



International Doctoral Program in Science Position Coherent Control Of Quantum Materials

Background and motivation

Controlling electronic quantum coherence in solids at ambient conditions is a long sought-after target in condensed matter physics. Quantum pathways could be exploited to coherently convert photons into charge excitations, to manipulate electronic phase transitions for quantum and neuromorphic computing, to control and store quantum information. Unfortunately, the quantum-coherent nature of electronic excitations in materials is usually lost on extremely fast timescales (few femtoseconds), as a consequence of the interactions with the incoherent fluctuations of the environment.

The ultimate goal of this project is to investigate strategies to achieve the coherent optical control of the macroscopic properties of technologically relevant quantum materials.

More specifically, the project will develop along the following lines:

- As a first step, we will develop an ultrafast experiment, based on the combination of a suitable number of phase coherent ultrashort optical pulses, to selectively excite solids. Particular effort will be dedicated to synthesize light pulses as short as 10 femtoseconds, via a non-collinear optical parametric amplifier (collaboration with Prof. Giulio Cerullo, Politecnico di Milano). In parallel, we will develop suitable theoretical modeling to treat quantum dynamics on ultrafast timescales and in interacting environments.
- As a second step, we will investigate the electronic decoherence dynamics in various correlated materials, such as LaVO_3 and V_2O_3 , which represent paradigmatic examples of correlation-driven Mott insulators. By combining the experimental and theoretical outcomes, we will address the possibility of enhancing the decoherence time by tuning the temperature, strain, excitation protocols and chemistry of the systems. We will also investigate the possibility of coherently manipulate the photoinduced insulator-to-metal transition in V_2O_3 and, possibly, to coherently control phase transition in other systems (e.g. superconductivity in copper oxides).

Within the present project, **two positions** (1 mainly experimental and 1 mainly theoretical) are available. While on the experimental side the candidate is expected to acquire, during his/her PhD studies, the knowledge in the field of ultrafast and material science necessary to successfully fulfill the main goals, from the theoretical side her/his study will be focused on the development of mathematical many-body models for describing the coherent dynamics of correlated materials and on their analytical/numerical solving procedure. Depending on the expertise of the applicants, possible combinations of the theoretical and experimental tasks can be considered.

The candidate will join the joint activities of internationally recognized experimental groups in the field of ultrafast spectroscopies (experiments, UCSC), open quantum (theory, UCSC and KULeuven), oxide synthesis (experiments, KULeuven) and will interact with external theoretical (e.g. Prof. M. Capone SISSA Trieste; Hubbard model, DFT) and experimental groups (e.g. Prof. G. Cerullo Politecnico di Milano; ultrafast experiments) collaborating to this project.

Profile

General requirements

- Diploma: Master's degree or comparable qualification in Physics, Materials Science, Electronic engineering or adjacent fields. The title must be obtained by October 31st, 2020.
- A strong interest for multidisciplinary research is required.



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- A solid background in solid state physics, optics, quantum mechanics and statistical physics is recommended.
- Good knowledge of the English language, both spoken and written, is essential.
- Strong commitment, ability to work in a team, and eager for international mobility.

Specific requirements

- For the experimental position: experience in ultrafast science, laser physics, pump-probe techniques, data analysis and numerical programming (LabView, Matlab, C, Python, Fortran) will be considered as an advantage.
- For the theoretical position: experience in quantum many-body theory, numerical simulation of many-body systems and open quantum systems will be considered as an advantage.

Opportunities

- The opportunity to perform experimental research in an interdisciplinary research environment and actively participate in the international collaboration among research groups in Italy and Belgium, with the aim of achieving a doctorate diploma under the joint supervision by KU Leuven and UCSC. The overall tutoring activity will be conducted by staff members at UCSC and KU Leuven. At the end of the program you will be awarded a degree from both UCSC and KULeuven (**double-degree**),
- The opportunity to gain teaching experience by being involved in teaching duties for a limited amount of time (e.g., co-supervising Bachelor and Master students during their experiments and research).

Contacts

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