Coherent spin states in quantum magnets

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Abstract

Strongly-correlated charge and spin degrees of freedom can lead to cooperative quantum-coherent many-body states with unusual properties. The emergent character of these states can give rise to non-linear excitations which are completely different from those observed in more conventional systems like the Fermi liquids or magnetically ordered spin structures. Strongly-correlated quantum states can also lead to field or temperature-driven quantum phase transitions which are believed to lie at the heart of important unsolved questions in condensed matter physics.

We have studied the antiferromagnetic spin-1/2 chain CuCl2.DMSO (CDC) in high magnetic fields. At zero field, the neutron scattering spectrum reveals the presence of fractional spin excitations characteristic for weakly-coupled spin-1/2 chains. An applied field induces a perpendicular staggered field, so that the excitation spectrum is gapped and contains well-defined commensurate and incommensurate modes. This is an impressive illustration of the hidden quantum order of the ground state. Further, the masses and intensities of the spin excitations match predictions for solitons and breathers of the quantum sine-Gordon model, which was proposed as the low-energy field theory of the system. CDC is thus an excellent model system where the intricate features of the widely applicable quantum sine-Gordon model can be explored experimentally in excruciating detail.