Circular Dichroism in Resonant Inelastic X-ray Scattering in Complex Altermagnets

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In recent years, altermagnets, which are collinear antiferromagnets that nevertheless exhibit time-reversal-symmetry-breaking responses, have attracted considerable interest. Although numerous candidate materials have been proposed theoretically, experimental techniques for identifying the realization of altermagnetism remain limited. Recently, circular dichroism in resonant inelastic x-ray scattering (RIXS-CD) has been proposed as a new probe for studying altermagnets [1,2]. However, due to the complexity of the second-order optical process of RIXS, even the selection rules governing its CD have not been sufficiently understood.

In this study, based on symmetry analysis, we derive the selection rules for RIXS-CD within the dipole and impurity approximations [3]. We show that RIXS-CD does not require time-reversal symmetry breaking and is therefore insensitive to it, but instead can probe the breaking of unitary symmetries across a phase transition. Our selection rules enable the design of measurement geometries in which RIXS-CD directly detects symmetry breaking associated with altermagnetic order in various candidate materials.

We demonstrate this capability by identifying the realization of a complex altermagnetic order, termed *bi-altermagnetic* order, in $Fe_2Mo_3O_8$. In this compound, two inequivalent Fe magnetic sublattices in the crystal structure independently host altermagnetic order. Fe *L*-edge RIXS-CD can resolve the altermagnetic order of each sublattice by exploiting the distinct sublattice-specific CD. This example highlights that RIXS-CD provides direct access to sublattice-resolved magnetic information in complex altermagnetic systems [4].

References

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