Shot-noise-limited operation of Mid-infrared lasers

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The Mid Infrared is a crucial region for a wide range of applications: spectroscopy, trace-gas sensing, and free-space communication. In addition, in last few years, the availability of high-performance semiconductor lasers capable of generating mid-infrared (MIR) coherent light has provided a significant boost to the development of MIR optical technologies.
Depending on the field, the intensity noise of optical source can represent one of the key parameters defining the achievable detection limit (sensitivity) of a sensor. Actually, the most famous mid-infrared laser sources are Quantum Cascade Lasers (QCLs) and Interband Cascade Lasers (ICLs).
Both lasers are able to operate at room-temperature pulsed or continuous-wave (CW) operation achieving high-performances. In this work, we thoroughly analyze and compare the Intensity Noise Power Spectral Density (INPSD) of different CW-emitting devices with similar emission wavelengths at 4.5 μm at room temperature: a Distributed-Feedback (DFB) QCL characterized by a particularly low threshold current, a custom-made Fabry-Perot (FP) QCL able to operate in single-towarmode laser or in comb regime, and a DFB ICL [1-3]. In this study, we demonstrate that the measured ICL radiation INPSD is approaching the shot-noise level in the entire frequency range and achieves the shot-noise for high Fourier frequencies. A higher noise level characterizes the radiation of the two QCLs. Such sources have been characterized operating in similar conditions (relative distance from the threshold and output power). In perspective, techniques like up-conversion and new single photon detectors open the way to noise studies in the challenging single photon regime.

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