Post: **PhD student position in Experimental Molecular Physics**
Institute : **Laboratoire de Physique des Lasers, CNRS-Université Paris 13**
Location: **Villetaneuse, France**
Team: **Metrology, Molecules and Fundamental Tests**
PhD supervisor: **Anne Amy-Klein, amy@univ-paris13.fr**

Precision measurements and tests of fundamental physics with cold molecules

Job Description: A PhD student position is available to pursue experimental research in the field of precise spectroscopic measurements with cold molecules in the gas phase. The position is associated with a project funded by the French national agency for research (ANR) and the Île-de-France region focused on the development of a new-generation molecular clock specifically designed for precision vibrational spectroscopy (around 10 µm) of complex polyatomic molecules. 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 the measurement of the tiny energy difference between enantiomers of a chiral molecule induced by electroweak interactions, a signature of parity (left-right symmetry) violation.

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 currently used to test fundamental symmetries, measure fundamental constants or their variation in time, test postulates of quantum mechanics. Many of these experiments can be cast as measurements of resonance frequencies of molecular transitions highlighting the importance of frequency metrology. They require advanced manipulation techniques already standard for atoms: individual hyperfine states addressing, high detection rates, long coherence times, cooling of both internal and external degrees of freedom. The instrumental developments to which the PhD student will participate constitute major steps in providing such techniques for molecules.

The successful applicant will be expected to take an active role in the operation and development of this experimental activity: implementation of a novel slow and intense source of cold polyatomic molecules, produced in a cryogenic chamber, so-called buffer-gas-cooled molecular beam; implementation of new laser sources emitting in the mid-infrared (3-25 µm) called quantum cascade lasers (QCLs) and development of a quantum cascade laser based Ramsey interferometer calibrated against primary frequency standards; implementation of a high-sensitivity microwave detector for the detection of individual internal quantum state populations of cold molecules; development of advanced manipulation techniques to obtain individual state addressing, high detection rates, long coherence times, cooling of various degrees of freedom, …

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 and lasers, vacuum techniques, electronics, programming and simulation

Relevant papers: Optica **6**, 411 (2019); New J Phys **19**, 053006 (2017), arXiv:1607.08741; Nature Photon **9**, 456 (2015), arXiv:1412.2207; Mol Phys **111**, 2363 (2013), arXiv:1309.5630

Requirements: The applicant should have an (almost) completed master degree in a relevant area of experimental physics or chemical physics: atomic, molecular and optical physics, spectroscopy, lasers, quantum optics.