FINAL REPORT

ON

NASA RESEARCH GRANT NGR 45-001-032

"Microwave Studies of Planetary Atmospheres"

Brigham Young University

Provo, Utah

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I. Introduction and Studies Conducted

This final report covers work conducted at BYU under NASA grant NGR 45-001-032, "Microwave Studies of Planetary Atmospheres." Work under this grant included studies in the following areas:

1. A brief study of the primary radio source flux calibration used in observations of Jupiter's microwave spectrum in the frequency interval 18.5 - 24.0 GHz.
2. The reduction, analysis and interpretation of microwave observations of the planet Venus at a number of frequencies in the interval 18.5 - 24.0 GHz.
3. The reinterpretation of the Venus microwave data obtained by the microwave radiometer on the Mariner 2 spacecraft.
4. The search for a correlation between observed departures from symmetry of the microwave temperatures of Venus and the radar "features."
5. The search for fluctuations in the 8.6 millimeter brightness temperature of Venus that might be caused by statistical changes in the disk averaged microwave cloud absorption.

II. Results

Papers have been published reporting the results obtained in the studies listed as items 1, 2, and 3 above. Reference is made to these published papers (Jones, 1972; Jones et al., 1972, Jones, 1975). A paper reporting the results obtained under item 3 was presented at a meeting of the Utah Academy of Sciences, Arts, and Letters (Jones, 1974).

Our studies related to the search for a possible correlation between disk assymmetries of the planet Venus observed by the Mariner 2 microwave radiometer and the observed radar features have been found to be negative.

That is, no anomalous character was seen in the Mariner 2 data when some of the radar features were scanned, and no radar features have been observed where anomalies were noted in the brightness temperature data.

Table I lists the radar features observed by Carpenter (1966) related to a coordinate system that has been modified so that the terminator nearest the S/C during encounter is the 0^{o} longitude reference and increasing longitude is to the right in the standard manner. The 0^{o} latitude line is in the orbital plane. Transformation to this coordinate system was necessary because the microwave beams were located on the planet in this coordinate system. The radiometer beam center locations on the planet corresponding to each data point are displayed in Table II. The differences in planetocentric longitude between the major radar features and the beam centers at the times when the corresponding planetocentric latitudes are the same are displayed in Table III. Since the diameter of the 3 dB response circle of the radiometer spans roughly 20^{o} on the planet at mid-scan, one notes that scan one came quite close to feature G, Scan 2 came fairly close to feature E, and Scan 3 was fairly close to feature A. However, nothing peculiar was noted in the radiometer data at these times. The primary anomaly, that which occurred towards the end of scan 2, and which was also seen in both the Mariner 2 and ground based infra-red maps, does not correspond to any observed radar feature although radar detection of topological features so near the poles would, of course, be difficult even if there were no atmosphere.

A brief but inconclusive measurement program involving a cooperative effort between BYU and members of the JPL radio astronomy group of the

Space Science Division was conducted in an attempt to establish an upper limit to changes in the disk average microwave brightness temperature near 8 mm wavelength. Such changes would presumably result from changes in the distribution of microwave absorbing clouds in the atmosphere which would in turn yield departures in the integrated disk opacity from the long term average. Observations were conducted sporadically over several months during the Summer of 1972, specifically for 8 days between June 29 and August 9. No variations greater than 1 - 2% were observed, which was close to the resolution capability during this period. Since the observation program was so short, these results are inconclusive. The next opportunity to observe Venus occurred during a 4 - 5 month interval centered about late January of 1974, but development work on the millimeter wavelength interferometer at Table Mountain was given top priority and the search for variations in the microwave cloud distribution was never completed. When the interferometer becomes fully operational we will propose that this study be continued on this new facility.

The data that were obtained yield an 8 mm phase effect for Venus of the form $T_B = 436.2^{o} + 4.82^{o}K \cos(\phi - 146^{o})$ showing there to be very little change due to solar heating high in the atmosphere but below the visible cloud deck.

III. Personnel

The principle investigator for the study programs listed above was Professor Douglas E. Jones. The students giving computer programming support were Michael A. Cosman and Steven K. Croft. The Venus observation program at the JPL Table Mountain Observatory involved a joint effort between the principle investigator and Bruce Gary of JPL.

IV. Budget

The funds available for this grant totaled $16,100.00 and supported studies of the atmospheres of Venus and Jupiter extending from June 1, 1970 through August 31, 1975. A breakdown of the budget used to fund this grant is as follows:

Wages and Salary	$10,623.67
Overhead	4,056.23
Travel	479.78
Computer	173.99
Supplies and Publication Costs	766.33
TOTAL	$16,100.00

V. List of Publications

1. Jones, D.E. "A revision of Jupiter brightness temperatures in the frequency interval 18.5 - 24.0 GHz (1968)." P.A.S.P., 84, 434, 1972.
2. Jones, D.E., D.M. Wrathall, and B.L. Meredith, "Spectral observations of Venus in the frequency interval 18.5 - 24.0 GHz; 1964 and 1967-68," P.A.S.P. 84, 435-442, 1972.
3. Jones, D.E., "Evidence for the nonuniform distribution of microwave attenuating clouds in the atmosphere of Venus: Mariner 2," Icarus, 25, 561-568, 1975.
4. Jones, D.E., "Observed departures from spherical symmetry of the microwave attenuating cloud layer in the atmosphere of Venus: Mariner 2," Proceed. of the Utah Acad. of Sciences, Arts and Letters, 51, 89, 1974 (Abstract of paper presented during the fall 1974 meeting at Logan, Utah).

TABLE I

Location of Radar Features Referenced to "Terminator Coordinate System.

Radar Feature	Latitude	Longitude
A	7^{o} 54'	289^{o} 52'
B_1	-10^{o} 52'	322^{o} 20'
C_1	$+17^{o}$ 45'	322^{o} 1'
C_2	-1^{o} 41'	328^{o} 21'
D_2	$+23^{o}$ 35'	329^{o} 1'
D_3	-1^{o} 52'	337^{o} 50'
E	7^{o} 1'	349^{o} 20'
F	-27^{o} 45'	37^{o} 43'
G	-13^{o} 47'	53^{o} 52'
B	-2^{o} 31'	320^{o} 14'
C	-5^{o} 56'	327^{o} 48'
D	-1^{o} 3'	337^{o} 22'

TABLE I1

Location of Mariner 2 Radiometer Beams

Scan No.	Latitude Degrees	Longitude Degrees
1	-34	66
	-22	56
	-12	46
	+ 2	41
	+16	36
	+32	40^{o}
2	36	5^{o}
	18	4^{o}
	2	3^{o}
	-11	2^{o}
	-24	1^{o}
	-38	0
	-52	359
	-74	357
3	-41	276
	-36	293
	-26	304
	- 4	303
	+11	302

TABLE III

Radar Feature - Beam Axis Longitude Difference at Latitude Coincidence

Scan	Feature	Δ Longitude Degrees	Location in Scan
1	A	54	
	B	83	
	C	75	
	D	66	
	E	49	
	F	23	towards beginning of scan 1
	G	6	near middle of scan 1
2	A	73	
	B	43	
	C	36	
	D	26	A little more than 1/3 into scan 2
	E	14	A little less than 1/3 into scan 2
	F	38	
	G	52	
3	A	12	towards the end of scan 3
	B	18	about 2/3 into scan 3
	C	25	
	D	34	
	E	47	
	F	34	
	G	51	