21 世紀 COE & 極限量子科学研究センタージョイントセミナー

Exactly solvable lattice-statistical models in condensed matter physics. Outlook and future perspectives.

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場所：極限量子科学研究センター会議室
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概要： This lecture reviews some recent achievements obtained in the field of exactly solvable lattice-statistical spin models, which have been proposed to elucidate various cooperative phenomena in the condensed matter physics. Exact solution for several low-dimensional Ising and Ising-Heisenberg models, which might be achieved by applying generalized mapping transformations, is discussed in connection with possible experimental realizations of those models. The special attention is devoted to possible macroscopic manifestations of low-dimensional quantum spin systems with a particular emphasis laid on the quantum entanglement of spin states, the quantum reduction of magnetization, the multistep magnetization plateaux, the enhanced magnetocaloric effect, the geometric frustration, etc.

Several planar Ising-Heisenberg models [1] with a remarkable long-range-ordering, which does not have any classical counterpart, will be discussed along with the trimerized and tetramerized Ising-Heisenberg chains [2,3] exhibiting a multistep magnetization process with particular magnetization plateaux obeying quantized Oshikawa-Yamanaka-Affleck condition [4]. The frustrated Ising-Heisenberg diamond chain [5] will be discussed in connection with an enhanced magnetocaloric effect as well as multistep magnetization process. The tetramerized ferro-ferro-antiferro-antiferro Ising-Heisenberg bond alternating chain [3] will be investigated as a suitable model system for $Cu(3\text{-}Clpy)_2(N_3)_2$ polymeric coordination compound. The ground state and thermodynamics of the frustrated spin-1/2 Ising Heisenberg model on a triangular Kagome lattice, which exhibits extraordinary large residual entropy, will be examined in detail as an useful model system for a series of polymeric copper complexes $Cu_9X_2(cpa)_6.xH_2O$ (X= F, Cl, Br, cpa=2-carboxypentonic acid) [6].

Last but not least, the exact solution of several mixed-spin Ising models on the decorated square [7], centered square [8], Shastry-Sutherland and bathroom-tile [9] lattices will be investigated in view of rich critical behaviour they display. To the best of our knowledge, the mixed-spin Ising model on the anisotropically decorated square lattice is the only long-range-ordered spin system, which is quasi one-dimensional in its nature [7]. On the other hand, the frustrated mixed-spin Ising model on the centered square lattice exhibits very intriguing phase transition lines along which critical exponents vary continuously with interaction parameters and thus contradict the ordinary universality hypothesis [8].

The possible future extensions of generalized mapping transformation technique will be conjectured for the low-dimensional hybrid Ising-Hubbard and Ising-Heisenberg models, while a spin-phonon coupling possibly leading to a magnetoelastic spin-Peierls phase transition might be possibly taken into account. Finally, the exact solution for the three-dimensional models will be discussed in connection with a recent putative exact solution of the spin-1/2 Ising model on the orthorhombic lattice [10].

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