Investigation of a 2.5 THz Quantum Cascade Laser as Local Oscillator

H.-W. Hübers, S. G. Pavlov, A. D. Semenov
German Aerospace Center (DLR)
Rutherfordstr. 2, 12489 Berlin, Germany

A. Tredicucci, R. Köhler, L. Mahler
NEST-INFM and Scuola Normale Superiore
Piazza dei Cavalieri 7, 56126 Pisa, Italy

H. E. Beere, E. H. Linfield, D. A. Ritchie
Cavendish Laboratory, University of Cambridge, Madingley Road,
Cambridge CB3 0HE, United Kingdom

Heterodyne spectroscopy of molecular rotational lines and fine structure lines of atoms or ions is a powerful tool for exploring the interstellar medium as well as planetary atmospheres. The Terahertz (THz) part of the electromagnetic spectrum is especially rich in these lines. Some examples are the CII fine structure line at 1.6 THz, the OH rotational transition at 2.5 THz, and the OI fine structure line at 4.7 THz. Typically, below ~2 THz multiplied microwave sources are used as local oscillator in a heterodyne receiver. However, at higher frequencies the output power of these sources is still too low to be used as local oscillator. Recently developed THz quantum cascade lasers (QCL) are a promising alternative. The lasing mechanism is based on intersubband transitions in the conduction band of GaAs/AlGaAs heterostructures. Attractive features of a QCL, which have been demonstrated until now, are laser emission between 1.9 THz and 4.8 THz, operation temperatures up to ~140 K, high output power up to ~90 mW, single mode operation and narrow linewidth. In addition, the laser threshold can be as low as 19 mA at 4.2 K. We will report on the characterization of a 2.5 THz QCL with respect to performance parameters relevant for the use as a local oscillator. Fourier transform measurements show that the laser emission is mono-mode over a wide range of current and temperature. At high current when the laser emission is multi-mode the mode structure has been analyzed by homodyne mixing experiments and the frequency stability with respect to the operation temperature and current was investigated. The linewidth of the QCL was below 30 kHz. The beam profile of the QCL was shaped in order to match it to the antenna pattern of a quasi-optical hot electron bolometer (HEB) mixer. With this optical setup the HEB could be pumped into the normal state. Noise temperature measurements of the HEB at 2.5 THz with the QCL as local oscillator yielded the same results as with a gas laser at 2.5 THz. For these measurements the HEB was mounted in an optical cryostat while the QCL stayed in a mechanical cryocooler. In summary the QCL is a very promising candidate for a local oscillator.