FINAL TECHNICAL REPORT

NASA Grant No. NGR 05-009-142

TITLE: Infrared Spectrometer Investigations of the Planets and Planetary Satellites

ABSTRACT

A set of cooled filter wheel spectrometers covering the wavelength range 2.8-24 μ have been constructed and tested. The two short wavelength systems (2.8-5.6 μ and 7-14 μ) have been found to be very useful and provide a substantial increase in signal-to-noise over previous systems. The 12-24 μ system, although still very useful, suffers from a low transmittance filter wheel and possibly poor wavelength resolution, intrinsic to the filter wheel.

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INTRODUCTION

NASA grant no. 05-009-142 has been used to develop a set of cooled filter wheel spectrometers for use in studying the infrared (2.8-24 μ) spectra of solar system objects, as well as other astronomical sources. This development has included the design and construction of Cu:Ge and Hg:Ge photoconductor detectors, design and construction of data handling and control electronics, as well as the development of the mechanical and optical operation of the spectrometer itself. The final form of this system is quite close to that initially envisaged. In the following sections each phase of this development will be briefly discussed, ending with a summary of results obtained with this equipment.

DEWARS

The dewar flasks are made by electroplating of Cu on an aluminum form. This work was carried out in the UCSD machine shop. Necks for the LN_2 flask and LHe flask are fiberglass with epoxy joints. The capacity of the LN_2 flask is about 1.5 ℓ and that of the LHe flask about 0.4 ℓ. The LN_2 hold time for an operational dewar is about $1\frac{1}{2}$ days and the LHe hold time (at 4.2 °K) about 4-5 days.

DETECTORS

Both Hg:Ge and Cu:Ge photoconductor detectors have been constructed at UCSD for these spectrometers. Hg:Ge is not suitable for the 12-24 μ system because the photoconductive cutoff for this material is around

15 μ. The best detectors so far constructed are within a factor of two of the background photon noise limit at an operating frequency of 5 cps.

OPTICS

The optics utilized in the spectrometers is essentially that discussed in the initial proposal. A field lens (KCL) is, in this case, required because of variations in sensitivity across the face of the detectors. A liquid helium temperature aperture changer has been incorporated into the spectrometer system allowing the observer to select one of three aperture sizes during operation.

All three systems utilize filter wheels and broad band filters purchased from OCLI. The 12-24 μ filter wheel is of considerably lower quality than the shorter wavelength wheels, suffering from low transmission and possibly poor spectral resolution. This system is probably useful for studying a number of brighter objects around 20 μ, however, it appears that an efficient grating or interferometer system would be superior.

ELECTRONICS

The final form of the spectrometer control and data handling is only slightly modified from that proposed. The filter wheel is positioned via a stepper motor, the detector output is conventionally amplified and synchronously detected, with the resultant signals stored and displayed using a ND 2200 multichannel analyzer. This system has been modified to allow the information in the multichannel analyzer to be dumped into a Wang 700. From this point spectral information is taped for further analysis and also printed out. An expanded memory for the Wang has been purchased which will allow on-line reduction of spectra.

RESULTS

The 8-14 μ spectrometer and the 2.8-5.6 μ spectrometer have been used extensively with the UCSD-U. of Minn. 60" telescope on Mt. Lemmon. They have proven to be extremely useful devices. Spectra have been obtained of a large number of very interesting objects which were previously too faint to be measured. Examples are: (1) planetary nebulae NGC 7027 and BD 30°3639 which show very unusual spectra in the 8-14 μ range; (2) Becklin's star and the Kleinman-Low nebula in Orion, both of which show strong broad absorption features in the 10 μ region, probably due to absorption by interstellar silicate dust. Becklin's star also shows strong absorption around 3 μ, probably due to interstellar H_2O ice; (3) the galactic center shows a very strong 10 μ absorption very similar to that seen in the Orion objects; (4) the IR sources in H II regions K3-50 and W51 both show somewhat weaker but similar 10 μ absorptions; (5) scans across the disk of Jupiter with a 5 arc sec beam (using the 200" telescope) at 7.9 μ show definite limb brightening, confirming the presence of an upper level temperature inversion; (6) spectra of quite a few stars have been obtained with quite high accuracy, for reference purposes as well as understanding the IR excess in these objects; (7) spectra of Saturn (7.5-13.5 μ) show considerable structure some of which is associated with a temperature inversion; (8) a number of points in the 8-13 μ spectrum of Titan -- the spectrum appears to be very similar to that of Saturn and definitely shows evidence of a very strong temperature inversion in this object.