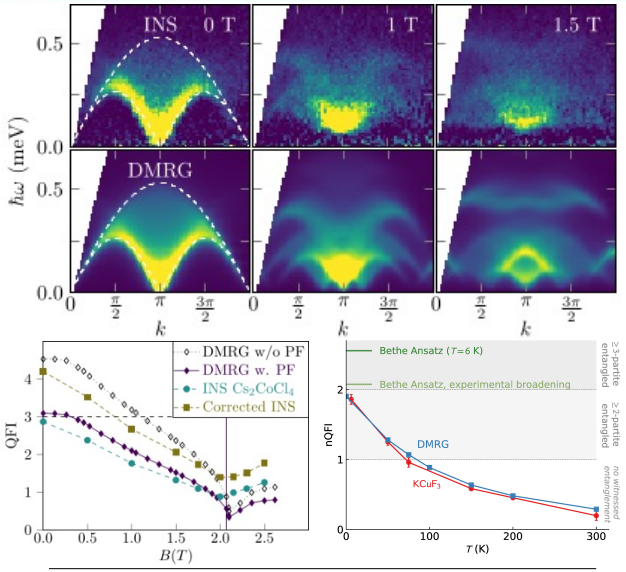
Quantifying entanglement in the solid state using neutrons



Comparison between experimental INS and numerical DMRG results. Top. Cs_2CoCl_4 INS spectra at various field strengths indicated. Bottom left. Cs_2CoCl_4 QFI as a function of applied magnetic field B. Bottom right. $KCuF_3$ QFI as a function of temperature.

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Accomplishment

Developed model-independent approach for entanglement quantification in quantum spin systems, using inelastic neutron scattering (INS) and density matrix renormalization group (DMRG) calculations.

Significance and Impact

This work lays the foundation for a general entanglement detection protocol for quantum spin systems, which is needed to identify quantum materials suitable for new applications such as topological quantum computing.

Details

- High-resolution INS measurements are carried out on Cs_2CoCl_4, a realization of the XXZ S=1/2 spin chain, where entanglement is controlled using the magnetic field, to detect entanglement witnesses (EWs), including quantum Fisher information (QFI).
- Our experimental results are validated by DMRG calculations.
- QFI is found to be a particularly robust experimental probe of entanglement, characterizing a field-induced quantum phase transition in Cs_2CoCl_4 and thermal entanglement in $KCuF_3$.

Work was performed at Oak Ridge National Laboratory