study the spin-states of a single SMM.

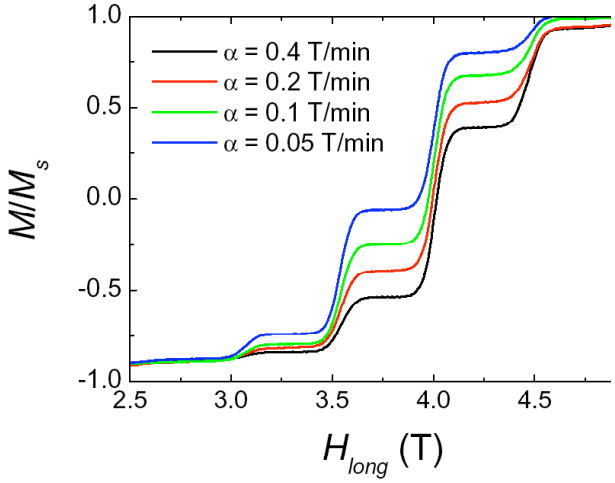

Fig 1. Magnetization versus longitudinal field of a Mn_{12}-acetate single crystal for several different field sweep rates at 0.6 K.

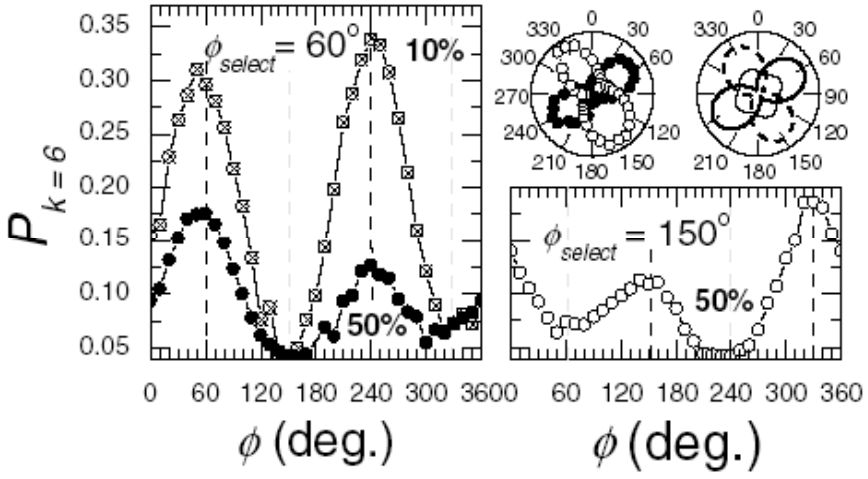

Fig. 2 MQT probability vs angle of the applied transverse magnetic field for resonance 6 (H_{long}~3 T). Left and right figures show the results for different subsets of molecules in a SMM crystal. Top right polar plots shows data for 10% of the molecules with the largest tunneling rates for both subsets of molecules. The polar plot on the right shows a model calculation (from Ref. [7]).

For more information see the following publications and references cited therein:

1. G. Christou, D. Gatteschi, D.N. Hendrickson, and R. Sessoli, *Single Molecule Magnets,* MRS Bulletin. **25**, 66 (2000).
2. E.M. Chudnovsky and D.A. Garanin, *Superradiance from crystals of molecular nanomagnets,* Phys. Rev. Lett. **89**, 157201 (2002).
3. M.N. Leuenberger and D. Loss, *Quantum Computing with Molecular Magnets,* Nature. **410**, 789 (2001).
4. J.R. Friedman, M.P. Sarachik, J. Tejada, and R. Ziolo, *Macroscopic measurements of resonant magnetization tunneling in high-spin molecules,* Phys. Rev. Lett. **76**, 3830 (1996).
5. L. Bokacheva, A.D. Kent, and M.A. Walters, *Crossover between thermally assisted and pure quantum tunneling in molecular magnet Mn_{12}-acetate,* Phys. Rev. Lett. **85**, 4803 (2000).
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9. S. Hill, R.S. Edwards, S.I. Jones, N.S. Dalal, and J.M. North, *Definitive spectroscopic determination of the transverse interactions responsible for the magnetic quantum tunneling in Mn_{12}-acetate,* Phys. Rev. Lett. **90**, 217204 (2003).
10. S. Hill, S. Takahashi, R.S. Edwards, J.M. North, and N.S. Dalal, *Discrete easy-axis tilting in Mn_{12}-acetate, as determined by EPR,* cond-mat/0401515.
11. W. Wernsdorfer, R. Sessoli, *Quantum phase interference and parity effects in magnetic molecular clusters,* Science **284**, 133 (1999).
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13. W. Wernsdorfer, N. Allaga-Alcalde, D.N. Hendrickson, and G. Christou, *Exchange-biased quantum tunnelling in a supramolecular dimer of single-molecule magnets,* Nature **416**, 406 (2002).
14. R. Tiron, W. Wernsdorfer, D. Foguet-Albiol, N. Aliaga-Alcalde, and G. Christou, *Spin quantum tunneling via entangled states in a dimer of exchange-coupled single-molecule magnets,* Phys. Rev. Lett. **91**, 227203 (2003).
15. S. Hill, R.S. Edwards, N. Aliaga-Alcalde, and G. Christou, *Quantum coherence in an exchange-coupled dimer of single-molecule magnets,* Science. **302**, 1015 (2003).
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Current GMAG Officers

Chair
Frances Hellman *fhellman@ucsd.edu*

Chair-Elect
Peter Schiffer *schiffer@phys.psu.edu*

Vice-Chair
Jack Bass *bass@pa.msu.edu*

Secretary-Treasurer
R Bruce van Dover *rbvd@mailaps.org*

Past Chair
David Sellmyer *dsellmyer1@unl.edu*
Jeff Lynn *jeff.lynn@nist.gov*
Si Foner *sfoner@mit.edu*
Lawrence Bennett *lbennett@seas.gwu.edu*
Carl Patton *patton@lamar.colostate.edu*
David Jiles *gauss@ameslab.gov*

Members at Large of the Executive Committee (Term ends March 200x)
Barbara Jones (2004) *bajones@almaden.ibm.com*
Julie Borchers (2005) *julie.borchers@nist.gov*
Jonathan Sun (2005) *jonsun@us.ibm.edu*
Laura Lewis (2006) *lhlewis@bnl.gov*
Mark Stiles (2006) *mark.stiles@nist.gov*

Standing Committees:

Nominating Committee: Chair (appointed by GMAG Chair): **Julie Borchers** *julie.borchers@nist.gov*
Members: **Mark Stiles, Robert O'Handley**

APS Council representative: **Robert Buhrman**

Fellowship Committee: **Jack Bass;** chair of 2003 fellowship committee; **to be named:** chair of 2004 fellowship committee. (GMAG Bylaws specify that the GMAG Vice-Chair be Chair of the Fellowship Committee, and all Members at Large serve on the Fellowship Committee. For 2004, these positions include some determined by the current election)

Program Committee (Chair-Elect is Chair of the Program Committee): **Peter Schiffer** *schiffer@phys.psu.edu*

Recruiting Committee: **Jonathan Sun**, **Jack Bass**

Student Dissertation Award Committee: **Frances Hellman, Julie Borchers, Mark Stiles**