NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2025-2026

Locally non-centrosymmetric Quantum Materials

General Scope: The symmetry of materials has a profound effect on their quantum properties. Recently, the scientific community identified intriguing materials that respect global centrosymmetry (the presence of an inversion centre), but lack an inversion centre on the most important atom, i.e. the rare earth atom (such as cerium or uranium). One major consequence is the presence of a new type of spin-orbit coupling with alternate orientation in the unit cell. As a consequence, new kind of quantum order emerges, such as **unconventional superconductivity** in $CeRh_2As_2$ (Cf. [1]) or new type of order built from **entangled electronic states of two Rare earth sites** (Cf. [2]). This quantum entanglement between localized state (similar to the formation of the molecular states) is a premiere and requires further experimental scrutiny. Our goal is to investigate these unusual situations in new materials that we have identified though big data analysis of thousands of compounds.

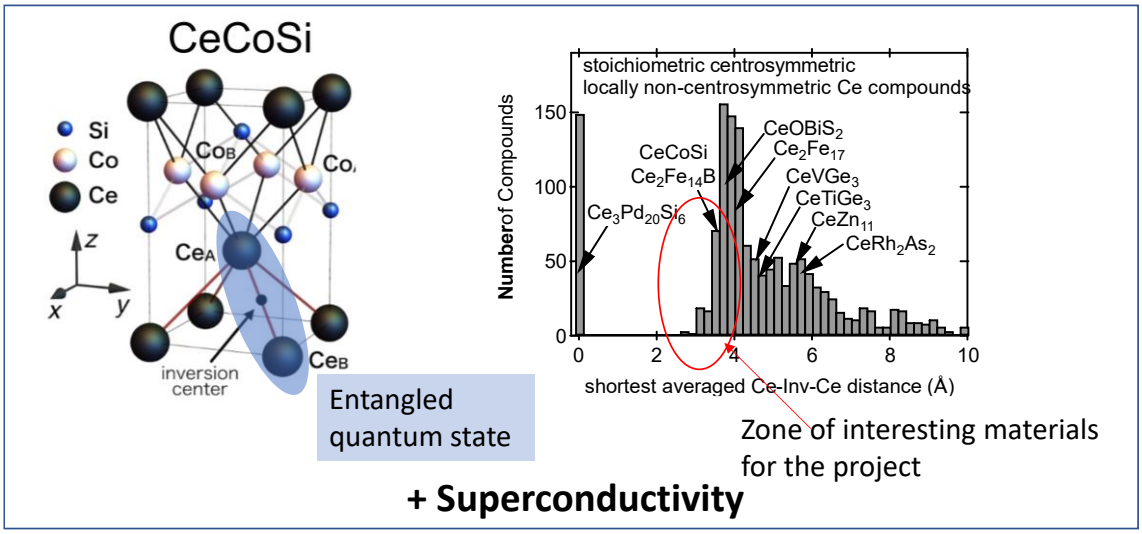

Figure: Summary of the project: Quest for new materials with locally broken inversion center and consequent multi-site entangled quantum state and unconventional Superconductivity.

Research topic:

More precisely, we identify few promising materials which lack local inversion center and with the smallest Ce-Ce distance therefore increasing the probability of effective quantum entanglement (Cf. Figure).
During the Master internship, the student will perform polarized Raman scattering experiment as a function of temperature down to 1.9 K to identify the entangled electronic modes and their symmetry. He/she will also look for superconductivity in materials identified among the thousands available. Part of this activity may be performed in the University of California (UC Davis) in collaboration with Valentin Taufour. If interested, the candidate can participate in data aggregation and curation of large material property databases using modern techniques to identify other potential candidate materials as locally non-centrosymmetric Ce-based superconductors.

Facilities: At the Institut Néel: Raman Spectrometers, cryostats, High pressure cell… and all necessary characterizations equipments.
At UC Davis, Department of Physics and Astronomy: equipment for the synthesis of high-quality single crystals (glass bench, glove boxes, 1500C box furnaces, tetra-arc-Czochralsky furnace, 3-zone furnace, Bridgman furnace) and measurements of physical properties (powder x-ray diffractometer,

Citations:
[1] DOI: 10.1126/science.abe7518
[2] https://arxiv.org/abs/2505.03249
[3] https://doi.org/10.1103/PhysRevB.110.245114: common published paper between Valentin and Marie-aude

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Laue diffractometer, quantum design MPMS for magnetization measurements (2K, 7T), quantum design PPMS for electrical transport or heat capacity measurements (0.4K, 14T)).

Possible collaboration and networking:
Strong collaboration between Marie-aude Méasson (Institut Néel) and Valentin Taufour (UC Davis, USA) with joint PhD as an extension of the Master 2 internship. Collaboration with the CEA-Grenoble/Phelips and Japan for theory.

Possible extension as a PhD: YES

Required skills: Curiosity, Problem-solver oriented, Good speaking and writing in english

Starting date: 2026

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