New phases of quantum matter explored in triangular lattice magnets

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Wednesday, Sept. 24th @ 2:00 pm in BRK 1001

Coffee and snacks served before seminar

also on [MS Teams](#)

Abstract: Quantum spin systems offer a rich playground for emergent phenomena, where collective excitations can behave like fermions, bosons, or even anyons, depending on the underlying Hamiltonian and its driving conditions. Such exotic spin states are central to both fundamental physics and quantum engineering, with potential applications in protected quantum memory, spin transport, and entangled operations for next-generation quantum technologies. Triangular lattice antiferromagnets, the simplest frustrated spin networks, were long ago proposed as hosts for resonating valence bond spin liquids. In this talk, I will present two complementary explorations of these elusive states. The first focuses on the triangular-lattice Heisenberg magnet $TlYbSe_2$, where Yb S=1/2 ions form a perfect triangular network. Through heat capacity measurements on samples prepared by us, and theoretical modeling, we provide evidence for an emergent U(1) Dirac quantum spin liquid with finite interactions between fermions and spinons. The second explores out-of-equilibrium dynamics using a programmable quantum simulator (D-Wave). By rapidly quenching the transverse field, we uncover a novel quantum coarsening dynamics. The results offer insight into how frustrated systems relax into ordered phases and long-range order can emerge in long time from short time dynamics, and inform the design of future field-quenched experiments in real magnets. Together, these results illustrate the diversity of quantum phases accessible in triangular magnets and how computational and experimental tools can jointly reveal new paradigms in frustrated magnetism.

[1] Finite Spinon Density-of-States in Triangular-Lattice Delafossite TlYbSe2, Belbase et al., https://doi.org/10.48550/arXiv.2504.05436 (2025).

[2] Quantum quench dynamics of geometrically frustrated Ising models, Ali et al., Nature Communications, 15, 10756 (2024).

Bio: Arnab Banerjee is an Assistant Professor of Physics and Astronomy at Purdue University. He received his Ph.D. in Physics from the University of Chicago and was previously a staff scientist at Oak Ridge National Laboratory before joining Purdue in 2020. His research explores emergent quantum phenomena in frustrated magnets, combining crystal growth, low-temperature transport, neutron scattering, and quantum computational simulations. He is widely recognized for pioneering spectroscopic studies of the Kitaev candidate α-$RuCl_3$, which revealed signatures of fractionalized excitations and helped establish a new experimental platform for quantum spin liquids. At Purdue, his group has extended these efforts through the synthesis of novel rare-earth-based magnets, cutting-edge neutron, thermal transport and optical experiments to millikelvin temperatures, and the development of algorithms for simulating many-body dynamics on quantum hardware. Dr. Banerjee's work has been featured in leading journals and is supported by DOE, ARO, NSF and the W. M. Keck Foundation.

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