Toward the realization of chiral spin liquids and non-Abelian anyons in quantum simulators

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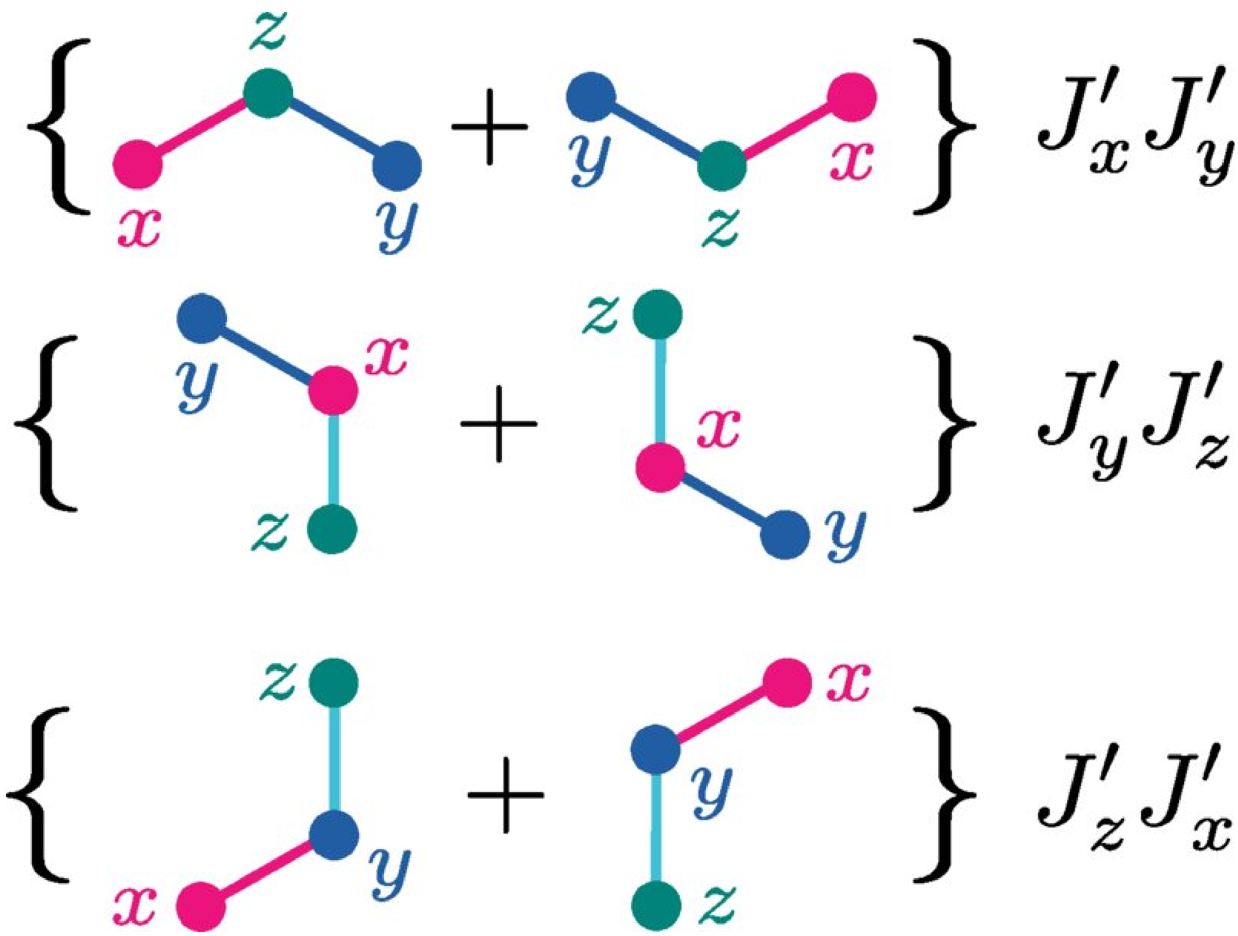

Schematic representation of the notation showing the three-body terms to order ω_D^{-1}, which are responsible for opening the topological bulk gap. The letters refer to the spin operator applied to each vertex, and the bond colors correspond to the bonds in the Kitaev honeycomb model. Credit: *PRX Quantum* (2023).

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Chiral spin liquids are one of the most fascinating phases of matter ever imagined by physicists. These exotic liquids exhibit quasi-particles known as non-Abelian anyons that are neither bosons nor fermions, and whose manipulation could allow for the realization of a universal quantum computer. Despite intense efforts in condensed matter physics, discovering such a phase in nature remains an outstanding challenge at the forefront of modern research.

From a theoretical point of view, chiral spin liquids emerge in a simple model that was imagined by Kitaev in 2006, and which allows researchers to reveal their properties using analytical tools. Remarkably, recent advances in the design of quantum simulators open a possible path for the first experimental realization of the original Kitaev model, hence suggesting that chiral spin liquids (including their exotic quasi-particles) can be studied and manipulated in a highly-controlled experimental environment.

In a new study published in *PRX Quantum*, BoYe Sun and Nathan Goldman (ULB, Brussels), Monika Aidelsburger (LMU, Munich), and Marin Bukov (MPI-PKS Dresden, Sofia University) propose a realistic implementation of the Kitaev model in quantum simulators.

Based on a precise pulse sequence, their system is shown to host a chiral spin liquid with non-Abelian anyons. The authors describe practical methods to probe the striking properties of these exotic states. In particular, their methods unambiguously reveal the topological heat current that flows on the edge of the system: a hallmark signature of the non-Abelian anyons that emerge on the edge of chiral spin liquids.

This work paves the way for the quantum simulation of chiral spin liquids, offering an appealing alternative to their experimental investigation in quantum materials.

More information: Bo-Ye Sun et al, Engineering and Probing Non-Abelian Chiral Spin Liquids Using Periodically Driven Ultracold Atoms, *PRX Quantum* (2023). DOI: 10.1103/PRXQuantum.4.020329

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