Spin group theory of ferromagnets, antiferromagnets and altermagnets

Libor Šmejkal

Institut für Physik, Johannes Gutenberg Universität Mainz, D-55099 Mainz, Germany
Institute of Physics, Academy of Sciences of the Czech Republic
lsmejkal@uni-mainz.de
@LiborPhysics

Magnetic symmetry groups are investigated in a wide range of research areas from topological condensed matter to spintronics. This approach commonly links magnetism and relativistic spin-orbit coupling because the magnetic symmetries operate simultaneously in both crystal and spin space. In this talk, we take a distinct approach based on nonrelativistic spin symmetries that act in decoupled crystal and spin space [1]. We show that there exist three types of spin symmetry groups.

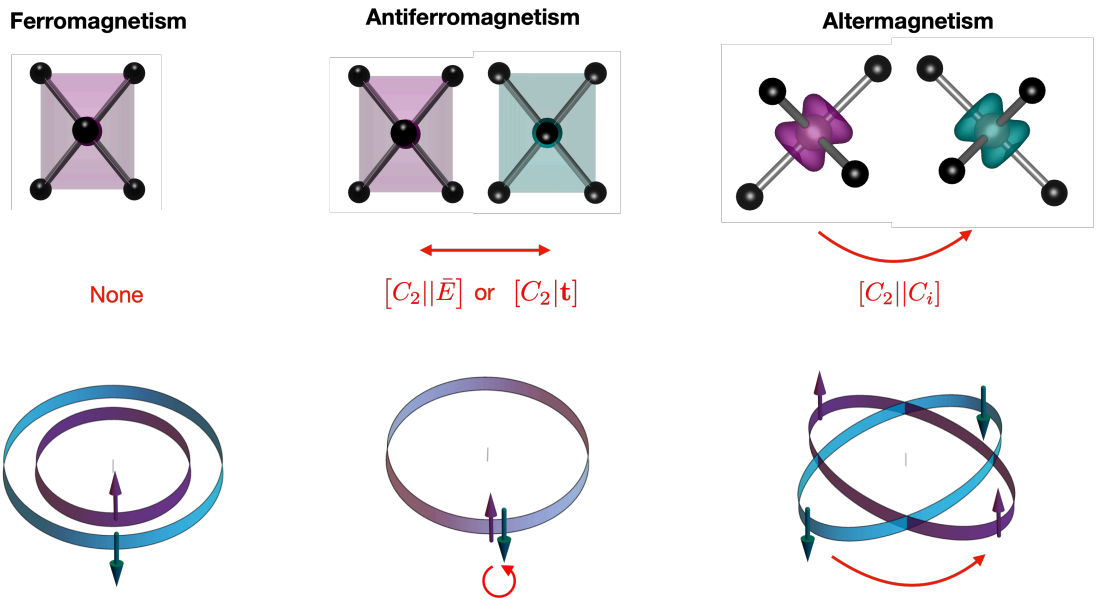

Figure Real space (top row) and momentum space (bottom row) structure of ferromagnets, antiferromagnets and altermagnets.

The first two types describe conventional ferromagnets and antiferromagnets with Kramers spin degenerate bands[2], magnetic phases known over thousands and over 80 years, respectively. Additionally, we find that the third type describes a third qualitatively distinct magnetic phase, the altermagnetism (see Figure). The altermagnetism combines antiparallel anisotropic magnetization densities and spin polarised momentum states (see right column of Figure)[1,3]. We will also demonstrate that our theory provides a unifying framework for the recently reported anomalies of magnets with antiparallel moments [see, for instance, 3-6 and references therein].

References:
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