81-beam supra-THz local oscillator by a phase grating and a quantum cascade laser

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THz heterodyne detection, combining the light intensity measurement with an exceptionally high spectral resolution, has been widely used to study astronomic fine structure lines at THz frequencies (0.3-1 THz) as well as the lines at supra-THz frequencies (>1 THz). In order to effectively map the lines from a large area of the sky, future heterodyne receivers need large arrays. Generating multiple beam local oscillators (LOs) is thus one of the key technologies demanded to realize such a goal.

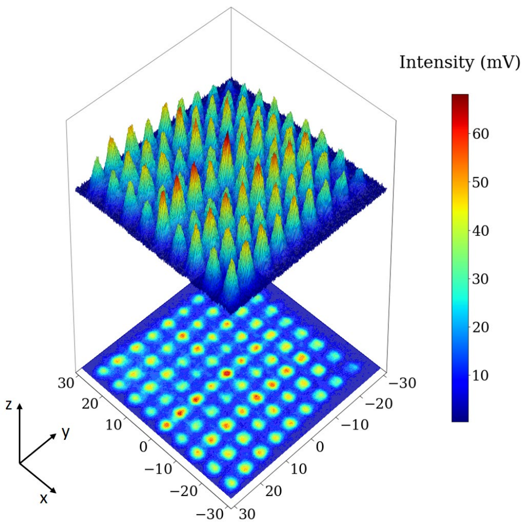

Fig. 1. Measured beam pattern from a 81-pixel Fourier grating using a 3.8 THz unidirectional photonic wire quantum cascade laser as the input source. The incident angle of the beam is 12° in y direction and 0° in x direction.

In supra-terahertz region, quantum cascade laser (QCL) is the most promising LO source. However, generating multiple QCLs with the exactly same frequency and phase is quite challenging. A phase grating[1], illuminated by a single THz QCL, has demonstrated multiple beam LOs at supra-THz[2]. However, so far it has been limited to less than 10 beams. Here we report for the first time a 81-beam LO using a newly simulated and fabricated Fourier grating and a novel quantum cascade laser that is based on an unidirectional photonic wire concept and that emits single mode line at 3.8 THz[3].

We succeeded in measuring 81 diffraction beams at 3.8 THz. The result is shown in figure 1, where the bottom panel plots the measured far field output beams in the 2D format, while the top panel illustrates the beams in a 3D format. Thanks to a high diffraction efficiency of the grating and a high output power of the QCL (>10 mW), we have achieved a high signal-to-noise ratio in the measurement, allowing us to do all the analysis including the diffraction efficiency. The latter is a ratio of the total diffraction beam power to that of the incoming beam. We can compare an experimental efficiency with the calculated one reliably. We believe our result is a milestone for the development of multiple beam supra-THz LOs towards ultimately a practical 100-pixel large heterodyne array.

References

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