NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2020-2021

2D superconductivity in cuprate oxychlorides

General Scope: Cuprates oxychlorides are unique among the high temperature superconducting cuprates (HTSCs) since it: lacks high Z atoms; has a simple I4/mmm 1-layer structure, typical of 214 (LSCO) cuprates, but which is stable at all doping and temperatures; and has a strong 2D character due to the replacement of apical oxygen with chlorine. All these characteristics made them particularly well adapted to calculation including correlation effects. Recently we obtained puzzling results on their superconducting properties that are highly anisotropic. This could be due to intrinsic properties of the superconducting nature of these materials, which can made pair-density-wave in an electronic structure already modulated by charge-density-wave (also a recent results of our team). Or it could be the result of an intrinsic bi-dimensional electronic structure, that would made them the equivalent, in superconductivity, of graphite for the 2D graphene layers. This anisotropy would be highly unusual and will allow to study 2D phenomenology in a bulk sample, a fascinating possibility.

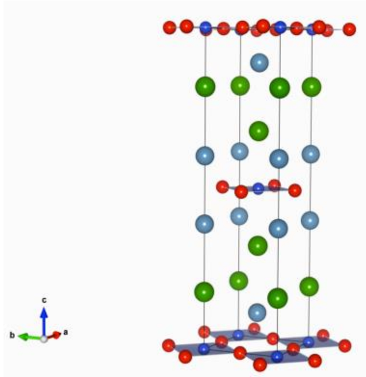

Figure 1: Unit cell of $Ca_2CuO_2Cl_2$ (Cu blue, O red, Cl green, Ca cyan), with the square unit of the CuO_2 plane visible, where the superconductivity take place.

Research topic and facilities available: The above-mentioned results are very recent, and many points needs to be clarified, namely: do this superconducting anisotropy arise only in a limited part of the phase diagram? How this superconducting anisotropy relate with the normal state resistivity one?
During the internship we will start to address part of these questions, using magnetization and resistivity measurements as a function of the crystallographic directions.
Preparation of these experiments will require special care, as these materials are sensitive to air, with a special glove box at the Néel institute. We will also use on-site facilities for crystal growth (large volume press), as well as crystalline (x-ray diffraction) and superconducting (magnetometry/resistivity) characterisation.

Possible collaboration and networking: Sample synthesis will be made in collaboration with the group of Prof. I. Yamada (Univ. of Osaka, Japan), P. Toulemonde (Inst. Néel) and M. Azuma (Tokyo Inst. Of Technology).

Possible extension as a PhD: Yes, this project is part of a PhD program, of which this Master Internship could be a first approach.

Required skills: A good background in electronic properties of material, with the will to have a global approach, from material synthesis and characterization to advanced spectroscopic properties. Team work will be an essential part of the project success.

Starting date: from winter 2020

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