THE PENNSYLVANIA STATE UNIVERSITY

IONOSPHERIC RESEARCH

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Semi-Annual Status Report No. 1

for the period

October 1, 1974 to March 31, 1975

IONOSPHERE RESEARCH LABORATORY

University Park, Pennsylvania

Ionosphere Research

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TABLE OF CONTENTS

INTRODUCTION

This report is a statement of work currently in progress and is intended to meet contractual report requirements. Many of the topics discussed are part of M. S. and Ph. D. thesis programs and great care should be taken in the use of this data. No part of the report should be quoted without the expressed permission of the author.

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A. RESEARCH PROGRESS

1. D-Region Theory

1.1 General - A. J. Ferraro

Received a supplement to the NSF grant to prepare for cross-modulation measurements at the Arecibo Observatory during April 1975. The facility has been upgraded to allow 15 D-region heights to be sampled at one time.

Additional funding received from ONR for a feasibility study of OHD radar studies leading to artificial doppler modulation created by D-region heating.

A paper by Kissick and Ferraro has been accepted by JATP for publication; the paper is concerned with heating during partial reflection measurements. A second paper by Newman and Ferraro is being prepared on the statistics of D-region partial echoes.

1.2 General - L. C. Hale

An Astrobee-D with an NO measuring payload was unsuccessfully launched from WSMR on October 10, 1974. This payload was recovered, refurbished, and successfully launched from Poker Flats on March 10, 1975 in conjunction with a normal Gerdien condenser and a blunt probe (see Croskey No. 5.2).

Space Data Corporation was visited on October 11, 1974 as a first step in the development of instrumentation suitable for the Super Loki-Dart rocket system. The first prototype conductivity probe has been completed (see Croskey No. 5.2), and will be launched in May or June.

A paper by Hale and Chesworth summarizing the application of the ice particulate concept to explaining observed ionospheric

phenomena was presented on October 14, 1974 at the URSI meeting in Boulder, Colorado. This paper is being prepared for publication.

A paper entitled "Recent measurements in the stratosphere and mesosphere," by C. L. Croskey, H. Farrokh, L. C. Hale, S. C. Leiden and V. Vyas was submitted to the forthcoming AGU meeting in June. This paper summarizes current data analysis and the abstract follows:

A parachute borne Gerdien condenser launched at 1145 LT on January 11, 1974 at WSMR confirms the result of Widdel, et al. that positive ions in the mesosphere occur in widely separated mobility groups. The heavy ions appear to be several thousand AMU. Below 46 km the ion mobility appears to be a broad continuous smear within the resolution of the instrument. Further Gerdien condenser launches performed on June 29, 1974 at Wallops Island during the Aladdin series provide additional information about ion mobility during twilight and nighttime conditions, and indicate the presence of very heavy negative as well as positive ions in the mesosphere. A blunt probe also launched on June 29 indicated that a "normal" NO distribution existed on that day. A balloon conductivity measurement through sunset at Aire-sur-l'Adour, France on May 14, 1968 indicates that very heavy ions are not present at 34 km at night, confirming a recent blunt probe result of Mitchell. They are present in the daytime, however, lending support to a suggestion of Mohnen that they may form by gas to particle conversion under the influence of ultraviolet light. A Gerdien condenser with a flashing ultraviolet light was successfully launched from Poker Flats on March 10, 1975.

1.4 General - M. Nicolet

A review has been made of the various reactions in which ozone and atomic oxygen are involved in the stratosphere. In a pure oxygen atmosphere, there is a discrepancy between theoretical and observational concentrations of ozone in the upper stratosphere where photochemical equilibrium conditions can be accepted.

In a hydrogen-oxygen atmosphere water vapor, methane and molecular hydrogen are the sources of hydroxyl and hydroperoxyl radicals which react with ozone and atomic oxygen. The origin of the H_2O, CH_4 and H_2 dissociation is the reaction of these molecules with the electronically excited oxygen atom $O(^1D)$ produced by the ozone photodissociation at $\lambda \leq 310$ nm. There is an important destruction of methane by reaction with OH radicals leading to H_2O, H_2 and CO molecules. Unfortunately, since several rate coefficients are not yet known with sufficient accuracy, precise determinations of the stratospheric H_2O and H_2 productions are not yet possible. Furthermore, the ratio of the hydroxyl and hydroperoxyl radical concentrations is not well determined and cannot lead to an exact calculation of the destruction of ozone in the upper stratosphere which occurs through reactions of OH and HO_2 with atomic oxygen. In the lower stratosphere, the simultaneous action of CO and NO on OH and HO_2, respectively, complicates the determination of this action on the ozone concentration. Without new laboratory measurements it will not be possible to obtain precise values of OH and HO_2 concentrations.

In a nitrogen-hydrogen-oxygen atmosphere the action of nitrogen dioxide can determine the ozone behavior above its peak

and below the stratopause when the observed values are used. However, the predictability of its action in the lower stratosphere depends strongly on the variation in the observed values of NO_2. Seasonal, latitudinal and day-to-day variations of the ozone concentrations observed in the lower stratosphere in association with variations of the tropopause height are related to advective and dynamic transports depending on meteorological conditions. In addition to the various reactions involving nitric oxide and nitrogen dioxide, the reactions leading to the production and destruction of nitrous acid and nitric acid must be considered. HNO_3 molecules are involved in a downward transport from the lower stratosphere into the troposphere strongly associated with variations of the tropopause height and lead to the removal of nitrogen oxides from the stratosphere. Various sources such as the NO production by cosmic rays, by solar proton events and by the reactions of the electronically excited oxygen atom $O(^1D)$ with nitrous oxide or even by artificial means lead to a complex problem which should require greater attention.

The action of chlorine compounds is related to the industrial production of fluoro-carbons and to a natural background of the compounds involving chlorine. At the present time, the cumulative effect of dichlorofluoromethane (CF_2Cl_2), of trichlorofluoromethane ($CFCl_3$), of carbon tetrachloride (CCl_4), of chloromethane (CH_3Cl) and also of CH_2Cl_2, $CHCl_3$, CH_3CCl_3, . . . could lead to a stratospheric mixing ratio of ClO_x greater than 10^{-10} and perhaps between 5×10^{-10} and 10^{-9}. However, very precise studies are required in order to compare the action of the catalytic reactions

$Cl + O_3 \rightarrow ClO + O_2$ and $ClO + O \rightarrow Cl + O_2$ with the effect of the interaction with nitric oxide due to the reaction $ClO + NO \rightarrow Cl + NO_2 \rightarrow Cl + NO + O$. In addition, the loss process due to the reaction of Cl with various molecules such as CH_4, H_2, . . . leading to HCl must be well known, since it determines the downward transport of HCl into the troposphere.

In the lower stratosphere, all aeronomic processes cannot be studied without introducing varying lower boundary conditions associated with the variations of the polar and tropical lower stratospheres which are observed by changes in the tropopause heights and by tropopause breaks.

1.5 General - A. P. Mitra

The paper on "Ionospheric constraints of mesospheric nitric oxide" prepared jointly with Rowe appeared in the November issue of JATP. In this, attempt is made to define acceptable ranges of NO concentration from 60 to 110 km, using different ionospheric approaches as follows:

I. Estimates from rocket mass-spectrometric observations of $\left[NO^+\right]$ and $\left[NO^+\right] / \left[O_2^+\right]$.

II. N_e constraints.

III. Solar Cycle reversal in N_e.

IV. Simultaneous measurements of flaretime N_e - t values and solar x-ray observations.

V. Measurements of N^+.

The invited paper presented at the Brazil STP meeting on "D-region in disturbed conditions, including flares and energetic particles" will appear soon in a special issue of the JATP. The

main thrust of this paper is a unified picture of the chemistry of the D-region under quiet and varying conditions of disturbance, including solar flares, PCA's and solar eclipses. The connecting thread is the six ion model of Mitra and Rowe, with appropriate modifications where necessary.

Meanwhile, Al Tomko and I have been working on some improvements in the six ion model to take care of different behaviors in "intermediate" and "terminal" types of negative ions, in which the "intermediate" species would have "detachment" rates comparable to the rate of conversion to the terminal ions, whereas the terminal ions would only be destroyed through mutual neutralization and consequently would have longer lifetimes. Some work on this has been completed.

A major effort was to extend electron density distributions below 70 km. There are two rather distinctly conflicting views. One view (expressed by the Illinois Group) is that N_e drops very rapidly below 70 km and at 60 km is $\lesssim 10\ cm^{-3}$. The other view is that there is still a sizeable bank of ionization below 70 km. In our D-region Part II paper (JATP, 36, 1974, p. 766) we expressed these two as two alternative constraints:

$$\left.\begin{array}{ll} \text{Constraint 4a:} & N_e \text{ at 60 km} < 10\ cm^{-3} \\ \text{Constraint 4b:} & N_e \text{ at 60 km} = 40 - 80\ cm^{-3} \end{array}\right\} \quad \chi = 60^{\circ}$$

The importance in resolving between these two types of values lies in that the first can be explained on the basis of detachment rates ($\backsim 10^{-2}\ s^{-1}$) that one invokes for heights around 70 km; the second would need a considerably larger detachment rate, perhaps

something 100 times as large. Professors Ferraro and Lee, Al Tomko and I, have recently been examining possible ways of resolving the conflict as well as generate profiles that would fit with the 9-22 KHz observations obtained by NELC, San Diego. The latter can in fact be the source for first order models. Tomko has tried out several models that could fit with these observations - in most of these trial attempts, he keeps N_e values above 70 km frozen to the ranges given by our constraints in the JATP paper, and then alters profiles below 70 km for best match. In this process he tries out Bain - Harrison profiles, the cross-modulation profiles as well as those generated by modified Mitra-Rowe schemes.

This approach appears to be quite promising.

1.7 Mesospheric Processes - J. J. Olivero

Ongoing investigations are in progress concerning the properties, effects, and the measurement of water vapor and aerosols in the mesosphere. These are discussed also in sections 1.8 - 1.10 below.

Mr. Longbothum's study of microwave water vapor measurements is providing extremely encouraging indications that water vapor mixing ratios as low as 10^{-7} or less can be adequately measured in the mesosphere. This work is presented in an IRL Scientific Report about to be released.

We have continued to look at the climatic implications of the aerosol scattering layer at the summer polar mesopause. A full mie scattering code with parameterized particle absorption has been incorporated into a radiative transfer model by Mr. Hummel. This model allows us to infer the affect of the scattering layer albedo on

average surface temperature. Although rather tenuous, the layer does appear to contribute to the surface energy balance - temperature on the order of one to several tenths of a degree (K). Some of these results were presented at the Fall AGU meeting in San Francisco (December 1974).

Much smaller particles, submicron embryonic structures, appear to be a normal constituent of the stratosphere and mesosphere, based on analysis of D-region conductivity and mobility measurements (Chesworth and Hale, 1974; Hale and Chesworth, 1974; Olivero, 1974). In February we visited Dr. Harvey Pataschnick and his colleagues at Dudley Observatory, Albany, New York and discussed their programs of upper atmospheric and astrophysical particle collection and analysis. Their work suggests that the particles we predict would be difficult to detect by impactors and, if volatire, would not necessarily leave any evidence at all. Dr. Pataschnick is performing careful laboratory simulation of the morphology of small ice spheres at low pressures and indicates that the structures we suggest would be far more stable than classical equilibrium calculations would suggest. This stability may arise in the atmosphere by formation of vapor phase water clathrates around suitable ions or neutral host molecules (Siksna, 1973).

Dr. Chesworth and I have been considering the possibility of optical detection of such small particles and find it to be virtually impossible in the visible, especially at the ruby laser wavelength (0.69 μ). In the ultraviolet, the non-Rayleigh scattering component can be non-negligible. We are presently examining published

rocket and satellite data which do show non-Rayleigh extinction characteristics at heights of 50 to 70 km. We hope to discuss these findings at the Annual AGU meeting in June, 1975.

References:

Chesworth, E. T. and L. C. Hale, "Ice particulates in the mesosphere," Geophysical Research Letters, 1, 347-350, 1974.

Hale, L. C. and E. T. Chesworth, "A model of ionization in the mesosphere," URSI meeting, Boulder, October 14-17, 1974.

Olivero, J. J., "Ice particulates in the mesosphere," Invited paper, Fall AGU meeting, 1974.

Siksna, R., "Water clathrates as aerosol particles," Institut for Hogspanningsforshning, Uppsala, Sweden, UURIE:53: 73, 1973.

1.8 Mesospheric Transport Process - E. T. Chesworth

The study of the possiblity of aerosols in the mesosphere and the effect they would have on ionization and chemistry of the air was continued.

In particular, the temperature conductivity was reviewed. Several lines of inquiry were pursued in the hope that a definitive causal connection between positive conductivity and air temperature could be found. These efforts have been only partially successful.

The possibility of mie-scatter of ultraviolet light by mesospheric aerosols was investigated. It was found that ozone measurements using back scatter ultraviolet light and ozone measurements using occultation of ultraviolet starlight could both be affected by mesospheric aerosols.

A paper "A model of ionization in the mesosphere" by L. C. Hale and E. T. Chesworth was prepared and presented at the URSI meeting, October 14-17, 1974, in Boulder, Colorado. A paper

"Ice particulates in the mesosphere" by E. T. Chesworth and L. C. Hale was published in Geophysical Research Letters, Vol. 1, 347-350, December 1974, and a paper "Ultraviolet scattering from mesospheric aerosols" by E. T. Chesworth and J. J. Olivero is being prepared for presentation at the 56th Annual meeting of AGU, June 16-20, 1975 in Washington, D. C.

1.9 Upper Atmospheric Water Vapor - R. Longbothum

The month of October 1974, I was conducting research in the area of microwave radiometry at the Jet Propulsion Laboratory. The results of this experimental research were presented at the 1974 URSI meeting in Boulder, Colorado by Dr. Joe Waters. Following my return to the Ionosphere Research Laboratory in November, a report was written and a seminar presented on my research. This report entitled "Atmospheric parameters inferred from microwave radiometer measurements," has been made into an Ionosphere Research Laboratory Internal Report (No. 44).

Upon completion of this work, a feasibility study of water vapor occultation measurements, started before the appointment at J.P.L. was finished and now is in preparation as an Ionosphere Research Scientific Report.

At the present, I am working on a very detailed feasibility study of water vapor measurements using microwave radiometry from various measurement platforms.

1.10 Aerosol Layer Studies - J. Hummel

The radiative transfer model published as Scientific Report 428, "A simple radiative transfer model of the high latitude mesospheric scattering layer," has been extensively revised to include changes in the mie scattering data and to incorporate a time-dependent

model of the layer. The model allows us to examine the temperature perturbations of the layer as it grows during the course of the summer. The model is near completion and the results will be incorporated as my Master's thesis.

The work being done with Dr. Bruce Guenther of the Goddard Space Flight Center to reexamine the OGO-6 photometric data of the mesospheric scattering layer was completed, the results being presented by Dr. J. J. Olivero at the Fall AGU meeting in San Francisco (Hummel and Olivero, 1974). The analysis was greatly complicated by horizontal inhomogenities apparent in the scattering layer and the small wavelength contrast of the two photometer channels. The results do suggest, however, that the majority of scatterers are less than 0.1 μ in radius.

Reference:

Hummel, J. R. and J. J. Olivero, "Radiative transfer model of the mesopause scattering layer," Fall AGU meeting, 1974.

1.11 Arecibo Wave Interaction Measurements - M. Sulzer

The wave interaction multiplex system has been placed into operation. Data is recorded onto a digital tape recorder such that each channel is sampled serially three times in one second. It has taken some time to develop the techniques and programming to process the data, but the results indicate that a profile may be obtained in about two minutes of D-transmitter operation time. The multiplex system will be used as an aid in locating gravity waves in the D-region.

The last two months have been almost entirely devoted to preparations for the upcoming Arecibo project. The multiplex

system and the W-transmitter will be shipped to Arecibo and used with the heater transmitter and dish to form a wave interaction detection system. All day runs are planned with the goals of finding gravity waves and studying the morning and evening behavior of the D-region.

1.13 D-Region Theory and Measurements Below 70 km - A. Tomko

Ionospheric reflection coefficients corresponding to published D-region electron density models near $\chi = 60^{o}$ have been calculated using a full wave program based upon the second method outlined by Budden (1955)[1]. These results have been compared with NELC steep incidence VLF observations at $\chi = 60^{o}$ for frequencies in the 9 to 22 KHz range. None of the published models have been found to adequately reproduce the observed reflection coefficient variation as a function of frequency. Trial and error modification of existing electron density profiles in the primary reflection region (60-80 km for 9-22 KHz) has been undertaken in order to construct an electron density profile which best fits the observed reflection coefficient variation. The results of this study will be published during the next report period as part of my Master's thesis.

[1]Budden, K. G. (1955), Proc. Roy. Soc. A, 227, 516-537.

1.14 Digitalization of WI and PR Experiments - K. Swanson

During this period I have been working on the digitalization of the Wave Interaction and Partial Reflection experiments. This work involves three areas:

1. Development of a 16 channel Wave Interaction Multiplex System.

peak of the solar cycle. A paper was presented at the 1974 Fall AGU meeting suggesting that much higher EUV fluxes are required under conditions of higher solar activity.

A study has been made with Dr. Monro and Terry Stick of the effect of tides in the E region on E-region electron densities. It was shown that the large temperature and density oscillations in the E region cause correspondingly large variations in the electron densities and that very large assymetries about noon are present in the E-region densities due to this effect. This is of interest because it answers the problem of the sluggishness of the E-region raised by Appleton in 1930 and which had not been completely explained until now. A paper has been written and submitted to JATP.

A paper was presented at the 1974 Fall AGU annual meeting reviewing the purpose of model ionospheres and the future requirements for the next generation of ionospheric models. An annotated bibliography has been prepared for our presentation at the URSI General Assembly in Lima, Peru in August outlining the progress that has been made on both theoretical and ionospheric models in the last three years.

Investigations have been made of the accuracy with which the densities of atomic oxygen, molecular nitrogen and the neutral temperature can be obtained from the new series of standardized incoherent measurements. An internal report has been prepared on the reduction of the collision frequencies to neutral densities and further papers on resolving of the ambiguity in the mean ion

molecular mass in the F1 region and the determination of the atomic oxygen densities at 400 km are being prepared.

Work has started on an investigation of the energy budget in the thermosphere under conditions of high magnitude activity.

A letter has been submitted to JGR commenting on the paper by Heroux, Cohen and Higgins which was published in the Dec. 1, 1974 issue of JGR. A paper on the cross coupling of the zonal and meridional winds has been written based on work done at the Max Planck Institute with Dan Baran and Peter Stubbe and submitted to JGR.

2.2 F-Region Scintillations - W. J. Ross

There have been a large number of papers on this subject appearing in the literature in recent months, including both theoretical and experimental studies. The results of direct measurements of plasma density variations by satellite sensors are particularly valuable in shedding light on some of the smaller scale physical characteristics of the phenomenon which are not amenable to ground-based measurement.

In the modeling of the effect of the thermospheric neutral wind in steepening density gradients, choice of conductivity profile between the E and F regions is critical, and little good information on this is available.

2.3 F-Region Dynamics - L. A. Carpenter

Examination of midlatitude electric fields continued during this period. The main emphasis involved separating and catagorizing results according to season and magnetic activity to examine the processes controlling the external electric fields. Recent interest

in thermospheric winds at F-region heights (F-region polarization electric fields) has generated more detail study of the conductivity along the magnetic field and through the E-region at various times of day.

Recent comparisons with whistler results of north-south drift throughout the day have been encouraging. The agreement is remarkable considering the observations refer to different days, different Kp, and different techniques.

The August 11-14 data results in cooperation with the Worldwide Balloon Electric Field and Aurora Parameters Program were examined in detail. Although this program was directed at magnetic storm conditions, these results are during some of the quietest magnetic conditions yet observed.

A new configuration points the L band antenna slightly east and then west of magnetic north such that returns are at the same L value. Better time resolution of the velocities reveals a wave-like structure that has not been previously seen.

The magnitudes of the velocities observed were within the normal ranges but somewhat below average values. The direction of the east-west velocities is generally westward between 20 and 23 L.T., but in this experiment, is eastward. An attempt to separate the data for very quiet conditions, ΣKp less than 16, has been completed. A slightly different variation is observed with a magnitude less than average.

The comments of the reviewer were incorporated in a revised version of "Comparison of high latitude and midlatitude ionospheric electric fields" that has been accepted for publication

in JGR. The paper "Dominance of the diurnal mode of horizontal drift velocities at F-region heights" was just published in JATP, 37, 419-428.

Two papers are presently in preparation with V. W. J. H. Kirchhoff for the June AGU meeting, "Nighttime electric fields and meridional neutral winds at midlatitudes" and "Magnetospheric electric fields at L = 3.2 measured with incoherent scatter radar." The first paper is a detailed study of the dynamic processes during the night. Both components of velocity show a peak around sunrise which may be the effect of F-region polarization electric fields. Meridional neutral winds are computed from vertical and northward drifts and compared with various thermospheric models.

The second paper deals with the variation of ionospheric electric fields with magnetic activity and with season. The main idea is to examine ionospheric effects of the convection electric field at an invariant latitude around 55°.

2.4 F-Region Theory - P. Stubbe

I have started working on ionospheric heating experiments during this period.

2.7 Ultraviolet Airglow Studies - R. Rohrbaugh

During this period research has been directed towards the study of the mechanisms of ultraviolet airglow emissions occurring in the atmosphere of Mars and Venus. The primary emissions of interest are those arising from excited states of CO_2^+, CO, CO^+, C, O, and N. Excitation cross sections by both photoelectrons and photons, as well as absorption cross sections, are being collected for the purpose of theoretically modeling these emissions.

A computer program is being written to generate neutral density profiles and photoelectron energy and altitude spectra for any given thermospheric temperature profile and neutral density boundary values. From this model, the production and radiative transfer of the ultraviolet emissions are to be obtained.

Consultation and guidance for this work has been conducted with Dr. Jay Herman of Goddard Space Flight Center, who will continue with such throughout this study.

A seminar entitled "Review of Recent Results on the Atmosphere and Ionosphere of Mars and Venus" has been presented at the IRL based upon a literature survey of the results of the explorations of these planets.

2.10 Incoherent Scatter Measurements of Electric Fields - V. Kirchhoff

The vertical drift velocities measured by the incoherent scatter radar are the result of three components: meridional neutral wind, north-south perpendicular drift velocities and diffusion velocity. Therefore from a conveniently planned experiment it is possible to deduce neutral wind information, from plasma drifts, densities and temperatures. Several days of measurements of this kind have been obtained from Millstone Hill and a program is now available for the calculation of diffusion velocities and meridional neutral winds.

The paper "Dominance of the diurnal mode of horizontal drift velocities at F-region heights" has been published in the April issue of JATP.

2.11 Thermospheric Neutral Temperature Variations - B. Wydra

The OGO-6 satellite neutral temperature data measured using a 6300A Fabrey-Perot interferometer and the neutral density data measured using a quadrupole mass spectrometer have been combined to describe the global effect of geomagnetic activity on the neutral temperature and density. The neutral constituents measured are O, He, and N_2. The data for the period around the "great storm" of 8 March 1970 has been contour plotted to indicate variations as a function of latitude and universal time. Analysis of another less severe disturbance in June 1970 is also being analyzed. Combining the two analyses, it may be possible to determine how season, local time, and strength of geomagnetic disturbance affect the changes of neutral temperature and density resulting from geomagnetic storms.

2.12 E-Region Tides - T. Stick

During the last six months I have been working on my thesis topic of E-Region tides. My work centered around analyzing E-region backscatter data. The results of this project were prepared by Dr. Monro, Dr. Nisbet and myself for presentation at the Annual Fall AGU conference. Further work was done on preparing these results for publication.

In addition to E-region studies I have also been doing some work on the Vest neutral atmospheric model in preparation to comparing it with other neutral models.

At present I am continuing the work of E-region investigation through analysis of data to understand the tides at this altitude. The results of this work will be used in my thesis.

2.13 F-Region Studies - M. Miller

Changes were made in the Stubbe F-region model. These changes take into account new measurements of the temperature dependence of ion-molecule reaction rate coefficients. The new rate coefficients were for the reactions of atomic oxygen ions with molecular nitrogen and molecular oxygen which have an important bearing on the electron continuity equation at high temperatures.

Using the Stubbe Model, comparisons were made between F region density profiles and observations at low, medium and very high levels of solar activities to determine the compatibility between the current understanding of the rates of production and loss and current solar EUV flux measurements.

The results of the above comparisons were presented in a paper entitled "Compatibility of EUV Flux Measurements and Solar Cycle Variations in the F-Region" at the Fall 1974 AGU meeting. The results show that the EUV fluxes should vary by a factor of two over a wide range of solar activity levels. More recently new solar EUV flux data have been obtained from Dr. Hans Hinteregger and group at AFCRL.

2.14 E-Region Waves - P. Monro

The work under this topic involves an investigation of the semi-diurnal tidal effects in the E-region with a view to determining the likely importance of these effects to a dynamic thermospheric model.

The data that was used was that tabulated by the group at the incoherent backscatter facility at St. Santin, France, which provided electron density, ion temperature, ion velocity and ion collision

frequency at the four heights 95, 100, 105 and 110 km. A model of the E-region was developed using this data to modify the mean CIRA 1972 neutral atmosphere, and electron densities were calculated using this model together with published values of solar fluxes and ionization cross-sections and all important chemical reactions. This was done to check the interval consisting of the data by comparing the measured electron densities with those calculated from the model. It was found that the agreement was good at 95 and 100 km, but significant deviations occurred at 105 and 110 km. These deviations were thought to be due to certain approximations in the model (there being no information about fluctuations in neutral atmosphere density above 110 km) or to the effects of wind-induced diffusion of atomic oxygen.

As good agreement was obtained at the lower two heights it was concluded that the variation in neutral atmosphere density, as implied by variations of ion collision frequency, could be very large in the E-region; factors of almost two are involved on some days. It was also shown that variations of relative atmospheric composition could be deduced from careful measurements of the parameters used in this investigation. It is clear that variations of the type found in this investigation have a profound effect on the development of accurate thermospheric models which have their boundary conditions specified in the E-region.

The work done under this topic has been compiled into a paper entitled "Effects of Tidal Oscillations on the Electron Density and Neutral Atmosphere in the E-Region" by P. E. Monro, J. S. Nisbet and T. L. Stick. This has been submitted to JATP.

3. Wave Propagation Studies

3.1 General - H. S. Lee

A new research grant was awarded by ONR on "A Feasibility Study of OTH Artificial Doppler Shifts." This work is expected to cover a one year period.

In preparation for the cooperative simultaneous measurements of D-region electron density using wave interaction and backscatter techniques at Arecibo Observatory, effort was made to generalize the existing wave interaction theory to handle wider range of geomagnetic conditions, both in analysis and synthesis of wave interaction data.

A paper on critical intercomparison of errors involved in data reduction techniques used by the wave interaction and partial reflection experiments is being prepared.

3.4 General - E. H. Klevans

Our work on midlatitude spread F is progressing well. In the Perkins model, Hall conductivity is neglected. When this is included, completely different short wavelength behavior is found. Surprisingly it is found that the growth rate γ is proportional to k^2. The mechanism and implications are not yet fully understood. This aspect of our research should be completed this term. We will then turn from homogeneous equilibria to inhomogeneous equilibrium ionospheres.

3.13 Satellite Recording and Analysis - W. J. Ross

This program is inactive.

3.18 Artificial Modification of the Ionosphere - P. J. Moser

Recent work has included a review of articles on laser

modification of laboratory plasmas. Conclusions of these papers are being compared with current ideas about ionosphere modification by HF radiation.

The dissertation is nearly complete.

4. Mass Spectrometer Measurements

4.1 Ion Analysis with Mass Spectrometers - General - B. Kendall

Several types of mass spectrometers are being studied from both theoretical and experimental viewpoints, with a view to establishing their value from measuring the ionic composition in the D and lower E regions of the ionosphere. During this reporting period the main effort has again been devoted to work on time-of-flight analyzers having cylindrical and hemispherical electrodes.

Analysis of data from the May 1974 Nike-Apache flight (No. 14.482) is still being analyzed. This work is taking much longer than expected because of late delivery of attitude data and because of unexpected attitude-dependent modulation of the received data. It has also been necessary to wait for the results of additional laboratory experiments before certain correction factors can be applied. Data analysis done so far continues to point to a high proportion of the ions in the upper D-region having extremely high masses. Even though the mass spectrometer upper mass limit had been extended beyond 250 atomic mass units on this flight, substantial currents produced by ions of even higher masses were present. Processing of the data from the mass spectrometer, the three different ion probes, and the neutral density gauge on this flight is continuing. A more detailed discussion of the results so far obtained is given in Section 4.2.

A paper describing the advantages of assembling surface electrodes on spacecraft by means of polyimide adhesives containing spherical glass insulators has been prepared and submitted for publication in Review of Scientific Instruments.

Experimental work has begun on a time-of-flight mass spectrometer with electrodes having double curvature. The intention is to exploit the potentially high sensitivity and relatively high resolving power of this type of instrument which were predicted by earlier theoretical work done in this laboratory. Preliminary tests have indicated that it will be extremely difficult to obtain the desired accuracy of the grids unless new constructional techniques can be developed. An alternative is to use planar grids or grids with single curvature, combined with auxilary electrodes which distort the electrostatic fields in the desired way. This alternative technique is now being investigated.

New apparatus for measuring the amount and composition of gases released from materials and components used in spacecraft is now in operation. The reduction in funding has prevented completion of this apparatus in the form originally planned, but useable results can be obtained in its present state. It is now being readied for a short series of measurements to establish thermal-inertia corrections to be applied to total-pressure data measured with a thermocouple gauge in an ascending or descending rocket-borne experiment.

4.2 Ion Analysis in the D and E-Regions - R. Reiter

The reduction of the data from the Nike-Apache sounding rocket flight of May 15, 1974 (NASA flight 14.482) has been worked

on throughout this reporting period. The feasibility of using the Ionosphere Research Laboratory's telemetry station for some of the data reduction was investigated but interface difficulties made this undesirable. Working with Walt Cuirle, of our research group, an analog computer program was written for the partial reduction of the data. This program has not yet been debugged. Simultaneously, Brad Kuhn of the Hybrid Computer Facility has written a program for analog-to-digital conversion of some of the flight data. This program is now being debugged. Digital programs are being worked on to evaluate the results of the A-to-D conversion program. Hand reduction of selected mass spectra have been done and the results indicate the presence of NO^+ and O_2^+ in the E-region and the upper D-region. Metallic ions (notably Fe^+) were observed at about 95 km. The presence of very heavy ions, probably water cluster ions, (mass >500 amu) is indicated in the D-region but the exact concentration has not yet been calculated. Finally, some smaller water cluster ions were observed (notably $H\cdot(H_2O)_2^+$) in the D-region. More work needs to be done in understanding the effect of vehicle attitude on the data and in understanding the operation of the cylindrical time-of-flight mass spectrometer in a high pressure environment.

The work on laboratory simulation of D-region ion collection and measurement by the cylindrical TOFMS was held up because of difficulty with the current measuring electrometer. A Keithly 302 electrometer had been used originally, but its low frequency response for such small, rapid currents and its poor stability made us decide to switch to an Intersil 8500A electrometer. This

electrometer does have a better gain-bandwidth product and stability but it is very sensitive to high frequency noise on its input and must be carefully shielded. Finally, a logarithmic electrometer developed by Locus, Inc. (which uses an Intersil 8500A) was used to make the necessary current measurements. Other difficulties with leaks in our high vacuum system were eliminated with the help of John Weeks.

Measurements were then made, using the cylindrical TOFMS, at high pressures (up to 50 microns) and at various operating conditions to evaluate high pressure current collection and especially to study the background current collected by the mass spectrometer. This background current gives a measure of the total ion current. When the current present in any mass peaks is subtracted from this total current, whatever remains is a measure of the concentration of very heavy ions (greater than 500 amu for the present mass spectrometer). This collection mechanism is similar in results to the measurement made in quadrople mass filters when the total current for the mass range 0 to ∞ is measured. The results of the tests on the cylindrical TOFMS show a much larger dependence of the background on the spectrometer operating voltages than had previously been thought.

Work has begun in computer simulation of the ion collection mechanism in time-of-flight mass spectrometers and especially the effect of gating on mass resolution and sensitivity. Preliminary results show complicated effects depending on the mass spectrometers operating voltages and the shape of the gate pulse. However, resolution can be improved by gating under certain conditions.

A paper entitled "Miniature Time-of-Flight Mass Spectrometer for Ion Composition Measurements in the Lower Ionosphere" to be written by Dr. Kendall and myself has been accepted for presentation at the twenty-third Annual Conference on Mass Spectrometry and Allied Topics to be held May 25-30, 1975 in Houston, Texas.

I have begun writing my thesis during this period and I hope to receive my degree by August of this year.

4.3 Ion Dynamics of Pulsed Mass Analyzers - B. Kendall

This project is temporarily inactive following the completion of R. Stein's Ph.D. thesis and the publication of key portions of it during 1974.

4.4 Deconvolution - B. Kendall

It has been definitely established that deterioration of the performance of the electrostatic resolution enhancement apparatus used for this work has been caused by corrosion on the moving copper-plated platen which carries the memory capacitors. This causes variations in surface potential which cause a large increase in background noise level. It has been found that these false signals can be greatly reduced by gold plating. Two methods of gold plating are being evaluated with a view to using the most effective technique to recondition all of the corroded components in this apparatus.

4.5 Ion Probes - W. Cuirle

During the past reporting period, the major effort has been directed towards the reduction of NA 14.482 probe and pressure data, together with participation in the design of NC 10.317, now scheduled for a mid-winter launch.

Pressure data reduction methods for NA 14.482 were developed under the guidance of Dr. T. M. York. If the agreement of the pressure profile with CIRA 1972 is an indication of the success of the reduction, then the method offers information on local pressures and flow speeds which may be useful in the interpretation of other 14.482 experiments.

A modest effort is being made to utilize the hybrid computer facility for reduction of data and the modeling of experiments. Particular attention has been paid to the unique capabilities of the analog computer, but it is still too early to judge the success of this venture.

4.7 Molecular - Flow Networks - B. Kendall

This project is temporarily inactive due to lack of funding. Recent publicity in a university publication has led to the possibility of outside support being made available for completion of this work.

4.8 Brownian Motion/Diamagnetic Levitation - R. S. Butler

The thesis "An Investigation of Levitated Graphite Particle Behavior as Related to the Development of a Brownian Motion Pressure Gauge" was completed.

4.9 Outgas Effects - Theory - T. M. York

No reportable progress for this time period.

4.11 Spread F - G. Imel

The past period has been spent extending the Perkins model of temperate latitude spread F (Perkins, F. W., JGR, (78), 218, 1973) by including the Hall conductivity terms, as well as the Pederson conductivity terms. Perkins' growth rate does not depend on

wavelength, and we felt that any wavelength dependence would be contained in the Hall terms. Mathematically, the inclusion of the Hall terms requires a third moment equation - this coupled with the condition that the divergence of the field integrated current must be zero leads to 4 x 4 determinant to solve for the growth rate.

Analytical expressions were obtained for the two limits of long and short wavelengths. The behavior of the growth rate (γ) is:

Long wavelength: $\gamma \sim A$

Short wavelength: $\gamma \sim BK^2$

where A and B are constants, and K is the wavenumber. The constant A only depends on Pederson terms, and C only depends on Hall terms, thus showing that the wavelength dependence is contained in Hall terms. In addition, the propagating term was found to be linear in K (at both limits). It also should be noted that the solution approaches that of Perkins in the long wavelength limit.

4.12 Water Vapor in the Lower Ionosphere - B. Kendall

A study is being carried out on a water vapor sampling technique intended to measure water vapor content as a function of height in the 40 to 80 kilometer region of the upper atmosphere. The proposed technique involves the successive opening of several sampling chambers during ascent and descent of a sounding rocket. Each chamber would be packed with an artificial zeolite material, pre-cooled to increase its absorption capacity. The sampling system would be recovered and determination of the water content in each of the sampling chambers would be made by an isotropic dilution technique. A proposal on this topic has been submitted to NSF.

4.13 Infra-Sound Measurements at Ground Level - B. Kendall

A differential pressure gauge intended for work at high vacuum is being evaluated as a possible infro-sound detector. Results are promising and, in collaboration with J. Olivero, brief recordings have been made of atmospheric pressure fluctuations on several different occasions. The apparatus has just been moved to Scotia in an attempt to establish which if any of the phenomena which have been observed on campus might have been artificially produced.

5. Direct Measurements

5.2 Methods of Minor Constituent Measurements - C. Croskey

In October, a Gerdien condenser with ultraviolet lamp for the photoionization of NO was flown on an Astrobee-D at White Sands, New Mexico on October 10, 1974. Since the parachute failed to deploy until a very low altitude was reached, no data was obtained. The recovered payload has been rebuilt with less battery capacity (to reduce the weight), enabling it to be flown on a Super Arcas.

During the last week of February and the first week of March, a blunt probe, normal Gerdien condenser, and the rebuilt NO Gerdien condenser were launched from Poker Flats, Alaska in conjunction with the Ice Cap '75 program. Data reduction of the NO Gerdien launch has begun. The data reduction of the normal Gerdien condensers from the Aladdin program is continuing. A working model of the Super Loki-Dart blunt probe has been finished. Environment testing and launch are expected in the near future.

5.5 Blunt Electrostatic Probes-Theory and Experiment - T. M. York

No reportable progress for this period.

5.9 Gerdien Condenser Data Analysis - S. C. Leiden

Having been accepted into the Ionosphere Research Laboratory in September, I immediately went to work with Dr. Hale. Due to the fact that I switched from Astronomy to IRL, much of this time has been spent indoctrinating myself with the upper atmosphere. Working in close collaboration with Charlie Croskey, the task of reducing the data from the Aladdin rocket shots in June, 1974 has been undertaken. The results from a blunt probe have been tabulated, and the data reduction from the two Gerdien condenser probes fired is in progress. Dr. Hale will be reporting on the Aladdin results at the AGU meeting this June in Washington.

6. Atmospheric Reactions

6.1 Reactions of HO_2 with NO and NO_2 - R. Simonaitis

The reactions of HO_2 radicals with NO and NO_2 have been studied using a steady state photolysis technique. The reactions are studied by monitoring the NO removal rate using a chemiluminescent technique.

6.3 Relative Reaction Rates of OH with CO and CH_3OH - T. Osif

The reactions of the HCO radical with O_2 and Cl_2 have been studied. The following rate coefficient ratios were measured at room temperature:

$$HCO + O_2 \xrightarrow{1} HCO_3$$
$$\xrightarrow{2} HO_2 + CO$$
$$\xrightarrow{3} OH + CO_2$$
$$HCO + Cl_2 \xrightarrow{4} COHCl + Cl$$

$k_3/k_2 \leq .15$, $k_1/k_2 = 5 \pm 1$, $k_4/k_2 = 45 \pm 5$

The CO_2 production was small and the results scattered. Therefore, only an upper limit could be given for k_3/k_2.

6.4 The Photolysis of Chlorofluoromethanes in the Presence of O_2 or O_3 at 213.9 nm and Their Reactions with $O(^1D)$ - R. K. M. Jayanty

The photolysis of $CFCl_3$ and CF_2Cl_2 in the presence of O_2 or O_3 has been studied at 298 K using light of 213.9 nm. The photolysis of $CFCl_3$ in the presence of O_2 or O_3 gives $CFClO$ and Cl_2 as products with $\phi\{CFClO\} = 0.90 \pm 0.15$ and $\phi\{Cl_2\} = 0.50\text{-}0.63$. With CF_2Cl_2 the photolysis was done only in the presence of O_2; $\phi\{CF_2O\} = 1.0 \pm 0.2$ and $\phi\{Cl_2\} = 0.52\text{-}0.66$. These results indicate that the dominant photochemical process is chlorine atom ejection with a quantum yield near 1.

For the reactions of the chlorofluoromethanes with $O(^1D)$ prepared from the photolysis of O_3 at 253.7 nm and 25°C, the same products are obtained as in the photooxidation, and with the same yields. The quantum yields of O_3 removed are 5.7 ± 1 and 6.3 ± 1 respectively for the $CFCl_3$ and CF_2Cl_2 systems. Thus the indicated dominant reaction path is chlorine atom abstraction by $O(^1D)$ with other paths ($O(^1D)$ deactivation or direct molecular formation of products) being negligible.

Rate coefficients were also obtained for the $O(^1D)$ reactions with O_3, CO_2, $CFCl_3$, CF_2Cl_2, CF_3Cl and CCl_4 relative to N_2O. The relative rate coefficients are as follows:

O_3	2.5
CO_2	0.65
$CFCl_3$	1.5
CF_2Cl_2	1.2
CF_3Cl	0.52
CCl_4	2.1

B. SUPPORTING OPERATIONS

101 Design, Construction of Instrumentation

101.3 J. O. Weeks

The Mark VI Mass Spectrometer for Nike-Cajun with suppressor electrode, solid outer shield on lower half, and an outer grid shield made of type 304 S.S. Steel was constructed and given a prototype shake test at Wallops Island. Construction work on four similar spectrometers is now in hand.

A micro-pressure-pulsation detector was built and is now under test.

Repaired leaks in U.H.V. System in Room 218 E.E.E.; also did repair work on veeco leak detector in E.E.East.

Made various pieces of equipment for graduate lab.

102 Programming

102.1 R. Divany

Preparations for a mid-October trip to NCAR included assembling and combining programs for the Ching and Chiu and

Jacchia 1971 models. These models were integrated with the initial condition program for the Vest 3-dimensional thermospheric model. A program for transforming output from the Vest model for the NCAR computers was completed immediately prior to leaving for Boulder. An effort was made to rewrite both the initial conditions program and the Vest model program to be compatible with the CDC 6600-7600 system. Upon my return the newly developed initial conditions program was converted back to IBM Fortran and tested.

An application for non-linear least squares curve fitting resulted in adding graphic output (H-P 7202A Plotter) to an existing curve fitting program.

The smoothing subroutine of the Visicon ionogram processing program was rewritten to eliminate a couple of bugs. A test ionogram was received and processed for comparison with other reduction techniques.

The ionogram true height reduction program was greatly modified as was shown necessary following the processing of about 100 ionograms. A complete rewrite of the program controlling the fitting of the underlying ionization correction portion was necessary. Ionograms with more than one critical frequency began to give poor results due to the lowest layer having the Ferriola correction and the next layer attempting to be processed with a "tail" from the Paul program. It was finally decided to go completely with the Ferriola correction and necessary modifications are in progress.

A start of a comprehensive IRL library of computer programs was begun. There is presently only one section. It contains various ionospheric models and ray tracing programs. Anyone with programs to be added or desiring to use the library should consult me or Mrs. Beiswenger.

A program for sorting RJE files according to creation, expiration, last save, last reference, save number, number of cards, and alphabetically is available from me.

102.2 B. Romaniec

1. Brought up to date the wall graph of March-June-September-December 1958. Ionosonde data processed; from: canned data received, data traced and tracings xeroxed to: canned data returned to World Data Center A in Boulder. (They have corroborated receipt of all data lent us on the Ionogram Reduction Program.)

2. June 1958 data:

A) All station test frequency frames checked if logarithmic, linear or quasi-linear.

B) Trace Listing produced for all frames by station; of Es, E, foE, 1st trough, 2nd hop F layer, foF1 and four conditions of the critical frequencies:

1) foF2, fxF2 indefinite

2) foF2 definite

3) fxF2 definite

4) both foF2, fxF2 definite

C) Catalog started to record completed h'F data by station, date, time of frame.

3. Instructed new personnel in:

   A) location and method of data filing systems for Ionogram Reduction Program.

   B) running and modification of existing computer programs to produce h'F data tapes.

   C) location of S10.7, calcium plage, K-Indices and Ap in publications and system for continual data storage in present card files.

   D) some aspects of Hewlett-Packard programming and plotting.

102.3 B. Beiswenger

Initial time was spent becoming familiar with the computation center and the machines in the IRL computing room, and learning to carry out all aspects of the Ionogram Reduction Process, from digitalizing data on the visicon recorder to running the data through the various programs, making checks and corrections, and putting the finished h'(f) profiles on tape. Twenty-seven of the thirty-eight stations are now complete on finished tape. An updated chart of the project's progress is available along with a map of the cooperating I.G.Y. stations' locations.

Graphs, computer cards, and a master tape of various Solar-Geophysical indices, including S10.7, CAII, Kp and Ap indices, were brought up to date, and a listing is now kept in the room for easy access.

Various graphs were plotted for Dr. Nisbet, and some test plots for R. L. Divany's true height reduction program were completed.

103 Drafting

103.1 A. Ott

No report available for this period.

104 Library

104.1 L. Shapira

The following books have been received into the library:

"Methods of Measurements and Results of Lower Ionosphere Structure," edited by: K. Rawer, 1974 (COSPAR).

"Space Research XIV," edited by M. J. Rycroft and R. D. Reasonberg, 1974 (COSPAR).

"Space Research XIII," Volume 1 and 2, edited by M. J. Rycroft and S. K. Runcorn.

"Physics and Chemistry of Ice," edited by: E. Whalley, S. J. Jones, and L. W. Gold.

"Structures and Dynamics of the Upper Atmosphere," by F. Verniani.

"Space Physics and Space Astronomy," by Michael D. Papagiannis.

Seven reprints written by staff members have been received into the library.

Four Scientific Reports have been received and distributed, (429, 431, 432, and 433).

C. OTHER ACTIVITIES

201 Publications and Presentations

201.1 Scientific Reports

429 Nicolet, Marcel, "On the Production of Nitric Oxide by Cosmic Rays in the Mesosphere and Stratosphere," September 3, 1974.

431 Baran, Daniel E., "Neutral Winds and Electric Fields From Model Studies Using Reduced Ionograms," October 10, 1974.

432 McGrath, Robert T., "Turbulent Magnetic Fields in a Collision Dominated Plasma," October 14, 1974.

433 Farrokh, Hashem, "Design of a Simple Gerdien Condenser for Ionospheric D-Region Charged Particle Density and Mobility Measurements," January 6, 1975.

201.2 Papers Published

431 Chesworth, E. T. and L. C. Hale, "Ice Particulates in the Mesosphere," Geophysical Research Letters, 1(8), 347-350, December 1974.

432 Mitra, A. P. and J. N. Rowe, "Ionospheric Constraints of Mesospheric Nitric Oxide," JATP, 36, 1797-1808, 1974.

433 Simonaitis, R. and J. Heicklen, "Reactions of CH_3, CH_3O, and CH_3O_2 Radicals with O_3," Journal of Physical Chemistry, 79, 298-302, 1975.

434 Lee, M. K. and J. S. Nisbet, "Propagation Predictions and Studies Using a Ray Tracing Program Combined with a Theoretical Ionospheric Model," IEEE Transactions on Antennas and Propagations, 123-136, 1975.

435 Meagher, J. F. and J. Heicklen, "The Photolysis of Hydrogen Peroxide in the Presence of Carbon Monoxide," Journal of Photochemistry, 3, 455-466, 1974/75.

436 Simonaitis, R. and J. Heicklen, "Reactions of CH_3O_2 with NO and NO_2," Journal of Physical Chemistry, 78(24), 2417-2421, 1974.

437 Kirchhoff, V. W. J. H. and L. A. Carpenter, "Dominance of the Diurnal Model of Horizontal Drift Velocities at F-Region Heights," JATP, 37, 419-428, 1975.

201.3 Papers Presented

Chesworth, E. T. and L. C. Hale, "Ice Particulates in the Mesosphere," AMS Meeting, Atlanta, Georgia, September 30, 1974.

Hale, L. C. and E. T. Chesworth, "A Model of Ionization in the Mesosphere," 1974 USNC/URSI - IEEE Meeting, Boulder, Colorado, October 14-17, 1974.

Nisbet, J. S., "Models of the Ionosphere," Fall AGU Meeting, San Francisco, December 1974.

Hummel, J. R. and J. J. Olivero, "Radiative Transfer Model of the Mesopause Scattering Layer," Fall AGU Meeting, San Francisco, December 1974.

Monro, P. E., T. L. Stick and J. S. Nisbet, "The 'Sluggishness' of the E-Region Reassessed," Fall AGU Meeting, San Francisco, December 1974.

Miller, M. J. and J. S. Nisbet, "Compatibility of EUV Flux Measurements and Solar Cycle Variations in the F-Region," Fall AGU Meeting, San Francisco, December 1974.

202 Seminars

Dr. J. H. E. Clark, Department of Meteorology, PSU, "The Propagation of Planetary Wave Energy in the Winter Stratosphere," November 7, 1974.

Richard L. Longbothum, Ionosphere Research Laboratory, "Atmospheric Studies at the Jet Propulsion Laboratory Using Microwave Radiometry," December 6, 1974.

James Breakall, Ionosphere Research Laboratory, "The Arecibo Summer Fellowship," January 10, 1975.

Dr. A. P. Mitra, National Physical Laboratory, New Delhi, India, "Indian Satellite Instructional Television Program in the Context of its Social and Scientific Background," January 17, 1975.

Dr. A. H. Waynick, Ionosphere Research Laboratory, "Early History of Ionospheric Investigations in the United States," January 24, 1975.

Ronald P. Rohrbaugh, Ionosphere Research Laboratory, "Review of Recent Results on the Atmosphere and Ionosphere of Mars and Venus," February 7, 1975.

Dr. R. K. M. Jayanty, Ionosphere Research Laboratory and Department of Chemistry, "Recent Results on the Reaction of Chlorofluoromethanes (Freons) with Ozone," February 28, 1975.

Dr. Douglas O. ReVelle, National Research Council of Canada, Ottawa, "Atmospheric/Geophysical Shock Wave Phenomena - Observational Evidence and Theoretical Challenges," March 13, 1975.

Dr. Silvia Braslavsky, University of Rio Cuarto, "Photochemical and Photophysical Processes Involved in the Red-Far Red Phototransformation of Phytochrome, a Plant Pigment," March 28, 1975.

203 Visitors

Dr. Peter Monro, University of Queensland, Queensland, Australia, September 14, 1974 - December 14, 1974.

Dr. A. P. Mitra, Head, Radio Propagation Unit, National Physical Laboratory, New Delhi 12, India, January 13-24, 1975.

Dr. Marcel Nicolet, Director, Institut d'Aeronomie, Brussels, Belgium, March 28, 1975.

D. PERSONNEL

Name	Title	Percent Funded Time	Problem
The National Aeronautics and Space Administration			
Grant NGL 39-009-003 - NASA IRL MD - 5932			
J. S. Nisbet	Prof. of Elec. Eng. Director, IRL	31.2	2.1
J. Heicklen	Prof. of Chemistry	25.0	- -
G. Fleming	Prof. of Physics	- -	- -
L. A. Carpenter	Asst. Prof. of Elec. Eng.	40.0	2.3
J. J. Olivero	Asst. Prof. of Meteorology	41.6	1.7
R. Simonaitis	Research Associate	- -	6.1
R. Jayanty	Postdoctoral Scholar	- -	6.4
J. Hummel	Graduate Assistant	100.0	1.10
G. Imel	Graduate Assistant	100.0	4.10
S. Leiden	Graduate Assistant	16.6	5.9
M. Miller	Graduate Assistant	100.0	2.13
R. Rohrbaugh	Graduate Assistant	100.0	2.7
T. Stick	Graduate Assistant	100.0	2.12
B. Wydra	Graduate Assistant	100.0	2.11
Grant NGL 39-009-002 - NASA SATELLITE - 5972			
W. J. Ross	Prof. of Elec. Eng.	- -	2.2, 3.13
E. H. Klevans	Assoc. Prof. of Nuc. Eng.	25.0	3.4
Grant NGR 39-009-032 - NASA CMMS IX - 5918			
B. R. F. Kendall	Prof. of Physics	22.9	4.1, 4.7
T. M. York	Assoc. Prof. of Aero. Eng.	- -	4.9, 5.0

Name	Title	Percent Funded Time	Problem
Grant NGR 39-009-032 - NASA CMMS IX - 5918 (Continued)			
S. Butler	Graduate Assistant	100.0	4.8
W. Cuirle	Graduate Assistant	100.0	4.5
R. Reiter	Graduate Assistant	100.0	4.2
Grant NAS6-2602 - NASA DART - 5922			
L. C. Hale	Prof. of Elec. Eng.	8.3	1.2
E. T. Chesworth	Postdoctoral Scholar	- -	1.8
C. Croskey	Graduate Assistant	- -	5.2
S. Leiden	Graduate Assistant	- -	5.9
Grant NGR 39-009-218 - NASA MESO III - 5941			
L. C. Hale	Prof. of Elec. Eng.	8.3	1.2
T. M. York	Assoc. Prof. of Aero. Eng.	- -	4.9, 5.5
E. T. Chesworth	Postdoctoral Scholar	52.5	1.8
C. Croskey	Graduate Assistant	- -	5.2
S. Leiden	Graduate Assistant	- -	5.9
The National Science Foundation			
Grant GA 33446 X2 - NSF FOUNDATION - 6306			
J. S. Nisbet	Prof. of Elec. Eng. Director, IRL	- -	2.1
A. P. Mitra	Consultant	12 days	1.5
P. Monro	Consutlant	90 days	2.14
M. Nicolet	Consultant	3 days	1.4
O. E. H. Rydbeck	Consultant	- -	- -

Name	Title	Percent Funded Time	Problem
Grant GA 33446 X 1 - NSF FOUNDATION - 6306 (Continued)			
P. Stubbe	Consultant	- -	2.4
R. Longbothum	Graduate Assistant	100.0	1.9
P. J. Moser	Graduate Assistant	100.0	3.18
T. Osif	Graduate Assistant	100.0	6.3
R. Rohrbaugh	Graduate Assistant	100.0	2.7
Grant GR-41854 - NSF D-REGION MEASUREMENTS - 6243			
A. J. Ferraro	Prof. of Elec. Eng.	22.5	1.1
H. S. Lee	Prof. of Elec. Eng.	22.5	3.1
J. R. Mentzer	Prof. of Eng. Sci.	- -	- -
R. Spooner	Graduate Assistant	100.0	3.21
M. Sulzer	Graduate Assistant	100.0	1.11
K. Swanson	Graduate Assistant	100.0	1.14
A. Tomko	Graduate Assistant	100.0	1.13
The Office of Naval Research			
Grant N00014-67-A-0385-0014 - DN INTERACTION - 7073			
A. J. Ferraro	Prof. of Elec. Eng.	11.2	1.1
H. S. Lee	Prof. of Elec. Eng.	11.2	3.1
R. Spooner	Graduate Assistant	100.0	3.21
M. Sulzer	Graduate Assistant	- -	1.11
K. Swanson	Graduate Assistant	- -	1,14
A. Tomko	Graduate Assistant	- -	1.13

Name	Title	Percent Funded Time	Problem
Department of the Army			
Grant DAHCO4-75-G-0031 - DA AERO - 4400			
L. C. Hale	Prof. of Elec. Eng.	16.6	1.2
E. T. Chesworth	Postdoctoral Scholar	25.0	1.8
C. Croskey	Graduate Assistant	- -	5.2
S. Leiden	Graduate Assistant	83.3	5.9