Field-Dependent Magnetic Ordering Dome and Quantum Spin Fluctuations in the Natural Mineral Henmilite

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Quantum materials have been playing a crucial role in the development of next-generation technologies and devices including quantum computers. Such materials are usually prepared under laboratory conditions. However, some naturally occurring minerals, have also been found to feature complex magnetic ground states, such as Henmilite [2], or Herbertsmithite [1,8]. They possess spin ½ Cu ions which exhibit a magnetic ground state favouring the creation of quantum fluctuations, hinting at a possible quantum spin liquid state [2].

Henmilite is a bright blue-violet colour mineral, which has been suggested to consist of coupled two-leg ladders, where strong quantum fluctuations suppress (AF) magnetic order at low temperatures [2]. It is an extremely rare mineral only found in the Fuka mines of Japan [6]. In Henmilite, the B-T phase diagram has an unusual antiferromagnetic dome [2]. The nuclear crystal structure is complex and contains well-separated sheets of $Cu(OH)_4$ square-planar plaquettes, separated by a network of $Ca(OH)_8$ and $B(OH)_4$ polyhedra. DFT (GGA+U) calculations found interlayer magnetic coupling less than 1% of the dominant intra-plane coupling, confirming the magnetic 2-dimensionality of the material [2].

We will present our experimental results of magnetic susceptibility, heat capacity, and thermal conductivity experiments as well as corresponding theoretical calculations for its magnetic ground structure. A Muon spectroscopy experiment is scheduled at HiFi instrument, ISIS UK, allowing us to study magnetic ground state and spin dynamics in short-range correlation regions above T_N. We will use the newly developed instrument ALSA [7], an AI-controlled robotic arm to co-align smaller crystals into mosaics to use for μSR experiment and later on for neutron spectroscopy.

References:

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