Spin-1/2 Chains in Uniform and Staggered Fields

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Quantum critical spin-1/2 chains respond in interesting ways to small perturbations. I describe neutron scattering experiments that probe the effects of a uniform and a staggered magnetic field on copper pyrazine dinitrate (CuPzN) and $CuCl_2{\cdot}2DMSO$ (CDC) respectively. CuPzN distinguishes itself by the absence of a magnetic phase transition down to T/J=0.03, which indicates a highly one dimensional system [1]. Application of a uniform magnetic field up to 8.7 T at T=0.25 K leaves CuPzN in a gapless, quantum critical state [2]. However, there are substantial changes in the excitation spectrum, which evolves from a commensurate two-spinon continuum to a complex pattern of overlapping continua with field dependent incommensurate soft modes. The data are compared to exact diagonalization results for finite length chains and to a recent analytical theory for the spin-1/2 chain in a uniform field. While the copper sites are crystallographically indistinguishable in CDC, the local coordinating environment is oriented differently on even and odd sites along the spin chains. Because of the associated alternating principal axis of the g-tensor and potential alternating Dzyaloshinskii-Moriya interactions, a uniform applied field in addition produces a small effective staggered field. In this system an applied field causes the zero field continuum at low energies to coalesce into resonant, dispersive modes [3] indicating spinon-binding. Where there were gapless soft spots in CuPzN, there are finite energy resonant modes in CDC. There is also a striking similarity in the overall high field intensity distribution in Q-E space despite the important qualitative differences in the low energy spectrum. Theoretically, it has been predicted that the spin-1/2 chain in a staggered field should map to the Quantum Sine-Gordon (QSG) model. We show that the relative energies for resonant modes in CDC are consistent with this prediction. In addition the polarization and intensities of the resonant modes are consistent with detailed structure factor calculations for Soliton and Breather excitations in the QSG model.

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