Stabilized HEB-QCL heterodyne spectrometer at super-terahertz

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Abstract—In the terahertz (THz) frequency range a high resolution heterodyne spectrometer is of crucial importance for astronomical observations and atmospheric remote sensing applications, based on its combination of high spectral resolution and sensitivity. As the mixer, a superconducting NbN hot-electron bolometer (HEB) mixer has demonstrated excellent sensitivities up to 5.3 THz. As the local oscillator (LO), terahertz quantum cascade lasers (QCLs) have shown advantages at frequencies above 2 THz, based on their single mode emission, wide frequency operating range, high output power and long term stability. Several progresses have been made for a THz QCL to be used as the local oscillator (LO) in a heterodyne receiver, such as a heterodyne spectroscopy measurement in the lab.[1]

Here we report a new experiment on high-resolution heterodyne spectrometer using a 3.5 THz QCL as LO and a HEB as mixer by stabilizing both frequency and amplitude of the QCL. We have already achieved the following results. The frequency locking of the QCL was demonstrated by using a molecular absorption line, a proportional-integral-derivative (PID) controller, and a direct power detector [2]. The intensity of the QCL emission is also stabilized by means of swing-arm actuator placed in the beam path using a second PID controller [3].

[1] Y. Ren, J.N. Hovenier, R. Higgins, J.R. Gao, T.M. Klapwijk, S.C. Shi, B. Klein, T-Y. Kao, Q. Hu, and J. L. Reno, High-resolution heterodyne spectroscopy using a tunable quantum cascade laser around 3.5 THz. Appl. Phys. Lett., **98**, 231109(2011).
[2] Y. Ren, J.N. Hovenier, M. Cui, D.J. Hayton, J.R. Gao, T.M. Klapwijk, S.C. Shi, T-Y. Kao, Q. Hu, and J. L. Reno, Frequency locking of 3.5 THz quantum cascade lasers using a gas cell, Appl. Phys. Lett. (submitted)
[3] D.J. Hayton, J.R. Gao, J.W. Kooi, Y. Ren, W. Zhang and G. de Lange, Stabilized hot electron bolometer heterodyne receiver at 2.5 THz, Appl. Phys. Lett. (submitted)