Stepwise magnetization curves and anomalous thermodynamics of an exactly solvable spin-1/2 Ising-Heisenberg branched chain

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The spin-1/2 Ising-Heisenberg branched chain composed of regularly alternating Ising spins and branched Heisenberg dimers is rigorously solved in a presence of the external magnetic field by the transfer-matrix approach following the partial trace over degrees of freedom of the Heisenberg dimers. The magnetic structure of the investigated spin-1/2 Ising-Heisenberg branched chain is inspired by the magnetic structure of the heterometallic one-dimensional coordination polymer [(Tp)2Fe2(CN)6(OAc)(bap)Cu2(CH3OH).2CH3OH.H2O] (HOAc = acetic acid, Tp=tris(pyrazolyl)hydroborate, bapH = 1,3-bis(amino)-2-propanol), which incorporates the highly anisotropic trivalent Fe(3+) cations and the almost isotropic divalent Cu(2+) cations [1]. Within the framework of exact transfer-matrix calculations we have examined in detail the magnetization process and basic thermodynamic quantities (entropy, specific heat, susceptibility). We have found three different ground states depending on a mutual interplay between the magnetic field, Ising and Heisenberg coupling constants, two of which have character of the quantum antiferromagnetic phase and the quantum ferrimagnetic phase, while one ground state is the classical ferromagnetic phase. The two quantum ground states are manifested in zero-temperature magnetization curves as intermediate plateaux at zero and one-half of the saturation magnetization, respectively. The quantum antiferromagnetic state presented as the zero magnetization plateau occurs regardless of the relative strength of the interaction parameters, while the quantum ferrimagnetic state presented as the intermediate one-half magnetization plateau emerges only if the relative ratio between the ferromagnetic Ising interaction and the antiferromagnetic Heisenberg interaction is sufficiently small. Interestingly, the two quantum ground states with an outstanding quantum entanglement of the Heisenberg spin dimers coalesce with the trivial fully polarized ferromagnetic state at a special triple point. It will be demonstrated that one detects anomalous thermodynamics in a vicinity of the triple point as well as in a close neighbourhood of phase boundaries between individual ground states.

[l] L. Kang, X. Chen, H. Wang, Inorg. Chem. **49**, 9275 (2010).