Highly sensitive heterodyne detection with stabilized QCL lasers

Mohammadreza Saemian[1], Djamal Gacemi[1], Yanko Todorov[1], Angela Vasanelli[1], Olivier Lopez[2], Benoît Darquié[2], Carlo Sirtori[1]

[1]*Laboratoire de Physique de l'Ecole Normale Supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université de Paris, 75005 Paris, France*

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

Corresponding author: Mohammadreza.saemian@phys.ens.fr

QCLs are semiconductor lasers based on inter subband transition in the conduction band of semiconductors. They are promising continuous wave light sources (c.w.) in the MIR range (from 3 to 25µm). However, their frequency stability is limited by many different external sources of noise and therefore the typical free-running linewidths are in the MHz level, partially limited by the noise that arises from electrical current fluctuations [1]. Their frequency fluctuations can be controlled by comparing to a reference, and by generating a correction signal to apply to the injection current [2].

In this work, we demonstrate the active stabilization of a DFB-QCL to another DFB-QCL by using a phased-lock loop (PLL) correction system, fabricated at the LPL laboratory. For this aim, we used two QCLs (one as a Local Oscillator and the other as the Signal, 96 and 47 mW respectively) and measured the heterodyne beating (up to 800MHz) of the two lasers on a fast commercial photodetector (VIGO). The RF beating is compared to a RF stable reference signal and the PLL is used to actively change the injection current of the Signal laser allowing us to stabilise the relative beatnote between the two lasers at the Hz level. Fig. 1 shows the power spectral density (PSD) of the beating for different beatnote frequencies. We achieved a signal to noise ratio of nearly 50 dB at 1Hz of RBW. Our results demonstrate that by active stabilization of QCLs and benefiting from phase correction with PLL box, it is possible to lock the frequency of one laser to another without any long-term drift. This method opens the way to the highly sensitive heterodyne detection with NEP in the fW range, while the heterodyne receiver is kept at 300 K [3].

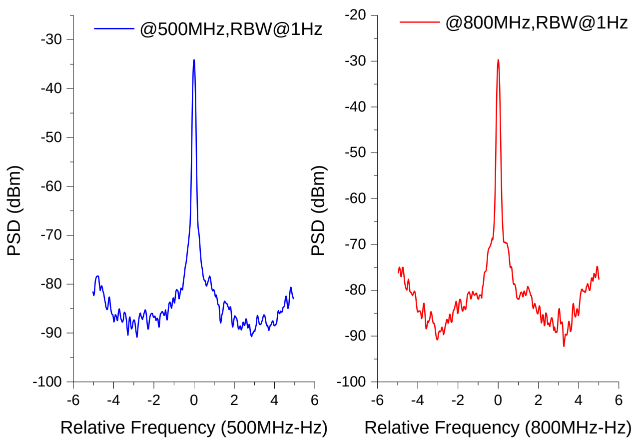

Fig. 1: Beatnote signals between two QCLs, one being phase-locked to the other.

References:

[1] L. Tombez et *al.* Optic Lettres, Vol. 38, issue 23, pp.5079-5082 (2013).

[2] B. Argence et *al.* Nature Photonics 9, 456-460 (2015).

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