Physik-Department

Walther Meissner Institut

Transregio SFB TRR 80

WALTER SCHOTTKY INSTITUT
Center for Nanotechnology and Nanomaterials

Festkörperkolloquium und TRR 80 Kolloquium

am Donnerstag, 13.01.2011

um 17:15 Uhr

spricht

Dr. Radu Coldea, Oxford University

über das Thema

Quantum criticality in an Ising spin chain

im HS 3 im Physik Department

ab 17:00 Uhr Kaffee vor dem Hörsaal

Einführung: C. Pfleiderer

Quantum criticality in an Ising spin chain

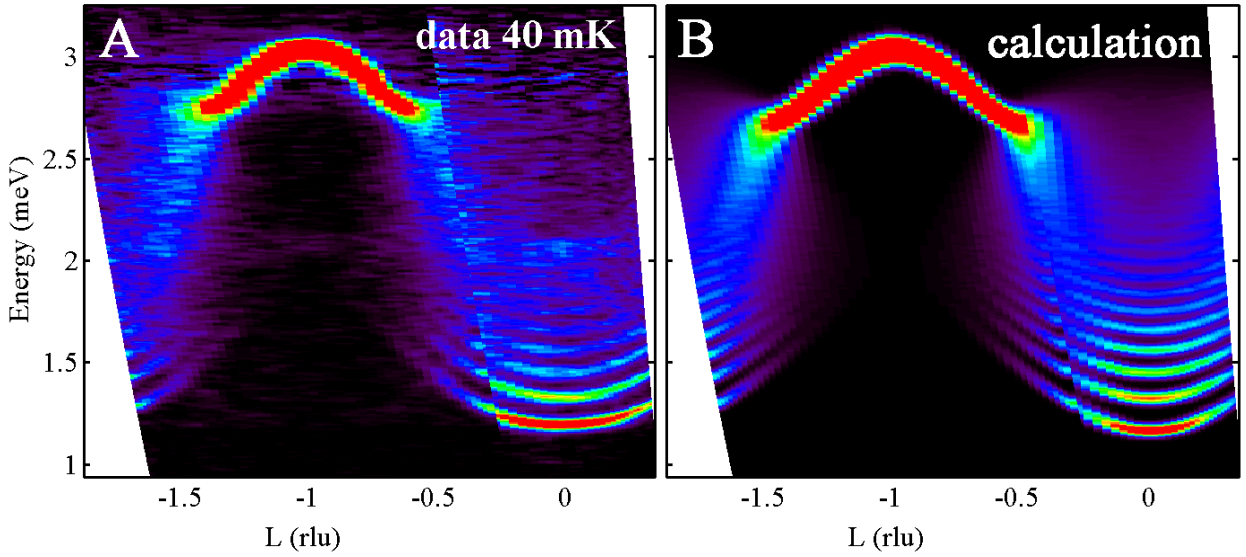
Radu Coldea, Oxford University

Ising magnets have been important systems in the study of magnetism and phase transitions due partly to Onsager's famous theoretical solution of the 2D Ising model, and partly to measurements of the spin fluctuations in Ising magnets via neutron scattering, that have enabled detailed tests of theoretical predictions. Ising systems are now attracting interest for the exploration of correlated quantum effects and zero-temperature (quantum) phase transitions driven by magnetic fields.

The one-dimensional (1D) chain of Ising spins in transverse field is one of the theoretically most studied systems with a continuous zero-temperature phase transition and is one of the cornerstones of the general theory of quantum criticality. We have realized this system experimentally by tuning the quasi-1D, low-exchange Ising ferromagnet $CoNb_2O_6$ to its quantum critical point where the spontaneous long-range magnetic order is suppressed by strong transverse applied magnetic field [1]. Using high-resolution single-crystal neutron scattering we have observed a dramatic change in the fundamental character of spin quasiparticles from pairs of domain-walls (kinks) in the ordered phase to spin-flips in the paramagnetic phase.

Moreover, we also observed how the weak, but finite 3D couplings between the 1D chains enrich the physics and lead to "confinement" of spin quasiparticles into a rich structure of bound states. The spectrum of such quantum resonances near the critical field is a direct fingerprint of the underlying symmetries that govern the physics of the critical point. Near criticality field theory predicts a remarkable spectrum of 8 resonances [2], stabilized by a hidden E8 symmetry that emerges in the scaling limit. The experiments observe that just below the critical field the spin dynamics shows a fine structure with two sharp modes at low energies, in a ratio that approaches the "golden mean" as predicted for the first two resonances of the E8 spectrum. Our results emphasize that exploration of continuous quantum phase transitions can open up new avenues to experimentally realize complex symmetries and dynamics in quantum matter.

[1] R. Coldea, D.A. Tennant, E.M. Wheeler, E. Wawrzynska, D. Prabhakaran, M. Telling, K. Habicht, P. Smeibidl, K. Kiefer, *Science* **327**, 177 (2010). *Quantum criticality in an Ising chain: experimental evidence for emergent E8 symmetry.* See also article by B.G. Levi, *A complex symmetry arises at a spin chain's quantum critical point, Physics Today* **63**, 3, 13 (2010).
[2] A.B. Zamolodchikov, *Int. J. Mod. Phys.* **A4**, 4235 (1989).



Spin excitations in the Ising chain magnet $CoNb_2O_6$: data and calculation.