4.7-THz Quantum-Cascade Laser for the upGREAT Array Heterodyne Spectrometer on SOFIA

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The upGREAT instrument is an array heterodyne spectrometer on SOFIA. It consists of two frequency channels. The low-frequency channel covers the 1.9–2.5 THz range using two 7-pixel waveguide-based hot-electron bolometer (HEB) mixer arrays and a multiplier-based local oscillator (LO). The high-frequency channel is designed for observations of the [OI] atomic fine structure line at 4.745 THz using a 7-pixel waveguide-based HEB mixer array and a quantum-cascade laser (QCL) as the LO [1]. The upGREAT spectrometer has significantly more rigorous requirements as compared to the GREAT heterodyne spectrometer, which comprises a single-pixel detector at 4.7 THz pumped with a QCL LO [2].

We report on the performance of the 4.7-THz LO for the upGREAT heterodyne spectrometer. The LO combines a QCL with a compact, low-input-power Stirling cooler. The QCL is based on a hybrid design and has been developed for continuous-wave operation, high output powers, and low electrical pump powers [3]. Efficient carrier injection is achieved by resonant longitudinal optical phonon scattering. The QCL has a single-plasmon waveguide and a lateral distributed feedback grating. The LO is a significant improvement over its predecessor, which is in routine operation in the GREAT heterodyne spectrometer on SOFIA since 2014. One key challenge was to increase the output power from less than 200 µW to about 1.5 mW while keeping the operating temperature at about 50 K and providing a frequency tunability of at least 5 GHz around the OI rest frequency. Another key issue is the beam profile. Because the beam emitted by the QCL will be split into seven parts by using a Fourier grating, a high-quality fundamental Gaussian beam is required. With an M_2 value of about 1.2, the new LO complies with this requirement. The design of the new LO and its performance in terms of output power, frequency accuracy, frequency stability, and beam profile will be presented, and potential applications in future space-based missions will be discussed.

References

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