# Criticality of Quantum Spin Liquids

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## Criticality of Quantum Spin Liquids

Project ID: 2228cd1396 (You will need this ID for your application)

Research Theme: Physical Sciences

UCL Lead department: London Centre for Nanotechnology (LCN)

Department Website

Lead Supervisor: Frank Kruger

Project Summary:

Quantum spin liquids (QSLs) are a novel class of materials in which geometric frustration suppresses magnetic order down to absolute zero temperature. Because of the topological character of the ground-state wave function with a special type of long-range quantum entanglement, QSLs exhibit exotic fractional excitations, which are believed to hold great potential for quantum communication and computation. These concepts were put on a firm footing in the seminal work by Alexei Kitaev who constructed an exactly solvable QSL model on the honeycomb lattice and demonstrated that the spins break-up (fractionalise) into a set of Majorana fermions. Although the emergent fermions don't carry electric charge, they essentially behave like the electrons in graphene with a relativistic Dirac dispersion.

There exist materials that are well described by Kitaev's toy model, but which exhibit additional interactions. These interactions stabilise magnetic order at very low temperatures. In addition, strain or magnetic anisotropy can drive topological phase transition between gapless and gapped QSLs.

The aim of this project is to understand the nature of such quantum phase transitions, in the Kitaev model and in related QSLs. You will learn to represent spin models in terms of interacting Majorana fermions and gauge fields. Using methods of quantum field theory, such as renormalisation-group calculations, you will analyse the behaviour near the magnetic ordering and topological phase transitions and compute critical exponents. You will investigate the changes of magnetic excitation spectra across the transitions and compare to experiments.

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