MA 8: Altermagnets II

Time: Monday 15:00–18:30 Location: HSZ/0002

MA 8.1 Mon 15:00 HSZ/0002

Odd-parity spin splitting and anomalous Hall effect in spiral magnets — •Shun Okumura[1,2], Moritz M. Hirschmann[2], and Yukitoshi Motome[3] — [1]Quantum-Phase Electronics Center, The University of Tokyo, Tokyo, Japan — [2]RIKEN Center for Emergent Matter Science, Wako, Japan — [3]Department of Applied Physics, The University of Tokyo, Tokyo, Japan

Altermagnetism with collinear antiferromagnetic order has recently attracted considerable interest for a spontaneous anomalous Hall effect (AHE) mediated by spin-orbit coupling (SOC). In contrast, noncoplanar magnetic textures such as skyrmions exhibit a topological Hall effect by imprinting a Berry phase on itinerant electrons even in the absence of SOC. However, in the case of spiral magnetism, a prototypical example of a non-collinear and coplanar magnetic structure, the conditions required to realize AHE have yet to be thoroughly explored.

In this study, we investigate the AHE in metallic systems coupled to commensurate spiral magnetic textures. The electronic bands exhibit odd-parity spin splitting with spin polarization perpendicular to the helical plane. In the presence of SOC and finite magnetization, the Berry curvature concentrated along the spin-nodal lines leads to a characteristic AHE in the spin spiral state. This spiral-induced AHE depends sensitively on the SOC type, helical plane, and magnetization direction. We also demonstrate that a "p-wave" magnet with a commensurate spin spiral, recently identified in an f-electron material, can host this enormous AHE.

MA 8.2 Mon 15:15 HSZ/0002

Pines' Demons in d-Wave Altermagnets: From Hidden Modes to Fano-Demon States — •Habib Rostami[1] and Johannes Hofmann[2] — [1]Department of Physics, University of Bath, United Kingdom — [2]Department of Physics, Gothenburg University, Sweden

We develop a Fermi-liquid description of d-wave altermagnets and analyze their charge and spin collective excitations [1]. In addition to the conventional undamped plasmon, where both spin components oscillate in phase, we find an acoustic plasmon (demon) mode with out-of-phase spin dynamics. Using the dynamical structure factor, we show that the demon frequency and spectral weight depend sensitively on the Landau parameters and on the propagation direction. As a function of angle, the acoustic mode evolves from a hidden state with vanishing spectral weight in the density response, to a weakly damped propagating demon, and, below a critical interaction parameter, to a Fano-demon mixed state that strongly hybridizes with particle-hole excitations and exhibits an asymmetric line shape. We briefly discuss possible implications for probing and exploiting collective electron spin oscillations in altermagnetic materials.

[1] H. Rostami and J. Hofmann, Fermi liquid theory of d-wave altermagnets: demon modes and Fano-demon states, arXiv:2505.07083, to appear in Physical Review Letters.

MA 8.3 Mon 15:30 HSZ/0002

Studying altermagnetism with muon-spin spectroscopy — •Thomas Hicken[1], Jonas Kreiger[1], Jennifer Graham[1], Zurab Guguchia[1], Franziska Walther[2], Kristin Kliemt[2], Cornelius Krellner[2], Helena Reichlova[3], Klára Uhlířová[4], Juraj Krempaský[1], Nirmal Ghimire[5], and Hubertus Luetkens[1] — [1]PSI, Switzerland — [2]Goethe-Universität Frankfurt, Germany — [3]Czech Academy of Science, Czech Republic — [4]École Polytechnique Fédérale de Lausanne, Switzerland — [5]University of Notre Dame, USA

With properties of both ferro- and antiferro-magnets, altermagnetism is of interest for fundamental physics and spintronic applications. Understanding the magnetic structure, and hence magnetic symmetries, is of utmost importance. Further, it has been suggested that altermagnets may have unique dynamic fluctuations. To answer these questions, muon spin spectroscopy (μSR) measurements provide information that is complementary to, and unique from, other probes. I will discuss how we are using μSR to probe a number of materials, including $Co_{1/4}NbSe_2$ [1], a proposed g-wave altermagnet, Ce_4Sb_3, which shows promise as an altermagnet with $4f$ moments, and MnTe [2], which is perhaps the best studied altermagnet so far. Our measurements, combined with muon stopping site calculations, reveal the sometimes unexpected magnetic structure of candidate altermagnetic materials, and test some of the key predictions of altermagnetism.

[1] J. N. Graham, T. J. Hicken et al., arXiv:2503.09193 (2025).
[2] T. J. Hicken et al., arXiv:2507.14710 (2025).

MA 8.4 Mon 15:45 HSZ/0002

Broadband nonlinear Hall response and multiple wave mixing in a room temperature altermagnet — •Berthold Jaeck — HKUST, Department of Physics, Clear Water Bay, Kowloong, Hong Kong

Altermagnets are characterized by magnetic crystal order that manifests in a non-relativistic spin-splitting of the electronic bands. Their electric material properties should thus be determined by the underlying symmetries. We report the discovery of a broadband third-order nonlinear anomalous Hall effect in altermagnetic CrSb at room temperature that exhibits a distinct spatial anisotropy [1]. The comparison of our experimental observations with symmetry analyses and model calculations shows that this nonlinear Hall response is induced by the nonlinear electric susceptibility of a Berry curvature quadrupole. This quadrupole precisely reflects the magnetic and crystalline symmetries encoded in the altermagnetic g-wave order parameter. We then utilize the nonlinear electric susceptibility of CrSb to realize a multiple wave mixing device with pronounced four wave mixing output. Our study provides a generalized understanding of the impact of magnetic crystal order on the electric material properties of altermagnets and significantly expands their technological scope to include high-frequency applications up to the THz regime.

We acknowledge funding by the Hong Kong RGC (Grant Nos.26304221, 16302422, 16302624, and C6033-22G) and the Croucher Foundation (Grant No.CIA22SC02).

[1] S. Sankar et al., arXiv:2511.10471 [cond-mat.mes-hall] (2025)

MA 8.5 Mon 16:00 HSZ/0002

Ce_4Sb_3: A Kondo metal as candidate for d-wave altermagnetism — •Franziska Walther[1], Thomas J. Hicken[2], Venkata Krishna Bharadwaj[3], Julian Kaiser[4], Bin Shen[4], Jan Priessnitz[5], Rahel Ohlendorf[6], Michelle Ocker[1], Alexander Fedorov[7], Anton Jesche[4], Hubertus Luetkens[2], Philipp Gegenwart[4], Elena Gati[7], Denis Vyalikh[8], Libor Šmejkal[5], Jairo Sinova[3], Cornelius Krellner[1], and Kristin Kliemt[1] — [1]Uni Frankfurt, Germany — [2]PSI, Switzerland — [3]Uni Mainz, Germany — [4]Uni Augsburg, Germany — [5]MPI PKS Dresden, Germany — [6]MPI CPfS Dresden, Germany — [7]HZB Berlin, Germany — [8]DIPC Donostia, Spain

The study of altermagnetic materials has been focused so far on magnetic d-systems. Here, we present Ce_4Sb_3 as a lanthanoid-based altermagnetic candidate to study the altermagnetism arising from local $4f$ moments, where magnetism is mediated indirectly by the RKKY interaction. Below 4 K, the cubic compound Ce_4Sb_3 orders magnetically and d-wave altermagnetism is theoretically predicted. Furthermore, the material shows Kondo behaviour, enabling it to be a promising candidate to study pressure-induced quantum critical phenomena in systems with altermagnetic spin fluctuations. Here, we report on the single crystal growth by the Czochralski method in a quasi-crucible free high pressure setup, the physical characterization of the magnetic ground state and a first study by angle-resolved photoemission and muon spin spectroscopy.

MA 8.6 Mon 16:15 HSZ/0002

Optical Kerr Signatures in d-wave and g-wave Altermagnets — •Luca Felipe Haag[1], Paul Herrgen[1], Jairo Sinova[2], Benjamin Stadtmüller[3], Martin Aeschlimann[1], and Hans Christian Schneider[1] — [1]Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau, Germany — [2]Institut für Physik, Johannes Gutenberg University, Mainz — [3]Experimentalphysik II, Institute of Physics, University of Augsburg, Germany

The non-relativistic spin splitting in the electronic states of altermagnets makes them promising candidates for next-generation spintronic materials [1,2], but the identification and characterization of these materials is difficult. In a previous study, we demonstrated that altermagnets show intriguing time-dependent magneto-optical properties when

probed by ultrashort pulses, which are linked to their particular spin symmetries [3]. In this contribution we analyze the pump-induced Kerr response of different candidate materials in detail. To this end, we theoretically investigate the probe response due to the pump induced birefringence and explain how to distinguish between anisotropic charge carrier distributions and magnetic signatures. Our results suggest that pump-probe Kerr microscopy is a viable tool to image the domain structure of specific altermagnets.

[1] Šmejkal et al., Phys. Rev. X 12, 040501 (2022) [2] Šmejkal et al., Phys. Rev. X 12, 031042 (2022) [3] Weber et al., arXiv:2408.05187 (2024)

MA 8.7 Mon 16:30 HSZ/0002

Ferroelectricity-driven altermagnetism in two-dimensional van der Waals multiferroics — •Bo Zhao[1], Fu Li[1], Wei Ren[2], Hao Wang[1], and Hongbin Zhang[1] — [1]Theory of Magnetic Materials, Institute of Materials Science, Technical University of Darmstadt, 64287 Darmstadt, Germany — [2]Institute for Quantum Science and Technology, State Key Laboratory of Advanced Refractories, Materials Genome Institute, Physics Department, Shanghai University, Shanghai 200444, China

Altermagnets (AMs) are an unconventional class of collinear compensated antiferromagnets that exhibit momentum-dependent spin splitting despite zero net magnetization. Using spin space group (SSG) symmetry analysis and first-principles calculations, we show that altermagnetism in two-dimensional multiferroics can be efficiently controlled by ferroelectric polarization and interlayer sliding. As a material platform, monolayer and bilayer $FeCuP_2S_6$ display finite spin splitting when ferroelectric sublattices are linked by nonsymmorphic screw-axis operations instead of pure translation or inversion. Interlayer sliding allows reversible switching or suppression of this spin splitting through SSG modifications. We further find that the anomalous Hall response directly probes these spin-split states. These results highlight 2D van der Waals multiferroics as promising systems for electrically tunable altermagnetism and next-generation spintronic applications.

[1] B. Zhao et al. arXiv:2511.00712.

15 min break

MA 8.8 Mon 17:00 HSZ/0002

Elastocaloric probing and tuning of multipolar order in the altermagnet MnF_2 — •Rahel Ohlendorf[1,2], Luca Buiarelli[3], Hilary M. L. Noad[1], Andrew P. Mackenzie[1,4], Rafael M. Fernandes[5], Turan Birol[3], Jörg Schmalian[6], and Elena Gati[1,2,7] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Technische Universität, Dresden, Germany — [3]University of Minnesota, Minneapolis, USA — [4]University of St Andrews, UK — [5]University of Illinois Urbana-Champain, Urbana, USA — [6]Karlsruhe Institute of Technology, Karlsruhe, Germany — [7]Goethe Universität, Frankfurt, Germany

Altermagnets break time-reversal symmetry without net magnetization [1], with the order parameter described by the ferroic ordering of multipoles rather than dipoles. In *d*-wave altermagnets, the predicted ferrooctupolar order couples to magnetic field and strain. In this talk, we demonstrate that elastocaloric experiments under strain and magnetic field are a powerful thermodynamic and symmetry-sensitive probe of the finite-temperature ferrooctupolar critical point. We resolve elastocaloric signatures of altermagnetic crossover lines and entropy accumulation. By combining our experiments with DFT calculations, we provide a micrsopic explanation for the size of the observed thermodynamic effects. As a result, we outline the route to stronger thermodynamic responses in insulating and metallic altermagnets (both *d*-wave and *g*-wave), establishing elastocaloric measurements as a key probe of altermagnetic criticality.

[1] L. Šmejkal et al., Phys. Rev. X 12, 031042 (2022)

MA 8.9 Mon 17:15 HSZ/0002

Optical phonons as a testing ground for spin group symmetries — Felix Schilberth[1], Mark Kondákor[4], Denis Ukulov[2], Lilian Prodan[1], Alexander Tsirlin[3], Peter Lemmens[2], Karlo Penc[4], Istvan Kézsmárki[1], and •Joachim Deisenhofer[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, Institute for Physics, University of Augsburg, D-86159 Augsburg, Germany — [2]Institute of Condensed Matter Physics, TU Braunschweig, Mendelssohnstr. 3, 38106 Braunschweig, Germany — [3]Felix Bloch Institute for Solid-State Physics, Leipzig University, 04103 Leipzig, Germany — [4]Institute for Solid State Physics and Optics, HUN-REN Wigner Research Centre for Physics, H-1525 Budapest, P.O.B. 49, Hungary

We present a detailed study of the infrared- and Raman-active modes in the collinear antiferromagnet and altermagnet candidate $Co_2Mo_3O_8$. Comparing to *ab initio* calculations accurately capturing the eigenfrequencies, we identify all expected phonon modes at room temperature and deduce their selection rules with the magnetic point group and the spin group. We observe the change of selection rules upon antiferromagnetic ordering, agreeing with the relativistic symmetry approach, while the spin group formalism predicts no changes. Therefore, optical phonons sensing the symmetry of the magnetic order can reveal if relevant magnon-phonon coupling is compatible with the spin-group approach or not.

MA 8.10 Mon 17:30 HSZ/0002

Optical properties of altermagnetic candidate MnTe — •Ece Uykur[1], Marcus Schmidt[2], Stephan Winnerl[1], and Alexander A. Tsirlin[3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany — [2]Max Planck Institute for Chemical Physics of Solids, 01067 Dresden, Germany — [3]Felix Bloch Institute for Solid-State Physics, University of Leipzig, 04103 Leipzig, Germany

MnTe is one of the promising altermagnetic candidates, where the band splitting, which is a key feature of altermagnetic materials, are confirmed via angle-resolved photoemission spectroscopy (ARPES) [1] and inelastic neutron scattering [2] experiments. In the next step, control of this unique property is desired. Given that in the spin configuration level the compound is antiferromagnetic, light control is a promising route in this regard.

Here, we present optical characterization of MnTe. Broadband infrared spectroscopy (down to the THz regime) and Raman spectroscopy of the compound are reported. Relevant phonon and magnon responses are identified. Results suggest that unusual optical activity is present in MnTe and provide a promising route for light-matter interactions.

[1] J. Krempaský et al., Nature 626, 517 (2024)
[2] Z. Liu et al., Phys. Rev. Lett. 133, 156702 (2024)

MA 8.11 Mon 17:45 HSZ/0002

First-principles study on piezomagnetism in altermagnet CoF_2 — •Hiroshi Katsumoto[1,2], Kunihiko Yamauchi[2], and Tamio Oguchi[2] — [1]Division of Materials and Manufacturing Science, Graduate School of Engineering, The University of Osaka, Suita, Japan — [2]Center for Spintronics Research Network, The University of Osaka, Toyonaka, Japan

Altermagnetic materials have recently attracted considerable interest due to their characteristic spin splitting in the absence of spin–orbit coupling (SOC). Among them, CoF_2 is notable not only for its altermagnetic band structure but also for its longstanding classification as a piezomagnetic material with large piezomagnetic coefficients [1]. Nevertheless, the microscopic link between its electronic structure and mechanical response has not been fully clarified. In this study, we investigate the origin of piezomagnetism in CoF_2 by means of first-principles calculations. We identify two distinct mechanisms: one driven by SOC-induced anisotropic spin–lattice coupling, and the other emerging from the SOC-independent spin splitting inherent to altermagnetism. By examining how strain influences the electronic states through these mechanisms, we gain new microscopic insights into piezomagnetism in CoF_2 and discuss implications for designing functional antiferromagnets with tailored magnetoelastic properties. This presentation was supported by JSPS KAKENHI Grand Number JP23H05457.

[1] M. Komuro *et al.*, Phys. Rev. B **111**, 214445 (2025).

MA 8.12 Mon 18:00 HSZ/0002

Influencing altermagnetic transitions by strain and layering — •Marnin Di Nunzio, Frank Lechermann, and Ilya Eremin — Institut für Theoretische Physik III, Ruhr-Universität Bochum, D-44780 Bochum, Germany

Altermagnets are collinearly ordered magnets, that break time-reversal symmetry, with a zero magnetization, and a spin-split band structure. By employing the minimal tight-binding Hubbard-like model within mean-field and rotationally invariant slave boson (RISB) approximation we explore the effect of uniaxial strain and electronic correlations on altermagnetism in mono- and bilayer systems. We single out two configurations of bilayer stackings and examine the altermagnetic transition and the effect of doping respectively. Following the application of uniaxial strain and doping in the monolayer, we uncover a fully spin-polarized Fermi surface. In the bilayer system doping itself is sufficient to achieve a complete metallic spin-polarization.

MA 8.13 Mon 18:15 HSZ/0002

Relativistically Distinct Altermagnetic States in α-Fe_2O_3 by X-ray Spectromicroscopy — •Rikako Yamamoto[1,2], Sina Mayr[3,4], Atsushi Hariki[5], Simone Finizio[3], Eugen Weschke[6], Markus Weigand[6], Libor Šmejkal[7], Jan Kuneš[8], Claire Donnelly[1,2], and Sebastian Wintz[6] — [1]MPI-CPfS, Dresden Germany — [2]WPI-SKCM[2] Hiroshima University, Hiroshima, Japan — [3]PSI, Villigen, Switzerland — [4]ETH, Zürich, Switzerland — [5]Osaka Metropolitan University, Osaka, Japan — [6]HZB, Berlin, Germany — [7]MPI-PKS, Dresden, Germany — [8]Masaryk University, Kotlářská, Czech Republic

In this study, we demonstrate the altermagnetic nature of α-Fe_2O_3 using x-ray magnetic linear and circular dichroism (XMLD and XMCD) spectroscopy and imaging. We observed an oscillatory XMCD signal for the x-ray beam along the *c*-axis, perpendicular to the net magnetization due to canting, which originates purely from altermagnetism.

Although the XMCD signal vanishes below the Morin reorientation transition as dictated by symmetry, we show that the x-ray absorption (XAS) alone provides sufficient contrast allowing to distinguish in- and out-of-plane orientations of the Néel vector. By combining the XMCD, XMLD and XAS contrast, we map out the continuous three-dimensional variation of the Néel vector in our samples. This approach can be broadly applied to a wide range of other materials.