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Quantum criticality and confinement effects in an Ising chain in transverse field

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The Ising chain in transverse field is one of the key paradigms for the theory of continuous zero-temperature quantum phase transitions. We have recently realized this system experimentally by applying strong magnetic fields to the quasi- 1D, low-exchange Ising ferromagnet CoNb2O6 to drive it to its quantum critical point where the spontaneous long-range magnetic order is suppressed by magnetic field [1]. Using high-resolution single-crystal neutron scattering we have probed how the spin dynamics evolves with the applied field and have observed a dramatic change in the character of spin excitations at the quantum critical point, from pairs of domain-wall (kink) quasiparticles in the magnetically-ordered phase, to sharp spin- flip quasiparticles in the paramagnetic phase. The weak, but finite couplings between the chains significantly enrich the physics by stabilizing a complex structure of two-kink bound states due to mean-field confinement effects. In zero field the rich spectrum of bound states can be quantitatitively understood following McCoy and Wu's analytic theory of weak confinement [2]. Just below the critical field the energies of the two lowest bound states approach the "golden ratio" as predicted by Zamolodchikov's E8 scaling limit solution of the off-critical Ising model in a weak longitudinal field [3].

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