Master / PhD Thesis Project

Exotic properties in magnetically frustrated superconductors

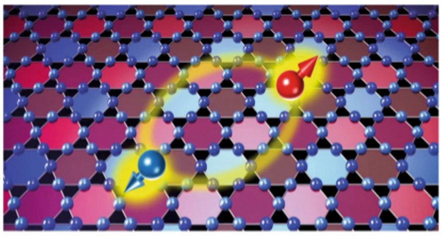

FIG. 1: Schematic of the charge order and superconductivity detected in Kagome superconductors AV_3Sb_5. The dark and light-blue spheres form the Kagome lattice. The shade of the colour represents the unusual distribution pattern of the charge order. The large red and blue spheres with arrows represent Cooper pairing of the superconductivity, from [1].

General Scope: Unveiling new physics from simple lattice models plays a vital role in modern condensed matter physics. One of these lattice models is the Kagome lattice (KL) formed by corner-sharing triangles, see Fig. 1. The KL contains geometric frustration for spin systems, which gives rise to extensively degenerate ground states in the nearest-neighbor antiferromagnetic Heisenberg model. Accordingly, the ground state of the Kagome spin model is the most promising candidate for the long-sought after quantum spin liquid state. Recently, fermionic models on KLs have also become an important platform for studying the interplay between electron-electron correlations, band topology and lattice geometry. The point group of the KL is the same as that of graphene, leading to similar Dirac cones in the electron excitations dispersion. Superconductivity also appears in some KL materials: it has been argued that the KLs can host a variety of unconventional pairing superconducting states, including chiral superconductivity (SC) and f-wave spin-triplet SC, among others. However, superconducting KL materials are rare in nature. Recently, the newly discovered KL material CsV_3Sb_5 was found to be a quasi-2D Kagome SC with a transition temperature $T_c \approx 2.3$ K [2]. Subsequently, superconductivity was also found across the entire family of compounds KV_3Sb ($T_c \approx 0.93$ K) [3] and RbV_3Sb_5 ($T_c \approx 0.75$ K) [4]. This discovery has stimulated extensive research activity in this field, with the underlying the natural question: would the frustration, accompanied by large fluctuations, favors the magnetic mechanism for superconductivity?

Subject: We propose an experimental and fundamental research project which will explore different types of frustrated superconductors among the AV_3Sb_5 (A = K, Rb, Cs) family. The goal is to use different transport (resistivity, thermoelectricity) and thermodynamic measurements (specific heat) under extreme conditions (low temperature, high magnetic field and high pressure), to characterize these materials, understand the different competing orders present and ultimately find new exotic orders.

Experimental environment: The candidate will benefit from a unique scientific environment: a dedicated dilution refrigerator (50mK-16T), a large range of experimental probes (resistivity, Hall effect, specific heat, thermal conductivity and thermoelectric effects…), the possibility to grow and characterize his own material in the laboratory, a strong interplay with theoreticians from the laboratory.

Possible collaboration and networking: The internship proposal is based on a long-term collaboration with the high magnetic field facility (LNCMI) in Grenoble and with close collaborators in Hong Kong and Japan.

Required skills: Master or Engineering degree. Skills on solid state physics or nanophysics will be appreciated. Motivation for experimental studies is needed.

The internship is aimed to be followed by a PhD.

[1] Yin, JX., *et al.* Nature **612**, 647 (2022)

[2] Ortiz BR, Phys. Rev. Mater. **3**, 094407 (2020)

[3] Ortiz BR, Phys. Rev. Mater. **5**, 034801 (2021)

[4] Yin Q, Chin. Phys. Lett. **38**, 037403 (2021)

APPLY NOW!

To apply for this position, send your application (including CV) by e-mail to: alexandre.pourret@cea.fr