Spin group theory of ferromagnets, antiferromagnets and altermagnets

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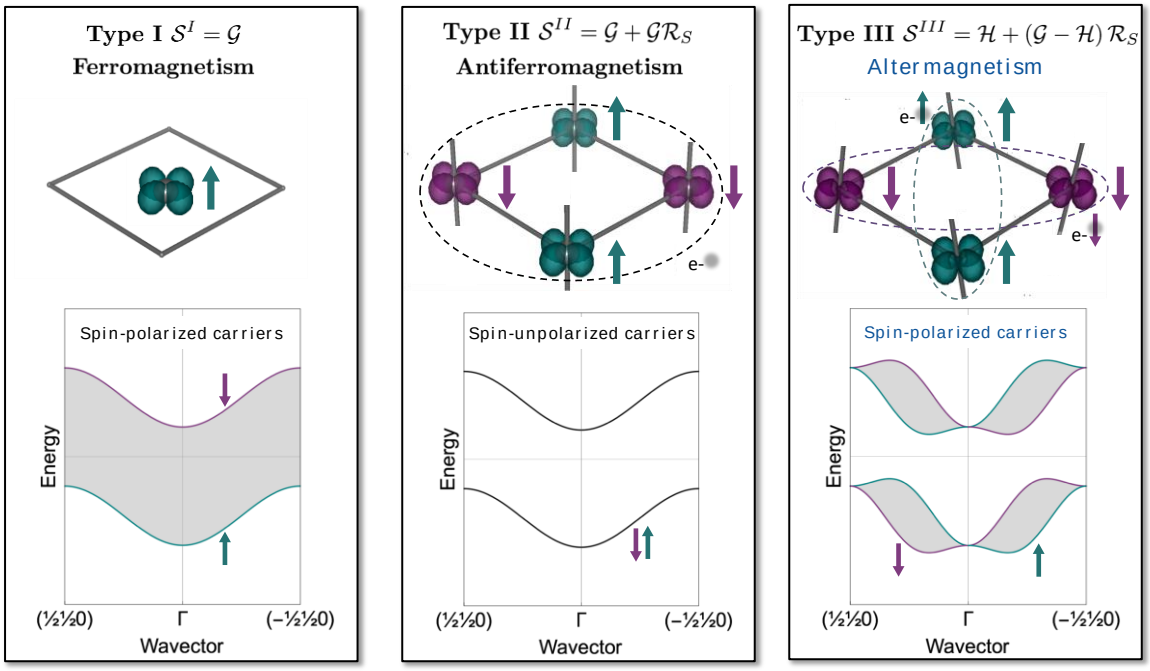
A broad range of research areas from topological condensed matter to spintronics explores magnetic symmetry groups. This approach commonly entangles magnetism and relativistic spin-orbit coupling since the symmetry operations are considered to act simultaneously in crystal and spin spaces. In this talk, we take a distinct approach based on constructing three types of nonrelativistic symmetry groups with decoupled crystal and spin space [1] (see Figure). We show that the Type -I and Type -II groups describe conventional ferromagnets and antiferromagnets with Kramers degenerate bands [2]. Additionally, we find that the Type – III group describe a third qualitatively distinct magnetic phase, the altermagnetism. The altermagnetism combines antiparallel moments and spin polarised momentum states and here we discuss in detail its symmetry and topology classes.



Furthermore, we identify large spin separation of the ~eV scale in energy bands of realistic altermagnetic crystal potentials. Altermagnetism thus represents a third fundamental route toward spin-separated states as it starkly contrasts spin separation mechanisms due to the ferromagnetic-exchange field or due to the relativistic spin-orbit coupling. We also employ our theory to identify altermagnetic material classes including insulators, metals, and parent phases of high-temperature superconductors. Finally, we will discuss that altermagnets can exhibit effects familiar in either ferromagnets or antiferromagnets but can also display phenomenology unparalleled in the two conventional magnetic classes. We will show 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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