NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2022-2023

Superconductivity and lattice instability

General Scope :
The superconducting state is characterized by macroscopic electronic coherence. Well known models have provided a deep understanding of the mechanisms in pure compounds and many superconducting alloys. The basis of these models is the attraction between electrons via lattice vibrations, the phonons. However, this electron-phonon interaction can give rise to other electronic instabilities and the formation of new phases such as charge density waves. These instabilities are characterized by a deformation of the lattice. If models have been proposed to explain the formation of these different electronic phases, they have rarely been confronted with real systems.
Currently, the coexistence of superconductivity and lattice instability seems to be far more general than previously expected. The aim of this internship is to study the coexistence of these two states in a model system. The use of hydrostatic pressure allows to modify the energy scales involved and the fundamental states. This technique is opening to many new probes, in particular those associated with synchrotron radiation facilities, and offers a growing field of exploration in the fundamental understanding of superconductivity.

Research topic and facilities available :
This subject is fundamental and experimental research. We will carry out measurements of magneto-transport at low temperature and under pressure in the Lu5Ir4Si10 system. This model of the coexistence of charge density wave with superconductivity is much more surprising than initially anticipated. Pressure allows us to destabilise the charge density wave in favour of superconductivity.
The fundamental question is to understand whether this destabilisation is associated with a reduction in the number of charge carriers at the origin of the charge density wave or with a hardening of the lattice dispersion. We will compare our experimental results with existing theories. Depending on the timetable, the student could participate in experiment in large scale facilities (ESRF), related to his main subject.

Possible collaboration and networking :
The student will interact with other members of the Magnetism and Superconductivity team of the Néel Institute. This research subject is directly connected to collaborations with other researchers in Toulouse and at the ESRF. This subject is at the heart of more general questions of national and international research networks around quantum materials and aperiodic crystals.

Possible extension as a PhD : Yes

Required skills:
This experimental internship includes an important part of measurements. The student should have a strong taste for practical work. He/she will handle small samples, but also cryogenic instrumentation. An understanding of the measurement chain is essential. The student will analyse the acquired data and confront them with theoretical models that he/she will have to assimilate well. The student will have a solid background in solid state physics.

Starting date : March

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