A Dynamical Landscape of Quantum Magnetism

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The emergence of novel magnetism stands as a hallmark of quantum materials, which has unveiled fascinating complexity arising from the interplay between quantum mechanics and many-body interactions. In this talk, we delve into the study of collective spin dynamics in quantum materials, which provides critical insights into exotic magnetic phases of matter and their dynamical and transport behaviors, as well as fosters innovative approaches in the realm of quantum information. We will explore a hydrodynamic picture of the spin dynamics in a three-dimensional quantum spin liquid candidate material, where strong quantum fluctuations defy a conventional magnetic order [1]. Our complementary analytical and numerical theories reveal an interactive coexistence of fast spin waves and slow ground-state motions, which produces an excitation spectrum that quantitatively agrees with inelastic neutron scattering experimental data [2,3]. This hydrodynamic understanding holds a general implication for spin dynamics and transport in the presence of frustrated magnetic interactions, where spin diffusion can manifest in an intermediate temperature regime as an intrinsic many-body effect [4]. In the final part, we offer a glimpse into the transformative potential of magnetic materials in the quantum-information domain. We envision a hybrid system, where the long-range spin correlations inherent in a magnetically active platform can generate stable entanglement between spin qubits [5].

[1]. K. W. Plumb, H. J. Changlani, A. Scheie, SZ, …, R. J. Cava, C. L. Broholm, Nat. Phys. 15, 54 (2019)
[2]. SZ, H. J. Changlani, K. W. Plumb, O. Tchernyshyov, and R. Moessner, Phys. Rev. Lett. 122, 167203 (2019)
[3]. A. Bhardwaj, SZ, H. Yan, R. Moessner, A. H. Nevidomskyy, H. J. Changlani, npj Quantum Mater. 7, 51 (2022)
[4]. N. Mao, D. Dahlbom, R. Moessner, Y Zhang, SZ, in preparation (2024)
[5]. J. Zou, SZ, Y. Tserkovnyak, Phy. Rev. B 106, L180406 (2022)