# FLAVOURS OF FERMI SURFACE IN THE ABSENCE OF A CONVENTIONAL FERMI LIQUID

## Reporting

Project Information

**FermiSurfaceFlavours**

Grant agreement ID: 772891

Project website

**DOI**
10.3030/772891

**EC signature date**
11 June 2018

**Start date**
1 April 2019

**End date**
31 March 2026

**Funded under**
EXCELLENT SCIENCE - European Research Council (ERC)

**Total cost**
€ 2 127 851,00

**EU contribution**
€ 2 127 851,00

**Coordinated by**
THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE
United Kingdom

# Periodic Reporting for period 3 - FermiSurfaceFlavours (FLAVOURS OF FERMI SURFACE IN THE ABSENCE OF A CONVENTIONAL FERMI LIQUID)

**Reporting period:** 2022-04-01 to 2023-09-30

## Summary of the context and overall objectives of the project

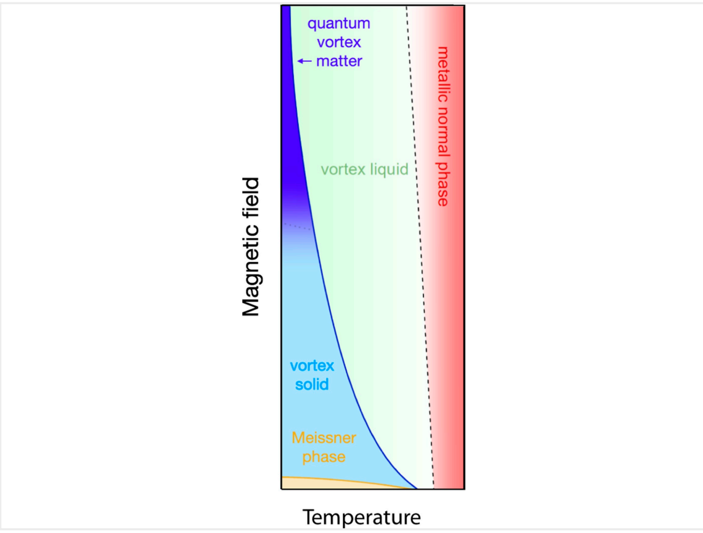
The project addresses fundamental scientific questions of discovering new and exotic quantum phases of matter. Quantum materials that will be our focus for this project are the unconventional insulators that our group has discovered, which exhibit a bulk Fermi surface despite bulk electrical insulating behaviour, and the high temperature cuprate superconductors. We propose to uncover novel quantum phase regimes within these broad areas of exploration by performing measurements under extreme conditions of high magnetic fields, high applied pressures, and low temperatures.

## Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

Advances have been made both in the area of unconventional insulators and cuprate superconductors. One of the breakthrough discoveries of our research group was the discovery of a neutral Fermi surface in families of correlated insulators, constituting a new class of unconventional insulators. During this period, we have performed rigorous measurements of a slew of complementary properties in the first unconventional insulator SmB6, based on which we are able to definitely rule out an extrinsic origin of the measured quantum oscillations. By establishing the intrinsic bulk origin of quantum oscillations in the bulk insulator SmB6, we place at the forefront the inherent theoretical conundrum posed by a neutral Fermi surface that couples to a magnetic field but not an electric field. Another achievement was the magnetic field tuning of the unconventional insulator YbB12 from the regime in which an insulating Fermi surface is observed to the high magnetic field regime in which a metallic Fermi surface is observed. Our measurements reveal surprising similarities in the Fermi surface sections on the insulating side and the metallic side, while more of the Fermi surface is revealed on the metallic side, providing strong clues as to the nature of neutral low energy excitations responsible for the insulating Fermi surface that mirrors the high field metallic Fermi surface. This finding of a small Fermi surface in which the antinodal density of states is completely gapped points to an origin from Mott physics, requiring new models beyond Fermi surface models involving conventional electronic quasiparticles, and potentially suggesting resonances with Fermi surface models developed for correlated insulators. Recently we have further discovered an unusual superconducting phase of matter that is resilient beyond the highest accessible DC magnetic fields of 45T, using sensitive high magnetic field electrical transport measurements down to the lowest temperatures, shedding new light on the cuprate superconducting phase diagram.

## Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

New unconventional insulators are in the process of being scoped. It is anticipated that by the end of the project, new unconventional insulators will have been identified, which will be crucial to shed light on the mysterious origin of a bulk Fermi surface in these bulk insulating materials.



Cuprate superconducting phase diagram showing new unconventional quantum vortex matter ground state

**Last update:** 9 July 2024

**Permalink:** https://cordis.europa.eu/project/id/772891/reporting