QCL- AND CO_2 LASER-BASED MID-IR SPECTROMETERS FOR HIGH ACCURACY MOLECULAR SPECTROSCOPY

P. L. T. SOW, B. CHANTEAU, F. AUGUSTE, S. MEJRI, S. K. TOKUNAGA, B. ARGENCE, O. LOPEZ, C. CHARDONNET, A. AMY-KLEIN, C. DAUSSY, and B. DARQUIÉ, *Laboratoire de Physique des Lasers, Université Paris 13, Sorbonne Paris Cité, CNRS, Villetaneuse, France*; D. NICOLODI, M. ABGRALL, Y. LE COQ, *LNE-SYRTE, Observatoire de Paris, CNRS, UPMC, Paris, France*; G. SANTARELLI, *Laboratoire Photonique, Numérique et Nanosciences, UMR 5298 Université de Bordeaux 1, Institut dOptique and CNRS, Talence, France*.

With their rich internal structure, molecules can play a decisive role in precision tests of fundamental physics. They are now being used, for example in our group, to test fundamental symmetries such as parity and time reversal, and to measure either absolute values of fundamental constants or their temporal variation. Most of those experiments can be cast as the measurement of molecular frequencies. Ultra-stable and accurate sources in the mid-IR spectral region, the so-called molecular fingerprint region that hosts many intense rovibrational signatures, are thus highly desirable.

We report on the development of a widely tunable quantum cascade laser (QCL) based spectrometer. Our first characterization of a free-running cw near-room-temperature DFB 10.3 μm QCL led to a $\sim$ 200 kHz linewidth beat-note with our frequency-stabilized CO_2 laser. Narrowing of the QCL linewidth was achieved by straightforwardly phase-locking the QCL to the CO_2 laser. The great stability of the CO_2 laser was transferred to the QCL resulting in a record linewidth of a few tens of hertz. The use of QCLs will allow the study of any species showing absorption between 3 and 25 μm which will broaden the scope of our experimental setups dedicated to molecular spectroscopy-based precision measurements.

Eventually we want to lock the QCL to a frequency comb itself stabilized to an ultra-stable near-IR reference provided via a 43-km long fibre by the French metrological institute and monitored against atomic fountain clocks. We report on the demonstration of this locking-scheme with a $\sim$ 10 μm CO_2 laser resulting in record 10^{-14}-10^{-15} fractional accuracy and stability. Stabilizing a QCL this way will free us from having to lock it to a molecular transition or a CO_2 laser. It will make it possible for any laboratory to have a stabilized QCL at any desired wavelength with spectral performances currently only achievable in the visible and near-IR, in metrological institutes.