PHYSICS

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Shining Light on Quantum Materials

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Despite the undeniably quantum nature of interactions in solids at the microscopic scale, macroscopic measurements of material properties nearly always give classical results. This is in contrast to so-called “quantum materials,” in which non-trivial topology or high levels of entanglement drive the emergence of demonstrably macroscopic quantum phenomena. A prototypical example of such quantum matter is highly frustrated magnetic insulators, which recent theoretical analyses have suggested may possess exotic fractionalized quasi-particles that are beneficial for quantum computation. However, despite intense interest in recent years, a microscopic understanding of these materials is lacking due to the many-body nature of spin-Hamiltonians as well as the hindrance of typical techniques for probing dynamic magnetic responses. In this talk, I will demonstrate how a suite linear and non-linear ultra-fast optical techniques are uniquely suited to probe and control strongly correlated quantum matter. First, I will demonstrate how the low-energy linear response of FeSc2S4 naturally encodes signatures of a unique long-ranged entangled "spin-orbital liquid" ground state that is on the edge of quantum criticality. Then, I will detail how non-linear optical techniques can exploit the intimate relationship between symmetry and ground state to uncover a hidden nematicity in the prototypical Kagome spin-liquid candidate Herbertsmithite ZnCu3(OH)6Cl2. Together, these results embody the unique promise that optical techniques hold in the emerging quantum materials research forefront.