Asymmetric thermal linehape broadening in dimerised antiferromagnets - evidence for strong correlations at finite temperature

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Abstract

In the accepted picture of temperature effects in magnetism, the excitations are long-lived at low temperatures and their lifetime decreases as temperature is increased. The accepted explanation is that thermally activated excitations collide with each other limiting their lifetimes - an effect that is observed experimentally as a Lorentzian energy broadening of the lineshape. This picture works well for gapless magnets with long-range magnetic order. The basic assumption is that the excitations interact only weakly and the available states cover a big region of phase space, so that as they collide they fluctuate among a large range of different states in an uncorrelated manner. The damping is then due simply to loss of coherence associated with the reduced lifetime of the excitations. The concept of thermal decoherence and the associated Lorentzian linewidth broadening have become so entrenched in current thinking that it is assumed to apply to all magnetic systems. However for some magnets where there are strong interactions between the excitations and the phase space is limited, it is not obvious that this reasoning should apply. Gapped antiferromagnets such as Haldane chains, spin ladders and dimer systems which have a singlet ground state and triplet excitations are potential candidates. In this presentation two dimer antiferromagnets will be discussed - copper nitrate which is highly dimerised and 1-dimensional, and $Sr_3Cr_2O_8$ which is 3-dimensional with a relatively weaker dimer interaction. In both systems the lineshapes are found to broaden *asymmetrically* indicating that far from becoming increasingly incoherent with temperature, the excitations behave collectively like a strongly correlated gas. The results from copper nitrate show good agreement with a theoretical model. While the results from $Sr_3Cr_2O_8$ suggests that this phenomenon is not confined to the special of highly dimerised 1-dimensional systems but is found generally in dimerized antiferromagnets of all dimensionalities and perhaps gapped magnets in general.