X-ray Spectroscopic Signatures of Altermagnetism

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Altermagnets represent a new class of collinear magnets that, in the nonrelativistic limit, possess compensated spin magnetic moments while exhibiting spin splitting in their band structures and responses associated with broken time-reversal symmetry. Despite a rapidly growing number of proposed candidates, experimental confirmations remain scarce. In this talk, we explore x-ray spectroscopic approaches to identify and characterize altermagnetism, based on computational simulations using density-functional theory combined with dynamical mean-field theory (DFT+DMFT) [1].

We first discuss x-ray magnetic circular dichroism (XMCD), a well-established probe of ferromagnets, by examining representative altermagnets with different crystal structures, including MnTe [2] and NiF_2 [3], together with recent experimental results. Using MnTe as a model system, we demonstrate that the characteristic frequency dependence of the XMCD spectrum enables an unambiguous identification of altermagnetism, clearly separating it from extrinsic weak ferromagnetic components induced by spin-orbit coupling. For NiF_2, we show that the intrinsic altermagnetic contributions to the XMCD signal can be extracted from relatively simple measurements under external magnetic fields.

We then turn to CD in resonant inelastic x-ray scattering (RIXS-CD). A key distinction from XMCD is that RIXS-CD is not intrinsically sensitive to time-reversal symmetry breaking, but instead probes broken unitary symmetries associated with magnetic order. Within the dipole and localized-excitation approximations, we derive the selection rules for RIXS-CD and apply them to various crystal and magnetic structures of current interest, including altermagnets [4]. Finally, we discuss how RIXS-CD can be exploited to study magnetic domains in altermagnets, taking MnTe as an example [5].

References

[1] A. Hariki *et al*., Phys. Rev. B **101**, 115130 (2020).

[2] A. Hariki *et al*., Phys. Rev. Lett. **132**, 176701 (2024).

[3] A. Hariki *et al*., npj Quantum Mater. **10**, 49 (2025).

[4] M. Furo *et al*., Phys. Rev. B **112**, 214429 (2025).

[5] D. Takegami *et al*., Phys. Rev. Lett. **135**, 196502 (2025).