NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

High temperature superconducting oxychlorides: a light element model for cuprates

General Scope: Cuprates were discovered in 1986 to show superconductivity at the highest temperature at ambient pressure, a record they still detain (see figure), but their phenomenology apparently cannot be grabbed by present theory, so that they are considered among the main unsolved problems in physics today. In this context, the discovery of the Na and vacancy doped $Ca_2CuO_2Cl_2$ oxychloride is very promising indeed to bridge the gap between theory and experiment since it: lacks high *Z* atoms; has a simplest crystalline structure for cuprates, stable at all doping and temperatures; and has a strong 2D character due to the replacement of apical oxygen with chlorine. Therefore, advanced calculations that incorporate correlation effects, such as quantum Monte Carlo are easier, but relatively little is known about $Ca_2CuO_2Cl_2$ from an experimental point of view. We are now filling this gap by a comprehensive experimental study covering the whole phase diagram, in particular of the magnon and phonon dispersion as well as their electronic structure, using advanced approaches based on synchrotron radiations and laboratory spectroscopies.

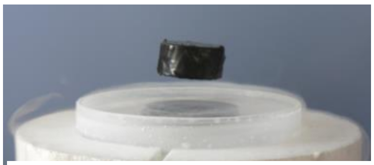

Figure 1: Cuprates allows exploiting magnetic levitation above the liquid Nitrogen temperature, as shown in the picture (Mai-Linh Doan wikimedia commons, © Creative commons).

Research topic and facilities available: During the internship we will measure, at the Instit. Néel, point contact spectroscopy, in collaboration with H. Cercellier, and magnetic penetration depth, in collaboration with P. Rodière. In the framework of the PhD project, most of experiment will be planned at synchrotron facilities in Europe and around the world, mainly at ESRF (Grenoble) and SOLEIL (Paris region), but also at NSLS-II (Brookhaven, US), Spring-8 (Japan) as well as other facilities depending on available techniques, in order to unveil their electronic properties at a microscopic level. Preparation of these experiments will require special care, as the materials are sensitive to air, so that a special glove box is under installation at the Néel institute, and we will use its facility also for crystal growth (large volume press), as well as crystalline (x-ray diffraction) and superconducting (magnetometry) characterisation.

Possible collaboration and networking: Interpretation of the results will be made in collaboration with group performing *ab-initio* electronic structure calculation including correlation effects in Paris (S. Biermann, Ecole Polytechnique) and USA (L. K. Wagner, University of Illinois, Urbana). 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). Part of the synchrotron spectroscopy studies will be performed in collaboration with L. Chaix and H. Cercellier (Inst. Néel) and M. Dean (Brookhaven National Laboratory).

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 2019

Contact:
Name: D'ASTUTO Matteo
Institut Néel - CNRS
Phone: : (+33)(0)4 76 88 12 84e-mail: matteo.dastuto@neel.cnrs.frMore information: http://neel.cnrs.fr