Mid-infrared frequency comb for QCL stabilisation and detectors assessment at 9µm

Livia Del Balzo[1], Djamal Gacemi[1],Yanko Todorov[1], Angela Vasanelli[1], Benoit Darquié[2], Olivier Lopez[2], Carlo Sirtori[1]

1 Laboratoire de Physique de l'Ecole Normale Supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université de Paris, Paris, France

2 Laboratoire de Physique des Lasers, Université Sorbonne Paris Nord (Université Paris 13), CNRS, Villetaneuse, France

Corresponding author: djamal.gacemi@phys.ens.fr

The mid-infrared (MIR) spectral region has numerous scientific and technological applications. In recent years even more applications have been empowered by the emergence of quantum cascade lasers (QCLs) as compact, reliable and commercially available semiconductor sources that can deliver up to hundreds of mW at room temperature. QCL technology lacks convenient metrological implementation such as frequency comb generation and frequency stability at the sub-Hz level, which would have a tremendous impact for applications that need extreme accuracies [1]. Moreover, detectors in MIR frequency range are much less performing than at shorter wavelength. Their sensitivity could be enormously improved by implementing coherent heterodyne detection scheme [2].

In the present work, we demonstrate the phase-stabilization of a MIR QCL source to a novel 9 µm frequency comb originating from a femtosecond mode-locked fiber laser. This MIR comb system has been commercially supplied by MenloSystems. By beating a DFB-QCL with one of the comb tooth on a fast QCD detector, we were able to phase-stabilize the resulting relative beat-note signal at the Hz level (Fig1a), and thus to copy the spectral performance of the MIR comb to the QCL. By measuring the beating of the comb teeth, we also demonstrated the electrical bandwidth optical characterisation of a quantum detectors (Fig1b).

In the future we are aiming to combine this stabilized QCL with a quantum detector to demonstrate the most sensitive heterodyne detection system that will endow applications such as high-resolution spectroscopy, coherent LIDAR measurements, test and design of systems for free-space coherent optical communications with GBits/s data transfer rate.

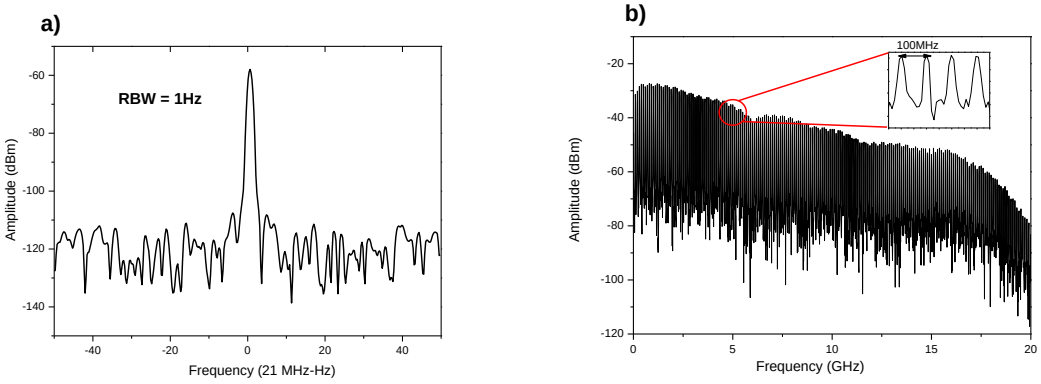

Figure 1 :a) Beatnote signal between the QCL and one tooth of the novel MIR comb when the QCL is phase-locked to the comb tooth. b) Harmonics of the MIR comb with a frequency repetition rate of 100MHz measured on a quantum cascade detector.

References:

[1] B. Argence *et al.Nat. Photonics*, vol. 9, no. 7, pp. 456–460, Jun. 2015.

[2] D. Palaferri et al., Nature, vol. 556, no. 7699, pp. 85–88, Mar. 2018.