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Circular Dichroism in Resonant Elastic X-ray Scattering-I

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Circular dichroism in resonant elastic X-ray scattering (CD-REXS) has emerged as a uniquely probe for chiral and topological magnetic orders in condensed matter systems. In this extended tutorial, we provide a comprehensive introduction to the fundamental principles, experimental implementations, and practical applications of CD-REXS, with a focus on its ability to extract symmetry, chirality, and topological invariants from spin textures.

We begin with the theoretical foundation of resonant scattering processes, highlighting the role of x-ray polarization in magnetic scattering cross-sections. Particular emphasis is placed on the geometric and symmetry constraints that govern dichroic signal formation, and how they relate to the vectorial structure of magnetization. We will then introduce the Dichroism Extinction Rule (DER), a recently developed principle that allows a one-to-one correspondence between spin motif and circular dichroic intensity, enabling direct determination of spin helicity and winding number.

The tutorial will feature case studies from chiral magnets, magnetic multilayers and heterostructures, demonstrating how CD-REXS can resolve complex spin structures, and even with a 3D depth profile. By the end of the session, participants will gain the conceptual and practical tools necessary to design, perform, and interpret CD-REXS experiments, as well as appreciate its unique role in modern spin and topological materials research.

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