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Topological phases of antiferromagnetic insulator

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We explore the topological phases of a three dimensional canted antiferromagnetic insulator featuring Dresselhaus and Rashba spin-orbit couplings. In contrast to previous studies that rely on assumed Néel order to classify topological properties, we acknowledge the potential impact of spin-orbit interactions on the Néel orde. Employing self-consistent magnetic order calculations, we observe distinctive spin arrangements under Dresselhaus and Rashba couplings. Under Dresselhaus spin-orbit coupling, the spin configuration exhibits antiferromagnetic order with spins pointing in arbitrary directions. On the other hand, Rashba interaction results in spins antiferromagnetically aligning in the xy-plane. Additionally, a small interaction controlled by hopping parameter induces spin tilting, causing antiferromagnetic alignment in the xy-plane but ferromagnetic alignment in the z-direction.
We categorize the topological properties of these phases: for pure antiferromagnetic order, the system possesses a modified time-reversal symmetry, characterized by Z2. In contrast, tilted antiferromagnetic orders are characterized by glide-mirror symmetry and inversion symmetry, described by a Z4 index. Moreover, we scrutinize the bulk-edge correspondence, revealing that the surface state becomes gapless when the surface symmetry aligns with that of the bulk state; otherwise, the surface state exhibits a gap. Our findings offer a comprehensive topological characterization for canted antiferromagnetic insulators with spin-orbit couplings, providing valuable insights into the interplay between spin arrangements, symmetries, and topological properties in these systems.

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