INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de physique des lasers
CNRS identification code: UMR 7538
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Internship location: Villetaneuse (93430)

Thesis possibility after internship: YES
Funding: YES If YES, which **type of funding**: ED

Precision Measurements and tests of fundamental physics with cold molecules

The master student will participate in the development of a **new-generation molecular clock** specifically designed for precision **vibrational spectroscopy of cold molecules in the gas phase**. The proposed technology is at the forefront of cold molecule research and frequency metrology, and opens possibilities for using polyatomic molecules to perform **tests of fundamental physics** and explore the limits of the standard model. The apparatus will be used in the first place for measuring the electroweak-interactions-induced tiny energy difference between enantiomers of a chiral molecule, a **signature of parity (left-right symmetry) violation**, and a sensitive probe of dark matter.

Compared to atoms, molecular systems, owing to their numerous degrees of freedom, offer promising perspectives for improving tests of fundamental physics and precision measurements in general. Molecules are increasingly being used internationally for instance to test fundamental symmetries, to measure fundamental constants or their variation in time, to search for dark matter, ... Many of these experiments can be cast as measurements of resonance frequencies of molecular transitions highlighting the importance of frequency metrology. They also require advanced manipulation techniques already standard for atoms: individual states addressing, high detection rates, long coherence times, cooling of internal and external degrees of freedom.

The master student will take an active role in various aspects of the initial developments of the experiment which constitute major steps in providing such techniques for molecules. She/he will:

- set up the mid-IR quantum cascade laser system at 6.4 μm to probe molecular vibrations in this spectral region;
- perform first Doppler and sub-Doppler absorption spectroscopy on cold molecules produced at ~1 K in a novel cold molecule apparatus, with a particular focus on well-chosen promising chiral and achiral organo-metallic species and polycyclic aromatic hydrocarbons.

Keywords:
frequency metrology, Ramsey interferometry, Doppler-free methods, precision measurements, parity violation, chiral molecules, molecular beams, buffer-gas cooling, cold molecules, frequency comb lasers, quantum cascade lasers, molecular physics, quantum physics, optics & lasers, vacuum, electronics, programming & simulation

Relevant publications from the team:
Fiechter et al, J Phys Chem Lett 13, 42 (2022), Santagata et al, Optica 6, 411 (2019); Cournol et al, Quantum Electron. 49, 288 (2019); Tokunaga et al, New J. Phys. 19, 053006 (2017); Argence et al, Nature Photon. 9, 456 (2015).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: NO Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: NO