THz Quantum-Cascade Laser as Local Oscillator for SOFIA

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Abstract— **We report on the development of a compact local oscillator (LO) for operation on board of SOFIA, namely for GREAT, the German Receiver for Astronomy at Terahertz Frequencies. The LO combines a quantum-cascade laser (QCL) with a compact, low-input-power Stirling cooler. The output power is sufficient for pumping a hot-electron bolometer mixer. Frequency stabilization is achieved by locking to a molecular absorption line. Detectors operating at room temperature can be used for the stabilization as well. High-resolution molecular spectroscopic experiments demonstrate the usability as LO for SOFIA.**

I. Introduction And Background

Heterodyne spectroscopy of molecular rotational lines and atomic fine-structure lines is a powerful tool in astronomy and planetary research. For frequencies beyond 2 THz, SOFIA, the Stratospheric Observatory for Infrared Astronomy, is currently the only platform which allows for heterodyne spectroscopy at these frequencies.

GREAT (German Receiver for Astronomy at Terahertz Frequencies) is the second instrument operating on board of SOFIA, the Stratospheric Observatory for Infrared Astronomy. It provides a new opportunity to study the atmospheres of planets, examine the chemical composition of the interstellar medium and it will expand our knowledge of circumstellar disks around young stars. The first successful observation with GREAT took place in April 2011.

A major challenge for heterodyne receivers operating at such high frequencies is the local oscillator (LO), which not only has to provide coherent radiation of certain quality, but also to operate in the specific environment of an airborne observatory. THz quantum-cascade lasers (QCLs) have the potential to comply with these requirements.

II. Results

Different QCLs operating between 3 and 5 THz were investigated. They are based on a two-miniband design and were developed for continuous-wave operation, high output powers, and low electrical pump powers [1]. Efficient carrier injection is achieved by resonant longitudinal-optical phonon scattering. At the same time, the operating voltage can be kept below 6 V. The amount of generated heat complies with the cooling capacity of the Stirling cooler of 7 W at 65 K with 240 W of electrical input power. Special care has been taken to achieve a good thermal coupling between the QCL and the cold finger of the cryostat. The whole system weights less than 15 kg including cooler, power supplies etc. [2]. We will present the performance of the lasers in the cryocooler with respect to output power and beam profiles. Frequency stabilization to below 300 kHz full width at half maximum is achieved by locking to a molecular absorption line [3]. Spectroscopic experiments demonstrate the capability of this system for high resolution molecular spectroscopy.

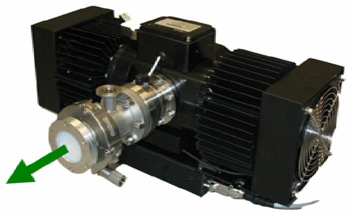

Fig. 1: Compact THz local oscillator for operation on board of SOFIA.

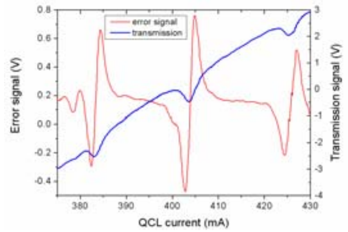

Fig. 2: Absorption signal of $^{12}CH_3OH$ as function of laser current and corresponding error signal which is used for frequency stabilization.

References

[1] M. Wienold, L. Schrottke, M. Giehler, R. Hey, W. Anders, and H. T. Grahn, Electron. Lett. **45**, 1030–1031 (2009).

[2] H. Richter, M. Greiner-Bär, S. G. Pavlov, A. D. Semenov, M. Wienold, L. Schrottke, M. Giehler, R. Hey, H. T. Grahn, and H.-W. Hübers, Opt. Express **18**, 10177–10187 (2010).

[3] H. Richter, S. G. Pavlov, A. D. Semenov, L. Mahler, A. Tredicucci, H. E. Beere, D. A. Ritchie, and H.-W. Hübers, Appl. Phys. Lett. **96**, 071112 (2010).