

Correlation driven phenomena in topological flat bands

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In the field of condensed matter physics and materials science, new states of matter due to the flat bands have attracted significant attention, such as exotic superconductivity, flux states and heavy fermion states found in twisted bilayer graphene, transition metal systems on geometrically frustrated lattices. The flat bands at the Fermi energy, or *itinerant flat bands*, are known to lead to exotic states through symmetry breaking due to the associated large density of states at the Fermi energy. On the other hand, once the system gets into a symmetry breaking state, normally the flat bands are removed from the Fermi energy to gain the condensation energy. Thus, an itinerant flat band system has never been found in an ordered state and limited to a paramagnetic or disordered state. The typical example is the opening of the gap in the superconducting states that pushes DOS apart from the Fermi energy. The popular elemental ferromagnet Co stabilizes a low DOS state around the Fermi energy after forming a ferromagnetic state at high temperatures while it carries a high DOS state in its paramagnetic state.

In this talk, we present several examples of an itinerant flat band system in a magnetically ordered state. First, in the ferrimagnet GdCo₅, we find that the flat bands are topological in character and host significantly enhanced Berry curvature in the momentum space [1]. Moreover, our experiment reveals that the topological flat bands produce the largest ever thermoelectric conversion efficiency at room temperature among all the magnets. This evidences a nontrivial topological state of the itinerant flat band, but at the same time a technological relevance of the materials hosting such a novel state of matter.

Unconventional functional antiferromagnets with strong spin-dependent transport have emerged as promising platforms for ultrafast, low-power spintronic technologies. Among them, Mn₃Sn has been central due to its noncollinear antichiral spin structure, which enables ultrafast switching and Weyl-node-driven large transverse responses at room temperature [2]. In this talk, we present that controlled Cr substitution in Mn₃Sn thin films provides a powerful, symmetry-preserving means of hole-doping and shifts the Fermi level toward the flat-band region. We show that Cr doping substantially enhances both the anomalous Hall and anomalous Nernst effects, accompanied by an increase in the Néel temperature [3]. Our findings provide the first experimental demonstration that

tuning the Fermi level toward kagome-derived topological flat bands can strongly amplify intrinsic anomalous transport and its stability range in an antiferromagnet.

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