ELECTRON SPIN RESONANCE IN S=1/2 ANTIFERROMAGNETIC CHAINS WITH ALTERNATING g-TENSOR AND THE DZYALOSHINSKII-MORIYA INTERACTION IN THE PERTURBATIVE SPINON REGIME

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Introduction

A new theoretical approach for calculating electron spin resonance (ESR) parameters of S=1/2 antiferromagnetic (AFM) chains, which is based on bosonization and the standard Feynman-Dyson self-energy formalism, has been recently developed by Oshikawa and Affleck (OA) [1]. In an ideal S=1/2 Heisenberg AFM chain, the resonance would occur exactly at the frequency $h\omega = g\mu_B H$, and have a zero linewidth in the low-temperature limit, due to the conservation of the total $S_z$. In the OA theory, the sole effect of the symmetry-breaking perturbation on the Green function is to produce the self-energy contribution $\Sigma$ whose real and imaginary part determine the frequency shift and the linewidth, respectively. Importantly, the new concept allows a precise calculation of the ESR parameters and their dependence on temperature and magnetic field avoiding the Hartree-Fock approximation (which was previously used for interpreting ESR in exchange-coupled spin systems, but appears to be generally invalid in one-dimensional magnets). In this study the OA theory is tested experimentally.

Experimental

Experiments were performed in a frequency range of 9 – 700 GHz, using high-quality single crystals of copper pyrimidine dinitrate ([PM-Cu(NO$_3$)$_2$(H$_2$O)$_2$]$_n$, PM = pyrimidine), a spin-1/2 AFM chain with alternating g-tensor and the Dzyaloshinskii-Moriya interaction [2].

Results and Discussion

Measurements were performed in the intermediate (“perturbative spinon”) temperature regime, $E_g < T < J$ (where $E_g$ is a field-induced gap, $J$ is a spin-spin coupling), at several frequencies, allowing us to check both the temperature and field dependencies of ESR parameters, predicted by Oshikawa and Affleck [1]. The obtained data were of a sufficient quality to perform an accurate quantitative comparison with theoretical predictions, achieving an excellent agreement between the theory and experiment [3]. Importantly, our results are fully consistent with the previous analysis [2] based on the study of the frequency-field dependencies of ESR excitations in Cu-PM in the soliton-breather regime. The Figure shows a temperature dependence of the effective $g$-factor in Cu-PM for a frequency of 184 GHz. Symbols denote the experimental results, and solid line corresponds to calculations using the OA theory [1].

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References