Development of a 2 × 2 reflective phase grating beam divider for heterodyne array receiver at 1.3 THz

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Heterodyne receiver has been widely used in radio-astronomy observation missions (e.g., HERSCHEL, GUSTO, SOFIA) since it can provide both excellent spectral resolution and high sensitivity. The essential element in a heterodyne receiver is the mixer of which the operation requires a local oscillator (LO). For frequencies above 1 THz, Hot-Electron-Bolometer (HEB) mixer is so far the most sensitive, with very low LO power requirement and without upper-frequency limit. There is recently a growing interest in the development of multi-pixel receivers in order to increase the consistency of the mapping region and boost the mapping speed. To provide the LO signal to each pixel of the mixer array, a typical way is to divide the single beam of a LO source into multiple beams: this can be done using a waveguide-splitter or a phase grating.

We have undertaken the realisation of a 2 × 2 reflective phase grating to distribute the LO power to the pixels of a HEB mixer array working around 1.3 THz. The beam divider is based on the Global Phase Grating concept developed in our lab [1]. Compared to existing Damman or Fourier Grating [2-3], this concept provides more possibilities in the design since there are no restrictions on the periodicity and shape of the grating surface. The grating's surface is first generated by a MATLAB code and then is simulated by a 3D electromagnetic software to investigate the effect of the surrounding environment on the output beams. Several factors that can affect the efficiency and homogeneity of the output beam have been analysed such as: the orientation, the size and the edge surface of the phase grating, and the incident angle of the input beam. We have also studied the influence of stepped levels instead of continuous levels of the structure, and the number of Fourier Coefficients used for the calculation of the grating with the aim of reducing the simulation time and facilitating the fabrication of the phase grating.

The phase grating is made of brass with the size of 20 mm × 21 mm × 0.12 mm. It is integrated into a quasi-optical system, which is designed to receive the HEB mixer array for the measurement of the output beam patterns. The input THz source is an Amplifier/Multiplier Chain, and the output pattern is recorded by a pyroelectric detector mounted on a linear translation stage. The measured efficiency of the phase grating is around 72 %, which is close to the simulation and comparable to the previous study [4]. We also found a good homogeneity of four output beams: each pixel contains between 17.5 – 19 % of input power.

The concept of the Global Phase Grating has been successfully demonstrated at THz frequencies. We are ready to develop devices with a greater number of pixels and at higher frequencies.

This work was supported by the joint PhD research program between CNES (Centre National d'Etudes Spatiales) and Observatoire de Paris.

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