Kitaev Spin Liquids

**Context**

**The Model**

Gus  “Lithium Ion Batteries”
Cory “Measuring Spin Waves with Neutrons”
Kevin “The Aharonov-Bohm Effect”

**Experimental Realizations**
Kitaev Materials

- Mott insulator
- Metal band insulator
- Topological insulator (Weyl semi-metal)
- Spin-orbit entangled Mott insulator
- Kitaev materials
Fig. 2: Formation of spin-orbit entangled $j = 1/2$ moments for ions in a $d^5$ electronic configuration such as for the typical iridium valence $Ir^{4+}$ or the ruthenium valence $Ru^{3+}$.

Fig. 3: Illustration of possible geometric orientations of neighboring $IrO_6$ octahedra that give rise to different types of (dominant) exchange interactions between the magnetic moments located on the iridium ion at the center of these octahedra. For the corner-sharing geometry (I) one finds a dominant symmetric Heisenberg exchange, while for the edge-sharing geometries (II) one finds a dominant bond-directional, Kitaev-type exchange.
The Kitaev Model on the Honeycomb Lattice

\[ H = - \sum_{\langle ij \rangle} K_\gamma S_i^\gamma S_j^\gamma \]

Ising Spins with Bond Anisotropies

Classical Model has Extensive Ground State Degeneracy

Two “happy” bonds/plaquette
The Kitaev Model on the Honeycomb Lattice

\[ H = - \sum_{\langle ij \rangle} K_{\gamma i} S_{i}^{\gamma} S_{j}^{\gamma} \]

Ising Spins with Bond Anisotropies

Superposition of Classical Configurations (similar to RVB)

Highly Entangled Quantum Spin Liquid State
The Kitaev Model on the Honeycomb Lattice

\[ H = - \sum_{\langle ij \rangle} K_{\gamma} S_i^\gamma S_j^\gamma \]

Ising Spins with Bond Anisotropies

\[ W_p = 2^6 S_1^z S_2^x S_3^y S_4^z S_5^x S_6^y \]

\[ [W_p, H] = 0 \]

Infinitely Many Conserved Quantities

\[ W = \pm 1 \]

Each many-body eigenstate can be labelled by conserved flux quanta through each hexagon.
The Kitaev Model on the Honeycomb Lattice

\[ H = - \sum_{\langle ij \rangle_{\gamma}} K_\gamma S_i^{\gamma} S_j^{\gamma} \]

Ising Spins with Bond Anisotropies