MA 47: Altermagnets III

Time: Friday 9:30–11:00 Location: H20

MA 47.1 Fri 9:30 H20

Growth and spectroscopy of altermagnetic MnTe — •Marco Dittmar, Lena Hirnet, Hannes Haberkamm, Maximilian Ünzelmann, and Friedrich Reinert — Exp. Physik VII and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, Germany

As a new type of fundamental magnetic order next to ferro- and antiferromagnetism, altermagnetism has recently attracted great attention [1]. It is characterized by antiferromagnetic spin alignment combined with rotational lattice symmetry, which results in a momentum-dependent spin-split band structure with spin polarized electronic states. One of the "workhorse" materials potentially exhibiting this type of magnetic order is MnTe in its hexagonal NiAs-type crystal structure [1,2]. Here, we investigate MnTe thin films grown by molecular beam epitaxy. The high film quality is confirmed by structural characterization methods, while we assess the three-dimensional bulk band structure using soft X-ray angle-resolved photoemission spectroscopy. The experimentally observed spectral features agree well with band structure calculations and — based on that — the possible occurance of the characteristic momentum-dependent spin splitting will be discussed.

[1] L. Šmejkal *et al.*, Phys. Rev. X **12**, 031042 (2022)
[2] J. Krempaský *et al.*, *Nature* **626**, 517-522 (2024)

MA 47.2 Fri 9:45 H20

Phonon-mediated unconventional superconductivity in altermagnets: A solid-state analog of the A_1 phase of superfluid Helium 3 — •Kristoffer Leraand[1], Kristian Maeland[2], and Asle Sudbø[1] — [1]Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway — [2]Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany

We have considered the possibility of phonon-mediated unconventional superconductivity in a recently discovered new class of antiferromagnets, dubbed altermagnets. Within a weak-coupling approach, and using a minimal band model for altermagnets [1], we have found a dominant superconducting instability odd in momentum and even in spin with fully spin-polarized Cooper pairs, a 2D solid-state analog of the A_1-phase of superfluid Helium 3 [2]. We discuss the origin of this unusual result in terms of phonon-modes and electron form factors. [1] B. Brekke, A. Brataas, and A. Sudbø, PRB 108, 224421 (2023). [2] G. Volovik, The Universe in a Helium Droplet, Oxford Science Publications (2003). Work supported by Norwegian Research Council, through Grant No. 262633, "Center of Excellence on Quantum Spintronics", as well as Grant No. 323766.

MA 47.3 Fri 10:00 H20

Non-linear anomalous Edelstein response at altermagnetic interfaces — •Mattia Trama[1,2], Irene Gaiardoni[3], Claudio Guarcello[3,4], Jorge I. Facio[5], Alfonso Maiellaro[3,6], Francesco Romeo[3,4], Roberta Citro[3,4,6], and Jeroen van den Brink[1,2] — [1]IFW Dresden — [2]Würzburg-Dresden Cluster of Excellence ct.qmat — [3]Università degli studi di Salerno — [4]INFN - Sezione collegata di Salerno — [5]Centro Atomico Bariloche, Instituto de Nanociencia y Nanotecnologia (CNEA-CONICET) and Instituto Balseiro — [6]CNR-SPIN

In altermagnets, time-reversal symmetry breaking spin-polarizes electronic states, while total magnetization remains zero. In addition, at altermagnetic surfaces Rashba-spin orbit coupling is activated due to broken inversion symmetry, introducing a competing spin-momentum locking interaction. Here we show that their interplay leads to the formation of complex, chiral spin textures that offer novel, non-linear spin-to-charge conversion properties. Whereas altermagnetic order suppresses the canonical linear in-plane Rashba-Edelstein response, we establish the presence of an anomalous transversal Edelstein effect for planar applied electric and magnetic field, or alternatively, an in-plane magnetization. Moreover the non-linear Edelstein response resulting purely from electric fields also triggers the anomalous out-of-plane magnetization. We determine the anomalous response with a model based on the ab-initio electronic structure of RuO2 bilayers, ultimately opening experimental avenues to explore spin-charge conversion phenomena at altermagnetic interfaces.

MA 47.4 Fri 10:15 H20

A Heisenberg model for *g*-wave altermagnets: the comparative analysis of CrSb and MnTe — •Volodymyr Kravchuk[1,2], Kostiantyn Yershov[1,2], Oleg Janson[1], and Jeroen van den Brink[1] — [1]Leibniz Institute for Solid State and Materials Research, 01069 Dresden, Germany — [2]Bogolyubov Institute for Theoretical Physics of the National Academy of Sciences of Ukraine, 03143 Kyiv, Ukraine

Here we construct a discrete Hamiltonian of the magnetic subsystem of altermagnets belonging to the crystallographic group $6/mmm$. The altermagnetic properties are captured through the additional Heisenberg exchange interactions whose symmetry respects the positions of the nonmagnetic atoms. We derive the dispersion relation for magnons for two opposite cases of magnetocrystalline anisotropy: easy-axis (as for CrSb) and easy-plane (as for MnTe). Due to the different magnetic ground states of CrSb and MnTe, their magnon spectra are drastically different. While the splitting of the magnon bands of CrSb possesses the *g*-wave symmetry, the splitting of the magnon bands of MnTe does not alternate sign within the Brillouin zone and does not possess *g*-wave symmetry. We formulate the continuous approximation of the model and derive the expression for magnetization of the noncollinear magnetization structures. We find that the amplitude of the magnetization of a domain wall in CrSb depends on the domain wall orientation relative to crystallographic axes, and determine twelve orientations that correspond to the maximal magnetization.

MA 47.5 Fri 10:30 H20

P-wave magnetism and spin symmetries — •Anna Birk Hellenes[1], Tomáš Jungwirth[2,3], Rodrigo Jaeschke-Ubiergo[1], Atasi Chakraborty[1], Jairo Sinova[1,4], and Libor Smejkal[1,2,5,6] — [1]JGU Mainz — [2]Czech Academy of Sciences — [3]University of Nottingham — [4]Texas A&M University — [5]MPI-PKS — [6]MPI-CPfS

The recent discovery of altermagnets was enabled by an unorthodox symmetry toolbox, crystallographic spin groups, allowing for the rigorous delineation of all collinear spontaneous exchange symmetry breakings. This raises a question: are further magnets with hitherto unknown symmetries and electronic structures hiding in plain sight? Our contribution will start with a brief history of a century-long debate on whether p-wave magnetic orders can exist. We will resolve this debate by demonstrating p-wave magnetism using the spin group formalism. We show that a collinear p-wave order arises in coplanar magnets for a subclass of noncentrosymmetric, noncollinear magnets with a combined translation and time-reversal symmetry. Contrary to common assumptions, we establish that such magnets can display non-relativistic spin-split electronic band structures. We demonstrate that these splittings preserve time-reversal symmetry, starkly contrasting splittings in ferromagnets and altermagnets, which break it. With first-principles calculations and symmetry analysis, we predict large, non-relativistic spin-splittings of several hundred meV and identify more than 40 realistic material candidates. Our work opens a wide range of possibilities for studying p-wave magnetism and using it for spintronics and topological physics. arXiv:2309.01607v3

MA 47.6 Fri 10:45 H20

Spin polarons in Altermagnets — •Maria Daghofer[1], Krzysztof Wohlfeld[2], and Jeroen van den Brink[3] — [1]FMQ, Universität Stuttgart, Stuttgart, Germany — [2]University of Warsaw, Warsaw, Poland — [3]IFW Dresden, Dresden, Germany

We numerically investigate hole motion in altermagnetic Mott insulators, beyond the weakly interacting case, where a mean-field description is applicable. In this strongly correlated regime, hole motion is strongly affected by coupling to quantum fluctuations of the magnetic background. We find that the underlying altermagnetic symmetries manifest themselves in spin-momentum locking of the coherent quasiparticle: At certain momenta, it has a spin-polarized character, while states corresponding to the opposite spin are considerably more incoherent. We also address the impact of quantum fluctuations.