Space Sciences Laboratory

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Final Report

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MILLIMETER WAVELENGTH OBSERVATIONS OF THE PLANETS

Principal Investigator: Wm. J. Welch

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I. PERSONNEL

In addition to the principal investigator, the following people worked on planetary studies during the final period of the grant:

Jeff Cuzzi

Douglas Thornton

Melvyn Wright

Deborah Haber

Francisco Valdes

Peter Schloerb

II. OVERVIEW AND SUMMARY

This has been a program of high resolution observations of the planets and their sattelites at millimeter wavelengths with the Hat Creek Interferometer. During the first stages, observations were made at wavelengths near 1 cm. In the final stages, wavelengths near 3 millimeters were used. A substantial effort was required to bring the instrument into good working order at the shorter wavelengths. A modest number of planetary observations were then undertaken.

At the present writing, the interferometer works quite well and has excellent sensitivity, thanks in part to the support of this program. In addition to the scientific work that has been carried out and is described briefly below, there remains much that is planned for the future.

III. INSTRUMENTATION

The two 6m antennas of the interferometer are equiped with cooled Schottky-diode mixer front ends which provide about 150k overall system temperatures (DSB) at 3 mm wavelength. The IF bandwidth is 400 MHz. The longest baseline of 300m East-West permits a mappng resolution of about 1.5

arc seconds. If a map is made with that resolution from observations at 15 different baselines, the pixel noise in the map will be about .05K (RMS). Thus most of the planets can be observed with excellent sensitivity as well as resolution comparable to that of a good optical photograph. Smaller objects, sattelites and asteroids, can be detected with good sensitivity.

A third antenna will go into operation in a few months. This will increase the number of baselines that can be obtained at one time from one to three, a dramatic increase in speed. Five configurations instead of 15 are then required to produce the map described above.

All parts of the instrument are under the control of a PDP-11/34 digital computer, and a substantial quantity of observation and calibration software has been developed for the system. Baseline calibration through the use of distant radio sources provides baselines to a typical accuracy of about one tenth of a wavelength. Antenna pointing is accurate to about one tenth of a beamwidth.

Experience with the weather at Hat Creek shows that high resolution observing (good 'seeing') is possible during much of the year. The projected median 'seeing' throughout the year is about 0.5". The worst conditions occur during hot summer afternoons when the resolution is degraded to about 5.0".

A considerable effort during the period of this grant has been applied toward achieving the good sensitivity and stability of the instrument.

IV. OBSERVATIONS

A few planetary studies have been completed to date and will be described briefly below. These include observations of the limb darkening of Venus and Jupiter, and the rings of Saturn. Preliminary observations of Titan, Neptune, Uranus, and the Galilean sattelites are not yet complete.

A. Saturn

The 3.4 mm visibility of Saturn has been measured at two North-South baselines that emphasize the brightness of the rings relative to that of the disk. Fitting a model to the visibility curve shows that whereas the rings are efficient scatterers their emissivity is low at this wavelength. The net brightness of the rings is only about 10-15K, much lower than in the infra-red. Further observations at more baselines will permit distinguishing the properties of the different rings and possibility the ring partical sizes.

B. Jupiter

A measurement of the visibility curve for Jupiter permitted an estimate of the global limb darkening of that planet at 3.4 mm. From the limb darkening, it was then possible to infer a mixing ratio for the Jovian ammonia. If one assumes that all the nitrogen is in the form of ammonia, then the inferred abundance is about a factor of three below the solar abundance. The solar abundance is excluded at the 95% confidence level. The implication is that a substantial fraction is in the solid state in the clouds. A paper describing this work appeared in Icarus: "The Jovian Ammonia Abundance from Interferometric Observations of Limb Darkening at 3.4 mm Wavelength" by F. Valdes, W J Welch, and D. Haber, 1982, 49, 17-26.

C. Venus

The zero point of the visibility curve for Venus at 86 GHz (3.4 mm) was measured with a precision of about 0.1 percent. At this wavelength and at the high pressure of the Venus atmosphere, the molecule SO2 absorbs significantly. The other constituents of the Venus atmosphere are well enough known that one can model the atmospheric emissivity accurately and search for trace compnents such as SO2. The inference from this experiment was that there was no evidence for SO2 in the middle Venus atmosphere. Thus the fairly large amounts

reported in the lower atmosphere apparently do not persist into the middle and upper atmosphere. There must be a sink for the gas below the lower cloud deck. A paper describing this work also appeared in Icarus: "Limits on the Venus SO2 Abundance Profile from Interferometric Observations at 3.4 mm Wavelength", by J. C. Good and F. P. Schloerb, 1983, 53, 538-547.

V. FINANCAIL STATUS

All funds have been expended.