

2531cs1104

Fractionalisation in Quantum Spin Liquids

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Project title	Fractionalisation in Quantum Spin Liquids
EPSRC theme	Physical Sciences
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Standard or collaborative project	Standard project
Restrictions for candidates applying	Only Home fees candidates can apply

Project summary

Quantum spin liquids (QSLs) represent one of the most striking manifestations of many-body quantum physics. In these states, local magnetic moments fail to order even at zero temperature, remaining in a highly entangled and dynamic quantum state. This phenomenon arises from geometric frustration and strong quantum fluctuations, producing a “liquid-like” magnetic phase in which fractionalised excitations and emergent gauge fields naturally emerge [1,2].

QSLs are of deep conceptual significance. They provide condensed matter realisations of gauge theories, exhibit topological order, and support anyonic quasiparticles that may enable fault-tolerant quantum computation [3]. They are also thought to act as parent states for unconventional superconductivity, offering potential insight into the mechanisms underlying high-temperature superconductivity [4].

This project aims to develop a comprehensive theoretical framework for understanding topological and symmetry-breaking phase transitions in QSLs and their metallic extensions, fractionalised Fermi liquids (FL*). The central objective is to identify and characterise new types of emergent quantum order and critical behaviour that cannot be captured by conventional Fermi-liquid or symmetry-based paradigms.

[1] P.W. Anderson, "Resonating Valence Bonds: A New Kind of Insulator?", Mater. Res. Bull. 8, 153 (1973)

[2] L. Balents, "Spin Liquids in Frustrated Magnets", Nature 464, 199 (2010)

[3] A. Kitaev, "Anyons in an Exactly Solved Model and Beyond", Ann. Phys. 321, 2 (2006)

[4] P.W. Anderson, "The Resonating Valence Bond State in La₂CuO₄ and Superconductivity", Science 235, 1196