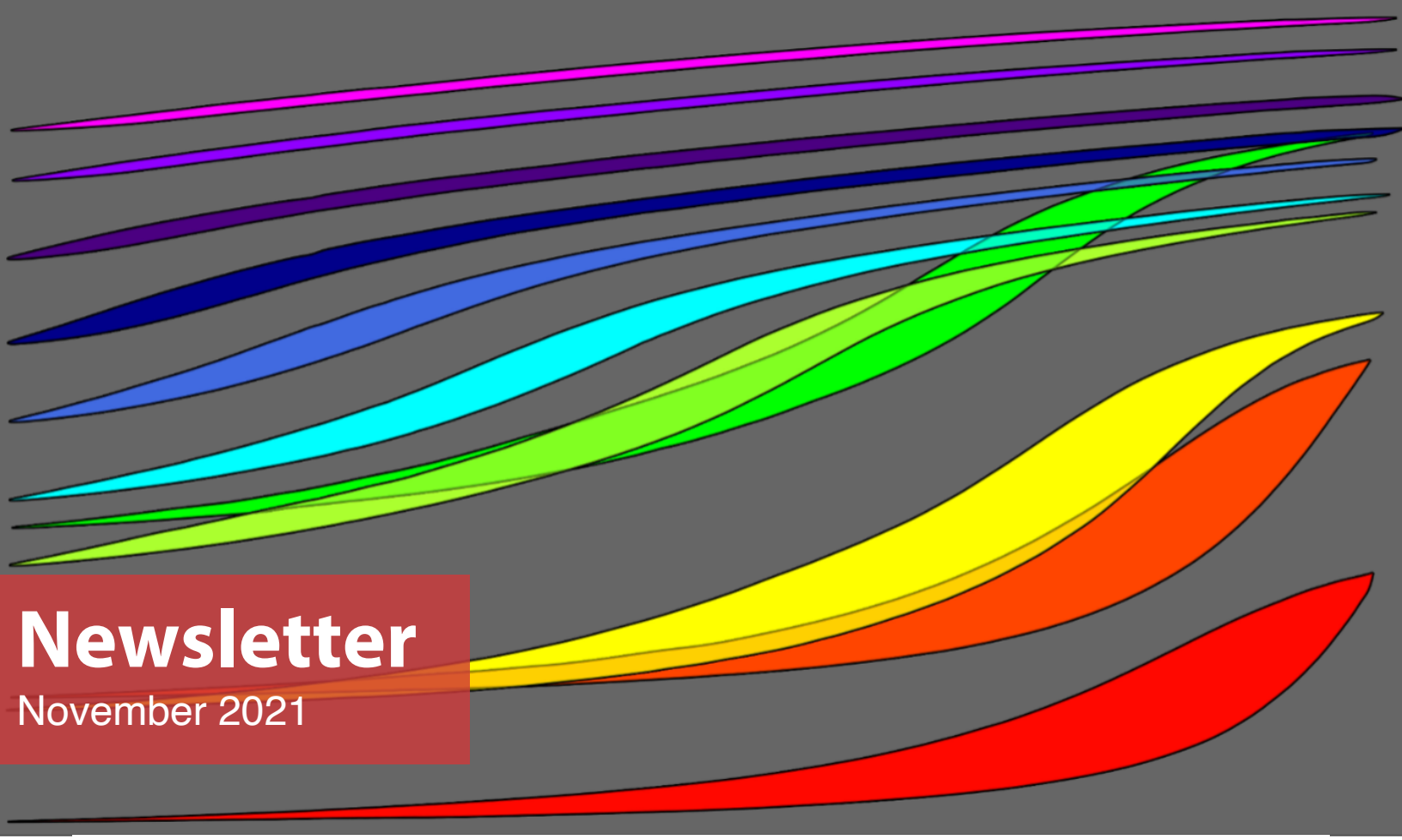


'Magnetostrictive Banana Loops': magnetic flux density variations under variable mechanical stresses for a Terfenol-D sample, a magnetostrictive material. Source: Daniele Davino, Carmine Stefano Clemente and Vincenzo Paolo Loschiavo (University of Studies of Sannio Benevento, Italy.)

Newsletter of the IEEE Magnetics Society

Volume 61 | Issue 4 | November 2021

Editor: Gareth Hatch

In this Issue:

From the President

*By **Masahiro Yamaguchi**, President of the IEEE Magnetics Society*

I hope that you are doing well in this difficult pandemic situation. The outlook for the future remains uncertain while the number of new infections is not as high as before. Knowing this, our IEEE Magnetics Society volunteers continue working hard to proceed with Society activities.

The Administrative Committee (AdCom) of the IEEE Magnetics Society approved nine initiatives in May 2021. These initiatives have been moved to implementation through the hard work of Society volunteers and interested individuals. I would like to share an update on these activities with you.

The hybrid conference and student membership initiatives will be supporting the 15th Joint MMM/INTERMAG conference for its virtual conference platform and networking event, as well as lowering student registration fees to increase student membership. For on-site and virtual registrants, all presentations will be pre-recorded and available online for on-demand viewing, starting December 29, 2021. Q&A will be conducted via the online Chat Boards. Mark Kief, Finance Chair and Victorino Franco, the Joint MMM/INTERMAG General Chair and his team, have enabled this. Please join the conference!

Educational seed-funding initiatives promote networking and student-initiated joint-research opportunities. This funding requires at least two institutions to be involved and encourages projects with diverse geographic and demographic participation. Submission was closed on October 25, 2021. Sara Majetich, Education Committee Chair, and Committee members are tenaciously working on this.

The initiative for the development of magnetism demonstrations, plans to design and develop a robust set of simple, interesting demos. The goal is to create a set of different demos and to test in our classrooms, or at a chapter event, and at one of our conferences. Post-docs could organize related activities to develop useful experience. Once tested and refined, the demos will become an open repository where people can share 3D designs. The person in charge of this initiative will be decided very soon.

A second outreach video has been developed to educate and to grow membership in Asia. The video shows activities in three research areas: bio-magnetics, power magnetics, and spintronics, with around three minutes devoted to each and around nine minutes in total for the entire video. Scripts are written in English and Japanese, with captions for other languages. The recordings are complete, and are expected to appear on IEEE.tv and our YouTube channel early next year. Sachiko Yamaguchi is leading the project.

The periodicals promotion initiative will include advertising the Society's journals and the Society's section of IEEE Access. Promotional activities will include email and social-media campaigns with the assistance of marketing professionals. This will target Society members and conference attendees who have agreed to receive communications. New monthly email bulletins by Philip Pong and Diana Leitão have been sent to the INTERMAG list. We will expand distribution to include those Society members who are not on the INTERMAG list. We are planning an email campaign to non-IEEE magnetics authors and a social-media campaign.

The oral-history pilot project will archive video recordings of interviews of Society "old timers." Transcripts will be archived on the Society's website. This project will continue in future years. Past Society President Liesl Folks will chair the associated committee.

The DL video initiative will archive Distinguished Lecturer talks which can then be uploaded to the Society channel at IEEE.tv. Records of the 2020-2021 Distinguished Lectures in a formal setting will be the first to be implemented.

Technical support is being provided for the 13th Magnetic Random-Access Memory Global Innovation Forum on December 16, 2021, as a satellite meeting to IEDM 2021. this event will promote communication and alignment between experts in magnetism and microelectronics to accelerate MRAM development. This initiative is being led by Bernard Dieny.

The student, diversity and equity Initiative will support students from diverse and low-equity groups worldwide with the goal of promoting Society membership. Individuals will apply and potentially receive free Society membership and travel/ registration support. This initiative will require a small group to help define the guidelines, review applications, and determine recipients.

Besides the initiatives, the 2021 Around-the-Clock Around-the-Globe Magnetics Conference (AtC-AtG) was successfully held online on August 21, 2021. This year's team of postdocs and students was assisted by the Advisory Board composed of last year's organizers. The Conference was again held in the signature 24-hours non-stop format. More details can be found elsewhere in this issue of the Newsletter.

The update of the Society's Bylaws has been completed! Details on the Conference Executive Committee and the Publications Committee are separately published in the new Operations

Manual. They became effective as of August 30, 2021, and can be found at the Society website. An update of the Society's Constitution is subject to Society membership review until November 15, 2021. The amended Constitution shall become binding unless five percent or more of the Society's membership objects by November 15, 2021.

The Planning Committee has been discussing the strategy for equality and diversity, as some concerns have been raised by Society members on the number of female Award winners and Distinguished Lecturers. Mentoring schemes by volunteers are under discussion, as a first step.

In August 2021, the Society received approximately $300,000 in as a result of pandemic-related insurance claims. Pallavi Dhagat and Ron Goldfarb are trying to transfer these monies to the IEEE Foundation to endow an "IEEE Magnetics Society Diversity, Talent, and Innovation Fund." If a transfer in 2021 is not possible, a transfer in 2022 of up to $300,000 from reserves is planned. This would help the Society's financial operation very much, and we await IEEE approval.

The family of Neil Smith, who passed away in 2021, would like to donate funds to establish student awards in his memory, to be presented at TMRC and perhaps INTERMAG. AdCom has approved a transfer of $50,000-$75,000 from reserves to the IEEE Foundation in 2022, to match a donation of equal amount, to the existing "IEEE Magnetics Society Awards Fund" to endow Neil Smith Student Awards for Contributions to the Understanding of Magnetic Phenomena in Materials and Devices. Jürgen Fassbender, Honors & Awards Chair, is leading this project in collaboration with Ron Goldfarb and Pallavi Dhagat.

IEEE NextGen (https://ieeemce.org/news/get-to-know-ieee-nextgen-on-new-website/) is an improved financial and contract system to simplify, streamline, and save time that allows for more visibility for the end user to improve business insights and decisions. New features will be phased into NextGen over a period of time. The system will be available for those who are authorized to act on financials and contracts. As the IEEE understands, this is a change for our volunteers and it can take time to adapt to the new platform. The implementation and transition to NextGen has frustrated Society activities and volunteers alike. Finance, Conference Executive, Education, and Chapters Committees are working extremely hard to overcome the difficulties.

AdCom gives special thanks Pavel Kabos for his 10 years of service as Editor-in-Chief of *IEEE Transactions on Magnetics*. Thank you very much Pavel, for your outstanding leadership! We also thank Takao Suzuki for his very successful and productive long-term service as Editorial Board member.

We welcome Amr Adly (Cairo University, Egypt) as the next Editor-in-Chief of the *IEEE Transactions on Magnetics*. A two-year renewal of the appointment of Massimiliano d'Aquino as Chief Editor of *IEEE Magnetics Letters* will be effective January 1, 2022. Amr and Massimiliano, we are very happy to work with you!

I am happy to announce the 2022 Distinguished Lecturers (DLs). My congratulations go to Jingsheng Chen (National University of Singapore), Michael E. Flatté (The University of Iowa, USA), Aurélien Manchon (Aix-Marseille University, France) and Tiffany S. Santos (Western Digital Corporation, USA) on their appointments. More details on the DLs and their lectures can be found elsewhere in this issue of the Newsletter. Interested Chapter Chairs please contact the DLs quickly to arrange their talks for your Chapter, either in-person or virtually.

Finally I would like to address my dearest congratulations to the 2022 Award winners: Hideo Ohno (Tohoku University, Japan) receives the Achievement Award "f*or fundamental discoveries of spintronic phenomena and their applications in memory and computing technologies*." Ilya Krivorotov (UC Irvine, USA) receives the Mid-Career Award "*for seminal contributions to the understanding of the interplay between spin transport and magnetization dynamics due to spin torques*." Qiming Shao (Hong Kong University of Science and Technology, China) receives the Early Career Award "*for contributions to exploring spin-orbit torque devices with quantum materials and systems.*" Pallavi Dhagat (Oregon State University, USA) receives the Distinguished Service Award "*for exceptional service to the IEEE Magnetics Society as demonstrated by her outstanding leadership during the coronavirus disease 2019 pandemic, her dedicated efforts to modernize the Society and implement new ways of work and communication through virtual conferences, and promotion of professional and leadership development opportunities for early-career professionals and women in magnetism*."

As always, please feel free to reach out to me by e-mail with feedback and suggestions for our Society.

Masahiro Yamaguchi can be contacted via email:
masahiro.yamaguchi@ieee.org.

In Memory of Mason Lamar Williams (1943-2021)

By Joe Feng, Roger Wood and Tom Coughlin

Mason Lamar Williams III, a well-known contributor to the field of magnetic data storage, died June 28, 2021 in San Jose, California. He had had a distinguished career in research and development while at IBM San Jose and Hitachi Global Storage Technologies (HGST), followed by volunteering at the Computer History Museum in Mountain View, California.

Mason received a B.S. degree in engineering from the California Institute of Technology in 1964, and M.S.E.E. and Ph.D. degrees from the University of Southern California in 1966 and 1970 respectively.

While at Caltech, Mason helped with the Great Rose Bowl Hoax. As one of Jan Smit's students at USC, one of his assignments was to measure the surface temperature of the moon in preparation for the proposed Apollo landing sites. While calibrating the thermometer, Mason observed a 2 K anomaly when he attempted to use the dark sky to calibrate the zero point. Perhaps he observed the Cosmic Microwave Background before Penzias and Wilson.

Mason was a generous teacher, mentoring several generations of engineers and scientists in various aspects of magnetic data storage. He is probably best known for the Williams-Comstock model, an elegant description of the physics in saturated DC magnetic recording. He also made contributions in thin-film recording heads, successive generations of magnetoresistive sensors, increasing the data rate in disk drives, and engineering magnetic-bubble storage.

Mason also represented IBM at the Lake Arrowhead conferences and the various recording consortia that included industry and academia, and was the IBM representative on the International Storage Industry Consortium (INSIC) UltraHigh Density Magnetic Recording Head project. In 1996, he became a member of the Extremely High-Density Recording Strategy Team at INSIC, which led to the proposal for TDMR technology.

Mason worked at IBM starting in 1970, initially in the HDD Manufacturing Research organization. In the late 1970s, he worked on magnetic-bubble memory and in 1982 he joined the Magnetic Recording Institute led by Denis Mee and managed an investigation of perpendicular magnetic recording. In 1985 Mason moved to the IBM Almaden Research Center to become manager of Advanced Recording Heads, with a focus on magnetic modelling.

When Hitachi purchased IBM's HDD division in 2002, Mason worked for HGST and continued to conduct fundamental research and modeling of magnetic recording physics and HDD system integration. He retired from HGST in 2005.

Mason was elevated to IEEE Fellow in 1999 for "*contributions to the understanding of the digital magnetic recording process and the continued progress of areal density of disk drives*." He was a Distinguished Lecturer for the IEEE Magnetics Society in 2006 and that same year he received the Reynold B Johnson Data Storage Technology Award. Mason authored or co-authored 27 US patents. Several of these are highly cited and cover magnetoresistive read heads, shingled recording and perpendicular magnetic recording. He was recognized as an IBM Master Inventor in 2001.

In addition to being an accomplished magnetician, Mason was an enthusiastic model railroader, microcomputer hobbyist, and skilled in several programming languages.

After he retired, Mason joined the project at the Computer History Museum to restore the IBM RAMAC, the first commercial disk drive. He used his programming skills to write the supervisor code to exercise the actuator on the RAMAC and decode the read back waveforms, and he created and animated a dynamic model of the mechanical control system. It can now be seen operating at the Computer History Museum.

New Senior Members

The following members of the IEEE Magnetics Society were recently elevated to the grade of Senior Member:

August 2021: Roger Daugherty and Kuntal Roy.

October 2021: Kerem Camsari and Zachary Kratzer.

For more information on elevation to Senior Member, visit the IEEE Senior Member Grade Web page.

Search for New Editor-in-Chief of *IEEE Transactions on Quantum Engineering*

Submitted by Ron Goldfarb, Magnetics Society Representative to the TQE Steering Committee

IEEE Transactions on Quantum Engineering (TQE) publishes regular, review, and tutorial articles based on the engineering applications of quantum phenomena, including quantum computation, information, communication, software, hardware, devices, and metrology. TQE is an all-electronic, open-access journal, published continuously. It is in its second year of publication. The journal's website is **https://tqe.ieee.org/**; articles are published on IEEE's Xplore platform at **https://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=8924785**. The Society is a co-sponsor of TQE.

The TQE Steering Committee is conducting a search for the next Editor-in-Chief (EIC) to start in January 2022 with an initial three-year appointment and one possible re-appointment. The qualified candidate should have a doctorate in engineering, physics, materials science, or a related area; at least five years of editorial experience; broad interest in quantum phenomena; an established network in the quantum engineering community; and project-management skills.

The Editor-in-Chief manages the operations of the journal with the help of an editorial assistant, helps recruit Associate Editors and members of the Advisory Board, examines incoming manuscripts for originality and scope, assigns them to associate editors to manage the reviews, and shapes and leads the journal. It is an unpaid, volunteer position. The EIC must be a member of the IEEE.

The new Editor-in-Chief will have the full support of the outgoing EIC and the journal's Steering Committee. To apply, please submit a brief resume and letter outlining your qualifications and position statement to the Steering Committee Chair, Elie Track via **etrack@ieee.org**. The current EIC, Britton Plourde, is available to answer questions via **bplourde@syr.edu**.

IEEE Magnetics Society Distinguished Lecturers for 2022

Submitted by Beth Stadler, Distinguished Lecturer Committee Chair

It is my pleasure to introduce the 2022 Distinguished Lecturers (DLs) on behalf of the IEEE Magnetics Society:

- **Jingsheng Chen** (National University of Singapore);
- **Michael Flatté** (The University of Iowa, USA);
- **Aurélien Manchon** (Aix-Marseille University, France); and
- **Tiffany S. Santos** (Western Digital Corporation, USA).

Speakers were chosen by committee on the basis of international reputation for excellence in their respective fields, speaking acumen, and widespread interest within the greater magnetics community of their proposed lecture topics.

Those in positions to organize and host DLs either physically or virtually are encouraged to contact the DLs directly.

On a related note, the IEEE Magnetics Society Distinguished Lecturers for 2000 served also in 2021 because of scheduling problems due to the coronavirus disease 2019 (COVID-19) pandemic.

Symmetry breaking by materials engineering for spin-orbit-torque technology

Jingsheng Chen
National University of Singapore

Electric manipulation of magnetization is essential for the integration of magnetic functionalities in integrated circuits. Spin-orbit torque (SOT), originating from the coupling of electron spin and orbital motion through spin-orbital interaction, is able to effectively manipulate magnetization. Symmetry breaking plays an important role in spintronics based on SOT. SOT requires inversion asymmetry in order to have a net effect on magnetic materials, which is commonly realized by spatial asymmetry: a thin magnetic layer sandwiched between two dissimilar layers. This kind of structure restricts the SOT by mirror and rotational symmetries to have a particular form: an "antidamping-like" component oriented in the film plane even upon reversal of the magnetization direction. Consequently, magnetization perpendicular to the film plane cannot be deterministically switched with pure electric current. To achieve all-electric switching of perpendicular magnetization, it is necessary to break the mirror and rotational symmetries of the sandwiched structure.

In this lecture, I will begin with a basic introduction of the physical origin of SOT, followed by the related symmetry analysis of a magnetic thin film in a sandwiched structure for the generation of a net SOT effect. Then I will introduce a new methoda composition gradient along the thin-film normal for breaking the inversion symmetryto generate bulk-like SOT [1], which enables a thicker magnetic layer with high magnetic anisotropy. An overview of the methods commonly used to break mirror and rotational symmetries in order to realize all-electric switching of perpendicular magnetization will follow. I will give a detailed discussion on our methods for the realization of all-electric switching of perpendicular magnetization: the use of a spin source layer with low magnetic symmetry and low crystal symmetry, which generates an out-of-plane SOT [2]-[4]; interfacial 3m1 symmetry, which induces a new "3m" spin torque [5]; precise control of the tilting of magnetocrystalline anisotropy easy axis [6]; and a spin-current gradient along the current direction [7].

[1] L. Liu et al., "Electrical switching of perpendicular magnetization in a single ferromagnetic layer," *Phys. Rev. B*, vol. 101, 220402, June 2020.

[2] J. Zhou et al., "Magnetic asymmetry induced anomalous spin-orbit torque in IrMn," *Phys. Rev. B*, vol. 101, 184403, May 2020.

[3] J. Zhou et al., "Large spin-orbit torque efficiency enhanced by magnetic structure of collinear antiferromagnet IrMn," *Sci. Adv.*, vol. 5, eaau6696, May 2019.

[4] Q. Xie et al., "Field-free magnetization switching induced by the unconventional spin–orbit torque from WTe2," *APL Mater.*, vol. 9, 051114, May 2021.

[5] L. Liu et al., "Symmetry-dependent field-free switching of perpendicular magnetization," *Nat. Nanotech.*, vol. 16, pp. 277-282, January 2021.

[6] L. Liu et al., "Current-induced magnetization switching in all-oxide heterostructures," *Nat. Nanotech.*, vol. 14, 939-944, September 2019.

[7] S. Chen et al., "Free field electric switching of perpendicularly

magnetized thin film by spin current gradient," *ACS Appl. Mater. Interfaces*, vol. 11, pp. 30446-30452, July 2019.

Jingsheng Chen *obtained the B.S and Ph.D degrees in 1994 and 1999 from Lanzhou University, China. From 1999 to 2001, he was postdoctoral fellow at Nanyang Technological University. During 2001-2007, he was a research scientist at the Data Storage Institute, Singapore. Currently he is an associate professor in the Department of Materials Science and Engineering, National University of Singapore. His present research interests include magnetic materials and devices for spintronics application, high anisotropy magnetic materials for hard disk drives, multiferroic materials, and emerging ferroelectric materials and devices. From 2008 till the present, he has been sponsored by Seagate Technology to develop high-anisotropy magnetic recording media for heat-assisted magnetic recording. He has authored or co-authored over 300 refereed journal papers, holds more than 10 patents, and has made over 50 invited presentations at international conferences. He is a Senior Member of the IEEE and has served as the program chair of 2018 INTERMAG Conference.*

Contact: Jingsheng Chen, Department of Materials Science and Engineering, National University of Singapore, 9 Engineering Drive 1, Singapore 117595; e-mail: ***msecj@nus.edu.sg****.*

Coherent magnonics for quantum information science

Michael E. Flatté
The University of Iowa, USA

The current revolution in quantum technologies relies on coherently linking quantum objects like quantum bits ("qubits"). Coherent magnonic excitations of low-loss magnetic materials can wire together these qubits for sensing, memory, and computing. Coherent magnonics may reduce the size of superconducting qubits (which otherwise struggle with the large scale of microwave excitations) and may increase the size of spin-based qubit networks (which otherwise contend with the very short distances of dipolar or exchange interactions). Compared to photonic devices, these magnonic devices require minimal energy and space. However, efforts to exploit coherent magnonic systems for quantum information science will require a new understanding of the linewidths of low-loss magnonic materials shaped into novel structures and operating at dilution-refrigerator temperatures.

This lecture will introduce the fundamental requirements for practically linking quantum objects into large scale coherent quantum systems as well as the advantages of coherent magnonics for next-generation quantum coherent systems (i.e., spin-entangling quantum gates [1]). Other critical challenges for quantum information science then will motivate the development of coherent magnonics for quantum transduction from "stationary" spin systems to "flying" magnons and for quantum memory [2]-[4]. Finally, the advantages of all-magnon quantum information technologies that rely on manipulating and encoding quantum information in superpositions of fixed magnon number states will highlight the potential of new magnetic materials, devices, and systems.

[1] M. Fukami, D. R. Candido, D. D. Awschalom, and M. E. Flatté, "Opportunities for long-range magnon-mediated entanglement of spin qubits via on- and off-resonant coupling," *PRX Quantum*, in press, arxiv:2101.09220.

[2] D. R. Candido, G. D. Fuchs, E. Johnston-Halperin, and M. E. Flatté, "Predicted strong coupling of solid-state spins via a single magnon mode," *Mat. Quant. Technol.*, vol. 1, 011001, 2021.

[3] Ö. O. Soykal and M. E. Flatté, "Strong field interactions between a nanomagnet and a photonic cavity," *Phys. Rev. Lett.*, vol. 104, 077202, February 2010.

[4] T. Liu, X. Zhang, H. X. Tang, and M. E. Flatté, "Optomagnonics in magnetic solids," *Phys. Rev. B*, vol. 94, 060405, August 2016.

Michael Flatté *is a professor in the Department of Physics and Astronomy at The University of Iowa (UI). His research interests include optical and electrical control of spin dynamics in materials, novel spintronic devices, quantum sensors, and solid-state realizations of quantum computation. He received the A.B. degree in physics from Harvard University in 1988 and the Ph.D. degree in physics from the University of California, Santa Barbara, in 1992. After postdoctoral work at the Institute for Theoretical Physics at the University of California, Santa Barbara, and in the Division of Applied Sciences at Harvard University, he joined the faculty at UI in 1995. Flatté has over 270 publications and 10 patents, is a Fellow of the American Association for the Advancement of Science and of the American Physical Society, and a Member of the IEEE. He has an adjunct appointment as professor in the Department of Applied Physics at Eindhoven University of Technology in the Netherlands.*

Contact: Michael Flatté, Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, USA; e-mail: ***michael-flatte@uiowa.edu****.*

Exploring the potential of spin-orbitronics

Aurélien Manchon
Aix-Marseille University, France

The ever-increasing demand of information technology for power-efficient components has led to the search for alternative solutions to mainstream microelectronics. In this context, spintronics devices stand out as competitive candidates, especially for memory and logic applications. A promising route harvests unconventional transport properties arising from spin-orbit coupling in magnetic heterostructures lacking inversion symmetry.

In these systems, typically multilayers of transition-metal ferromagnets and heavy materials (e.g., W, Pt, Ta, Bi_2Se_3, WTe_2), interfacial spin-orbit coupling promotes a wealth of remarkable physical phenomena: the generation of spin-orbit torques, the interconversion between spin and charge currents, and the stabilization of topological magnetic skyrmions. These effects have gathered extraordinary interest and have led to remarkable experimental breakthroughs, including extremely fast magnetic reversal, terahertz emission, and current-driven skyrmion motion. The recent synthesis of novel classes of materials, including all-oxide heterostructures, noncollinear antiferromagnets, and van der Waals heterostructures, has profoundly enriched this vivid field of research by unlocking unforeseen forms of torques and magnetic interactions, thereby enhancing the functionalities of spin-orbitronic devices.

This lecture will provide a theoretical perspective of the advancement of the fascinating field of spin-orbitronics, focusing on two emblematic mechanisms: the spin-orbit torque and the Dzyaloshinskii-Moriya interaction. I will examine what theory and materials modeling can tell us about these two effects, and what future research directions they open. I will first introduce key concepts in spintronics, such as spin currents and spin-transfer torque, and show how spin-orbit coupling enables new physical effects of high interest for potential applications. I will present standard phenomenological descriptions of these two effects, spin-orbit torque, and the Dzyaloshinskii-Moriya interaction, determine the symmetry rules that govern them, and give a broad overview of the current state-of-the-art of the field from experimental and theoretical standpoints. Finally, I will explore how spin-orbitronics takes a completely new form in materials possessing low crystalline symmetries, such as Fe_3GeTe_2, CuPt/CoPt bilayers, and noncollinear antiferromagnets (e.g., Mn_3Sn).

I hope that this seminar will not only encourage electrical engineers to engage in this beguiling field of research and explore the device implications of this new technology, but also reach out to scientists working in adjacent fields (terahertz science, for instance) who could bring inspiring new ideas to spintronics [1]-[5].

[1] A. Manchon, J. Železný, I. M. Miron, T. Jungwirth, J. Sinova, A. Thiaville, K. Garello, and P. Gambardella, "Current-induced spin-orbit torques in ferromagnetic and antiferromagnetic systems," *Rev. Mod. Phys.*, vol. 91, 035004, September 2019.

[2] A. Belabbes, G. Bihlmayer, F. Bechstedt, S. Blügel, and A. Manchon, "Hund's rule-driven Dzyaloshinskii-Moriya interaction at 3d-5d interfaces," *Phys. Rev. Lett.*, vol. 117, 247202, December 2016.

[3] E. Jué, C. K. Safeer, M. Drouard, A. Lopez, P. Balint, L. Buda-Prejbeanu, O. Boulle, S. Auffret, A. Schuhl, A. Manchon, I. M. Miron, and G. Gaudin, "Chiral damping of magnetic domain walls," *Nature Mater.*, vol. 15, pp. 272-277, March 2016.

[4] S. Laref, K.-W. Kim, and A. Manchon, "Elusive Dzyaloshinskii-Moriya interaction in monolayer Fe3GeTe2," *Phys. Rev. B*, vol. 102, 060402, August 2020.

[5] L. Liu et al., "Symmetry-dependent field-free switching of perpendicular magnetization," *Nat. Nanotech.*, vol. 16, pp. 277-282, January 2021.

Aurélien Manchon *is a Professor of Physics at Aix-Marseille University in the Interdisciplinary Center for Nanoscience of Marseille. He graduated from the École Polytechnique, Palaiseau, in 2004 and earned the Ph.D. in physics in 2007 from Université Joseph Fourier and SPINTEC lab in Grenoble, France. He was a postdoctoral fellow at University of Missouri-Columbia and University of Arizona, Tucson. He was an Assistant (2009-2015) and Associate Professor (2015-2019) of Materials Science and Engineering at King Abdullah University of Science and Technology, Saudi Arabia. His research focuses on theoretical spintronics and aims at identifying novel mechanisms that can be used to operate low-power, ultrafast, spin-based devices. His research interests include spin-orbit coupled transport, chiral magnetism, antiferromagnets, and ultrafast dynamics.*

Contact: Aurélien Manchon, Centre Interdisciplinaire de Nanoscience de Marseille, Aix-Marseille Université, 163 Avenue de Luminy, Marseille 13009, France; e-mail: ***aurelien.manchon@univ-amu.fr***.

Spin, bits, and flips: essentials for high-density magnetic random-access memory

Tiffany S. Santos
Western Digital Corporation, USA

The magnetic tunnel junction (MTJ), a device comprised of two

ferromagnetic electrodes with a thin (about 1 nm) insulating tunnel barrier in between, was first proposed in a Ph.D. thesis by Michel Jullière in 1975 [1], and reached widespread commercialization nearly 30 years later as the read sensor in hard disk drives. MTJs became essential for data storage in consumer laptop and desktop computers, early-generation iPods, and now in data centers that store the information in "the Cloud." The application of MTJs has expanded even further, becoming the storage element in non-volatile memory, first in toggle magnetic random-access memory (MRAM) used in automotive applications and outer space, and now in the production of spin-transfer torque MRAM as a replacement for embedded Flash memory. As computing capabilities advance and drive demand for high performance memory, innovation in MTJ continues in order to deliver faster, high-density MRAM that can support last-level cache, in-memory computing, and artificial intelligence.

In this talk, I will describe the seminal discoveries [2] that enabled MTJs for pervasive use in hard disk drives, MRAM, and magnetic sensors, such as the discovery of tunnel magnetoresistance (TMR) at room temperature, the invention of spin transfer torque as the means to flip magnetization without a magnetic field, and the prediction and realization of high TMR using MgO tunnel barriers. As the demand for faster and higher density memory persists, still more breakthroughs are needed for MTJs contained in device pillars (or bits) just tens of nanometers in diameter. These advances require tuning of the materials properties at the atomic scale as well as across arrays of millions of bits in a memory chip. I will describe the magnetic properties of MTJs that are essential for high performance MRAM, including perpendicular magnetic anisotropy, damping parameter, exchange constant, thermal stability factor, and TMR, and how to engineer these properties to deliver high spin-transfer torque efficiency and high data retention in spin-transfer torque MRAM devices [3],[4].

[1] M. Jullière, Ph.D. thesis, Rennes University, No. B368/217, Rennes, France, 1975; M. Jullière, "Tunneling between ferromagnetic films," *Phys. Lett. A*, vol. 54, pp. 225-226, September 1975.

[2] J. S. Moodera, G.-X. Miao, and T. S. Santos, "Frontiers in spin-polarized tunneling," *Physics Today*, vol. 63, pp. 46-51, April 2010.

[3] T. S. Santos, G. Mihajlović, N. Smith, J.-L. Li, M. Carey, J. A. Katine, and B. D. Terris, "Ultrathin perpendicular free layers for lowering the switching current in STT-MRAM," *J. Appl. Phys.*, vol. 128, 113904, September 2020.

[4] G. Mihajlović, N. Smith, T. Santos, J. Li, B. D. Terris, and J. A. Katine, "Thermal stability for domain wall mediated magnetization reversal in perpendicular STT MRAM cells with W insertion layers," *Appl. Phys. Lett.*, vol. 117, 242404, December 2020.

Tiffany Santos *is director of non-volatile memory materials research in the Research Division of Western Digital Corporation in San Jose, California, where she leads a team working on materials for magnetic random-access memory technology and other exploratory projects. She first joined the company in 2011, when it was previously known as Hitachi Global Storage Technologies, to work on research on granular FePt media for heat-assisted magnetic recording. She received the S.B. and Ph.D. degrees in Materials Science and Engineering from the Massachusetts Institute of Technology, where she did her thesis research on thin film magnetism and spin-polarized tunneling in magnetic tunnel junctions under the supervision of Jagadeesh Moodera in the Francis Bitter Magnet Laboratory. She became a Distinguished Postdoctoral Fellow, and later an Assistant Scientist, in the Center for Nanoscale Materials at Argonne National Laboratory, where she studied emergent phenomena at the interfaces of complex oxide heterostuctures. She has played an active role in professional societies in the magnetism community, serving as Sectretary/Treasurer of the Topical Group on Magnetism and Its Applications (GMAG) of the American Physical Society, on the program committees of several Magnetism and Magnetic Materials (MMM) and INTERMAG conferences, as Program Co-Chair of INTERMAG 2020, as Exhibits Chair of several MMMs and the International Conference on Magnetism, multiple terms on the MMM Conference Advisory Committee, and as Publicity Chair of The Magnetic Recording Conference. In 2009, she was awarded a L'Oréal USA Fellowship for Women in Science. She is a wife and a mother to two young, curious, and energetic children.*

Contact: Tiffany Santos, Western Digital Research Center, Western Digital Corporation, San Jose, California 95119, USA; e-mail: ***tiffany.santos@wdc.com****.*

Search for New Editor of the Newsletter

By Tom Thomson, Publications Committee Chair

The Newsletter of the IEEE Magnetics Society is published four times per year and includes articles on activities, conferences, workshops and other information of interest to Society members, and other people in the area of applied magnetics.

The Society's Publications Committee is conducting a search for the next Editor of the Newsletter, ideally to start in early 2022. The qualified candidate should be a member of the IEEE and the Magnetics Society, and have a background in engineering, physics, materials science, or a related area; prior editorial

experience is desirable.

The Editor manages the publication of the Newsletter, including the solicitation and editing of contributions to it. It is an unpaid, volunteer position.

The new Editor will have the full support of the outgoing Editor and the Publications Committee.

To apply, please submit a brief resume and letter outlining your qualifications and position statement to me via email at **thomas.thomson@manchester.ac.uk**. The current Editor, Gareth Hatch, is available to answer questions via **g.p.hatch@ieee.org**.

The 2nd Around-the-Clock Around-the-Globe Magnetics Conference

By Hans Nembach and Helmut Schultheiss, Steering Committee Co-Chairs

Following the great success of the 1st Around-the-Clock Around-the-Globe (AtC-AtG) Conference in 2020, the IEEE Magnetics Society sponsored the 2021 AtC-AtG, which was held on August 24, 2021 with its signature 24-hour non-stop virtual format.

The conference was organized by a highly motivated and talented group of students and post-docs, who were supported by last year's organizers and the Steering Committee. The Conference program included 69 oral presentations given by students and post-docs and 12 invited talks given by speakers from different continents. The program also included poster sessions, in order to be able to maintain the single-session format, while also giving more students and post-docs the opportunity to actively participate in the conference.

A challenge for most virtual conferences is the difficulty to replicate the poster-session experience. The organizing committee developed a special AtC-AtG Conference site in Gather.town, a virtual meeting place, which provided opportunities to discuss and network. It was very well received by the participants and extensively used. The organizing graduate students and post-docs used Gather.town to design dedicated areas for poster sessions and Q&A after invited talks and tutorials, to maximize the opportunity for interaction between the speakers and the participants. This approach of integrating the Conference Program into a virtual socializing platform received very positive feedback from all over the world, and sets an example of how online global meetings can successfully integrate networking opportunities.

The conference had 723 registrations and received 190 abstracts. The registrations from a total of 51 countries with the highest number of registrations were India, USA, and Germany.

The student and post-doc organizers gave us very positive feedback on their experience, which went beyond organizing the Conference. The 2nd "Around-the-Clock Around-the-Globe" Magnetics Conference was a great success, which can best be highlighted by a few testimonials from the organizing students and post-docs: "*Participating in this year's organization of the AtC-AtG Magnetics Conference has really been a gratifying and enriching experience.*" • "*taught me a lot about collaborating with different people from diverse backgrounds (and time zones!). I have created strong bonds with many of the co-organizers and I hope I can work with them in the future.*" • "*The AtC-AtG Magnetics Conference also allowed us to create new scientific collaborations not only among the ProCom members but also with other attendees.*"

Trends in Magnetism 2020

Submitted by Giovanni Finocchio, Italy Chapter Chair; and Vito Puliafito, Italy Chapter Treasurer

After its postponement due to the Covid-19 pandemic, the conference Trends in Magnetism (TMAG 2020) was held during September 6-10, 2021 in the beautiful location of Cefalù in Italy. The conference Chair, Giovanni Finocchio (University of Messina, Italy), and the Co-Chair Anna Giordano (INGV, Italy), organized a hybrid program. TMAG2020 had a total of 159 participants, including 64 in-person attendees, from Italy, USA, Spain, Germany, Hungary, Sweden, Poland, Switzerland, France, Greece, Russia, and UK.

TMAG 2020 was enriched by the Nobel lecture given by Prof. Albert Fert during the virtual opening; by a lecture on the history of the IEEE Magnetics Society; and by the in-person talk by IEEE Society Distinguished Lecturer Prof. Mathias Klaui. In addition, many other recognized scientists presented the very latest

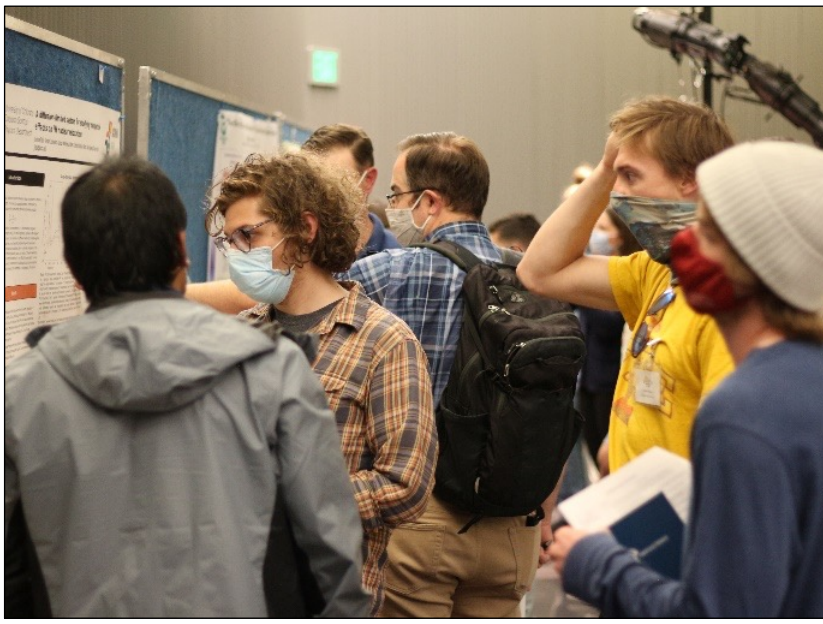
Attendees of TMAG2020, at the top of the rock of Cefalù, with a view of the city and coastline.

trends in magnetism and related applications.

The main sponsors of TMAG 2020 were the IEEE Magnetics Society, IUPAP, Petaspin Association, the Italian Association of Magnetism, AIMagn, Qnami and MARIS. The conference was also sponsored by the Universities of Messina and Perugia. Thanks to that support, registration fees were kept very low, above all for IEEE members and students. The TMAG evaluation commission composed by Prof. Andrei Slavin (President), Paola Tiberto (President of the Italian Association of Magnetism) and Juan Carlos (CNRS, Nancy, France), selected four finalists for the Young Researcher Award. The winner of this award was Víctor López Domínguez (Northwestern University, USA).

The program also included several social activities planned and managed by Susy Garescì. The social dinner was organized on the roof of the conference venue, with a night view of the beautiful town and coastline of Cefalù. A visit to the city, with the famous Arab Norman cathedral, and the climb to the top of the rock over the city (see the group picture) saw wide and enthusiastic participation of those present in Cefalù.

During the conference, the second edition of Trends in Magnetism was announced and scheduled during September 5-9, 2022, in the charming city of Venice, Italy. Chairs of the conference will be Stefano Bonetti (University of Venice Ca' Foscari, Italy), and Vito Puliafito (Politecnico di Bari, Italy).



The 7th Front Range Advanced Magnetics Symposium

Submitted by Mingzhong Wu

The 7th Front Range Advanced Magnetics Symposium (FRAMS) was successfully held at Colorado State University, Fort Collins, Colorado, USA, during September 18-19, 2021. The FRAMS conferences are for researchers working in magnetics primarily in the Front Range of the Rocky Mountains, which includes the American states of Colorado, Wyoming, and New Mexico. The mission of FRAMS is to foster and enhance interactions and collaborations, among geographically separated researchers in different institutions, and thereby strengthen the overall magnetics program in the Front Range.

The 7th FRAMS, chaired by Prof. Hua Chen, had 88 in-person participants and some 34 remote participants. The conference program included plenary talks given by Prof. Axel Hoffmann and Dr. Justin Shaw, 25 invited talks, and 44 poster presentations. It also included two special social sessions to celebrate the careers and achievements of two senior scientists: Prof. Carl Patton and Prof. Bret Heinrich.

The IEEE Magnetics Society and its two chapters in Colorado sponsored the student activities during the conference. Those

activities included two poster sessions with 41 in-person posters and three remote posters presented by post-doctoral researchers, graduate students, and undergraduate students; the selection of six best poster awards; and lunch with experts (Prof. Robert Camley, Prof. Axel Hoffmann, and Prof. Jinke Tang). The 8th FRAMS will be held at the University of Wyoming during the summer of 2022.

Conference Calendar

*By **Gareth Hatch**, Newsletter Editor*

Please check the conference websites shown below for the latest information on COVID-19-related schedule or format changes.

IEEE International Conference on Rebooting Computing (ICRC 2021)
30 November - 2 December 2021 - online.

67th Annual IEEE International Electron Devices Meeting (IEDM 2021)
11-15 December 2021 - San Francisco, California, USA.

13th MRAM Global Innovation Forum
16 December 2021 - San Francisco, California, USA.

2022 Joint MMM-INTERMAG Conference
10-14 January 2022 - New Orleans, Louisiana, USA.

COMPUMAG 2021
10-14 January 2022 - online.

Magnetism 2022
28-29 March 2022 - York, UK.

3rd European Conference on Molecular Spintronics (ECMolS 2022)
5-8 April 2022 - Dortmund, Germany.

Magnetic Frontiers: Quantum Technology
25-28 April 2022 - New York, New York, USA.

25th Soft Magnetic Materials Conference (SMM25)
2-5 May 2022 - Grenoble, France.

International Conference on Fine Particle Magnetism (ICFPM 2022)
30 May - 3 June 2022 - Yokohama, Japan.

13th International Conference on the Scientific and Clinical Applications of Magnetic Carriers
10-14 January 2022 - New Orleans, Louisiana, USA.

7th International Conference on Microwave Magnetics (ICMM 2022)
19-22 June 2022 - Beijing, China.

22nd International Conference on Magnetism (ICM 2022)
3-8 July 2022 - Shanghai, China.

The Joint European Magnetic Symposia (JEMS2022)
25-29 July 2022 - Warsaw, Poland and online.

The European School on Magnetism 2022 (ESM2022)
19-30 September 2022 - Saabrücken, Germany and online.

67th Annual Conference on Magnetism and Magnetic Materials (MMM 2022)
31 October - 4 November 2022 - Minneapolis, Minnesota, USA.

To list your conference in the Newsletter Conference Calendar in a future edition, please contact the **Newsletter Editor**.

About the Newsletter

The purpose of the Newsletter of the IEEE Magnetics Society is to publicize activities, conferences, workshops and other information of interest to Society members and other people in the area of applied magnetics.

Contributions are solicited from Society members, Officers & other volunteers, conference organizers, local chapters, and other individuals with relevant material. The Newsletter is published quarterly on the Society webpage at: http://www.ieeemagnetics.org

Please send all contributions via email to the Newsletter Editor, Gareth Hatch, at: g.p.hatch@ieee.org