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(NASA-CR-143218) INFRARED SPECTRA OF PLANETARY ATMOSPHERES Semiannual Report, 1 Jan. - 30 Jun. 1975 (California Univ.) 8 p HC $3.25 CSCL 03B

N75-28989

Unclas
G3/91 31030

Semi-annual Report

NGR 05-003-452

"Infrared Spectra of Planetary Atmospheres"

January 1, 1975 - June 30, 1975

Principal Investigator: Professor C. H. Towne

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Space Sciences Laboratory Series 16, Issue 37

August, 1975

Semi-Annual Report - 1/1/75 - 6/30/75 8/1/75

Grant: NGR 05-003-452

INTRODUCTION

The primary goal of this grant has been to develop instrumentation at the longer infrared wavelengths (5μ - 20μ) with high spectral resolution and sensitivity, and with this instrumentation to examine molecular lines in planetary atmospheres in enough detail to obtain new information about these atmospheres. Such information includes (1) pressure and temperature relations in planetary atmospheres and (2) molecular and isotopic composition. Much of the initial work has been devoted to instrumental development and observational testing, but several instruments have advanced to the point where substantial new information is being obtained.

NH_3 and the Jovian Atmosphere

The attached xeroxed reprint (Ap. J. 198:L145 (1975)) of measurements and new conclusions on the atmosphere of Jupiter results primarily from work done last fall. Additional measurements of the abundance of ^{15}N in Jupiter's atmosphere have been made from the 10μ band of NH_3. These are being analyzed, and a paper on $^{15}NH_3$ will be prepared for publication.

High Resolution 10μ and 20μ Spectrometers

The spectrometer with which the above high resolution spectra were taken is an upgraded version of an earlier spectrometer and is shown schmatically in Figure 1. The spectrometer system has a sensitivity of about 1.5×10^{-14} watts/$\sqrt{Hz}$ at 5μ wavelength and about 5×10^{-14} watts/$\sqrt{Hz}$ at 10μ wavelength with resolution as narrow as about $\frac{1}{20}cm^{-1}$. J. Lacy is designing a new version of such a spectrometer with a cooled Fabry-Perot interferometer to obtain even higher sensitivity in the 10μ region. Critical components have been tested, and construction of a number of parts of the system is under way.

A 20μ spectrometer using in combination a Fabry-Perot interferometer and a cooled grating has been constructed by Greenberg and Dyal (the latter on leave of absence from NASA-Ames) and has been successfully used to obtain the first detection of the 20μ line of S III. It has also detected 20μ CO_2 lines in the atmosphere of Venus and will be used further on H_2 lines and a variety of planetary problems. Its sensitivity is 3×10^{-14} watts/$\sqrt{Hz}$ and its resolution about 0.2 cm^{-1}.

Heterodyne Spectroscopy at 10μ

The ultimate resolution for examination of line profiles and hence determination of atmospheric characteristics of the planets will surely come from heterodyne detection. A 10μ heterodyne detection system has been constructed, initially for a spatial interferometer, and adapted to the measurement of absorption in planetary atmospheres. Preliminary measurements on the shape of $^{13}CO_2$ lines in the atmosphere of Mars have been made with this system,* and provided a resolution of $\frac{1}{2000}$ cm^{-1}. This easily resolved the CO_2 line shapes even in the thin atmosphere of Mars. A spectrum of a $^{13}CO_2$ line in the Martian atmosphere made with such system but with resolution improved to $\frac{1}{6000}$ cm^{-1} is represented in Figure 2. While more precise than our previous heterodyne measurement, it agrees well with the earlier results. There is a discrepancy as large as a factor of two between the intensity of this line and that expected from accepted models of the Martian atmosphere. This discrepancy could be explained by any one of the following three differences with present expectations, each of which would be surprising.

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*Peterson, D. W., Johnson, M. A., and Betz, A. L., Nature. Vol. 250, 128 (1974)

1. The Martian atmosphere is about 25° hotter than usual models.
2. The Martian atmosphere contains substantially more CO_2 than present models.
3. The relative abundance of ^{13}C is about 2.5 times as great as that on earth.

Additional measurements and analyses are being made to determine more precisely the source of this discrepancy.

Infrared Imaging and Upconversion

A system for converting 10μ radiation into visible light while preserving a field of view has been demonstrated in the laboratory and is being designed for taking telescopic pictures of planets in this wavelength range. The system, made by Boyd and shown schematically in Figure 3, upconverts 10μ photons by non-linearities in a proustite crystal excited by a laser. The upconverted light produces an image through an image converter. "Infrared photographs" of objects have been made in the laboratory and sensitivity demonstrated which will allow pictures to be made in a modest time of the 10μ images of the Moon, Mars, and Venus. The images will be of a narrow frequency band of radiation, about 3 cm^{-1} wide, which can be varied by rotation of the crystal. Spatial resolution about twice the diffraction limit associated with the laboratory optics have been obtained, which should allow images limited in resolution only by the diffraction limit of a large telescope. It is hoped that informative IR photographs of planets can be taken during the next six months.

Figure Captions

Figure 1	High resolution tandem Fabry-Perot Interferometer for the 5μ and 10μ regions.
Figure 2.	Spectral Lines of CO_2.
Figure 3.	10μ imaging upconverter for Astronomy.

Publications since last report

1. "An Upper Limit on the Evolution of Carbon Monoxide from Comet Kohoutek", E.R. Wollman et al, Icarus 23, 599-600 (1974)

2. "Observations and Analysis of the Jovian Spectrum in the 10-Micron ν_2 Band of NH_3", J.H. Lacy et al, Ap. J. 198:L145-L148 (1975)

Figure 1

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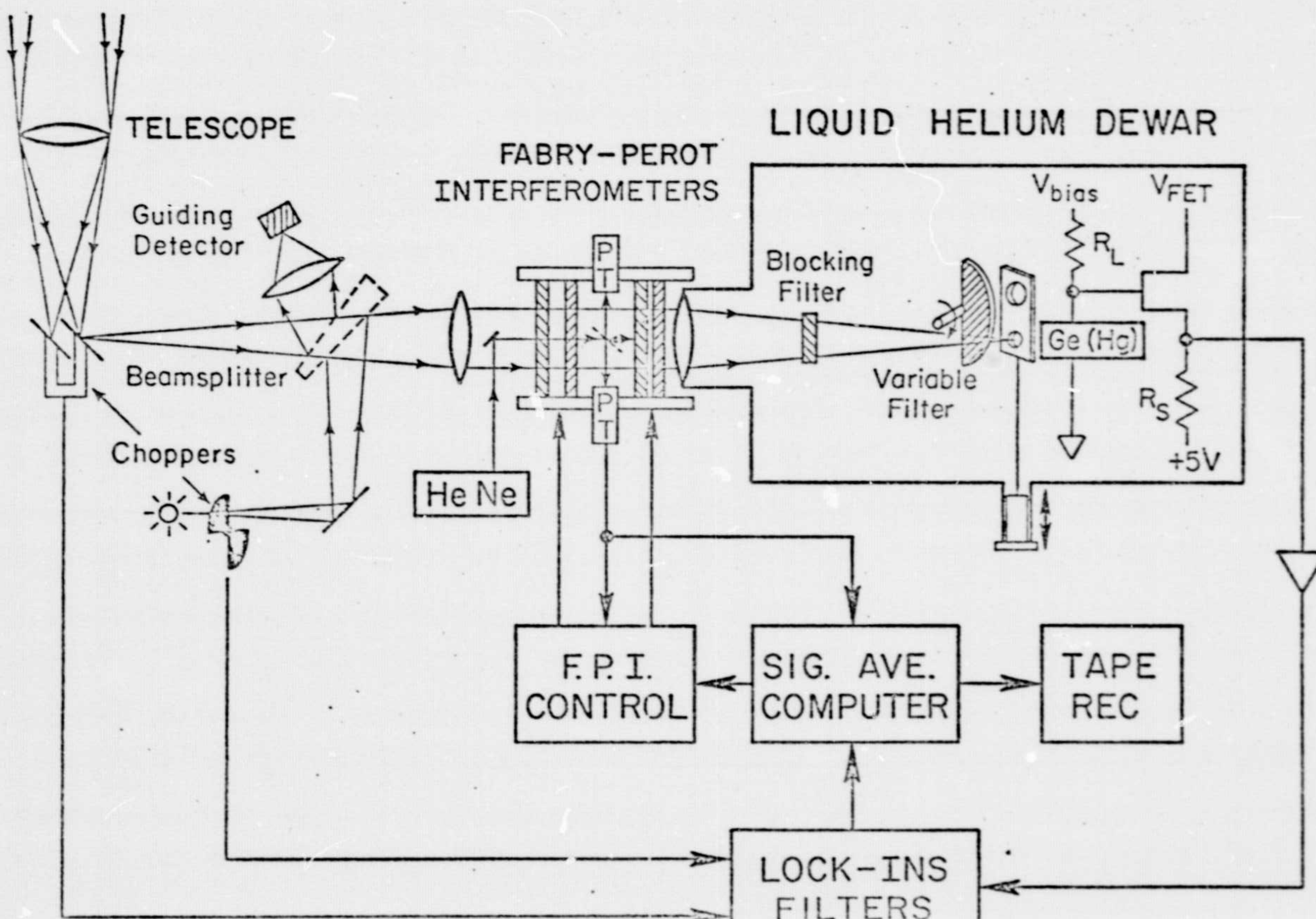

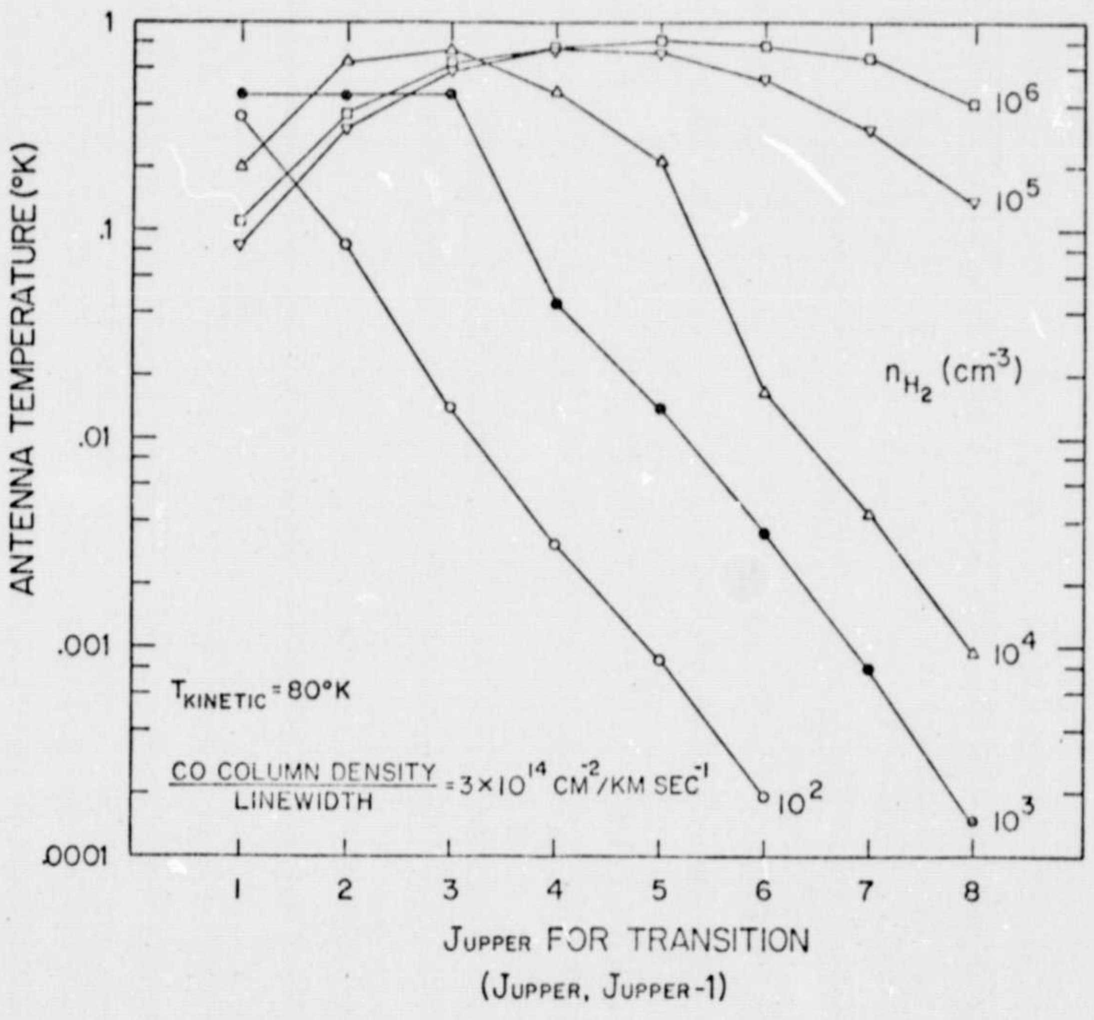

ANTENNA TEMPERATURE (°K)
1
.1
.01
.001
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1 2 3 4 5 6 7 8
JUPPER FOR TRANSITION
(JUPPER, JUPPER-1)
10^6
10^5
n_H2 (cm^-3)
10^4
10^3
10^2
TKINETIC = 80°K
CO COLUMN DENSITY / LINEWIDTH = 3×10^14 CM^-2/KM SEC^-1

Figure 2

Figure 3

10 μ IMAGING UP-CONVERTER FOR ASTRONOMY