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Summary of the dissertation: Influence of dimensionality and structure on the ground-state and the thermodynamics of quantum spin systems

At the beginning of the work zero-dimensional quantum spin systems (magnetic molecules) have been investigated, which can be described by the Heisenberg antiferromagnet, that is expanded by the Zeeman term. The variation of the spin quantum number and the calculation of thermodynamic properties give the possibility to make conclusions about the role of quantum fluctuations.

In addition the transition of the XY model from one dimension to two dimensions has been considered for systems with the spin quantum number $s = \frac{1}{2}$ in the ground-state ($T = 0$). In contrast to the isotropic Heisenberg antiferromagnet the impact of the quantum fluctuations is less for the XY model.

The investigation of two-dimensional systems also involved systems with $s = \frac{1}{2}$, that can be described with the Heisenberg antiferromagnet in the ground-state. It was the transition between two Archimedean lattices, the bounce- and the maple-leaf lattices, that had been studied.

At the end the canonical J_1-J_2 model on the body centered cubic lattice had been discussed in comparison to the two-dimensional square lattice for $s = \frac{1}{2}$ at $T = 0$.

In the focus of the investigations was the interplay of quantum fluctuations, frustrating structures and dimensionality.

The used methods, the exact diagonalization and the linear spin-wave theory, have been proved to be efficient to examine such questions.

The results confirm, that the influence of quantum fluctuation decreases with increasing dimensionality. Frustration enhances the influence of quantum fluctuations and leads for example for the zero-dimensional cuboctahedron under the impact of an external field to plateaus of extra large width and jumps to full magnetization, which are twice as large as the other steps. The spin spin correlation functions of the cuboctahedron show a clear difference in the behavior of half-integer and integer spin quantum numbers. Remarkable is as well the low-temperature maxima in the specific heat, that can be referred to low-lying singlets.

The findings of the linear spin-wave theory point to an infinitesimal small bond leading into the second dimension, that is necessary to establish the long-range order. In contrary the results of the exact diagonalization give a hint to a finite strength of the bond, at which the quantum phase transition takes place leading into the long-range ordered phase.

The additional frustration put into the system for the transition of the bounce lattice to the maple-leaf lattice lowers the sublattice magnetization. After the quantum phase transition of first order the ground-state of the system is a product state that is composed of singlets.

For the body centered cubic lattice the influence of quantum fluctuation is not sufficient to create a disordered phase alike for the square lattice.