

## VI. INFRARED INSTRUMENTATION AND ASTRONOMY

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### RESEARCH OBJECTIVES AND SUMMARY OF RESEARCH

The spectral region from 1 mm to 10  $\mu\text{m}$  is still an unexplored field in astronomical research. The major difficulties in this region of the spectrum are the lack of good detectors and the opacity of the atmosphere, which, except for several narrow spectral windows, precludes observing from the ground. Our research is directed toward improving far infrared detector technology and implementing an astronomical observing program in which instruments flown by high-altitude balloons are used.

#### 1. Measurement of the Isotropy of Cosmic Background Radiation in the Far Infrared

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

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Our objective is to measure the anisotropy of cosmic background radiation with a precision better than 0.03% with a beamwidth of approximately  $15^\circ$ . Medium-scale anisotropy may furnish evidence for the formation of galaxies in the early universe. An anisotropy which must be evident at this level if the cosmology that is accepted at present has any relation to the truth is a first moment of the intensity distribution caused by the motion of the Earth relative to the co-moving reference frame determined by the expansion of the universe.

The program is carried out from high-altitude balloons with a dual-channel differential radiometer. This instrument was described in Quarterly Progress Report No. 112 (pp. 23-27). Several flights have been made and have established that the background radiation is isotropic to 0.1% in the spectral region  $3\text{-}10\text{ cm}^{-1}$ . An unexpected anisotropy at the 0.08% level has been observed. The source of this anisotropy is still under investigation and may be instrumental.

#### 2. Heterodyne Detection in the Infrared

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

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Tunable oscillators for research in several parts of the infrared region have become available during the last few years. This development will have a profound impact on

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infrared astronomy because it makes narrow-band quantum-noise-limited detection possible. By using tunable IR lasers as local oscillators, heterodyne detection techniques for the radio and microwave regions can be extended to the infrared. While heterodyne detection offers no advantage over existing detectors for broadband measurements, it will be many orders of magnitude more sensitive in measuring spectral lines than spectrometer-detector combinations. The first objective of this program is to develop a compact tunable heterodyne receiver for the 10-30  $\mu\text{m}$  spectral region. The primary motivation for this development is the desire to detect the rotational quadrupole lines of molecular hydrogen emitted by dark interstellar clouds. This program was described in Quarterly Progress Report No. 112 (pp. 27-31).

The local oscillator in the receiver is a tunable solid-state injection laser operating at liquid helium temperature. We have tested a laser made by our collaborator Kenneth W. Nill at M. I. T. Lincoln Laboratory. This laser is tunable continuously over several wave numbers near 12  $\mu\text{m}$  and delivers 1 mW in a single mode. It does not oscillate at one of the hydrogen lines, but can be tuned over several  $\text{NH}_3$  absorption lines. A low-pressure  $\text{NH}_3$  absorption cell has been constructed and is used as a frequency reference, as well as a means of studying the modes of the laser with high resolution. The same  $\text{NH}_3$  transitions will be used as narrow-band sources in testing the complete heterodyne receiver.

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### 3. Sky Survey for Extended Sources in the Far Infrared

National Aeronautics and Space Administration (Grant NGR 22-009-526)

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In the course of two high-altitude balloon flights with the isotropy apparatus a bright far infrared source, approximately 1/10 as intense as the moon in the 10-25  $\text{cm}^{-1}$  bandwidth, was observed. The nature of this source is unknown. The object covers an angle of 5° or less and has a spectrum that varies as  $f^n$  with  $n$  greater than 3. Several observing groups have attempted unsuccessfully to find this object from the ground. This brings up two possible interpretations: either it is a diffuse object such as a dust cloud, or it has a peculiar spectrum that is cut out by the atmosphere.

The objective of this project is to make a sky survey with a moderate angular resolution of  $\sim 2^\circ$  in this unexplored region of the spectrum. This should enable us to make a better determination of the position of the peculiar object, and also to search for other sources. The instrument will be a modified version of the dual-channel radiometer used in the isotropy experiment.