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Possibility to detect the bound state of the Heisenberg ferromagnetic chain at intermediate temperature

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Motivated by the lack of direct evidence with inelastic neutron scattering of the well documented bound state of Heisenberg ferromagnets, we use the time-dependent Thermal Density Matrix Renormalization Group algorithm to study the temperature dependence of the dynamical spin structure factor of Heisenberg ferromagnetic spin chains [1]. For spin-1/2, we show that the bound state appears as a well defined excitation with significant spectral weight in the temperature range $J/12 \lesssim T \lesssim J/3$, pointing to the possibility of detecting it with inelastic neutron scattering near $k = \pi$ provided the temperature is neither too low nor too high - at low temperature, the spectral weight only grows as $T^{3/2}$, and at high temperature the bound state peak merges with the two-magnon continuum. For spin-1, the situation is more subtle because the bound state with two neighboring spin flips competes with an anti-bound state with two spin-flips on the same site. As a consequence, the relative spectral weight of the bound state is smaller than for spin-1/2, and a weak resonance due to the anti-bound state appears in the continuum. A clearer signature of the bound state (resp. anti-bound state) can be obtained if a negative (resp. positive) biquadratic interaction is present.

[1] Mithilesh Nayak, Frédéric Mila, Phys. Rev. B 105 094407 (Mar 2022).