Nuclear magnetic resonance in spin Luttinger liquids

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Effective low-energy description of interacting quantum particles in one dimension (1D) is called a Luttinger liquid (LL). Its main property is the existence of gapless excitations characterized by correlation functions decaying as power laws, with exponents being simple functions of the dimensionless exponent K. The physics of a LL is quite elegant as it is directed by two LL parameters only: exponent K and velocity of excitations u. Chains and ladders of antiferromagnetically coupled electronic spins are examples of LL's. Nuclear magnetic resonance (NMR) is a precise probe for the lattice dynamics on the frequency scale of 100 MHz, which coincides with the low-frequency part of electron spin fluctuations in spin systems. As such, NMR is an ideal tool for probing the spin LL physics in model materials.

We present an NMR study of two model materials: spin-ladder compound $CuBr_4(C_5H_{12}N)_2$ [1] and spin-chain compound $BaCo_2V_2O_8$. Once the exchange couplings between electronic spins are known, the LL theory of a 1D spin system (chain, ladder) is left without adjustable parameters. Weak exchange couplings between individual 1D spin systems, which are responsible for an emergence of 3D magnetic order at low temperature, are included in the theory within the random phase approximation. We show that such an extended LL theory can successfully account for several observables (order parameter, transition temperature, electron spin fluctuations) as obtained by NMR in rich phase diagrams of both model materials.

[1] M. Klanjšek *et al.*, Phys. Rev. Lett. **101**, 137207 (2008).