Bound magnon crystals of spin-1/2 Heisenberg diamond and octahedral chains as a statistical-mechanical monomer-dimer problem

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It has been recently verified that the lowest-energy eigenstates of the spin-1/2 Heisenberg diamond [1] and octahedral [2,3] chains follow in a highly-frustrated parameter region from flat bands, which correspond to magnons bound on vertical dimers of a diamond chain and square plaquettes of an octahedral chain, respectively. This fact allows a precise description of low-temperature thermodynamics above the monomer-dimer and monomer-tetramer ground states of the spin-1/2 Heisenberg diamond and octahedral chains from a mapping correspondence with a classical one-dimensional lattice-gas model of hard-core monomers.

In the present work we will adapt the localized-magnon approach to a less frustrated parameter region supporting more peculiar dimer-tetramer and tetramer-hexamer ground states of the spin-1/2 Heisenberg diamond and octahedral chains with a spontaneously broken symmetry. A direct comparison between the results stemming from the exact diagonalization and the developed localized-magnon approach implies that the low-temperature thermodynamics of the spin-1/2 Heisenberg diamond and octahedral chain above the dimer-tetramer and tetramer-hexamer ground states can be reformulated as a statistical-mechanical problem of hard-core monomers and dimers.

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