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A Four Channel ^{3}He Cooled Balloon-borne Bolometer Radiometer

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A four channel ^{3}He cooled balloon-borne bolometer radiometer has been constructed at MIT. The principal goal of the instrument is to measure the anisotropy of the 3 K cosmic background radiation on angular scales of 4 to 180°. Our goal is to improve the sensitivity of the measurements to $\Delta T/T < 10^{-5}$. A secondary goal is to survey the galactic thermal dust emission in the submillimeter range.

The detectors are cooled to 0.23 K using a ^{3}He evaporation cryostat. At this temperature the detectors operate with an electrical NEP of about 1.5×10^{-16} watts/$\sqrt{\text{Hz}}$.

The response curves of the four radiometer channels are shown in FIGURE 1, which is a plot of the absolute efficiency; this includes the losses of the high-frequency blocking filter and the losses of all the optics and the detectors. The radiation sensitivity to a Planck emitter at 4 K is about 0.2 mK/$\sqrt{\text{Hz}}$ for the three lower frequency channels. The fourth channel is well above the peak of a four degree emitter, and so has a lower NET. This channel is sensitive to the galactic dust. The bands are defined by a system of resonant mesh filters. The band-pass filter efficiencies are better than 50% peak.

For the LDR effort, a bolometer system consisting of several bolometer arrays, each operating in a different spectral band, would be the detector system of choice for broadband imaging in the submm band. A filter system not too different from that in our radiometer would serve to split the incoming radiation to the different arrays. The system would operate from 400 μm to 1 mm with 4 to 6 spectral channels. Such a system would have an NET considerably below that of a quantum-limited heterodyne system with an IF bandwidth of 1 GHz.

Due to the relatively high background on LDR, there is no requirement for temperatures lower than what can be reached with ^{3}He cooling. This depends somewhat on the bandwidth chosen for each spectral channel. If the number of channels is kept below 6 to keep the complexity of the system to a manageable level, the detectors would be limited by the emission from the hot primary reflector.

For the measurement of the flux and spectral character of broadband sources in the submm, this would be the detector system of choice. Thermal sources with a temperature <15 K are examples of such sources. The science which goes with such sources ranges from cosmology to star formation.

There are several groups in the process of making bolometer arrays on a small scale. There is no reason to believe that the construction of arrays which cover the entire field of LDR with about 10 x 10 elements will not come about on its own on the time scale of LDR. Filter systems which are large enough to cover such a large area are probably also possible, although space qualifying such a thing will be difficult.

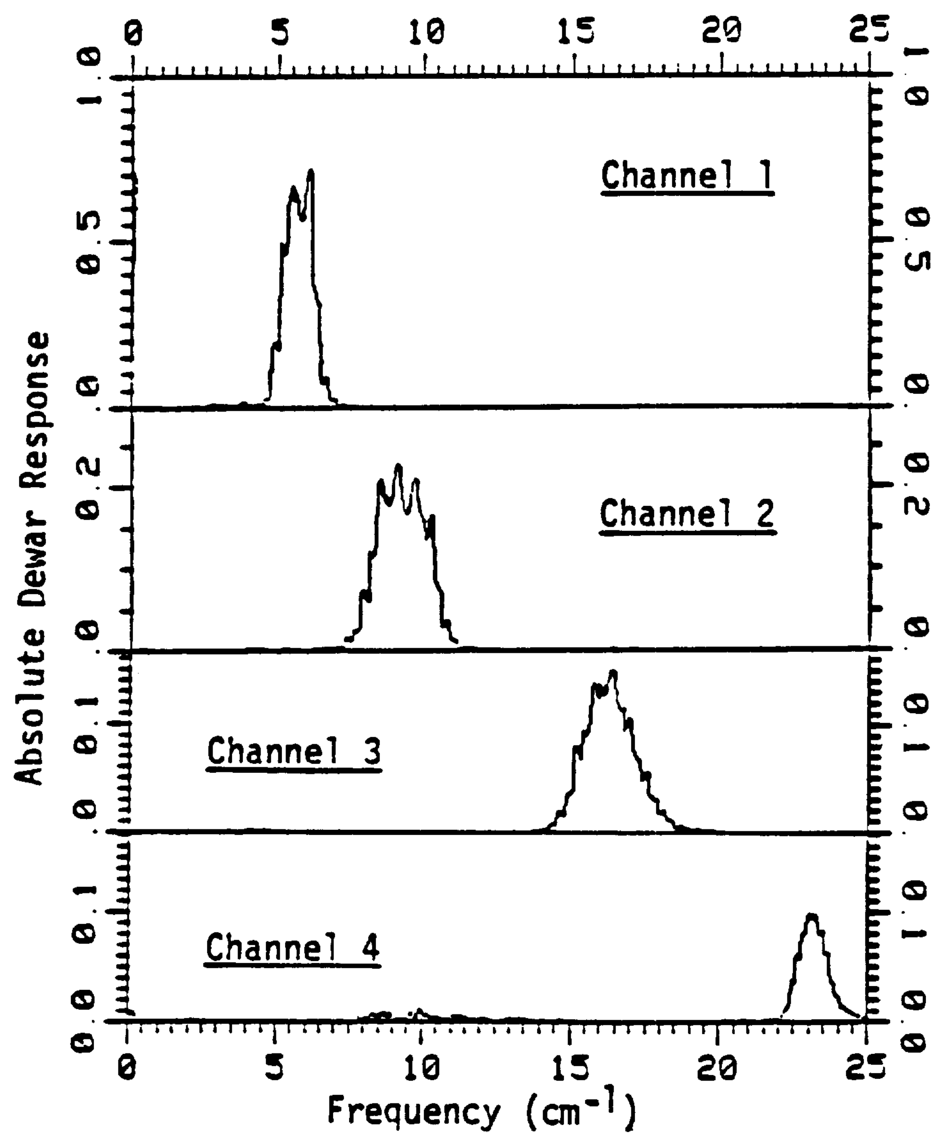

FIGURE 1. The response of the MIT bolometer dewar. The figures represent the absolute dewar efficiency and can be used to convert the electrical NEP to a radiation NET at the input aperture of the radiometer.