Magnetic Interfaces and Nanostructures Division
Room 330 - Session MI-WeM

Spin Landscape I (Magnetic Structures in Real and Momentum Space)

Moderator: Mikel Holcomb, West Virginia University

8:00am **MI-WeM-1 Voltage Controlled Néel Vector Rotation in Zero Magnetic Field**, ***Christian Binek***, *A. Mahmood,* University of Nebraska-Lincoln; *W. Echtenkamp,* University of Minnesota; *M. Street, J. Wang, S. Cao, T. Komesu, P. Dowben, P. Buragohain, H. Lu, A. Gruverman, A. Parthasaraty, S. Rakheja,* University of Nebraska-Lincoln; *J. Weaver, J. Lynn,* NIST-Gaithersburg **INVITED**

Voltage-controlled switching of remnant magnetic states paves the way towards ultra-low power and non-volatile spintronics. In this presentation, I report on a decade-long journey which took us from isothermal electric switching of exchange bias with the help of simultaneously applied electric and magnetic fields to pure voltage-controlled antiferromagnetic spintronics in zero magnetic field and at CMOS compatible temperatures. Nonvolatile Néel vector reorientation in the absence of an applied magnetic field, *H*, is demonstrated at CMOS compatible temperatures in prototype device structures which exploit the multi-functional properties of thin films of boron (B) doped Cr_2O_3. Boundary magnetization associated with the Néel vector orientation serves as state variable which is read via magnetoresistive detection in a Pt Hall bar adjacent to the B: Cr_2O_3 film. Switching of the Hall voltage between zero and non-zero values implies Néel vector rotation by 90-degrees in agreement with the observed voltage dependent contrast in magnetic force microscopy images. Piezo force microscopy data suggest the presence of polar nanoregions which give rise to uniform polarization in the presence of an applied electric field. The polarization is accompanied piezoelectric straining which, via magnetoelastic coupling, changes the magnetic anisotropy and thus the Néel vector orientation from out of plane to in-plane and back. B-doping enhances the Néel temperature, T_N, of pure chromia. Annealing of the device further increases the T_N-enhancement (up to 500K) at the interface between the Hall bar and the B: Cr_2O_3 surface via thermally activated B-diffusion. The diffusion mechanism is confirmed via cold neutron depth profiling measurements. Robust switching is demonstrated post-annealing for temperature as high as 400K. Theoretical modeling estimates switching speeds of about 100 ps making B: Cr_2O_3 a promising multifunctional single-phase material for energy efficient nonvolatile CMOS compatible memory applications.

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8:40am **MI-WeM-3 Discovering Magnetic Mechanisms in Room-Temperature Metallic Antiferromagnet Fe_3Ga_4**, ***Michelle Jamer***, *B. Wilfong,* United States Naval Academy; *D. Baigutlin, O. Miroshkina, V. Buchelnikov, V. Sokolovskiy,* Chelyabinsk State University, Russian Federation; *G. Stephen, A. Friedman,* Laboratory for Physical Sciences; *R. Barua,* Virginia Commonwealth University; *B. Barbiellini,* LUT University, Finland; *D. Heiman,* Northeastern University **INVITED**

Recently, Fe_3Ga_4 has garnered much interest due to its unique magnetic structure which supports two unique magnetic transitions- one metamagnetic transition at low temperature to an antiferromagnetic helical spin structure (~70 K), and a second transition between the antiferromagnetic state to ferromagnetic state (~360 K). Due to the helical spin structure of the intermediate antiferromagnetic state, metallicity is not prohibited leading to the possibility of a room temperature metallic antiferromagnet, which is attractive for potential spintronic devices. Of particular interest, is fully understanding the magnetic phase diagram and the Fe-Fe coupling in the lattice which gives rise to the special helical ordering. In our work, we have prepared bulk ingots and single crystals of this compound to understand the magnetic coupling of Fe_3Ga_4 to determine the baseline properties. Through adding pressure to the system, we have found that we are able to change the transition temperatures of the magnetic states- leading to an increase in the low temperature transition and a decrease in the high temperature transition. In these measurements, we have found that we are able to tune the high temperature transition to room temperature by adding pressure -while the structure retains its metallicity. A full discussion on the baseline Fe_3Ga_4 as well as its changes with pressure will be presented, including theoretical calculations supporting the magnetic structure as detected via magnetometry measurements.

11:00am **MI-WeM-10 Irradiative Control of FeRh's Metamagnetic Phase Change Under Three-Dimensional Spatial Confinement Interrogated by Polarized Neutron Scattering**, ***Steven Bennett,*** Naval Research Laboratory **INVITED**

Phase change materials have been a staple for a wide array of memory technologies for many decades. The promise of antiferromagnetic electronics has pushed the envelope past using a straight forward resistive phase change, to the realm of high speed spin flipping, incommensurate spin density waves and magnonics which can propagate without a local magnetic anisotropy to hinder spin rotation. In this new memory paradigm we will need to develop a new set of materials and understanding of spin physics from which to build this next generation of high speed and low energy loss devices. In this seminar I will provide an overview of my teams recent discoveries on how the metamagnetic transition in FeRh, from antiferromagnetic to ferromagnetic ordering, can be controlled and triggered using low energy heavy and light ion irradiation [1][2], as well as joule heating in confined wire device geometries at high switching speeds. We interrogate the complexities of these spin systems using polarized neutron scattering, revealing highly localized effects of ion irradiation in the films and uncover a new effect for metamagnetic spin dynamics which could be pivotally important for modern antiferromagnetic spintronics.

[1] S.P. Bennett et. Al., Coatings, 11(6), 661, (2021)

[2] C. D. Cress et. Al., ACS Appl. Mater. Interfaces 13, 1, 836–847, (2021)

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