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Searching for Spin Liquids in Buckled Compounds

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The phrase 'quantum spin liquid'(QSL) refers to a system in which strong quantum fluctuations prevent long-range magnetic order from being established, even at temperatures well below any interaction energy scale. No spontaneous symmetry breaking is involved, nor a conventional local order parameter. Thus, it is not described using the Landau theory of phase transitions and constitutes a novel phase of matter. These systems exhibit a wealth of exotic phenomena like long-range entanglement and fractional quantum excitations, which are of fundamental interest but also hold great potential for quantum communication and computation.

Magnetic species decorating a two dimensional kagome lattice constitute the most heavily studied QSL candidates. Quantum fluctuations are prevalent due to geometrical magnetic frustration, low coordination number and quasi low dimensionality. Two particularly well-studied experimental realisations are volborthite, where it is believed spatial anisotropy plays an important role and herbertsmithite $ZnCu_3(OH)_6Cl_2$. However, the presence of excess Cu^{2+} replacing the nonmagnetic Zn^{2+} induces randomness in the magnetic exchange coupling, complicating explanations of the experimental observations.

Our focus is the investigation of a series of newly synthesised QSL candidates. The insulating materials $YCu_3(OH)_6O_xCl_{3-x}$ (x = 0, 1/3) display a kapellasite-like structure and no sign of Cu/Y mixing from single crystal x-ray refinements. In the x = 0 compound, the kagome lattice is perfect; in the x = 1/3 compound, it is slightly buckled.
In $Ba_4Ir_3O_{10}$, $Ir^{4+}(5d^5)$ ions form Ir_3O_{12} trimers of three dimensional face-sharing IrO_6 octahedra, which are vertex-linked, forming wavelike 2D sheets. However, it is proposed that intra-trimer exchange is reduced and the lattice recombines into an array of coupled 1D chains with additional spins. As such, the compound is a candidate Tomonaga-Luttinger liquid (TLL) and presents a novel route to exploring quantum liquid behaviour. A muon spin relaxation investigation of these novel compounds is discussed.

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