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Optical-Pulse Excitation and Ultrafast Electron Dynamics in Altermagnets

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I will present theoretical and experimental results on the optically excited electron dynamics in different altermagnetic candidate materials. The altermagnetic symmetries, in particular time-reversal symmetry breaking, allow for the excitation of an electronic spin polarization by linearly polarized optical fields. Using an ab-initio based approach for a prototypical planar d-wave altermagnet, it is demonstrated how this optically excited non-equilibrium spin polarization depends on the direction of the exciting E-field vector. This is a robust prediction rooted in the altermagnetic symmetries that has been observed using magneto-optical measurements on ultrathin films of RuO2 [1].

For the case of the bulk g-wave altermagnet, MnTe it is further demonstrated that the optical excitation leads to different dependences of the optically induced spin polarization on the exciting laser-field polarization. Depending on the angle of incidence, this dependence on the optical polarization can resemble that found for a planar d-wave system, but the six-fold symmetry of the crystal structure is never reflected in the excited spin polarization [2]

Once an electronic spin polarization has been excited in the way described above, it can decay by electronic spin-flip scattering due to the influence of spin-orbit coupling. In planar d-wave altermagnets, however, the anisotropic spin splitting in the band structure restricts the phase space for such electronic spin-flip transitions compared to ferromagnetic metals. Microscopic calculations of electron-electron and electron-phonon scattering processes for altermagnetic KRu4O8 show how non-thermalized, anisotropic electronic distributions survive on time scales long compared to the typical momentum relaxation times and thus give rise to a long-lived spin polarization [3].

References:

[1] M. Weber et al., arXiv 2408.05187 (2024).

[2] L. Haag, M. Weber, K. Leckron, L. Smejkal, J. Sinova, H. C. Schneider, arXiv 2505.13415 (2025).

[3] M. Weber et al., Newton 1, 100266 (2025).