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1 to 8 beam distributor at 4.7 THz for GUSTO

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NASA GUSTO (Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory), equipped with three 8-pixel heterodyne detection channels, will perform the largest, single-flight mapping of three important interstellar lines of nitrogen [NII], carbon [CII], and oxygen [OI]. GUSTO will provide comprehensive understanding of the life-cycle of the interstellar medium in Milky Way and Large Magellanic Cloud (LMC). The local oscillators (LO) coupling to the state of the art mixers applied in GUSTO is quite crucial for all three channels and more challenging at [OI] frequency of 4.7 THz, where frequency multiplied sources are not available. For the latter frequency applying a single quantum cascade laser (QCL) beam as the LO multiplexed to 8 by a phase grating is shown to be the most practical and efficient way [1].

In GUSTO a 4.7 THz QCL beam will be coupled to the mixer array through a warm optical unit, allowing for spatially filtering, steering and multiplexing. There the QCL amplitude stabilization and spectral monitoring will take place too. The geometrical limits in that unit demand a certain combination of the input beam size and the angular separation of the output beams, which can only be addressed by a grating with an asymmetric profile. The design of such a grating and the influences of its tolerances on the overall coupling were presented in the previous ISSTT. Here we report the grating manufacturing and its experimental qualifications to give a full study of the instrument driven grating.

A CNC (Computer Numerical Control) micro-milling machine at Arizona State University (ASU) is used to transform the designed surface profile onto an aluminum plate, where the post-machining profile measurements using a 3D microscope were done too. The achieved surfaces were evaluated at SRON/TUDelft, where a deviation less than 1 μm in height from the design is found.

We characterized one of the manufactured gratings using an engineering GUSTO QCL (from MIT) as the input source, which emits a single-mode beam at 4.715 THz with an output power of about 5 mW operating at 60 K. We focused on the angular separation, power distribution among the output beams, and the grating efficiency (the ratio between the total power of the wanted diffracted beams and the input). We found the angular distribution agreeing to the simulation within an experimental accuracy of ≤ 0.5°. We also found the efficiency to be 70%, and the non-uniformity (the difference between the maximum and minimum powers divided by the average power from all 8 beams) to be 13%, both agreeing well to what is expected from the simulation.

It is the first time that such a complete characterization of a THz phase grating is being reported. Figure 1 shows the output beams measured at a distance of 34 cm from the grating, together with the input beam, mapped on the same plane when the grating is replaced with a flat mirror.

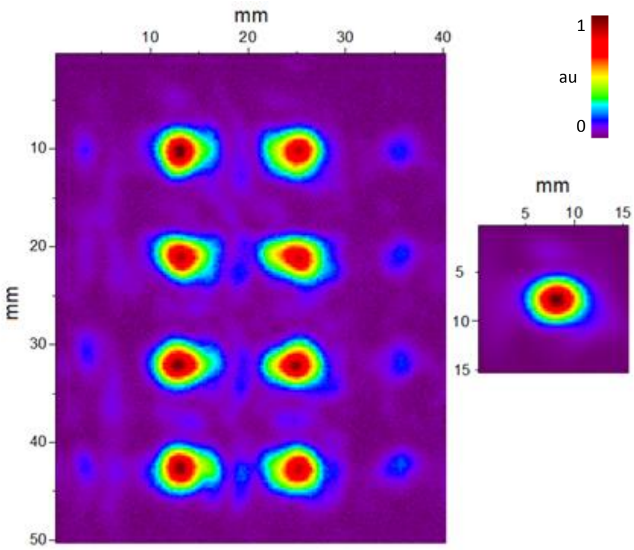

Fig. 1. The measured 8-beam pattern (left) and the incident beam on the same plane when the grating is replaced with a flat mirror (right). The color indicates the intensity.

In conclusion, we designed, manufactured, measured and confirmed a phase grating as the 1 to 8 beam multiplexer for 4.7 THz channel of GUSTO.

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References

[1] B. Mirzaei, et al, "8-beam local oscillator array at 4.7 THz generated by a phase grating and a quantum cascade laser," Opt. Express 25, 29587-29596 (2017).

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