Toward a Terahertz Local Oscillator for SOFIA Based on a Quantum-Cascade Laser

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***Abstract*— Heterodyne spectroscopy of molecular rotational lines and atomic fine-structure lines is a powerful tool in astronomy and planetary research. It allows for studying the chemical composition, the evolution, and the dynamical behaviour of astronomical objects, such as molecular clouds and star-forming regions. 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. 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.**

We report on the development of a compact LO for operation on board of SOFIA, namely for the GREAT (German Receiver for Astronomy at Terahertz Frequencies) heterodyne receiver. The LO combines a QCL with a compact, low-input-power Stirling cooler. Two QCLs operating at 3.1 and 4.7 THz have been investigated. Both are based on a two-miniband design and have been 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 weighs 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]. Finally, we will discuss the integration of a 4.7-THz QCL-based LO into GREAT.

[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).