Progress toward a 4.7-THz front-end for the GREAT heterodyne spectrometer on SOFIA

H.-W. Hübers [1), 2)*], H. Richter [2)], S. G. Pavlov [2)], A. Semenov[2)], M. Wienold [3)], L. Schrottke [3)], K. Biermann [3)], R. Hey [3)], H. T. Grahn [3)], K. Il'in[4)], and M. Siegel[4)]

1 Institute of Planetary Research, German Aerospace Center (DLR), Rutherfordstr. 2, 12489 Berlin, Germany

2 Institut für Optik und Atomare Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

3 Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5–7, 10117 Berlin, Germany

4 Institut für Mikro-und Nanoelektronische Systeme, Karlruhe Institut für Technologie, Hertzstr. 16, 76187 Karlsruhe, Germany

* Contact: heinz-wilhelm.huebers@dlr.de, phone +49-30-67055 596

This work was supported by Federal Ministry of Economics and Technology and by the European Commission through the ProFIT program of the Investitionsbank Berlin.

***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. One example is the OI fine structure line at 4.7 THz, which is a main target to be observed with GREAT, the German Receiver for Astronomy at Terahertz Frequencies, on board of SOFIA**

We report on the development of the 4.7-THz high-frequency channel for GREAT. The local oscillator (LO) combines a quantum-cascade laser (QCL) with a compact, low-input-power Stirling cooler. The 4.7-THz QCL is based on a two-miniband design and has been developed for continuous-wave operation, high output powers, and low electrical pump powers. 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 [1]. The whole system weighs less than 15 kg including cooler, power supplies etc. Frequency stabilization to below 300 kHz full width at half maximum can be achieved by locking the emission from the QCL to a molecular absorption line [2]. The mixer is a phonon-cooled NbN hot electron bolometer (HEB). It is a 2 µm wide, 0.2 µm long, and 5.5 nm thin NbN strip on a high resistivity (> 5 kΩ) silicon substrate located in the center of a planar logarithmic spiral antenna and glued onto the flat side of an extended hemispherical 12 mm diameter silicon lens. The design of the front-end, its implementation into GREAT, and first results of its subcomponents, in particular the LO and the mixer, will be presented.

[1] 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).

[2] 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).