NASA-CR-198648

p, 3

Final Report

SEARCH FOR MOLECULAR ABSORPTIONS WITH THE FOURIER TRANSFORM SPECTROMETER NAG 2-495 (Stony Brook Account 431-3072A)

ROGER F. KNACKE, PRINCIPAL INVESTIGATOR

May 21, 1995

(NASA-CR-198648) SEARCH FOR MOLECULAR ABSORPTIONS WITH THE FOURIER TRANSFORM SPECTROMETER Final Report (Pennsylvania State Univ.) 3 p

N95-28222

Unclas

G3/90 0050142

Division of Science
Penn State Erie
The Behrend College
Station Road
Erie, PA 16563

(814) 898 6105
RFK2@PSUVM.PSU.EDU

1. Summary

This is the final report of NASA Ames grant NAG 2-495, "Search for Molecular Absorptions with the Fourier Transform Spectrometer" (Stony Brook Account 431-3072A). The award was made to the University at Stony Brook where the PI, Roger F. Knacke, was employed through the duration of the project. Observations with the Kuiper Airborne Observatory (KAO) resulted in the first direct detection of gas phase H_2O in a molecular cloud.

2. Objectives

The objective of this research was a search for water molecules in the gas phase in molecular clouds. Water should be among the most abundant gases in the clouds and is of fundamental importance in gas chemistry, cloud cooling, shock wave chemistry, and gas-grain interactions of interstellar dust. Detection of water in Comet Halley in the 2.7 μm ν_3 band in 1986 had shown that airborne H_2O observations are feasible (ground-based observations of H_2O are impossible because of the massive water content of the atmosphere).

We proposed to observe the ν_3 band in interstellar clouds where a number of lines of this band should be in absorption. A Michelson Interferometer built by H. P. Larson of the University of Arizona was determined to be the instrument of choice for the observations. The project was conducted as a collaborative experiment between Larson and the Roger F. Knacke, the PI, with initial assistance from Keith S. Noll, then at the University of Arizona.

3. Results

The search for H_2O commenced in 1988 with a two flight program on the KAO. This resulted in a detection of interstellar H_2O with S/N of 2-4 in the ν_3 1_{01}-2_{02} line at 3801.42 cm^{-1}. A subsequent flight series of two flights in 1989 resulted in confirmation to the 3801.42 cm^{-1} line detection and the detection of altogether four strong lines in the 000-001 ν_3 vibration-rotation band of H_2O.

The details of the observations and results are given in two papers (Knacke, Larson, & Noll 1988; Knacke & Larson 1991) which are attached as Appendices 1 and 2. We summarize them briefly here.

The column density of gaseous H_2O toward the Becklin Neugebauer (BN) object in Orion in the OMC-1 cloud is $(2 \pm 1) \times 10^{17}$ cm^{-2}. The gas-phase abundance ratios in this object are $H_2O/CO = 0.03 \pm 0.02$ and $HDO/H_2O = 10^{-3} - 10^{-4}$. The velocities of the H_2O absorptions agree with those for the Ridge Source and the CO outflow, but the position along the line of sight of the observed H_2O is not well constrained. The gas/solid ratio is $H_2O_{gas}/H_2O_{solid} <$ 0.05. This implies that less than 1% of the oxygen in the interstellar medium is in H_2O gas (assuming cosmic abundance). Most of the H_2O in the line of sight toward BN, and by inference in quiescent molecular clouds generally, must be frozen on grains.

The intensities of the H_2O lines imply an ortho/para ratio of 1 ± 0.5, indicating recent sublimation of H_2O from low-temperature grains.

4. Further Development of the Project

Clearly the observation of only one object, while laying the fundamental groundwork, does not give the statistical basis one would wish for a general overview of the role of H_2O in the interstellar medium. BN was the only object observed in this work. It is the brightest infrared source that is also obscured by a thick cloud. In the course of the KAO observations, it became clear that observations of other sources, even those only a factor of two weaker (requiring four times the integration time) was not practical with the KAO and the detectors in the Larson spectrometer. We therefore decided not to request more observing time until Larson could develop more sensitive, He-cooled detectors for the interferometer. This project evolved slowly and was eventually abandoned when funding for the University of Arizona Interferometer was cancelled.

The next major opportunity to observe H_2O in the interstellar medium will be with the European Space Agency Infrared Space Observatory (ISO) to be launched in September 1995. It will be possible to observe many far-infrared H_2O lines with the spectrometers of this earth-orbiting infrared telescope. Neither of the KAO investigators will be directly involved with such observations (although Knacke is a member of the planetary team of ISO), but the team focusing on interstellar studies has H_2O as a high priority. If ISO is successful we should soon have extensive data about H_2O in the interstellar medium. We are pleased, of course, that the KAO work has set the basis for these observations and set some of the parameters to be tested.

5. Publications and Reporting

Knacke, R. F., Larson, H. P., & Noll, K. S. 1988, ApJ, 335, L27.
Knacke, R. F., & Larson, H. P. 1991, ApJ, 367, 162.

Results of this Research were reported at two meetings of the American Astronomical Society and at the 22nd Eslab Symposium, Salamaca, Spain (1988).

5. Inventions

No inventions resulted from this research.

7. Appendices

Appendix 1. Evidence for Interstellar H_2O in the Orion Molecular Cloud, R. F. Knacke, H. P. Larson, & K. S. Noll.

Appendix 2. Water Vapor in the Orion Molecular Cloud, R. F. Knacke & H. P. Larson.