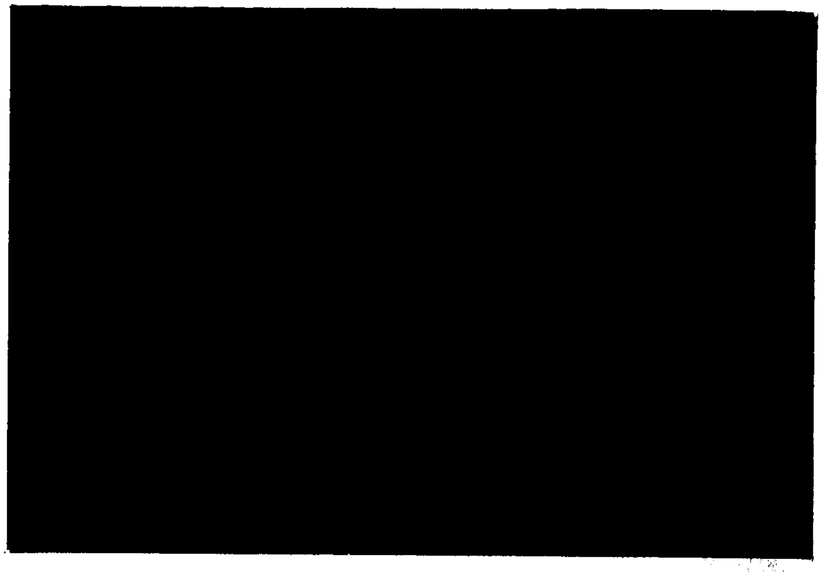
View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

THE UNIVERSITY OF MICHIGAN
RADIO ASTRONOMY OBSERVATORY



FACILITY FORM 602

N66 23713 (ACCESSION NUMBER) — (THRU)

26 (PAGES) — 1 (CODE)

CR 74173 (NASA CR OR TMX OR AD NUMBER) — 30 (CATEGORY)

DEPARTMENT OF ASTRONOMY
DEPARTMENT OF ELECTRICAL ENGINEERING

GPO PRICE $ ____

CFSTI PRICE(S) $ ____

Hard copy (HC) $1.00

Microfiche (MF) .50

INVESTIGATION OF GALACTIC AND PLANETARY RADIO ASTRONOMY

Status Report

July 1965 thru December 1965

NASA Grant NSG 572

Submitted by Fred T. Haddock

March 1966

The University of Michigan
Radio Astronomy Observatory

Department of Astronomy
Department of Electrical Engineering

INTRODUCTION

This is the fourth semi-annual status report on NSG-572, initiated in October 1963.

NSG-572 is a three year, step-funded grant which continues investigation previously carried on under NASw54 and NSG-181-61.

The organization of the following sections reflect the two tasks of the grant (I and II) Galactic Radio Astronomy and (III) Planetary Radio Astronomy Investigation.

I. Galactic Radio Astronomy

11.03 Rocket Experiment

The second rocket payload built by UM/RAO was launched from Wallops Island on 30 June 1965 on the 11.03 Journeyman rocket. It achieved an altitude of 1708 km, good telemetry was received throughout the flight and the payload apparently functioned perfectly.

The payload was similar to that on 11.02, but incorporated a number of modifications and additions. The same three frequencies as on 11.02 were retained, namely 0.75, 1.225 and 2.0 Mc/s. (A cosmic intensity at 0.75 Mc/s was not obtained on 11.02 largely through lack of sensitivity.) The pre-flight calibration was much more thorough than on 11.02.

In order to realize the accuracy inherent in the data, it has proved necessary to carry out a lengthy program of data analysis. This involves a number of operations on the raw telemetry data, detailed checks of the data for internal consistency and for consistency with pre-flight calibration, comparison of observed with theoretically predicted behavior, etc. This program has only been feasible because of use of digital computers at many stages, and even so is very laborious. Some 42 programs have already been written and at this time our program is well-advanced and final results should be forthcoming in the near future.

A preliminary analysis, without full corrections, indicates that the final values at 1.225 and 2.0 Mc/s should be close to those obtained from the 11.02 rocket, confirming the sharp fall in the spectrum, but with greatly improved accuracy. It might be mentioned that the relatively crude analysis used for 11.02, involving much hand reduction, could have been applied to 11.03 and yielded final results by now, but without the accuracy we hope to achieve.

There is every reason to believe that the target accuracy of 0.5 db at the two higher frequencies will be achieved, together with a significant measurement at 0.75 Mc/s. If this is so, then this experiment may reasonably be claimed to be the first of the second-generation measurements and it may appreciably narrow the range of possible models that will account for the cosmic radio spectrum. As a by-product it should yield a great deal of information about antenna behavior in a plasma which will be valuable for design of future experiments.

Downward Extension of the Spectrum at Moderate Altitudes

It is appropriate at this stage to discuss briefly some points in connection with the 0.75 Mc/s measurement, since they are important also to the proposed future work. Fig. 1 has been discussed extensively in other places, and some knowledge of it is assumed; it uses the usual magneto-ionic parameters:

$$X = (\text{plasma frequency}/\text{operating frequency})^2,$$

$$Y = (\text{gyro frequency}/\text{operating frequency}).$$

At a given operating frequency, decreasing altitude above the peak of the ionosphere corresponds to moving upwards and to the right of fig. 1, and in the course of a rocket flight a particular operating frequency traces out a corresponding trajectory on fig. 1. When conditions are such that the payload is in region 1, both ordinary and extraordinary waves (hereafter, referred to as I and II) can be received from outside the ionosphere. Wave II cannot cross the boundary into region 2, but wave I can propagate freely in the regions for which $X < 1$, i.e. regions 1, 2, 3, and 6. The measurements of cosmic noise at 1.225 and 2.0 Mc/s near apogee on both 11.02 and 11.03 were made in region 1. Much greater altitude would have been required for the 0.75 Mc/s receiver to have reached region 1; in fact on both shots it was in region 3 at apogee. Unfortunately, cosmic noise cannot be measured in region 3 conditions because of high noise levels, probably of local origin. However, at lower altitudes in the trajectory, the 0.75 Mc/s receiver on 11.02 and, it is believed, on 11.03 also, passed through region 6 and measurements of wave I should in principle be possible. This was unsuccessful on 11.02 because of lack of sensitivity, but it is believed that a successful result will be obtained from the 11.03 data.

The important points to note are that region 6 corresponds to the condition: plasma frequency < operating frequency < gyro frequency, and that this may occur appreciably below apogee. On both 11.02 and 11.03, use of this region could best be made at altitudes around 1000 km although apogee was at 1700 km. Thus region 6 seems to be the key to extending spectral measurements downward relatively inexpensively by use of vehicles with moderate altitude performance.

To exploit region 6, it is clearly desirable to have the plasma frequency as low as possible but the gyro frequency as high as possible. Both these conditions are best satisfied at high latitudes. The lower limit to observing frequency is set by the lowest plasma frequency obtainable in region 6. Recent Alouette top-side sounder data suggest that at altitudes of 1000 km, the plasma frequency at certain high magnetic latitudes sometimes falls as low as 100 kc/s at night-time. Thus it may well be possible to measure cosmic noise down to two or three hundred kc/s at altitudes around 1000 km and at high latitudes.

II. Scientific Studies Relating to Large Low-Frequency Radio Telescopes in Space.

In order to initiate and conduct engineering feasibility studies on orbiting radio telescopes having relatively high angular resolving power at a frequency near 1 Mc/s, it is necessary to set forth in as much detail as possible the scientific objectives of the telescope and to make predictions of approximately what the characteristics of the observational data will be. This can be approached by using data from high-resolution observations obtained at high frequencies from the ground and from low-resolution observations from space together with theoretical models of the radio galaxy and extragalactic sources. Large deviations from direct extrapolation from high frequencies are due to the absorption effects of interstellar and, perhaps, intergalactic ionized gas and of self-absorption in the synchrotron sources themselves. This definition of the scientific objectives continued throughout the reporting period.

III. Planetary Radio Astronomy

Martian Ionospheric Studies

The analysis of Kaplan, et al (1964) together with the results from Mariner IV suggest a serious doubt that there is any significant constituent of the lower Martian atmosphere but CO_2, and that the consideration of N_2 as a constituent is based on traditional, rather than scientific reasons. The most recently published model (Johnson, 1965) still contains some N_2, but in an amount small enough so that it does not affect the pressure lapse rate in the lower atmosphere. The structure appears to be based on the requirement of predominant atomic oxygen in the upper atmosphere at a temperature low enough to produce the small scale height observed by Mariner. A number of physical inconsistencies are present. Because of the low temperature assumed, most of the heat produced by photochemical processes can not be radiated away, and the atmosphere cannot be isothermal. If O is present there must also be a significant amount of O_2 and one would find the O_2^+ ion rather than the O^+ ion to predominate in the lower ionosphere, around the level of the peak electron density. This could account for a 25 km scale height at a more reasonable temperature of 180 deg. K.

Model Martian Atmosphere and Ionosphere

Further analysis of the Martian atmosphere and ionosphere was done. The model described in the last progress report was extended to much greater heights, and detailed photoionization and heat balance factors were included. The following preliminary conclusions may be stated, regarding the atmosphere above the subsolar region:

1. A positive temperature gradient must exist if the heat produced by photochemical processes is greater than about 0.1 erg. Daytime exospheric temperatures on Mars at sunspot maximum are slightly lower than those on the earth at sunspot minimum.

2. The ion-production is bimodal with an E region maximum due to O_2 and CO_2 between 90 and 100 km, and a broad F-region maximum at 140 km due to CO and O.

3. Equilibrium ion densities show an O_2^+ peak at about 100 km, a lower density ledge at 140 to 160 km where O^+ becomes significant, and an F_2 maximum, also somewhat lower, at the level of 250 km or so, above which diffusion, rather than equilibrium predominates.

4. At no level is CO_2 in chemical equilibrium with its dissociation products.

5. Atomic O is the significant heat radiator above 110 km, but most of the heat produced by photochemical processes is radiated away by CO_2 below 90 km. At no level is the vibrational radiation by CO significant; rotational radiation may be.

6. As the incident radiation decreases the concentration of O^+ decreases much faster than does that of O_2^+. Near the terminator, and especially at sunspot minimum, only a vestigial F_2 ledge may remain. This would be consistent with the Mariner IV observations.

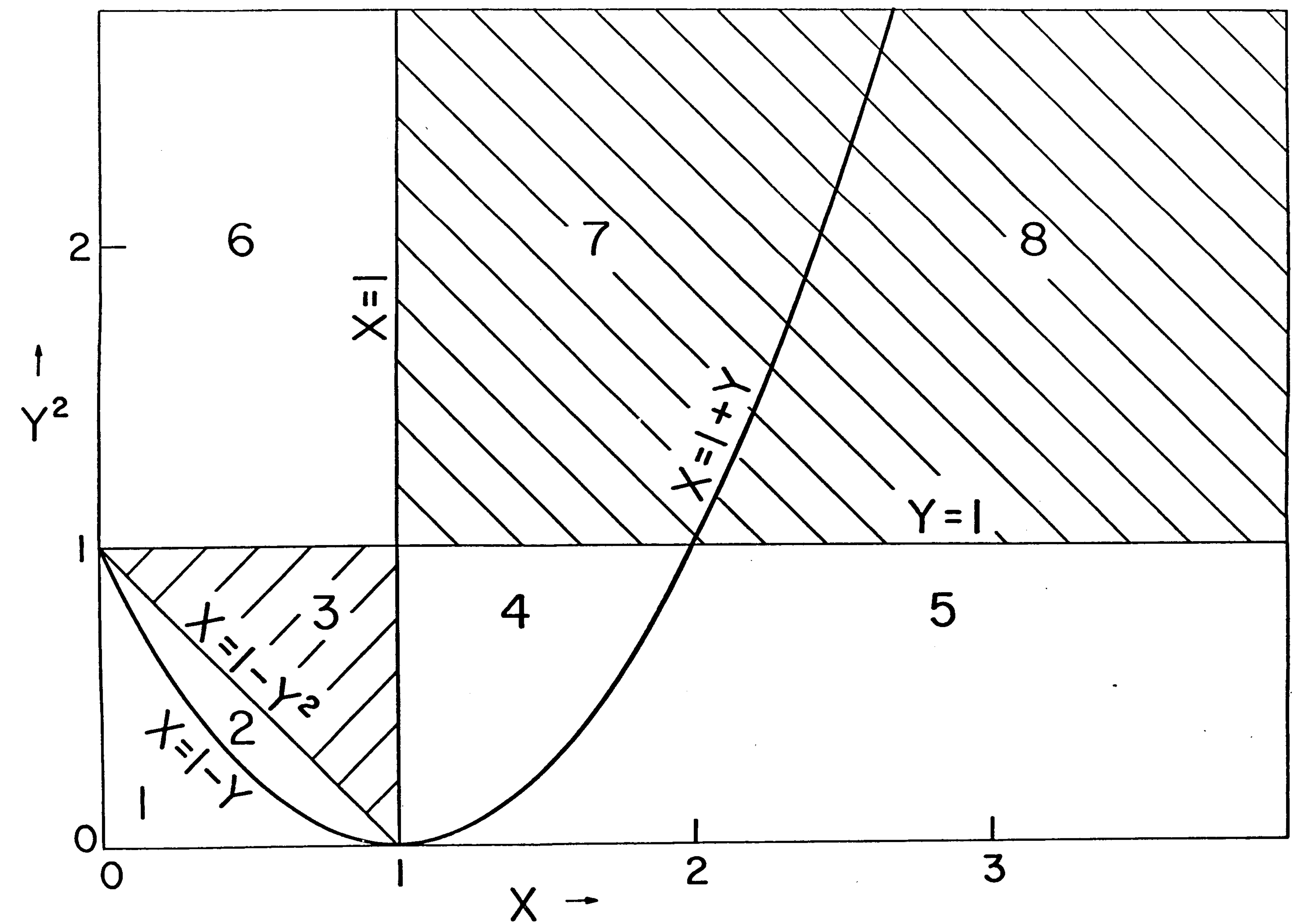
Papers summarizing the above research and the radio propagation implications of a Martian ionosphere were submitted for presentation at the 1966 Spring meeting of the AGU and the URSI.

Reports Issued

Newbern Smith, "The Lower Martian Atmosphere." UM/RAO Report 65-17, Nov. 1965.

Newbern Smith, "Photoionization in a Partially Dissociated Carbon Dioxide Atmosphere." UM/RAO Report 66-1, Jan. 1966.

Newbern Smith and A. E. Beutler, "A Model Atmosphere and Ionosphere of Mars." UM/RAO Report 66-2, Jan. 1966.



THE $X - Y^2$ PLANE