Post:	**PhD student position in ultra-precise mid-infrared molecular spectroscopy**
Department:	Laboratoire de Physique des Lasers, CNRS-Université Sorbonne Paris Nord
Location:	Villetaneuse, France
Team:	Metrology, Molecules and Fundamental Tests
Supervisor:	Pr. Anne Amy-Klein (amy@univ-paris13.fr)
Co-supervisor:	Dr. Benoît Darquié (benoit.darquie@univ-paris13.fr)
Contract type:	Fixed Term, 36 months, starting in autumn 2022

Widely tunable ultra-stable and SI-traceable quantum cascade lasers for frequency metrology and mid-infrared precise spectroscopy: application to 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. Among recent instrumental advances, the stabilization of quantum cascade lasers (QCLs) on commercial optical frequency combs with traceability to primary frequency standards, a method recently implemented in our team, is a breakthrough technology. It offers an unprecedented level of precision and resolution in the mid-infrared, an essential region known as the molecular fingerprint region, which hosts a considerable number of intense vibrational signatures of molecules of various interests. While the need for ultimate frequency control is obvious for fundamental applications such as testing fundamental symmetries or measuring fundamental constants and their possible variations, other fields such as atmospheric monitoring have surprisingly the same requirement. Molecular remote sensing measurements are often limited by the quality of spectroscopic data, resulting from the limited resolution of traditional spectrometers. The limited accuracy obtained for parameters affecting the line profile, such as frequency shifts and widths, leads to systematic biases in the determination of atmospheric species abundances, which is a crucial information for environmental and human health issues.

The techniques developed at the Laboratoire de Physique des Lasers can be used to overcome this type of bottlenecks (we have for example recently improved by 3 orders of magnitude the accuracy on some methanol rovibrational line centres compared to previous measurements reported in the literature), but they still suffer from certain limitations that allow only a limited number of relatively simple species to be studied over a reduced spectral window. The successful candidate will actively participate in the development and operation of a new generation spectrometer for precise mid-infrared vibrational spectroscopy that will combine QCLs calibrated on some of the world's best atomic clocks and an enhancement Fabry-Perot cavity that increases both our spectroscopic resolution and the effective interaction length of the light and the molecular absorbers in order to reach higher sensitivities. The proposed technology is at the forefront of time-frequency metrology and bring increasingly complex polyatomic molecular systems within reach of precision measurement experiments and frequency metrology.

The successful candidate will be responsible for characterizing and improving the device in terms of spectral resolution, tunability, spectral coverage, detection sensitivity and flexibility. She/he will conduct spectroscopy at unprecedented levels of accuracy of more complex species of various interests, from fundamental physics (chiral organo-metallic species for probing the violation of fundamental symmetries) to astrophysics (trioxane, $(CH_2O)_3$, proposed as a source of formaldehyde in cometary comae) and Earth sciences (dimethyl sulphide, CH_3SCH_3, the most abundant sulphide complex of biogenic origin in the atmosphere).

Keywords: ultra-high resolution vibrational spectroscopy, mid-infrared, frequency metrology, Doppler-free methods, precision measurements, optical frequency comb lasers, quantum cascade lasers, molecular physics, quantum physics, optics and lasers, vacuum techniques, electronics, programming and simulation

Relevant publications from the team: Santagata *et al*, Optica **6**, 411 (2019); Argence *et al*, Nature Photon. **9**, 456 (2015), arXiv:1412.2207

Requirements: The applicant should be doing its master studies in a relevant area of experimental physics or chemical physics: atomic, molecular and optical physics, spectroscopy, lasers, quantum optics. She/he will be expected to display the initiative and creativity, together 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).