# A compact 4.7-THz source based on a high-power quantum-cascade laser with a back-facet mirror

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A key challenge for heterodyne receivers operating above approximately 3 THz is the local oscillator (LO), which has to be a compact source requiring high output power and low electrical input power. The neutral atomic oxygen (OI) fine structure line at 4.7448 THz is of particular interest for several spaceborne missions that are proposed for measuring this transition. Examples are OST (Origins Space Telescope), LOCUS (Low-Cost UpperAtmosphere Sounder) and FIRSPEX (Far-Infrared Spectroscopic Explorer). THz quantum-cascade lasers (QCLs) are compact semiconductor lasers, which are very attractive as LO. During the last five years, a 4.7-THz LO based on a QCL has been in operation on SOFIA (the Stratospheric Observatory for Infrared Astronomy). It is part of the heterodyne receivers GREAT (German REceiver for Astronomy at Terahertz frequencies) and upGREAT [1]. While the QCL is only about 1 mm long, the mechanical cryocooler, which is required for laser operation, determines the mass and power budget of the LO. The LO of GREAT and upGREAT has a mass of about 40 kg and a power consumption of about 400 W. For spaceborne applications, an LO with the same performance has to be significantly more compact and to consume less power than for airborne instruments.

We report on the development of a compact, easy-to-use source, which is based on a QCL with a mirror at its back facet. The QCL is operated in a compact, low-input-power linear Stirling cooler (AIM SL400). The QCL has been developed for optimum LO performance. The active region consists of a GaAs/AlAs heterostructure [2], which provides a three times higher wall plug efficiency than QCLs based on GaAs/(Al,Ga)As heterostructures such as currently used for GREAT and upGREAT [1]. This leads to reduced QCL pump powers and a minimum of dissipated heat, which opens the path for operation in a miniature cryocooler. For improvement of the LO power, the QCL has a mirror at its back facet.

Figure 1 presents a photograph of the 4.7 THz source. The miniature cryocooler consists of two components, a cold finger mounted in a vacuum housing and a cylindrical compressor unit operating at a cycling frequency of 37 Hz. A copper submount with the QCL is mounted to the cold finger. The THz beam, indicated by the red arrow, passes the vacuum housing through an exit window made of poly-4-methylpentene-1 (TPX). The whole system covers a volume of approximately 300×120×140 mm$^3$ with a mass of less than 4 kg. The QCL provides up to 10 mW output power in an almost Gaussian-shaped beam profile and fulfills the requirements for observation of the OI transition as demonstrated by measuring the absorption spectrum of $CH_3OH$ gas in an absorption cell.

The results indicate that a compact LO based on a high-power QCL with a back-facet mirror and a miniature cryocooler is feasible for spaceborne applications.

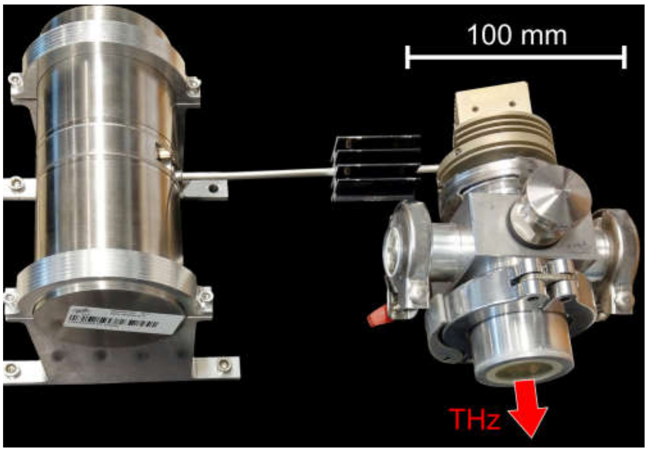


Fig. 1. Photograph of the miniature cryocooler system. The red arrow indicates the direction of the exiting THz beam.

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## References

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