

Internship proposal 2011-2012

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*Title for the scientific project*

**Circulating current phases in high-T<sub>c</sub> copper oxides superconductors**

**Scientific project:** The phase diagram of high temperature copper oxide superconductors exhibits a mysterious *pseudo-gap* phase, tightly bound to the superconducting state. Friend or foe of superconductivity, the pseudo-gap state is associated with a competing state in many theories, but no consensus has been yet reached concerning its intrinsic nature. Beyond usual charge or spin instability, it has been proposed that the pseudo-gap phase could correspond to a *new state of matter* made of an array of nanoscopic current loops circulating between a copper and neighboring oxygens. This state breaks time reversal symmetry, but preserves the lattice invariance. While competing with superconductivity, this fascinating state could actually produce specific charge fluctuations involved in the superconducting pairing mechanism.

Current loops, if they exist, should generate staggered orbital magnetic moments in the vicinity of each Cu site: a magnetic *fingerprnt* observable by neutron diffraction. Using spin polarized neutron scattering technique, we were the first to report the existence of a magnetic hidden in the pseudo-gap phase of two cuprate families: YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6+x</sub> and HgBa<sub>2</sub>CuO<sub>4+x</sub> (See a review : P. Bourges and Y.Sidis at <http://arxiv.org/abs/1101.1786>). A large variety of samples from the underdoped part of the phase diagram of the high-T<sub>c</sub> compound of both families have been studied, showing the reproducibility and the universal character of this magnetic order in high-T<sub>c</sub> cuprates. The observed symmetry corresponds to the theoretically-predicted broken-symmetry state consisting of circulating charge currents, suggesting that the observed magnetism is associated with orbital moments.

The proposed internship concerns the study of samples around the optimal doping where the superconductivity is at the maximum and starts to overcome the pseudo-gap phase. Two different samples will be measured: YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6,95</sub> and Bi<sub>2</sub>Sr<sub>2</sub>CaCu<sub>2</sub>O<sub>8</sub>. The experimental technique of neutron diffraction will be used in relation with magnetic structure factors calculations. This internship can be followed by a PhD on related topics.

**Techniques in use :** Polarized neutron diffraction

**Applicant skills:** Good knowledge in condensed matter physics and magnetism

**Granted internship :** yes ( 450 €/month)

**C'nano IdF laboratory (France only) :** yes

**Possibility for a thesis :** yes (type of grant : \_CFR/CEA\_)