Project 4.20. Dynamics of topological defects coupled to environments (theoretical)

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Background:

Topology has found a route from purely mathematical concepts to physics applications. The discovery of the quantum spin Hall effect and topological insulators more than a decade ago has revolutionised modern condensed matter physics. Today, the field of topological states of matter is one of the most active and fruitful research areas, and intense efforts have been devoted to the exploration of new phases of matter. One of the most exciting application is topological quantum computation with topological qubits such as the Majorana fermions emerging as excitations in topological superconductors. It is thus of great importance to (i) identify and study such topological materials (ii) investigate the dynamics of their excitations.

(i) Magnetic impurities inserted in s-wave superconductors can give rise to topological superconductivity pertaining to the so called in-gap Shiba states. That in turn offers a great platform for Majorana fermion physics. A drawback, however, is that such systems are particularly rigid and their parameters extremely hard to tune. This project aims at studying theoretically the Shiba states emerging from dynamical magnetic textures. Among the goals of the project is to find ways to control topology via texture dynamics and finding the feedback of the emergent topology (e.g. winding numbers, Chern numbers) on this dynamics.
(ii) Majorana fermions dynamics (such as braiding) is at the core of topological quantum computation. It is thus crucial to be able to monitor and manipulate their evolution. That can be achieved by utilising the environments the Majoranas interact with (e.g photons, phonons, magnons, etc). The goal of the project is to study the interplay of the geometry and topology of the braiding trajectories and the environment degrees of freedom, which in turn can be observed. Moreover, the project will address realistic experimental implementations.

Aim:

1. Theory of the interplay between magnetisation dynamics and emerging topological order
2. Theory of spintronic detection of topology and edge modes (e.g. Majoranas)
3. Theory for the dynamics of Majorana fermions or, more generally, of topological defects in the presence of environments

Requirements:

- MSc in Theoretical Physics

Funding:

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