

QUANTUM CRITICAL SPIN DYNAMICS OF A Cu(II) $S=1/2$ ANTIFERROMAGNETIC HEISENBERG CHAIN STUDIED BY HIGH-FIELD NMR SPECTROSCOPY

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$\text{Cu}(\text{C}_4\text{H}_4\text{N}_2)(\text{NO}_3)_2$ (CuPzN) is one of the best available realizations of an antiferromagnetic $S=1/2$ Heisenberg chain. In this compound Cu(II) $S=1/2$ spins interact magnetically via the pyrazine molecule ($\text{C}_4\text{H}_4\text{N}_2$) along the a -axis of the crystal. It has been characterized by thermodynamic measurements like magnetic susceptibility, high field magnetization and specific heat as well as inelastic neutron scattering [1].

We study the spin dynamics of the Cu(II) $S=1/2$ spin chain system by means of ^{13}C -NMR. The antiferromagnetic Heisenberg exchange constant $J/k_B=10.7$ K allows to access the full parameter range from the low field limit to beyond the critical magnetic field strength of $H_{\text{crit}}\sim 15.2$ Tesla, where the system is tuned through a quantum critical point (QCP) from a non-magnetic spin-liquid into a ferromagnetic state. Our goal is to map the low energy spin dynamics as a function of field and temperature, exploring both the QCP and the transition between quantum and classical regime.

At the NHMFL we measured the temperature dependence of the T_1 -relaxation rate on single crystals of CuPzN at fields between 9T and 22T in the 15T superconductor of the CM NMR User Facility and the 25 Tesla resistive magnet in cell 6. Figure 1 shows T_1^{-1} as a function of temperature for 3 selected fields: 2T (low field regime), 12T (critical regime) and 22T (high field regime). Below 10K we find a significant increase of T_1^{-1} as the critical field is approached, and a decrease by several orders of magnitude in the high field regime.

For low temperatures T_1^{-1} displays the density of states near the Fermi level of the one-magnon excitation spectrum[2]. Coming from low fields, at the QCP the density of these states becomes greatest. Above the QCP an excitation gap is induced by the external field and very few states can be occupied.

At elevated temperatures larger than J/k_B the system behavior is dominated by diffusive modes, which become successively suppressed as the field is increased.

For a quantitative understanding of these results quantum Monte-Carlo (QMC) calculations for the full field and temperature range are performed by S. Grossjohann and W. Brenig at TU Braunschweig. They exhibit an excellent agreement with the experimental data.

Further experiments slightly below and above 15T are planned to exploit the detailed properties in the critical field range.

Acknowledgements

This work was supported by the German Science Foundation (DFG) grant KL1086/4-4 and the NHMFL first time user support.

References

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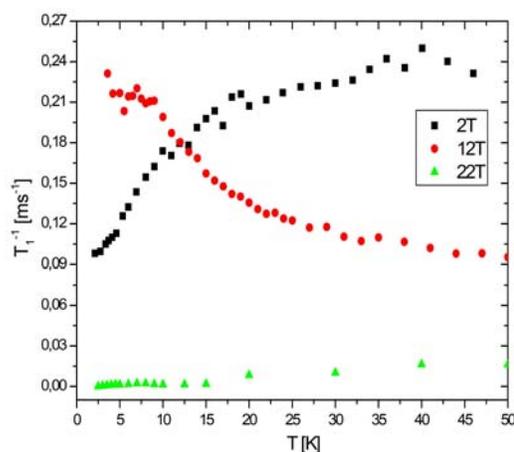


Fig. 1: Temperature dependence of the nuclear spin relaxation rate of ^{13}C for different fields; the rates at 12T and 22T have been measured at the NHMFL.