Towards an understanding of spin excitations in low-dimensional quantum antiferromagnets

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Since the discovery of high T_c superconductors it has been speculated that spin fluctuations in the two-dimensional CuO_2 planes are related to superconductivity, if not being responsible for the pairing mechanism. As a consequence, not only long-wavelength, low-energy spin excitations should be considered, instead the entire dynamical spectrum of spin correlations has to be investigated, both experimentally and theoretically.

The high-energy features of the spin excitation spectra of the undoped mother compounds, as observed in the optical conductivity and with Raman scattering, are still not sufficiently understood. An obvious approach to understand the strong quantum fluctuations in this regime is a detailed dynamical study of lower-dimensional spin systems. Spin chains and spin ladders can be tackled more efficiently with numerical and analytical techniques than their two-dimensional cousins. Results from dynamical DMRG, from an analytical fermionic approach and from CUT (continuous unitary transformation) are presented. We resolve the puzzle whether the strong continuum contribution of spin excitations above the singlet bound states is intrinsic to the Heisenberg model or if it is rather generated by cyclic spin exchange processes, by comparing our results to recent measurements of the optical conductivity in $(La,Ca)_{14}Cu_{24}O_{41}$. Preliminary DMRG results for 4-leg spin ladders are discussed as a further step towards two dimensions.