Critical properties of the Kitaev-Heisenberg model

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A prominent example of anisotropic spin-orbital models is the Kitaev-Heisenberg (KH) model on the honeycomb lattice [1,2]. This model was proposed as the minimal model to describe the low-energy physics of the quasi two-dimensional compounds, Na_2IrO_3 and Li_2IrO_3. In these compounds, Ir^{4+} ions are in a low spin $5d^5$ configuration and form weakly coupled hexagonal layers. Due to strong SOC, the atomic ground state is a doublet where the spin and orbital angular momenta of Ir^{4+} ions are coupled into $J_{\rm eff} = 1/2$. The KH model describing the interactions between $J_{\rm eff}$ moments contains two competing nearest neighbor interactions: an isotropic antiferromagnetic Heisenberg exchange interaction originated mainly from direct direct overlap of Ir t_{2g} orbitals and a highly anisotropic Kitaev exchange interaction [3] which originates from hopping between Ir t_{2g} and O $2p$ orbitals via the charge-transfer gap.

We study critical properties of the KH model on the honeycomb lattice at finite temperatures [4,5]. The model undergoes two phase transitions as a function of temperature. At low temperature, thermal fluctuations induce magnetic long-range order by order-by-disorder mechanism. This magnetically ordered state with a spontaneously broken Z_6 symmetry persists up to a certain critical temperature. We find that there is an intermediate phase between the low-temperature, ordered phase and the high-temperature, disordered phase. Finite-size scaling analysis suggests that the intermediate phase is a critical Kosterlitz-Thouless phase with continuously variable exponents. We argue that the intermediate phase has been likely observed above the magnetically ordered phase in A_2IrO_3 compounds.

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