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MAGNETIC QUANTUM PHASE TRANSITIONS AND ENTROPY IN VAN VLECK MAGNET

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Field-induced magnetic quantum phase transitions in the Van Vleck paramagnet with easy-plane single-ion anisotropy and competing Ising exchange between ions with the spin S=1 have been studied theoretically. The description was made by minimizing the Lagrange function at zero temperature (T = 0) and the free energy at $T \neq 0$. Stable and unstable solutions of equations corresponding to the case $T \neq 0$ asymptotically transform into those following from the Lagrange function at T = 0. First-order phase transitions from the Van Vleck paramagnet state into the ferromagnet one were found to take place at a sufficiently high single-ion anisotropy. The entropy of such a magnet was shown to grow with its magnetization, as it occurs for antiferromagnets. At the point of quantum phase transition, the entropy has a jump, which magnitude depends on the ratio between the Ising exchange and anisotropy constants, as well as on the temperature. The described magnetic phase transition was supposed to be accompanied by the magnetocaloric effect. In the case when the Ising exchange dominates over the single-ion anisotropy, the magnetization reversal of ferromagnetic state by an external field was shown to be a phase transition of the first kind, which does not belong to orientational ones and which should be regarded as a quantum order-order phase transition.

1. Introduction

In this paper, quantum phase transitions (QPTs) in the Van Vleck paramagnet (VVPM) are studied theoretically. The VVPM is supposed to be characterized by the Ising exchange (IE) of the ferromagnetic (FM) type between ions with the spin S=1 and by the easy-plane single-ion anisotropy (SIA) that is perpendicular to the Ising exchange direction [1-7]. A model with competing IE and