

# Geometric Meets Exchange Frustration in the Kitaev-Heisenberg Model

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Quantum spin liquids (QSLs) are highly entangled quantum phases in which strong fluctuations suppress magnetic order down to zero temperature, giving rise to topologically nontrivial ground states and fractionalized excitations. Two distinct mechanisms can stabilize QSLs: geometric frustration, as in Anderson's resonating valence bond picture on the triangular lattice [1], and exchange frustration, realized in the exactly solvable Kitaev honeycomb model with bond-dependent interactions [2]. Since these two types of frustration originate from different physical mechanisms, their coexistence may give rise to qualitatively new quantum states, yet their interplay remains largely unexplored.

In this work, we investigate this interplay in the Kitaev-Heisenberg model on a lattice that can be continuously tuned between triangular and honeycomb geometries (Fig. 1). Although a related lattice geometry was studied previously [3], our model is motivated by the recent discovery of rare-earth magnets with double-layer triangular lattices [4]. Combining exact diagonalization, density-matrix renormalization group, and pseudo-fermion functional renormalization group methods, we construct the ground-state phase diagram as a function of lattice geometry and interaction ratio. We trace the evolution of magnetic phases between the two limits and show how the interplay of geometric and exchange frustration enhances quantum fluctuations, potentially stabilizing spin-liquid or quantum paramagnetic states in the intermediate regime.

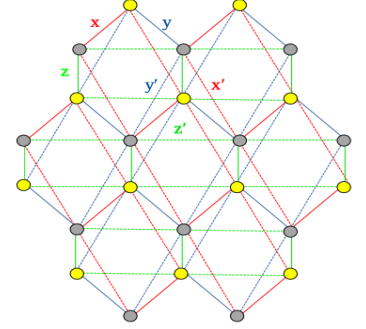


Figure 1: Schematic of the Kitaev-Heisenberg model on a two-dimensional honeycomb-triangular lattice, including nearest-neighbor  $(x,y,z)$  and next-nearest-neighbor  $(x',y',z')$  Kitaev and Heisenberg interactions.

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