Low Temperature Dynamics of Magnons in a Spin-1/2 Ladder Compound

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We have used a combination of neutron resonant spin-echo and triple-axis spectroscopies (NRSE-TAS) to determine the intrinsic fine structure, linewidth, and energy of the magnon resonance in the model spin-1/2 ladder antiferromagnet IPA-$CuCl_3$ at temperatures $T < \Delta_0/k_B$, where Δ_0 is the spin gap at $T = 0$. Calculations based on the non-linear sigma model with isotropic 1D exchange interactions yield a surprisingly good description of the data at high temperatures. At temperatures $T \ll \Delta_0/k_B$, however, where magnons are expected to be good quasiparticles, we have found that spin-space and real-space anisotropies in the spin Hamiltonian as well as scattering of magnons from a dilute density of impurities induce substantial deviations from the predictions of this model. These effects are generic to all experimental realizations of 1D model Hamiltonians and should therefore be taken into account in order to obtain quantitative descriptions of experimental data. We have shown that the spectroscopic information derived from NRSE-TAS experiments can provide a solid basis for such a fully realistic theory of quasi-1D quantum magnets.