MA 3: Complex Magnetic Oxides

Time: Monday 9:30–12:45 Location: POT/0112

MA 3.1 Mon 9:30 POT/0112

Twisted planar freestanding La0.7Sr0.3MnO3 junctions — •Alejandro Martín Merodio, Victor Rouco, Fernando Gallego, David Sanchez-Manzano, Carlos León, and Jacobo Santamaria — GFMC, Dpto. de Física de Materiales, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, 28040 Madrid, Spain

The recent realization of membranes of transition metal oxides has enabled their mechanical assembly in twisted bilayers opening avenues to wards oxide twistronics. The ferroic orders hosted by transition metal oxides, many of which are stable at room temperature, offer exciting opportunities for the search of chiral ferroic properties in twisted ox ide membranes. In this work we present the growth, fabrication and characterization of twisted stacks made of La0.7Sr0.3MnO3 (LSMO), a half-metallic ferromagnetic perovskite with highly tunable properties. We have studied the temperature dependent magnetotransport across the interface of two twisted LSMO membranes for different twisting angles. These samples exhibit a large low temperature magnetoresistance MR up to 32% which switches abruptly at small (10 mT) magnetic fields. These MR values are well above the 0,01% AMR typically observed in single LSMO flakes. This approach allows exploring material combinations which are not possible in epitaxial heterostructures and opens promising avenues towards oxide based CMOS compatible spintronic devices.

MA 3.2 Mon 9:45 POT/0112

Controlling Magnetic Anisotropy in Barium Hexaferrite by Cation Doping — •Jakob Baumsteiger[1,2] and Cesare Franchini[1,2] — [1]Faculty of Physics and Center for Computational Materials Science, University of Vienna, Vienna, Austria — [2]Department of Physics and Astronomy "Augusto Righi", Alma Mater Studiorum - Università di Bologna, Bologna, Italy

Circulators are essential components in many radio-frequency systems, including 5G base stations. Their operating frequency is primarily determined by the magnetic properties of the ferrite core - specifically the anisotropy field and the saturation magnetization. Experimental studies suggest that both quantities can be actively modified in barium hexaferrite - one of the ferrites commonly used in circulators - through cation doping. However, the relationship between doping and the resulting magnetic properties is highly complex and not yet fully understood. We investigate the electronic structure of pristine and cobalt-doped barium hexaferrite using density functional theory. Our calculations show that the additional electron introduced by cobalt plays a key role in modifying the material's magnetocrystalline anisotropy. By occupying a localized orbital at the cobalt site, it locally activates spin-orbit interactions, leading to substantial changes in the magnetocrystalline anisotropy energy even at low doping concentrations. The insights gained from our results support the design of miniaturized circulators capable of operating over broad frequency bands.

MA 3.3 Mon 10:00 POT/0112

Emergent magnetic ordering in high-entropy oxides — •Laura T. Corredor[1,2], Augustè Stanionytè[3], Richard Matyšek[3], Anja U. B. Wolter[4], Carlos F. Eugenio[2,5], Andrea Kirsch[2,5], Giuditta Perversi[6], and Anna Isaeva[1,2,3] — [1]TU Dortmund University, Germany — [2]Research Center Future Energy Materials and Systems, Germany — [3]University of Amsterdam, The Netherlands — [4]Leibniz IFW Dresden, Germany — [5]Ruhr University Bochum, Germany — [6]Maastricht University, The Netherlands

Magnetism in high-entropy oxides (HEOs) has emerged as a compelling topic due to the unique behavior arising from extreme cationic disorder. HEOs offer a rich platform for fundamental studies and are promising for applications like energy-efficient magnetic devices and catalysts. Recently, long-range magnetic order was reported in some HEOs, e.g. the AFM rocksalt $(Co_{0.2}Ni_{0.2}Cu_{0.2}Mg_{0.2}Zn_{0.2})O$[1] and cubic perovskite $La(Cr_{0.2}Mn_{0.2}Fe_{0.2}Co_{0.2}Ni_{0.2})O$[2], demonstrating that HEOs can host long-range magnetic order despite substantial chemical disorder. We present the exploration of magnetism across three HEO families: (1) cubic perovskites $BaIn_{1-x}M_xO_{3-\delta}$[3], (2) spinel M_3O_4 and (3) rocksalt MO. The M site is shared by up to five (post-)transition metals. Some members of the M_3O_4 family exhibit remarkably high T_N up to 618 K, highlighting its potential for stabilizing robust magnetic interactions. In contrast, $BaIn_{1-x}M_xO_{3-\delta}$ display glassy behavior. We examine how chemical complexity shapes magnetic properties across these families. [1] Chem. Mat. 2019 31 (10), 3705-3711. [2] Adv. Sci. 2022, 9, 2200391. [3] Solid State Ionics (2024) 427, 116901.

MA 3.4 Mon 10:15 POT/0112

Exploring the electronic structure of (111)-oriented $La_{0.7}Sr_{0.3}MnO_3$ through soft X-ray ARPES and DFT — •Øyvind Finnseth, Sverre M. Selbach, Hendrik Bentmann, and Ingrid Hallsteinsen — NTNU, Trondheim, Norway

While $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) has been widely studied due to its room-temperature ferromagnetism and half-metallicity, the majority of work has been focused on thin films in the (001)-orientation. The less conventional (111)-orientation has received far less attention despite its distinct intriguing properties, including sixfold in-plane magnetic anisotropy and enhanced interfacial coupling in heterostructures. As such, a full description of the electronic structure of LSMO in this orientation is lacking. Here, we consider epitaxial thin films of LSMO grown by pulsed laser deposition on (111)-oriented $SrTiO_3$ substrates. We first develop an in-vacuum methodology for surface preparation of the films by annealing in an oxygen atmosphere. The electronic band structure of the films is probed by soft X-ray angle-resolved photoemission spectroscopy (ARPES) using a synchrotron lightsource. The tunability of the photon energy allows for precise control of the probed out-of-plane momentum, yielding a full description of the LSMO electronic band structure. Density functional theory (DFT) calculations are performed to obtain the theoretical band structure of bulk LSMO modeled through the use of the special quasirandom structures approach. By comparing the calculated band structure to the experimental results, we find that the DFT calculations are able to accurately predict the LSMO electronic band structure.

MA 3.5 Mon 10:30 POT/0112

Unveiling the Origins of Strong Magnetostriction in Cobalt Ferrite using neutron scattering. — •Guratinder Kaur — School of Physics and Astronomy, The University of Edinburgh, UK

Cobalt ferrite (CoFe2O4, CFO) stands out among advanced functional materials due to its exceptional magnetostrictive behaviour. This property allows its shape to be influenced by its magnetic state, making it desirable for various technological applications such as electronic devices, ferrofluids, magnetic drug delivery, microwave devices, and high-density information storage1-3. The present study provides a comprehensive investigation using neutron diffraction to explore the interplay between CFO's nuclear and magnetic structures4 across varying temperatures. This study complements our recent inelastic neutron scattering (INS) experiments on single crystal and powder samples. The combined data, along with our INS findings and developed excitonic theory, will provide a deeper understanding of the underlying mechanism responsible for CFO's strong magnetostrictive effect5. This knowledge will be valuable for designing novel materials with precisely controlled magnetostrictive properties for applications in areas like sensors and actuators6. References: 1)*Slonczewski J C, Phys. Rev. 110 1341 (1958). 2)*Zheng H et al., Science 303 661 (2004). 3)*Bhame S D et al., J. Appl. Phys. 100 113911 (2006). 4)*Teillet et al., J. Mag. Magn. Mater. 123, 93 (1993). 5)*Lane et al., Adv. Funct. Mater. 2025, e16830. 6)*Chen Y, et al., IEEE Trans. Magn. 35 3652 (1999).

MA 3.6 Mon 10:45 POT/0112

Polarized Neutron Scattering Studies on SDW Order in $Sr_{1.5}Ca_{0.5}RuO_4$ and $Sr_2Ru_{0.95}Co_{0.05}O_4$ — •Felix Wirth[1], Yvan Sidis[2], Paul Steffens[3], Kevin Jenni[1], Agustinus Agung Nugroho[4], Karin Schmalzl[5], Mechthild Enderle[3], and Markus Braden[1] — [1]II. Physic. Inst., Univ. Cologne, Germany — [2]LLB, CEA Saclay, France — [3]ILL, Grenoble, France — [4]Inst. Teknologi, Bandung, Indonesia — [5]JCNS Outst. ILL, Grenoble, France

Superconductivity in Sr_2RuO_4 emerges close to magnetic instabilities from Fermi-surface nesting at incommensurate $Q^{\alpha\beta} \approx$(0.3,0.3,L) and $Q^{\gamma} \approx$(0.15,0.15,L)[1]. In $Sr_{1.5}Ca_{0.5}RuO_4$ the anisotropic fluctuations at $Q^{\alpha\beta}$ condense into a c-axis polarized spin-density-wave[2]. Polarized inelastic neutron scattering reveals an unusual hierarchy of excitations with enhanced longitudinal modes. In contrast, transverse modes are suppressed, although their energy dependence remains similar to that of the parent compound. Above the SDW transition, longitudinal

and transverse contributions show a split response, incompatible with tetragonal symmetry and suggestive of electronic nematicity. Ti^{4+} and Mn^{3+} substitution stabilise the same static order at $Q^{\alpha\beta}$[3]. By contrast, 5% Co doping does not yield the expected ferromagnetic cluster glass but a new magnetic order at Q≈(0.2,0.2,0) with intensity following the Ru^{4+} form factor that cannot be attributed to the known nesting vectors in this system. [1] Jenni, K. et al., Phys. Rev. B 103, 104511 (2021), [2] Kunkemöller, S. et al., Phys. Rev. B 89, 045119 (2014), [3] Braden, M. et al., Phys. Rev. Lett. 88, 197002 (2002)

15 min break

MA 3.7 Mon 11:15 POT/0112

Magnetic structure and magnetic excitations of the triple layer $Sr_4Ru_3O_{10}$ — •Lara Kiefer[1], Zahrasadat Ghazinezhad[1], Felix Wirth[1], Jens Mettler[1], Ursula Bengaard Hansen[2], Paul Steffens[2], Oksana Zaharko[3], Vladimir Pomjakushin[3], Karin Schmalzl[4], Devashibhai Androja[5], Augustinus Agung Nugroho[6], and Markus Braden[1] — [1]Inst. Phys. 2, Cologne, Germany — [2]ILL, Grenoble, France — [3]PSI, Villingen, Switzerland — [4]JCNS Out. ILL, Grenoble, France — [5]ISIS, Didcot, UK — [6]FMIPA ITB, Badung, Indonesia

The triple-layer transition-metal oxide $Sr_4Ru_3O_{10}$ is a member of the Ruddlesden-Popper series with a layered orthorhombic structure. It is a ferromagnetic metal (T_C=105 K) with an additional metamagnetic transition below 60 K. The nature of the intermediate phase is still under debate. Using multiple neutron diffraction techniques, we were able to determine its magnetic structure. Our inelastic neutron experiments revealed a parabolic, isotropic dispersion with a stiffness constant comparable to that of $SrRuO_3$ [1,2]. However, the spin-wave scattering at low constant energy transfer deviates from the expected isotropic ring, and the stiffness increases upon heating, mirroring $SrRuO_3$ [1,2]. Polarized neutron measurements reveal longitudinal spin excitations inside the ferromagnetic phase. These amplitude-type fluctuations are unexpected in a standard Heisenberg ferromagnet, suggesting the emergence of a new class of magnetic excitations beyond conventional transverse magnons. [1] K. Jenni et al., Phys. Rev. B 107, 174429 (2023). [2] K. Jenni et al., Phys. Rev. Lett. 123, 017202 (2019).

MA 3.8 Mon 11:30 POT/0112

Multi-length scale investigation of the Perovskite-Brownmillerite topotactic phase transition in $La_{0.7}Sr_{0.3}MnO_{3-\delta}$ thin films — •C. Yin[1,2], X. Bai[3], Z. Xu[4], V. Lauter[5], S. Zhou[6], F. Gunkel[7], L. Cao[2,8], G. Puebla Hellmann[4], R.E. Dunin-Borkowski[3], and O. Petracic[2,1] — [1]Faculty of Mathematics and Natural Sciences, Heinrich Heine University Düsseldorf — [2]Jülich Centre for Neutron Science (JCNS-2), JARA-FIT, Forschungszentrum Jülich GmbH — [3]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons (ER-C), JARA-FIT, Forschungszentrum Jülich GmbH — [4]QZabre LLC, Zürich, 8050, Switzerland — [5]Neutron Scattering Division, Neutron Sciences Directorate, Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA — [6]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR) — [7]Peter Grünberg Institut (PGI-7), JARA-FIT, Forschungszentrum Jülich GmbH — [8]School of Advanced Materials, Peking University, Shenzhen Graduate School, Shenzhen, 518055, China

In $La_{0.7}Sr_{0.3}MnO_{3-\delta}$, the introduction of oxygen vacancies induces a topotactic phase transition from the perovskite phase to an oxygen-vacancy ordered Brownmillerite phase. The influence of oxygen vacancies on near-surface magnetic domains is probed via Nitrogen-Vacancy (NV) magnetometry. Polarized Neutron Reflectometry (PNR) provide depth-resolved magnetization profiles and oxygen stoichiometry. Scanning Transmission Electron Microscopy (STEM) elucidates the atomic structure and depth-dependent oxidation states.

MA 3.9 Mon 11:45 POT/0112

Probing Spin-Waves and Spin-Phonon Coupling in a Double Perovskite Oxide: A Raman Study — •Akriti Singh and Surajit Saha — Indian Institute of Science Education and Research Bhopal, Bhopal, India

Double perovskites have emerged as a promising class of materials to explore the novel magnetic phenomena. This includes high-TC magnetic orderings, spin-reorientation, magnetostriction, and multiferroicity due to the presence of complex spin arrangements, competing exchange pathways or magneto-elastic couplings. Here, we report the evolution of magnetic excitations in Ca2NiWO6 using inelastic light scattering and explore the complex interplay between the lattice and spin degrees of freedom. To get insights into the underlying magnetic dynamics, we performed temperature-dependent magnetization, x-ray diffraction, and Raman spectroscopic measurements. Our results indicate an antiferromagnetic ground state below 50 K along with signatures of magnetostriction and spin-phonon coupling. Additionally, we employ magneto-Raman spectroscopy to probe the low-energy spin-waves (magnons), providing evidence of the nature and origin of magnetism in the system. Taken together, our findings on Ca2NiWO6 highlight its potential as a fertile ground to study the complex magnetic phenomena arising due to its exchange interactions, suggesting that it may be a possible candidate for applications in spintronics, magnonics, and other advanced spin-based technologies.

MA 3.10 Mon 12:00 POT/0112

resonant inelastic x-ray scattering spectra of the dynamic jahn-teller Cu^{2+} center in $CuAl_2O_4$ — •Takumi Gengo[1], Kenta Touge[2], Ara Go[3], and Naoya Iwahara[1] — [1]Graduate School of Engineering, Chiba University, Chiba, Japan — [2]Department of Materials Science, Faculty of Engineering, Chiba University, Chiba, Japan — [3]Department of Physics, Chonnam National University, Gwangju, South Korea

Cu spinel compounds such as $CuAl_2O_4$ and $CuGa_2O_4$ attract attention as spin-orbit entangled magnets. The density mean-field theory calculations show that the spin-orbit coupling on the Cu site suppresses the Jahn-Teller deformation in the ground state, which is consistent with the x-ray diffraction data. On the contrary, recent resonant inelastic x-ray scattering (RIXS) measurement of $CuAl_2O_4$ suggests the possibility that the Jahn-Teller deformation develops. Such a contradictory situation could occur due to the development of the dynamic Jahn-Teller effect .

This study aims to theoretically elucidate the nature of quantum states on Cu sites induced by the competition between spin-orbit and electron-phonon (vibronic) couplings. We successfully reproduced the Cu L_2- and L_3-edge RIXS spectra based on our model with the quantum mechanical treatment of the lattice degrees of freedom (i.e., dynamic Jahn-Teller effect), which is consistent with the structural data. This study supports the former theoretical prediction that $CuAl_2O_4$ is a 3d spin-orbit coupled magnet.

MA 3.11 Mon 12:15 POT/0112

EMCD analysis of ferrimagnetic moments changes in Ti-doped barium hexaferrite — •Hitoshi Makino[1], Rolf Erni[2], Devendra Singh Negi[3], Ján Rusz[4], Bernd Rellinghaus[1], and Darius Pohl[1] — [1]DCN, TU Dresden, Dresden, Germany — [2]Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland — [3]Indian Institute of Technology Jodhpur, Jodhpur, India — [4]Uppsala University, Uppsala, Sweden

Barium hexaferrite ($BaFe_{12}O_{19}$) is a robust permanent magnet material with good thermal and environmental stability. Small substitutions of Fe by Ti are known to enhance the coercivity at elevated temperatures. Our goal is to reveal changes of the ferrimagnetic arrangement of the moments by the Ti doping using electron energy-loss magnetic chiral dichroism (EMCD), an element- and site-specific probe of magnetic moments via electron energy-loss spectroscopy (EELS). We modified a highly accurate classical EMCD methodology with an improved signal-to-noise ratio, enabling the quantitative deconvolution of the Fe-$L_{2,3}$ edges into oxidation- and site-resolved magnetic contributions. The results suggest that the magnetic structure changes primarily at the tetrahedral site. Using the recently established atomic-resolution electron vortex beam EMCD, we verified these results from an alternative perspective. These measurements reveal a threefold supersymmetry in the magnetic-moments, consistent with the symmetry of the site occupied by Ti substitution identified in the STEM-EELS elemental map. These observations deepen our understanding of magnetic structure changes induced by Ti doping in barium hexaferrite.

MA 3.12 Mon 12:30 POT/0112

Long-range spin density wave order in bilayer nickelates revealed by neutron diffraction — •Igor Plokhikh — TU Dortmund University, Department of Physics, 44227 Dortmund, Germany — Research Center Future Energy Materials and Systems, 44227 Dortmund, Germany

The observation of pressure-induced superconductivity in Ruddlesden Popper nickelates has triggered renewed interest in their magnetic ground states as potential precursors to unconventional superconduc-

tivity [1]. Using high-intensity neutron powder diffraction (NPD) complemented by muon-spin rotation/relaxation (μSR), we directly resolve long-range spin-density-wave (SDW) order in bilayer $La_3Ni_2O_7$ and $La_2PrNi_2O_7$ below 150 K [2].

Magnetic Bragg reflections appear at propagation vectors $q_1 = (0, \frac{1}{2}, 0)$ for both compounds and an additional vector $q_2 = (\frac{1}{2}, \frac{1}{2}, 0)$ exclusively in undoped $La_3Ni_2O_7$. Representation analysis reveals amplitude-modulated SDW structures composed of alternating low- ($\approx 0.05\ \mu_B$) and high-moment ($\approx 0.7\ \mu_B$) Ni sites forming antiferromagnetically stacked bilayers along the c-axis. The coexistence of two distinct stacking polymorphs corresponding to q_1 and q_2 reflects quasi-two-dimensional magnetic order intrinsic to this system.

These findings provide the first direct neutron evidence for SDW order in bilayer nickelates and offer crucial insights into their ground state.

[1] Wang et al., Chinese Phys. Lett. 41, 077402 (2024).
[2] Plokhikh et al., arXiv:2503.05287(2025).