Monte Carlo studies of magnetization processes in an extended Ising model on the Shastry-Sutherland lattice

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The ground-state properties of the Ising model on the Shastry-Sutherland lattice with the first (J_1), second (J_2), third (J_3) and fourth (J_4) nearest-neighbour spin interacions are studied numerically by the classical Monte Carlo method up to clusters of $L = 120 \times 120$ sites. We have found that the switching on J_3 and J_4 interactions changes dramatically the ground-state phase diagrams as well as the picture of magnetization processes found for the conventional Ising model on the Shastry-Sutherland lattice (with only J_1 and J_2 interactions). In particular, it is shown that the combination of J_3 and J_4 interaction generates the new magnetization plateau at m/m_s=1/2 in the limit of $J_4 \leq 0$ and the following relevant magnetization plateaus at m/m_s=1/10, 1/9, 1/6, 1/5, 2/5, 4/9, 7/15, 1/2 and 5/9 for $J_4 > 0$. The ground states corresponding to these magnetization plateaus are identified by an exhaustive finite-size scaling analysis and the complete ground-state phase diagrams of the model are presented for both, negative as well as positive J_4 interaction. The relevance of these results for description of magnetization processes in rare-earth tetraborides is discussed.