Focal Plane Heterodyne SIS Receiver Array with Photonic LO Injection

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Abstract

We present the design and first results from a 130 GHz -170 GHz SIS receiver array driven by a photonic local oscillator. This development has been jointly carried out by the Institut de Radio Astronomie Millimétrique (IRAM) and the Rutherford Appleton Laboratory. The work is partially funded by the EU AMSTAR/Radionet programme. The project goal is to build a four-pixel focal plane array demonstrator, composed of double sideband SIS mixers pumped by a photomixer integrated into the receiver cryostat, and to test the array on IRAM's Pico Veleta Telescope in Granada, Spain.

The photomixer and the SIS mixer designed were first characterised separately. The output power available from the p-i-n photodiode based photomixer at room temperature is greater than 10 μW in the 125 GHz – 175 GHz frequency range. This was achieved for around 10 mW of optical input power, $\lambda \approx 1550$ nm, and a corresponding photocurrent of 4 mA. Little change in output power is observed when the optical fibre coupled photomixer is cooled to below 30 K. The average double sideband noise temperature of the SIS mixer – when measured using a conventional local oscillator (LO) source comprising a Gunn diode oscillator followed by a frequency doubler - was found to be 40 K over the frequency range 130 GHz to 170 GHz. Tests performed on the same SIS receiver pumped by a room temperature photomixer LO have shown a) that the output power delivered by the photonic LO is more than sufficient to pump the SIS mixer over the same frequency range and b) that the measured noise temperature is virtually identical to that obtained with the doubled Gunn LO.

The four-pixel linear array and associated receiver optics design are presented. This array configuration was chosen to be simple, compact, and to allow straightforward extension into a two-dimensional 16-pixel array. The receiver array optics have been designed to meet general requirements for sensitivity, compactness for cold optics integration, and minimisation of thermal loading on the cold stages of the cryostat.

The performance of this type of receiver, measured in terms of bandwidth coverage, noise temperature, LO integration, compactness, elimination of spurious harmonics and thermal budget, represents a clear demonstration of the excellent potential offered by the photonic LO approach with regard to the construction of future large format focal plane array receivers.