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Spin density wave phase protected by long-range charge order in a Kagome antiferromagnet

The interplay between charge density wave (CDW) and spin density wave (SDW) orders in quantum materials play a crucial role in the determination of their electronic, structural, and magnetic properties. Kagome lattice materials provide a platform to study these complex interactions, owing to their exotic electronic structures, including Dirac cones, van Hove singularities, and flat bands. The Kagome metal FeGe (B35 phase) undergoes a sequence of phase transitions upon cooling: it first develops an A-type antiferromagnetic (AFM) order, followed by a 2×2×2 CDW order, and ultimately an incommensurate (IC) SDW order with a propagation vector along the c-axis. Remarkably, the CDW can be tuned—from long-range order to complete suppression—via post-growth annealing, and the onset temperature and ordered moment of the SDW phase exhibit a correlated trend. In this work, we identify FeGe with long-range charge order as a rare example in which the magnetic structure of the SDW phase has been unambiguously determined via neutron diffraction. The magnetic moment of the transverse SDW order exhibits a sinusoidal modulation with an amplitude of 0.94 μB, and the evolution of magnetic domain volume quantitatively accounts for the variation in IC diffraction peak intensities. The observed changes in the incommensurate propagation vector further highlight the coupling between CDW and SDW orders. Polarized neutron diffraction results are also consistent with this magnetic structure model. Moreover, we find that the long-range CDW-modulated lattice stabilizes the SDW order. On the contrary, in samples exhibiting only short-range CDW order, the reported phase transitions between double-cone structures and suppression of ordered moment size are a consequence of the interplay between the magnetic field and imperfect Fermi surface nesting. These findings provide compelling evidence for the itinerant nature of the IC magnetic order and highlight the intricate coupling among lattice, spin, and charge degrees of freedom.

Topical Area

Hard matter: quantum, electronic, semiconducting materials

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