

A 1.5 THZ SUPERCONDUCTING HETERODYNE RECEIVER FOR GROUND-BASED ASTRONOMICAL OBSERVATIONS

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A heterodyne receiver designed for astronomical observations in the partially transmissive 200 micron (1.5 THz) atmospheric window has been deployed on a telescope on Cerro Sairecabur in Northern Chile. The 0.8 meter telescope, built by Smithsonian Astrophysical Observatory, is situated at an altitude of 5525 meters and has been in operation since 2002. It permits, on a regular basis, observations in three atmospheric windows between 1 and 2 THz, and provides access to the 350 microns window most of the time. The key lines of astronomical interest in the 200 micron window are CO(J = 13-12) at 1.5 THz and the fine-structure transition in singly ionized nitrogen at 1.46 THz.

In the receiver, the mixer element is a superconductive NbTiN phonon-cooled hot-electron bolometer. A small area (≈ 1 square micron) of very thin (4 nm) NbTiN film with normal metal electrical contacts is fabricated on a single-crystal quartz substrate, which is incorporated in a waveguide mount designed originally for the Submillimeter Array receivers. The mixer is mounted in a liquid helium cooled cryostat, which also houses the first stage low-noise intermediate frequency amplifier. The local oscillator is an all-solid-state chain, with a Gunn oscillator followed by power amplifiers driving a cascade of four frequency doublers. Operating at ambient temperature, the LO can provide a minimum of several microwatts of output power at the lines of interest, which is sufficient to pump the mixer optimally. The LO and signal beams are combined optically using a Martin-Puplett polarizing interferometer. Referenced to the input of diplexer, the double-sideband receiver noise temperature is about 1500 K at an intermediate frequency of 3.0 GHz and a bandwidth of 1 GHz. A digital autocorrelator is used to generate spectra. The astronomical spectra are calibrated using atmospheric transmission data taken continuously with a Fourier transform spectrometer.

The receiver was used to detect the CO(J=13-12) emission line at 1.5 THz toward Orion to verify the end-to-end operation of the mixer; since then, we have made a detection of the 1.46 THz line emission from singly ionized nitrogen.

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