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Spinons, Solitons, and Breathers in Quasi-One-Dimensional Magnets[1]

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By scattering neutrons from coordination polymer magnets, we contrast the effects of a uniform and a staggered magnetic field on the quantum critical state of a spin-1/2 chain. In a partially magnetized state of copper pyrazine dinitrate (CuPzN) we find bounded spectral continua indicating that neutrons scatter from spin-1/2 quasi-particle pairs [1]. The complex boundaries including an incommensurate soft spot result from a field induced shift in the Fermi points for these quasi-particles. The measurements indicate that the magnetized state of CuPzN remains quantum critical. Copper benzoate [2] and $CuCl_2$2(dimethylsulfoxide) (CDC) [3] differ from CuPzN in that there are two spins per unit cell along the spin chain. Rather than continuous spectra, we find resolution limited gapped excitations when these materials are subject to high fields. So with two spins per unit cell, an applied field can drive the spin-1/2 chain away from criticality. The explanation for this effect was provided by Affleck and Oshikawa. The alternating coordination environment induces a transverse staggered field and spinon binding. The quantum sine-Gordon model is the relevant low energy field theory and it predicts soliton and breather excitations at specific energies and wave vectors that we compare to the experiments. We shall also compare a complete measurement of the dynamic spin correlation function for CDC in a field to exact diagonalization results for a spin-1/2 chain with a staggered and uniform magnetic field [4].

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