Exchange renormalized crystal field excitation in a quantum Ising magnet $KTmSe_2$

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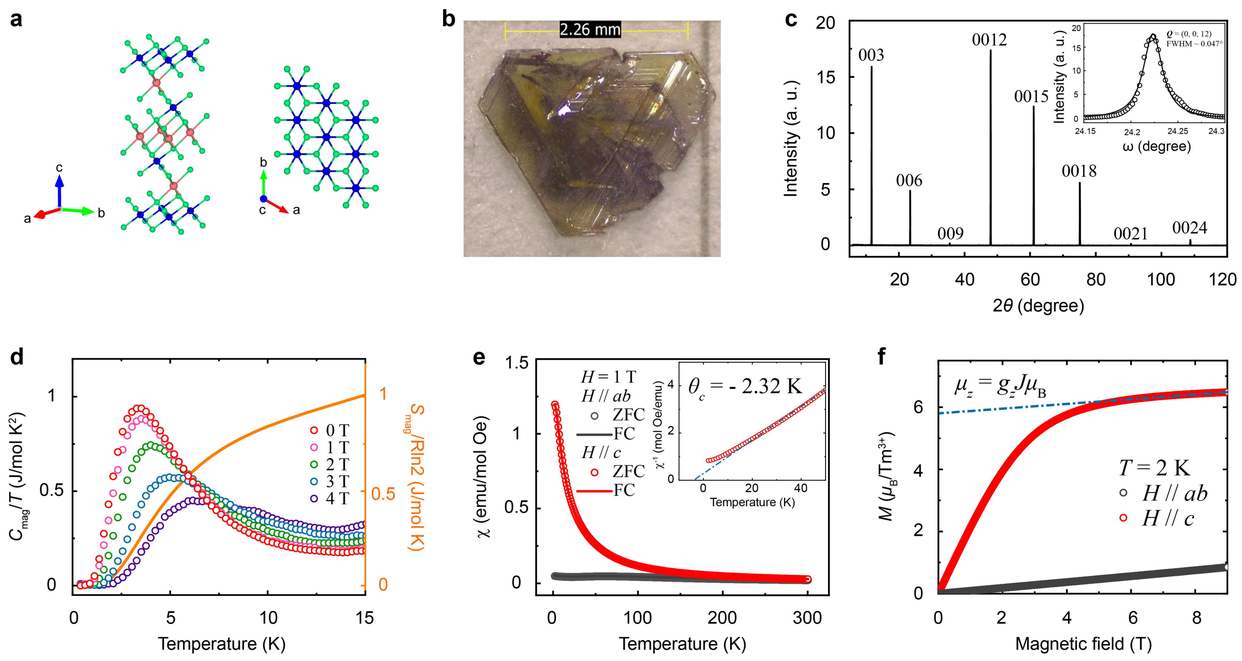
Abstract

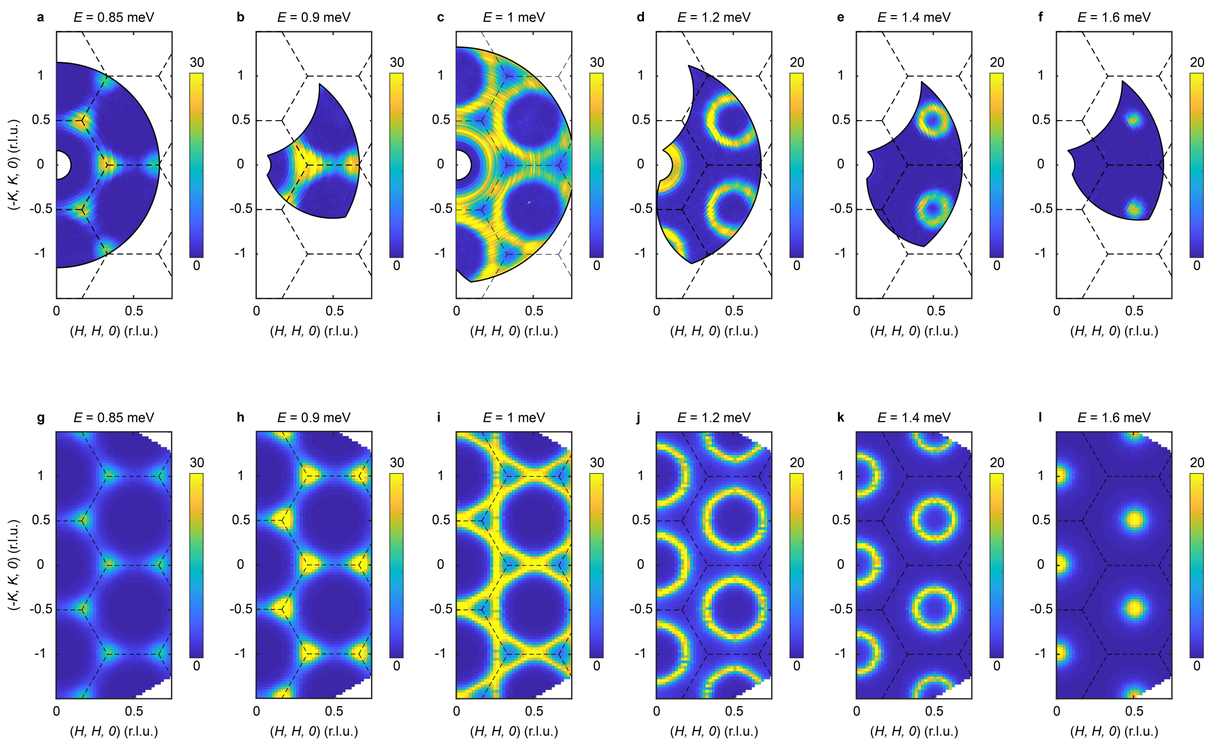
Rare-earth delafossite compounds, $ARCh_2$ (A = alkali, R = rare earth, Ch = chalcogen), have been proposed for many quantum phenomena. Particularly, the Tm series, $ATmCh_2$, featuring Tm ions on a triangular lattice, serves as a representative group of compounds to illustrate the interplay between spin-orbit coupling, crystal fields, and exchange couplings in the presence of geometric frustration. Here we report the thermodynamic and inelastic neutron scattering on the new triangular-lattice magnet $KTmSe_2$. Heat capacity and neutron diffraction reveal the absence of magnetic order, while susptibility and magnetization show strong Ising interactions with AFM correlations. Additionally, a branch of dispersive CEF excitation is illustrated by INS. To analyze these observations, we employ both the transverse field Ising model and full CEF scheme, along with exchange interactions. This work is expected to offer a valuable framework for understanding low-temperature magnetism in similar systems.

Physical properties of $KTmSe_2$ single crystal



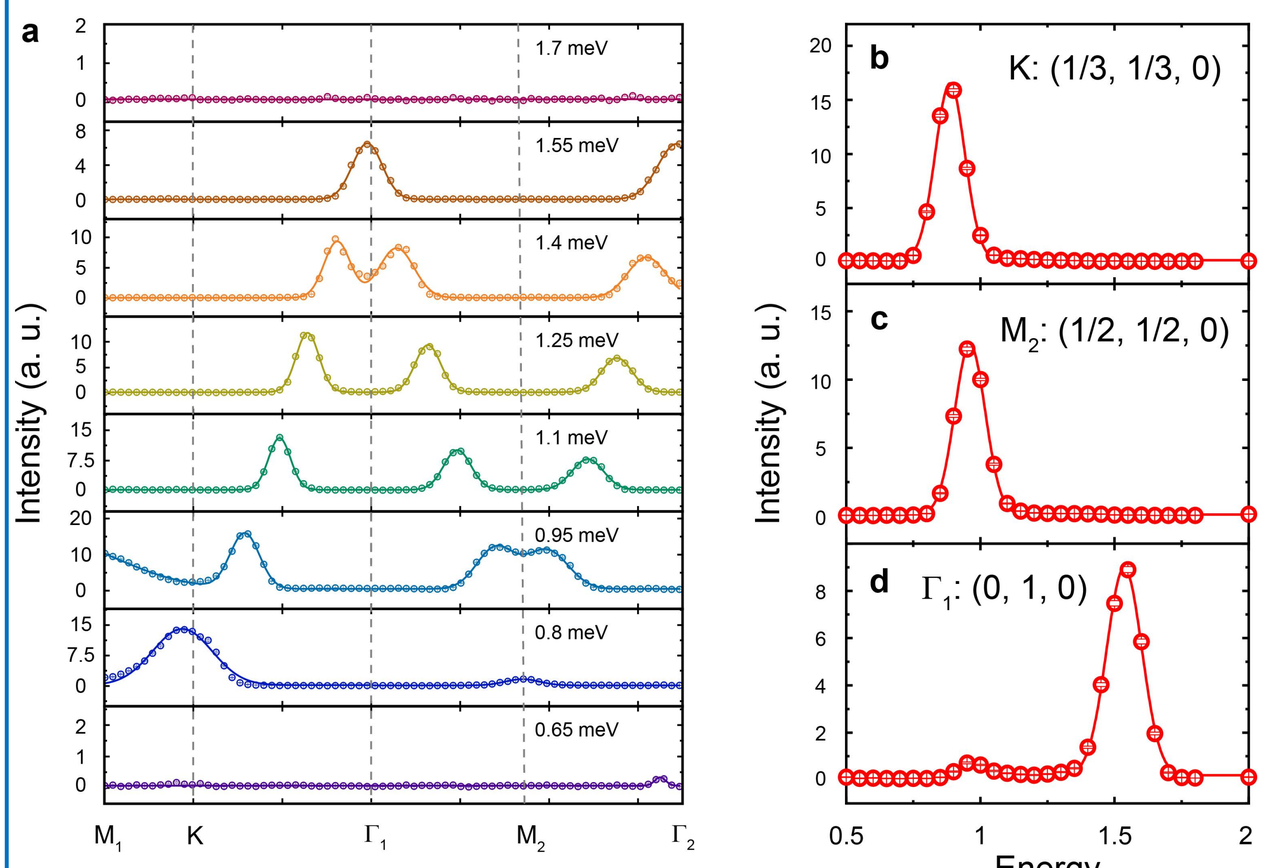
a Schematic diagram of $NaTmTe_2$ crystal structure. **b** Image of a typical single crystal. **c** X-ray diffraction measurements in the (*H*, *K*, 0) plane. **d** Heat capacity measurements. **e** Temperature-dependence of susceptibility under 1 T. The insert suggests negative Curie-Weiss temperatures. **f** Isothermal magnetization measurements along the c direction and in the ab plane at 2 K.

Momentum dependence at 60 mK



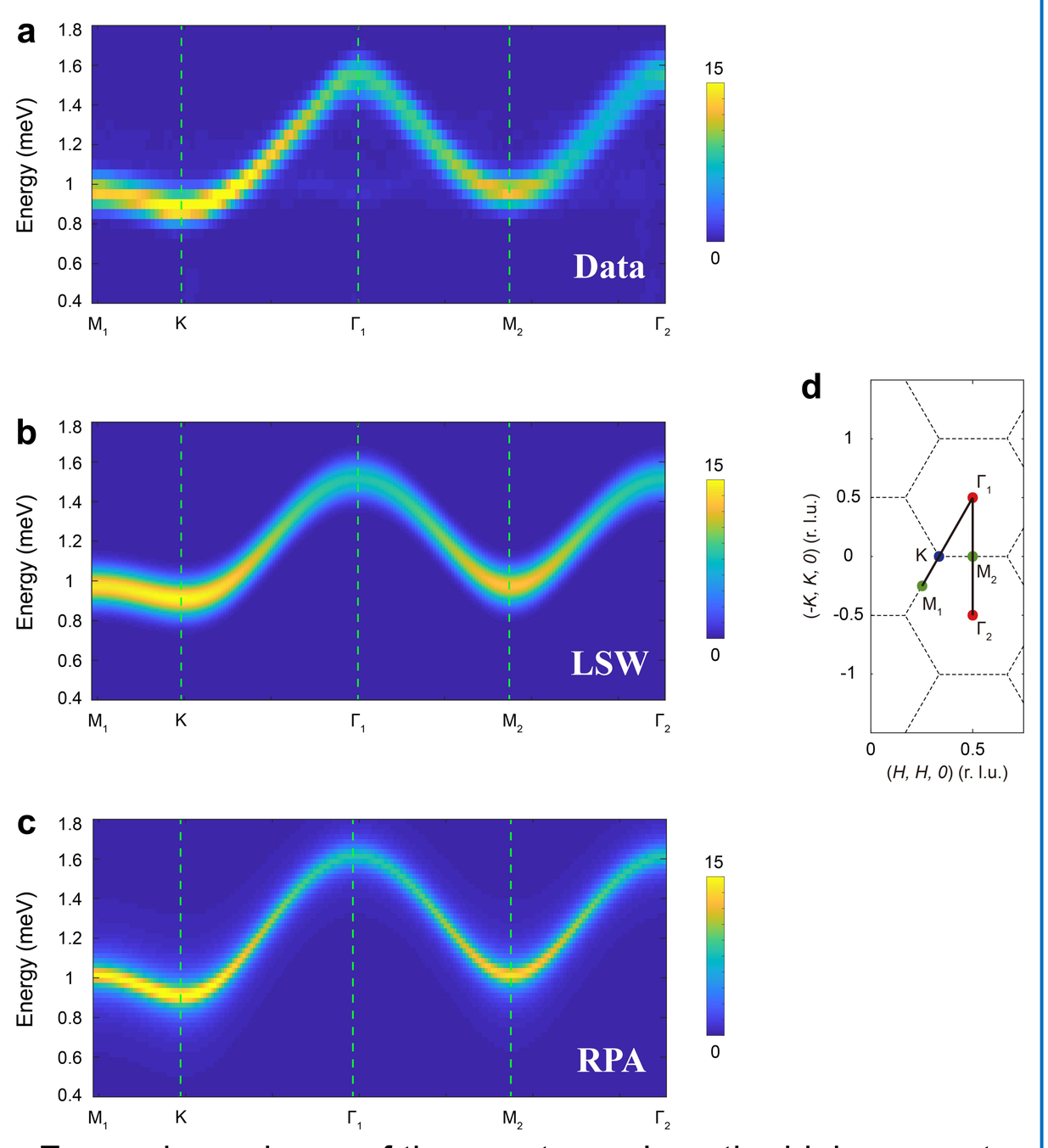
a-f Raw contour plots of the constant energy images at 60 mK. g-l Calculated CEF excitation using the MF-RPA model. The measurements were performed on the ThALES triple-axis spectrometer with E_f = 4.066 meV.

Q- and Energy-cuts



a Constant energy cuts along the M_1-K-Γ_1-M_2-Γ_1 direction at indicated energies at 60 mK. The vertical dashed lines indicate the high-symmetry points. **b** The constant Q cuts at three points, the error bars denote the standard deviation.

Energy dependence of magnetic excitation



a Enegy dependence of the spectrum along the high-symmetry momentum direction. **b,c** Simulated magnetic excitation based on LSW and MF-RPA methods. **d** Schematic of the path.

Reference

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Yao Shen, *et al*., Nature Communications **10**, 4530 (2019).
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