VI. INFRARED INSTRUMENTATION AND ASTRONOMY

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A. MEASUREMENT OF THE ISOTROPY OF THE COSMIC BACKGROUND RADIATION IN THE FAR INFRARED

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Joint Services Electronics Program (Contract DAAB07-74-C-0630)
National Aeronautics and Space Administration (Grant NGR 22-009-526)

Dirk J. Muehlner, Rainer Weiss, Richard L. Benford

The objective of this project is to measure anisotropies of the cosmic background radiation to a level smaller than 0.03% with a beamwidth of approximately 15°. The program is being carried out from high-altitude balloons using a dual channel differential radiometer having spectral responses of 3-10 cm^{-1} and 10-25 cm^{-1}. The instrument was described in Quarterly Progress Report No. 112 (pp. 23-27).

The results of three previous flights indicate that the background radiation is isotropic to 0.1% in the spectral region 3-10 cm^{-1}, but that the noise in the measurements is not randomly distributed. There are correlations in the data extending over periods of approximately 1 hour on a level equivalent to a 0.1% anisotropy. The major effort in the last half year has been attempting to understand the cause of these extended correlations. Among the possible causes of the systematic noise, the following have occurred to us.

1. Insufficient shielding of radiation from the ground and varying cloud cover under the balloon.

2. Constituent inhomogeneities in the atmosphere which are not properly measured by the high-frequency channel of the differential radiometer. The strategy for removing atmospheric radiation in this experiment is sensitive to density and temperature fluctuations in the atmosphere. If the water and ozone concentration in the stratosphere do not maintain a constant ratio, the atmospheric correction applied to the low-frequency channel using the data in the high-frequency channel will be incorrect.

3. Discrete but unresolved astronomical sources or an actual medium scale (10° to 20°) anisotropy in the cosmic background itself.

In June 1975, three flights were made to address some of these questions. In the first two flights the instrument was modified to look for discrete sources with a beamwidth of 1.6°. The third flight was made with the instrument in its original

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JSEP configuration but with improved ground shielding. Unfortunately, in this flight a reel used to lower the instrument 2000 ft below the balloon became snarled in the launching process and as a consequence the payload remained approximately 200 ft below the balloon. The reflection of the ground on the balloon may prove to be a serious problem. The entire data from this series of flights have not yet been analyzed.

B. INFRARED HETERODYNE DETECTION

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A prototype infrared heterodyne receiver has been constructed. The optical components, tunable diode laser local oscillator, Ge:Cu mixer, and cold impedance-matching amplifier, have been assembled in a compact 3-liter liquid helium dewar. Heterodyne detection of thermal radiation at ~830 cm^{-1} has been demonstrated with this system. The S/N ratio was limited to ~1/20 of the theoretical limit because of the low power and excess noise of the diode laser that was used as a local oscillator. An improved laser which will be tunable to the astrophysically interesting H_2 line at 814 cm^{-1} (12.3 μm) has been ordered.

We are investigating photovoltaic HgCdTe detectors (made by David L. Spears at Lincoln Laboratory) for use as mixers. These mixers are usually operated at liquid nitrogen temperature, but they also work well at much lower temperatures. They are operated in the liquid helium dewar mounted on thermally resistive posts, which allows control of their temperatures from below 20°K to above 100°K.

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