CeCo2P2: unique Co-antiferromagnetic topological heavy-fermion system with P · T -protected Kondo effect and nodal-line excitations

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Based on experimental data, we find that CeCo2P2 is unique in heavy-fermion materials: it has a Kondo effect at a high temperature which is nonetheless below a Co- antiferromagnetic ordering temperature. This begs the question: how is the Kondo singlet formed? All other magnetic Kondo materials do not first form magnetism on the atoms whose electrons are supposed to screen the local moments. We theoretically explain these observations and show the multifaceted uniqueness of CeCo2P2: a playground for Kondo, magnetism, flat band, and topological physics. At high temperatures, the itinerant Co c electrons of the system form non- atomic bands with a narrow bandwidth, leading to a high antiferromagnetic transition temperature. We show that the quantum geometry of the bands promotes in-plane ferromagnetism, while the weak dispersion along the z direction facilitates out-of-plane antiferromagnetism. At low temperatures, we uncover a novel phase that manifests the coexistence of Co-antiferromagnetism and the Kondo effect, linked to the Kramers' doublets of c electrons, protected by P · T symmetry in the antiferromagnetic phase. Subsequently, the emergence of the Kondo effect, in cooperation with glide-mirror-z symmetry, creates nodal-line excitation near the Fermi energy. Our results emphasize the importance of lattice symmetry and quantum geometry, Kondo physics, and magnetism in the understanding of the correlation physics of this unique compound. We also test our theory on the structurally similar compound LaCo2P2 and show how we are able to understand its vastly different phase diagram.