Post: **PhD student position in ultra-precise molecular physics**
Location: Laboratoire de Physique des Lasers (LPL), CNRS-Univ Sorbonne Paris Nord, Villetaneuse, France
Team: Metrology, Molecules and Fundamental Tests (MMFT)
Supervisor: Pr Anne Amy-Klein (amy@univ-paris13.fr)
Co-supervisor: Dr Benoît Darquié (benoit.darquie@univ-paris13.fr),
Contract: Fixed Term, 36 months, starting in autumn 2023

Ultra-precise spectroscopic measurements with cold molecules for probing space, atmospheric and fundamental physics

Ultra-high spectral resolution molecular spectroscopy is an interdisciplinary field with fascinating and far-reaching applications ranging from fundamental physics to astrophysics, earth sciences, remote sensing, metrology and quantum technologies. The PhD student will participate in the development of a **new-generation of molecular clocks** specifically designed for **precision vibrational spectroscopy of potentially cold molecules in the gas phase**. The proposed technology is at the forefront of frequency metrology and cold molecule research. It will be used to perform tests of fundamental physics and explore the limits of the standard model (tests of fundamental symmetries[1], measurement of fundamental constants[2] or their variation in time[3], searches for dark matter[4]…), and to provide accurate spectroscopic data on species of interest for modelling our atmosphere or for understanding astrophysical environments.

The successful applicant will take an active role in various aspects of the development of the experiment:
- development of a novel cold molecule apparatus, an intense source of cold and slow polyatomic molecules, produced in a ~1 K cryogenic chamber, called a buffer-gas-cooled beam, one of the latest cold molecule technology, so far mostly implemented on simple species;
- implementation of a high-sensitivity microwave detector, for the detection of individual internal quantum state populations in molecules;
- setting up mid-infrared systems based on high-purity quantum cascade lasers (QCLs) calibrated against primary frequency standards;
The PhD student will then use these technologies to conduct for the first time metrology-grade precision spectroscopy measurements on well-chosen complex molecular systems – species of interest for atmospheric sciences (CH_3SCH_3) and astrophysics ($C_3H_6O_3$), chiral organo-metallics of interest for probing the violation of parity (a fundamental symmetry), polycyclic aromatic hydrocarbons which are abundant in the interstellar medium … – at room temperature or produced in the cold molecule apparatus using saturated absorption spectroscopy and Ramsey interferometry, the same quantum optics method as used in the world's best atomic clocks.

The PhD will be carried out in the frame of Excellence French programs EquipEx REFIMEVE+ and LabEx FIRST-TF allowing the applicant to fully integrate with the time-frequency metrology community in France and beyond.

[1]Andreev *et al*, Nature **562**, 355 (2018). [2]Alighanbari *et al*, Nature **581**, 152 (2020). [3]Bagdonaite *et al*, Science **339**, 46 (2013). [4]Gaul et al, Phys. Rev. Lett. **125**, 123004 (2020).

Keywords: ultra-high resolution vibrational spectroscopy, frequency metrology, precision measurements, parity violation, chiral molecules, Doppler-free methods, Ramsey interferometry, 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: Darquié, Reflets Phys 73, 16 (2022); Fiechter *et al*, J Phys Chem Lett 13, 10011 (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), arXiv:1607.08741 ; Argence *et al*, Nature Photon **9**, 456 (2015), arXiv:1412.2207

Requirements: The applicant should be doing its master in a relevant area of experimental physics or chemical physics: atomic, molecular and optical physics, spectroscopy, lasers, quantum optics. He/She will be expected to display the initiative and creativity, with the appropriate skills and knowledge, required to meet the project goals.

Interested applicants should email a CV, a brief description of research interests and the contact details of 2 referents to B. Darquié (benoit.darquie@univ-paris13.fr).