

ANNUAL REPORT
of the
E. O. Hulburt Center for Space Research
Naval Research Laboratory
Washington, D. C.

CASE FILE
COPY

to

The National Aeronautics and
Space Administration

for

Fiscal Year 1969

Herbert Friedman
Chief Scientist

1 July 1971

Encl (1) to NRL Ltr
7150-6:HF:jmw
SER: 9090

CONTENTS

.....

II.	The Hulburt Center Appointees.....	v
III.	Introduction.....	vii
IV.	New Discoveries and Highlights of the Space Science Division.....	xi
V.	Upper Air Physics Branch.....	1
VI.	Radio Astronomy Branch.....	13
VII.	Rocket Spectroscopy Branch.....	21
VIII.	Publications and Talks.....	A1
IX.	E. O. Hulburt Center for Space Research and Lab. for Cosmic Ray Physics Joint Colloquia...	B1

THE HULBURT CENTER APPOINTEES

APPOINTEE	PROJECT	STATUS
Dr. Paul D. Feldman	Infrared airglow spectroscopy, infrared astronomy [ROCKET]	<u>Black Brant NF 9.250</u> scheduled March 1972. Most recent paper Nov. 8, Nature, on IR Background (D. P. McNutt)
Dr. Richard C. Henry	Celestial x-ray background and sources. UV spectra of stars. Solar Ly- α absorption in atmosphere. [AEROBEE]	Papers on x-ray background and spectra. Analysis of data from NB 3.237: x-ray, UV and visible light photometry. Analysis of UV data from <u>Blue Scout</u> rocket.
Dr. Stephen W. Kahler	Solar x-rays, theory of non-thermal solar x-ray phenomena	Papers on low energy impulsive x-ray bursts; investigation of physics of flare onsets. (J. F. Meekins)
Dr. James D. Kurfess	Solar and celestial gamma-ray spectroscopy from balloons. Hard x-ray mapping experiment on HEAO [BALLOONS]	Three <u>balloon</u> flights launched in year. Crab Pulsar observation published Ap. J., hard x-ray emission from sub-flare to be published. Atmospheric gamma-ray background to be published. Enters full-time employment December 1971.
Dr. Barry K. Moritz	Theory and behavior of solar corona; development of real-time interactive digital processing systems for OSO-7 and ATM data analysis.	Scientific consultant, OSO-7 and ATM data reduction teams.
Dr. Dianne K. Prinz	Lyman- α disk rocket experiment. Atmospheric ultraviolet airglow from satellite	Redesigned and built Lyman- α disk rocket experiment. Developed computer ray-tracing programs. Analyzed OGO-4 ultraviolet (Accepted permanent employment June 1971).
Dr. Seth Shulman	X-ray astronomy [ROCKET]	Papers on x-ray source variability and diffuse x-ray background. Experiment on <u>Super-Chief</u> to be launched October 1972.
Dr. Chet B. Opal	UV rocket astronomy electronic imaging devices. [ROCKET]	Preparing rocket payloads for launch in early 1972 and in early 1973. Evaluating performance of new instruments.

INTRODUCTION

This year marks a quarter century since astronomical observations were first carried out in space through use of V-2 rockets brought to the United States in 1946. The V-2's were later superseded by the Aerobee, Viking, Rockoons and various two-stage combinations of small rockets and the Nike booster.

Although the solar spectrum was soon mapped from the ozone cutoff near $3000\text{\AA}$ to the shortest x-ray wavelengths, full identification of x-ray and ultraviolet sources and the spectral influence of solar activity has required continuing effort.

Success in the solar program led naturally to efforts to probe the spectra of galactic and extragalactic objects. In the ultraviolet range from 1000 to $3000\text{\AA}$ these culminated in identification of the Lyman bands of molecular hydrogen and the discovery of large stellar winds. But the greatest surprise was discovery of the enormous x-ray power radiated by a multitude of celestial objects. Thus, today's picture includes stellar objects which radiate a thousand times as much x-ray power as optical, supernova remnants which include the Crab pulsar, variable x-ray galaxies, and a background from soft x-rays to gamma rays which contains

the story of the hierarchical structure of the universe.

Within the current research program other studies are also yielding new insights. Among them are investigation of the infrared background and of the ultraviolet emissions of the celestial sphere. In radio astronomy the search for water vapor sources has been extended, very long baseline techniques have been further developed and the application of active and passive techniques in the study of sea state continues.

During this report year the Solrad X solar radiation monitoring satellite was launched, and the NASA orbiting solar observatory, OSO-7, was placed in orbit with major NRL instrumentation on board.

An ultraviolet lunar surface camera is scheduled for launch on the Apollo 16 spacecraft in March 1972.

Construction and delivery of the instruments for SKYLAB have progressed very well. Henceforth, full effort will be devoted to instrument test and integration, and astronaut training in preparation for launch in April 1973.

The High Energy Astrophysical Observatory experiment will enter its major construction phase next spring with considerable expansion in effort, and an OSO-EYE ultraviolet experiment to survey the Earth's

near environment is scheduled for launch in 1973.

The Division's contributions to technical publications, from August 1970 through October 1971, total 116. Of these 13 have appeared in books. To this list must be added three NRL Reports and 3 Ph.D. theses. Seventy-five talks have been given.

NEW DISCOVERIES AND HIGHLIGHTS
OF THE SPACE SCIENCE PROGRAM

1. Observations of the Crab pulsar (with 33 millisecond period) reveal distinctive differences in time behavior between soft and hard x-rays. Those at 1-3 MeV are the most energetic pulsar emissions yet observed with certainty. (BALLOON)
2. γ -ray observations carried out from balloons show the presence of two high energy lines of atmospheric origin at 4.5 and 6.2 MeV.
3. X-ray emission from a slow (3.8 second) pulsar in the Crab has been observed. (BALLOON)
4. The morphology of the night helium ion glow at 304 m μ has been duplicated by theoretical calculation of the expected scattering of solar radiation from a model of the known helium ion distribution in the ionosphere.
5. Infrared rocket observations of the celestial glow within a few hours after sunset reveal a background much higher than the midnight intensity which may be as low as the postulated primordial background.
(BLACK BRANT ROCKET)
6. X-ray observations of hot and cool solar flares reveal lines which have been identified with various states of highly ionized iron.

7. Very long baseline interferometry of H_2O radio sources was extended to longest baseline in wavelengths yet accomplished (USSR-USA, 7400 km, 547 million wavelengths) and interference fringes were detected.
8. High resolution (1.5) radio circular polarization measurements of $H\alpha$ plages, flare regions and dark filaments show bi-polar magnetic fields in most cases and complex magnetic field in flare regions.
9. H_2O radio sources are shown by very long baseline interferometry to be aggregates of very small diameter sources ($d < 5$ A.U.), each associated with a doppler shifted line. No ordering in radial velocity and position is apparent.
10. Very long baseline interferometer experiments have been made at the low frequency of 120 MHz showing position coincidence of Crab Pulsar with compact low frequency source in Crab Nebula.
11. Seven new H_2O radio sources have been discovered in the southern hemisphere.
12. It has been shown that ocean oil slicks are detectable by passive microwave radiometry.
13. From rocket observation of the 1970 eclipse it has been shown that emissions from higher ionized states of silicon, aluminum and carbon extend to

10,000 km altitude, higher than explicable from conventional solar models.

14. Extreme ultraviolet solar limb spectra reveal many new lines of un-ionized silicon. The center-limb variation of continuum temperature across the sun has been re-verified. (AEROBEE)
15. Solar spectra in the range 170-600 Å reveal the presence of iron in the states corresponding to iron ionized from nine to thirteen times. (AEROBEE)
16. Highly ionized states of nickel, argon and calcium have been discovered in solar flare spectra. The observation of calcium seventeen times ionized implies a flare temperature of 8 million degrees as long as ten minutes after explosive phase of the flare.
17. Fluorescent behavior of the carbon monoxide molecule excited by the 1306 Å OI line has been analyzed in the laboratory from its ultraviolet spectrum.

UPPER AIR PHYSICS BRANCH

I. New Results

γ and X-Ray Astronomy

A balloon-borne gamma-ray detector, launched by NRL from Palestine, Texas, on October 9 and 20, 1970, detected gamma radiation from the Crab Nebula pulsar NP 0532 in the energy region from 0.1-10 million electron volts (MeV). The detector was a thallium-activated sodium iodide crystal, 33 cm in diameter and 15.2 cm thick. A search for radiation from the Crab pulsar was made by comparing the excess counting rate in phase with the pulsar period, which was known to be 33.115 milliseconds (ms) during the period of observation.

Analysis of the data obtained from the balloon clearly showed emission in synchronism with the Crab pulsar CP 0532 in several spectral bands. The light curve obtained in the 100-400 keV band showed the greatest detail yet revealed in any X-ray measurement, and revealed a distinctly different time character than that observed at soft X-ray wavelengths or in the visible or radio portions of the spectrum. Strong pulsar emission was also observed in the 0.4-1.0 MeV range; emission was detectable from the 1-3 MeV band. These data are the highest energies of pulsar radiation yet detected with certainty.

Atmospheric γ -Ray Lines (unpublished)

Analysis of the spectroscopic data obtained in three flights of the 13" x 6" Kurfess scintillator reveals the presence of two high energy γ -ray lines. The preliminary energies are 4.5 MeV and 6.2 MeV. The 4.5 MeV line might be the lowest transition of C^{12} resulting from cosmic ray reactions (p,n 2p) with N. The 6.2 MeV line might be the lowest transition of O^{16} , resulting from cosmic ray reaction (p,p γ) with O.

Effect of Lead on Background Measured by Large Scintillator (unpublished)

A knowledge of the factors contributing to background count is vital to the development of γ -ray astronomy. A study of the effect of passive high Z shielding on the count spectrum observed by the Kurfess scintillator was carried out by flying the sensor unshielded twice, and shielded once on all sides but the top with one-inch of lead. The lead caused a decrease in counts in the range above 2 MeV with the decrease at 6 MeV being a factor of 1.25. The lead caused an increase in counts in the 0.6-2 MeV range with the increase being a factor of 1.5 at 1.0 MeV. Both effects are believed to be the result of Compton scattering, which shifts photons to lower energy. Prompt particle-induced

X-rays and γ -rays were excluded from the count by a plastic anticoincidence shield.

Possible Discovery of an X-Ray Pulsar Associated with CP 0527 (unpublished)

Proportional counter data recorded in the 25-60 keV range during a balloon flight on October 17, 1970, were analyzed to extract the power spectrum for periods when the sensing system was directed at the Crab Nebula and at other portions of the sky. For the Crab an X-ray periodicity of $3.821 \pm .015$ seconds was observed, in addition to the 33 ms periodicity associated with pulsar CP 0532, as reported in 1970. The 3.821 second X-ray period is 2% slower than that of the radio pulsar CP 0527, which occurs in the same view-field. The possibility that both periods are manifestations of rotation of the same neutron star, with the period difference caused by the inertial frame drag of general relativity or some other effect has been considered speculatively, but inconclusively. The experimental result is considered marginal, but interesting.

Possible Observation of a Spectral Line Emission in the Cosmic Diffuse Background

Analysis of the pulse amplitude data obtained in rockets on 13 March 1969 and 28 February 1970,

showed the presence of a local excess in pulses at amplitudes corresponding to 6 to 7 keV of energy loss in the proportional counter. Attempts to explain these results in terms of instrumental effects failed, and the evidence was published for the presence of a line emission in the background spectrum. Such a result is very difficult to explain theoretically, since electrons interacting with iron atoms would produce line and background with a line/background ratio very much less than that observed. Initially, other X-ray observers disputed the results, but supportive data by others has been more recently obtained. The results nevertheless remain statistically marginal, and flights in the near future are planned to prove or disprove the observation.

Optical Geophysics and Solar Wind Studies:

Modeling of the Magnetoglow and Background

304 Å Emissions

A theoretical study was carried out of the resonant helium emission produced by scattering of sunlight by He^+ ions distributed in the magnetosphere as indicated by satellite data. A morphological match to observations obtained on rocket NC 3.136 flown 13 October 1969 was obtained. The fit to the observations requires that part of the glow observed from

the rocket originates outside the magnetosphere, possibly due to He^+ ions in the solar or interstellar wind.

A study of the location of the main equatorward arc of the aurora was carried out to determine whether the angle between the earth's magnetic dipole axis and the earth-sun line was important as regards the location of the oval. The analysis showed that this angle is not a major controlling parameter.

Infrared Astronomy

A rocket with far infrared photometers was flown from Wallops Island, and showed the presence of anomalous strong intensities of far IR glow. A comparison of NRL and Cornell University flights suggests that the local time of the flights affects the glow intensity observed. Flights flown shortly after sunset have shown high glow intensities; flights near midnight have shown lower intensities. The phenomenon is not understood, and confirming data are needed.

Solar X-Ray Spectroscopy

Analysis of flare spectra from OSO-6 has continued. The different behavior of lines in hot and cool flares has permitted sorting out of lines due to different stages of ionization in iron. As a result lines observed at 7.990, 8.233, 8.290, 8.317,

and 8.378 Å have been identified as transitions of Fe XXIV and a line at 8.307 has been identified as a transition of Fe XXXIII, in near agreement with calculations by R. D. Cowan. A comprehensive list of lines shortward of 8.49 Å was published.

SOLRAD

The SOLRAD X satellite was placed in operation as a solar XUV monitor and as a test of concepts for SOLRAD HI and HEAO A. Operation has been quite satisfactory with the result that solar monitoring with extended spectral coverage is now available.

Another year of solar monitoring by SOLRAD IX, in which all major solar events have been recorded, has been completed.

Electronic Imaging Program

Good progress has been made on a Mil Spec TV camera chain under NavShips' sponsorship. A range-gated TV system has been nearly completed but not fully tested. It awaits completion of the companion pulsed Nd laser by NEL before full testing can be implemented.

II. New Programs

The past year has seen a substantial shift in emphasis in the programs of the Upper Air Physics Branch from small projects and data reduction to the

preparation of equipment for large undertakings.

These are: (1) The Lunar Surface UV Camera/Spectrograph, scheduled for flight on Apollo 16 in March 1972; (2) The SOLRAD HI two-satellite observatory, scheduled for launch to an orbit of 20 earth radii about December 1974; and (3) The LAXRAY Experiment (AXR-3), scheduled for launch aboard HEAO A about June 1975. Lesser, but still large, projects are the NRL XUV experiments, NNRL 114, scheduled for flight aboard SESP 72-1 about May 1972, the NRL XUV Solar Wind experiment, scheduled for flight aboard the NASA OSO-I spacecraft about December 1973, the DNA "Rocket Instrumentation Program," not yet scheduled for initial flight testing, and the Auroral IR Spectroscopy Study, scheduled for launch on a Black Brant 3 rocket about March 1972. An attempt to secure support for an Optical Geophysics and/or Astronomy Satellite, based on far UV imaging technology, has also been carried out during the year. A report on each of the firm programs follows.

Lunar Surface UV Camera/Spectrograph

The Lunar Surface UV Camera/Spectrograph is a Schmidt camera of 3-inch aperture, f/1.0, which uses electronographic, rather than photographic, recording. Two modes of operation are used with the camera on the lunar surface--direct imaging, and spectroscopy.

In the direct imaging mode, the camera will record in the range 1600 Å to 1050 Å or 1230 Å with two interchangeable corrector plates. In the spectrographic mode of operation, the camera views an objective grating, ahead of which is placed a photoengraved-grid collimator. The extreme spectral range will extend to 500 Å.

Objectives for the experiment include photography and spectral photography of geocoronal, airglow and auroral emissions, photography of patches of increased H in the solar wind, photographs of gaseous nebulae and other sources of UV emission outside the solar system, including likely extragalactic sources, and photographs of possible locally vented gas escaping from the lunar surface. Spectroscopic and photometric data on stellar emission is also expected. Instrument construction is proceeding on schedule.

SOLRAD HI

SOLRAD HI consists of a pair of spin-stabilized satellite observatories maintained at opposite sides of a 20 earth radius, low latitude circular orbit. The satellite sensors will monitor: solar X-ray and XUV radiation levels; ambient high energy particle fluxes; solar wind velocity, density, alpha-proton ratio, temperature and UV emissions; auroral X-ray fluxes; and earth albedo. A solar wind magnetic

field sensor and a solar X-ray polarimeter experiment are under consideration. Arrangements are to be made with AFCRL and Aerospace to provide the high energy particle sensing system, and with MIT to provide the main solar wind sensors. The primary objective of the satellite is to provide realtime space environmental data suitable for calculation of radio transmission attenuations and for prediction of communication disturbance conditions: radio fadeouts (SID), polar blackouts, and auroral absorption.

Work by all of the experimenters has been initiated; firm set of experiment designs is hoped for by Fall 1972.

LAXRAY Experiment for HEAO A (AXR-3)

The LAXRAY experiment for the NASA High Energy Astronomical Observatory (HEAO A) is a 1575 lb X-ray astronomy experiment designed to map the X-ray sky. It consists of a set of nine collimated X-ray proportional counters and one diffuse background module, supported by an auxiliary gas module and a central electronics module. The X-ray sensors are large area plastic window counters for the soft X-ray range, backed by scintillation counters to provide hard X-ray sensitivity. The counters view the sky mainly through $1^\circ \times 4^\circ$ collimators, and scan the sky by means of a uniform 30-minute roll provided by the HEAO spacecraft.

The objective of the program is to provide a catalog of X-ray sources comparable to the 3C catalog of radio sources, giving locations, intensities, and spectral emission character of the observed X-ray objects. It is planned to have the experiment built by a contractor.

A small plastic window test counter has been flown on the SOLRAD X satellite and has operated properly.

SESP Experiment

The NRL SESP Experiment will provide data on the broadband spectral intensity of the XUV airglow and the intensity of earth X-rays originating in the aurora. The XUV sensors are sensitive from about 170 Å to about 1500 Å in several bands. The auroral X-ray sensor consists of a single proportional counter and a 4-channel pulse height analyser. The main motivation for flying the proportional counter is to obtain intensity and spectral information on auroral X-rays to judge their usefulness as auroral intensity indices, and to provide a basis for design of the SOLRAD HI auroral X-ray sensing system.

The experiments have been delivered to the spacecraft contractor for initial integration.

Rocket Instrumentation Program

The Rocket Instrumentation Program is a rocket experiment program undertaken in support of DNA needs. The program uses Code 7127 personnel, supported by Code 6612 personnel of the Nuclear Science Division. It is in a funded formative stage.

Auroral IR Spectroscopy Rocket

The Auroral IR Spectroscopy Experiment is an airglow emission study in the 5-60 micron range based on use of a liquid He-cooled Ebert-Fastie spectrometer. The spectrometer is being built by the Ray-Lee Corporation. The experiment is planned for flight in a Black Brant 5 rocket from Ft. Churchill in March 1972. Cryogenic problems and loss of ESD personnel assigned to the research team have threatened the flight schedule. The problem is partially supported by ARPA.

RADIO ASTRONOMY - CODE 7130

PROGRAM - SUMMARY AND ACCOMPLISHMENTS FOR PAST YEAR

Very Long Baseline Interferometry

Two VLBI measurements of the 22 GHz H₂O sources were made: (1) between NRL, Green Bank, and Haystack with hydrogen masers, and (2) between Semeiz, U.S.S.R. and Haystack. A map of the W49 source region was made showing that the sources with sizes less than 0".0005 associated with individual lines are in different positions all within 1".5, but with no apparent relation between positions and radial velocities of the corresponding lines. For some lines the size limit is 0".0003 which corresponds to less than 5 A.U., i.e., less than the radius of Jupiter's orbit. Where the positions were separated by only a few fringes, high relative position accuracies of 10^{-4} arc seconds were obtained with hydrogen masers. The absolute position of the strongest component was measured to an accuracy of $1".5 \times 10^{-4}$ where most of the error is systematic. This position for the water molecules agrees with that of the OH to within errors. Preliminary results indicate a precision of 10 to 15 meters in determining the position of the 85-foot antenna with respect to Haystack. For the Orion source, which is the closest to earth, some of the

components are partially resolved on the longer baselines; a source which was unresolved in June 1970 was partially resolved in February 1971 indicating a change in size from 0.4 to 1.5 A.U. A preliminary result for the USSR-USA baseline shows interference fringes on W49 at this baseline of 7400 km. The new Mark II VLBI system was used for the recent experiments.

A low frequency (120 MHz) VLBI experiment was done with Univ. of Maryland and NASA-Goddard between NRL and Green Bank to investigate the feasibility of VLBI at low frequencies and effects of the ionosphere. The phase stability of the interference fringes was excellent. The association of the compact source in the Crab Nebula with the Crab pulsar was confirmed through position coincidence, and flux densities measured for small diameter components of 10 other sources showing an increasing spectrum with frequency. Preliminary results of an experiment between NRL-Sugar Grove, Danville, Ill., and Owens Valley, Cal., indicate fringe detection over a 4000 km distance.

The potential for application of VLBI technology to navigation is being investigated, and a study of a moderate accuracy approach using a simple system measuring only fringe frequency on intense H_2O sources

was evaluated theoretically. With a 6 foot antenna on the ship, navigation accuracies of 500 to 1000 meters are feasible at latitudes greater than $\pm 30^\circ$. The main accuracy limitation is the knowledge of ship velocity. The accuracy can be increased by using hydrogen masers and time delay measurements with broader bandwidths.

22 GHz Water Molecule Radiation

Two searches for new H_2O sources using NRL radiometers in Australia discovered 7 new sources: the first by NRL personnel using a 29-foot NASA antenna; the second with scientists of the Australian CSIRO using the central 104 feet of the 210-foot Parkes radiotelescope. This increased the number of known celestial H_2O sources to 28.

One of the H_2O sources discovered at NRL in 1969 is associated with the variable star VY CMa, and for 2 years the H_2O emission remained stable. Between March and July 1971, the intensity decreased by a factor of 6. The possible association with characteristics of the star will be investigated. An extremely intense line in the spectrum of W49 has remained nearly constant for more than a year. Other extremely intense lines have varied rapidly.

Study of H_2O source time variations over 2 years

shows that some lines varied dramatically while others remained stable. The peak source intensity (any line) does not vary greatly in most cases. Only small variations in line frequency have been observed and are probably due to line blends. Since the H_2O and OH emission arise in the same general regions, and both are time variable and masers, an attempt has been made to associate their spectra and time variations without success.

Searches for New Molecular Line Sources

Line searches can be made more efficiently with the new radiometer system and more effort will be put into this area. Searches have been made at transition frequencies for C_3H_4 , C_3H_6 , HNO_3 , OCS , CH_3CN , HC_3N , NH_2CN , CH_3CHO , HNCO , and NH_2HCO with varying degrees of effort so far without success.

Solar Activity

A radiometer-polarimeter at 9.5 mm was developed for studies of small diameter radio emission regions associated with regions of solar activity using the 1.6 resolution of the 85-foot. Good correlation is found with plage regions and between sense of circular polarization and the sense of magnetic field measured optically. Radio absorption is observed in H α dark

filaments. The radio emission regions may give clues to the development of active regions, magnetic fields, and flare activity. Polarization structure of a minor flare region indicates a complex magnetic field.

Radio Source Characteristics

The variability of the radiation of quasars can be adequately fitted to the simple expanding cloud model in some cases but not others.

Polarization measurements of 10 sources at 9.5 mm gave intrinsic polarization and Faraday rotation.

Electronics

Initial problems in mounting and contacting Gallium Arsenide Schottky Barrier Diode chips produced in the cooperative program with the Electronics Division have been largely overcome. Initial tests show good characteristics at 30 GHz.

A new phase stable oscillator system for VLBI receivers has been designed and is under development.

The computer-controlled radiometer system was instrumented to perform the synchronous detection and integration of the signals to present a continuous oscilloscope display of the integration in the 50 channels, to calibrate and reduce the data on line, and to present the results on graphs, printouts, and punched tape.

The 18-26 GHz and 26-40 GHz spectral line radiometers were improved in performance.

Passive Remote Sensing of the Ocean

A dependence of the microwave brightness temperature of the sea on wind speed and sea state has been established arising from (1) the roughness of the water surface, and (2) the coverage of sea foam and white caps. The correlation of brightness with sea roughness increases with increasing observational frequency interpreted as a relative unimportance of roughness smaller than the radio wavelength. Enhancements of microwave brightness temperature $> 100^{\circ}\text{K}$ due to foam have been measured and found insensitive to polarization and angle of incidence. At high wind speeds effects of sea foam will dominate with the expected transition in the range of 30 to 40 knots.

A promising method for determining the thickness of oil slicks on water using passive microwave radiometry from airborne platforms was developed and tested. As the oil thickness increases through successive multiples of a quarter wavelength in oil, the brightness temperature passes through maxima and minima. By using two or more frequencies, ambiguities may be removed and the oil thickness determined.

Radar Remote Sensing of the Ocean

A theoretical investigation of satellite altimeter observations shows that the varying bias of the electromagnetic centroid relative to the geometric centroid due to different sea states must be determined. Measurements indicate the bias is about 5 percent of the significant wave height, and that sea state derived from radar measurements has a negative bias of only 6 percent of the significant wave height showing that sea state can be measured with short pulse radar.

ROCKET SPECTROSCOPY BRANCH

The following sections describe the accomplishment in each of the main areas of research emphasis in the Rocket Spectroscopy Branch.

OSO-7

On September 29, 1971 the seventh of NASA's series of Orbiting Solar Observatories was placed in orbit with the result that OSO-H became OSO-7. The pointed section carried two experiments prepared by NRL: A white light coronagraph covering the corona from 3 to 10 solar radii; an extreme ultraviolet coronagraph that recorded the range 171-630 Å over and beyond the disk and with coverage decreasing to about 50% at about 5 solar radii. The objective of the pair of experiments is to relate changes occurring in the chromosphere and corona, as seen in the XUV, with changes in the solar wind as seen by the white light corona.

Both experiments are operating very well. They show striking day to day changes in both the white light and XUV coronas. The general changes are related to the magnetic field distribution over the sun and to the sectors in the magnetic field in space as observed by earth-orbiting satellites. The white light corona shows that the solar wind and the solar streamers are clearly related to the active regions seen in the XUV.

The white light coronagraph for the first time makes use of an SEC Vidicon operated in a digital mode to read and transmit images from a spacecraft to ground. The

image contains 256 x 256 picture elements. The corona is an object of very low light level. To detect the very low contrast features full use was made of the target storage capacity to obtain a high signal-to-noise ratio of 50 in each picture element. (The theoretical limit is 70 r.m.s.) In operation the SEC Vidicon is exposed for approximately 3 seconds to the sun's faint corona; on-board transfer of the target image to tape requires 44 minutes. The telemetered data are received at NRL by telephone line and reconstructed on a cathode ray tube. For the first time a polarizing plate has been used in the white light coronagraph in order to separate the F and K coronas. The white light instrument is operated in 3 to 5 successive orbits each day; in the normal mode one picture per orbit is obtained.

The XUV coronagraph is also operating very well, except for a reduction in sensitivity with time that is somewhat greater than expected. This is suspected to be caused by abnormal oxidation of thin film aluminum filters, used to exclude wavelengths from the visible to about 650Å. It appears that oxidation is occurring at an accelerated rate, owing to the presence of atomic oxygen in the atmosphere at spacecraft orbital altitudes. Nevertheless, excellent XUV images are being obtained. These show emission of XUV far beyond the sun's limb, extending to one solar radius with certainty, and probably to several radii. Research is planned to determine whether this is simply emission

from ions that are excited by collision or whether it is resonance scattering from photons emitted from the close-in corona.

The OSO-7 operation is extremely demanding of personnel and time. One or more members of the branch is required at the OSO Control Center at GSFC during certain periods each day to ensure that commands are sent and executed without error. It is possible for a command error to destroy the white light coronagraph.

The amount of data recorded from the two experiments is very great. Their volume causes a storage problem, and a manpower problem in processing and interpreting them in terms of the physical processes on the sun. The life of the spacecraft and experiments should be at least a year. At present the computerized data reproduction equipment is not completely operational, but is receiving maximum effort to prepare for the final data tapes when they do arrive.

SKYLAB:

The experiments being prepared by this branch for Skylab were described in the report for 1970. For ATM (the Apollo Telescope Mount) they are: the XUV spectroheliograph, S082A, the XUV high-resolving spectrograph, S-082B, and the television XUV system that forms part of S-082B. The two other experiments are S-020, a small grazing incidence XUV spectrograph, legally a "Corollary" experiment, but in fact included among the ATM solar experiments, and S-063, a Corollary experiment to photograph the twilight airglow and also the ultraviolet day airglow in an attempt to track ozone.

Construction and delivery of the instruments have progressed very well. We anticipate increasing demands upon our time during integration of the experiments in the Skylab, to train the astronauts, and incidentally ourselves in operating the mission after launch on April 30, 1973. From January 1973, four months prior to launch, until January 1974, conclusion of the third visitation, it will be necessary for a large group of scientists and engineers to take up continuous or at least intermittent residence at Houston, Texas, in order to control operation of the instruments. Inevitably these operations result in some reduction in the scientific productivity of the branch.

There are several continuing problems associated with Skylab. The ATM units, both prototype and flight, have been delivered, with the exception of the photographic

camera mechanisms. The latter are so intricate that more testing and debugging is required. A second problem on which progress has been made is the minimization of contamination, which can seriously affect the XUV instruments. NRL has designed and produced a Real Time Contamination Monitor consisting of a reflectometer that is placed in the test thermal vacuum chamber; it continuously measures the reflectance of a standard mirror for Lyman alpha radiation, $1216\text{\AA}$. Still another problem is the expected deterioration of the photographs during orbit through the proton flux over the South Atlantic anomaly, and as a result of high storage temperatures. All possible steps to minimize these effects have been taken. Nevertheless, it becomes absolutely necessary to calibrate the ATM instruments while in orbit. This is to be done by flying a series of calibration rockets which will use well-calibrated equipment to record exactly those solar features that are being recorded at the same time with the instrument in ATM. This rocket program is extremely complicated and expensive, but essential. It is not yet supported by NASA to the extent necessary to ensure complete success.

Another area of Skylab, and one where NRL has made perhaps the major input, is in programming the astronauts observing program. There are five institutions involved in ATM, and each has one or more instruments which serve several different purposes. To operate them all in such a way as to obtain the maximum and best results is a difficult problem, especially in view of other competition

for astronaut time. It was finally decided to set up a series of observing programs each designed to acquire data bearing on a particular problem in solar physics. NRL has taken the major responsibility in coordinating the interests of the Principal Investigators. As a result, it appears that the ATM will be operated as a single large solar observatory with a series of separate but related purposes. Moreover, it appears probable that observatories all over the world will collaborate to observe special features of the sun simultaneously with observations from ATM. It is probable that each institution will receive a number of guests who will use the ATM data together with data they have obtained from ground during the mission.

NRL is in process of preparing for this data reduction effort. The most highly sophisticated computer-controlled microphotometer known to us has finally been delivered and is ready for assembly. It is intended to provide quickly on magnetic tape the readout of photographic images in accordance with a programmed scan. Following readout the data will be transformed by programs to calibrate them or weight them as desired.

ROCKETS:

To obtain solar XUV spectra one payload, a prototype ATM "B" instrument, was flown this year (in August 1971): it utilized an Aerobee-170 instead of a 150. As a result of a great improvement made in the ruling on the predisperser diffraction grating the spectra were free from scattered light. However, the NASA SPARCS II control system did not stabilize the instrument as well as the SPARCS I used on a previous flight. Analysis of these spectra has barely started. They will complement spectra obtained the previous year.

The so-called conglomerate payload, funded largely by NASA, is nearing completion for flight. This will contain a white light photographic coronagraph, a high resolution Lyman-alpha spectroheliograph, a repeat of the 1959 and 1960 Lyman-alpha profile photography to measure the hydrogen in the earth's atmosphere, and several other instruments.

Following this, it is not clear when funds will be available in sufficient quantity to prepare another rocket payload.

MAGNETOGRAPH:

Joint construction of the solar real-time vector magnetograph with the Marshall Space Flight Center is once again underway after a lapse caused by loss of funding. A technical difficulty was the de-bugging of the electronics associated with the SEC Vidicon. This work was transferred from EMR Sarasota, to EMR Princeton, and is now progressing satisfactorily. The equipment should be completed for

assembly and integration into the solar tower at Huntsville within six months.

LABORATORY WORK:

The most important work conducted in the extreme ultraviolet radiometry laboratory has been the study of diffraction gratings in order to ensure success of the ATM experiments. Two major problems have been resolved. The first was the excessive focused stray light produced by pre-disperser gratings being ruled by Bausch and Lomb. This was traced down to a variety of sources, and we have received at least one type of predisperser that is satisfactory. The second major problem was that the principal grating for the S-082B experiment was found to have deteriorated after one year to an extent that it was unusable. This was traced to the over-coating with aluminum of the gold replica. An inter-metallic compound was gradually formed. After a year this destroyed the smoothness of the groove surfaces. The effect is related to the disease in electronic components called the "purple plague."

A sophisticated ray-tracing program has been produced for optical systems using more than one diffraction grating. It was found to be extremely useful, and has been applied to analysis of the performance of the S-082B ATM experiment. Consequently, anomalies in the behaviour of the spectrograph are understood and it became possible to arrive at optimum focus much more quickly. Although ray tracing has been in common use for complicated optical systems using lenses and mirrors, this has not been the case with diffraction

gratings for which little is available in the open literature. We believe that a major breakthrough in ray tracing was made in this work on diffraction gratings.

In the extreme ultraviolet spectroscopy laboratory, fluorescence of CO excited by the $1306\text{\AA}$ O I resonance line was investigated, because of its application to the earth's upper atmosphere and to planetary atmospheres. Work on the fine structure and perturbation analyses of the $A^3\Pi$ state, the lowest metastable state of CO, is approaching completion. The work is associated with the possible use of CO in UV lasers, and also with transitions that have been observed in atmospheres of other planets by satellites.

DATA ANALYSIS:

As mentioned in the introduction, data reduction of results from the space program has lagged owing to the urgency of ongoing programs. The results of the March 7 1970 eclipse have been analyzed and it has been shown that emission from SiIII, AlIII, SiIV, and CIV actually extends to 10,000km altitude in the solar atmosphere, much farther than can be explained on the basis of a homogeneous solar atmosphere. A model that explains the behaviour is proposed with cylindrical spicules, extending to 7000 km or more, each assumed to have a cool center sheathed by a transition zone extending to the interspicular corona.

Work has continued on analysis of the high resolution extreme ultraviolet limb spectra. Many new lines of SiI approaching the 3P limits, were discovered. The temperature in the continuum was also redetermined from the

center to limb variation in the range 1400-1790Å. The values from the 1970 flight are in agreement with those obtained in 1971, and also with the earlier data of NRL. Thus disagreement with intensity of the data reported by the Harvard College Observatory has not yet been resolved.

Work on the analysis of the solar spectrum in the range 171-630Å continues, based on the various grazing incidence spectra and also the flare spectrum of November 4, 1969. A number of important new identifications have been made, particularly in the spectra of Fe X, XI, XII, XIII, and XIV. In the flare, emission by Ni XVII and XVIII, Ar XV and XVI, and Ca XVII and XVIII have been discovered. The observation of CaXVIII implies that the flare plasma is still at a temperature of 8 million degrees from 6 to 10 minutes after the explosive phase of the flare.

SUMMARY:

The major success during this period has been completion of the experiments for OSO-H and their successful operation in orbit. Also successful was a rocket reflight of the ATM B instrument, resulting in solar spectra having negligible stray light. The third success was the delivery of the prototype and flight experiments for ATM, except for the camera mechanisms. A great deal of effort has been expended in the design of rocket-borne payloads required for calibration of the experiments in ATM, once they are placed in orbit. Unfortunately, support of this project by NASA is not sufficient. As a result of the great amount

of time spent on current and future experimental problems, and the difficulty in freeing personnel to work on theory and interpretation, publications in the area of space research have not been extensive. Extreme ultraviolet research in the laboratory, however, continues with publication at about the same level, in spite of limited funding.

APPENDIX A

SPACE SCIENCE DIVISION
and
E. O. HULBURT CENTER FOR SPACE RESEARCH

Publications and Talks
October 1970 - October 1971

Publications*

Friedman, Herbert

"Astronautics: Space Probes," 1971 Britannica Yearbook of Science and the Future (William Benton, 1970), pp. 129-133.

Friedman, Herbert

"X-ray Background Radiation," presented at the Pontifical Academy of Sciences, Vatican City, April 1970; "Semaine d'Etude sur Les Noyaux des Galaxies - 13-18 avril 1970," Pontificae Academiae Scientiarum Scripta Varia No. 35 (1971), pp. 669-697.

Friedman, Herbert

"Priorities in Space Science and Applications," Statement by Herbert Friedman, The National Space Program--Present and Future, a Compilation of Papers prepared for the Subcommittee on NASA Oversight of the Committee on Science and Astronautics, U. S. House of Representatives, 91st Congress, December 10, 1970, pp. 107-118.

Friedman, Herbert

"Priorities for Space Research, 1971-1980," Report of a Study on Space Science and Earth Observations Priorities conducted by the Space Science Board--National Research Council, chaired by Herbert Friedman, Woods Hole, Massachusetts, July-August 1970, published by the National Academy of Sciences, 1971, 147 pp.

H. Friedman, T. A. Chubb, C. H. Mayer, R. Tousey

"Observatory Report: E. O. Hulburt Center for Space Research, Naval Research Laboratory," Bull. Amer. Astron. Soc. 3, No. 1, Part II, pp. 90-101 (1971).

* Other co-authored papers appear in Code 7120 listing.

Code 7100 (Cont'd):

Papers to be published:

Friedman, Herbert

"Astronomical Observations from Outside the Terrestrial Atmosphere," Encyclopaedia of Istituto di Scienze E Arti, Rome Observatory (In Press).

Friedman, H.

"Twenty-five Years of Rocket and Satellite Astronomy," Nature (Submitted October 1971).

Friedman, Herbert

"Rocket Astronomy," to be published in the Annals of The New York Academy of Sciences.

Friedman, H.

"Recent Progress and Future Prospects in High Energy Astronomy," Astronautics & Aeronautics (submitted October 1971).

Invited Talks - H. Friedman

1. "X-ray and Gamma Ray Astronomy," Autumn Meeting of the National Academy of Sciences, Rice University, Houston, 21 October 1970.
2. "X-ray Galaxies," Physics Colloquium, Imperial College, London, England, 11 February 1971.
3. "Quasars, Pulsars and Neutron Stars," Cosmos Club, Washington, D. C., 15 March 1971.
4. "Recent Results in X-ray Astronomy," Joint Colloquium of the Center for Radiophysics and Space Research and the Laboratory of Plasma Studies, Cornell University, Ithaca, 25 March 1971.
5. "Recent Results in X-ray Astronomy," Space Astrophysics Seminar, University of Maryland, 29 March 1971.
6. Introductory Remarks as Program Chairman, "Symposium on Energy for the Future--Problems and Prospects," 108th Annual Meeting of the National Academy of Sciences, Washington, D. C., 26 April 1971; published in the Proceedings of the National Academy of Sciences 68, pp. 1919-1943, August 1971.
7. "Rocket Astronomy," Conference on Education in and History of Modern Astronomy, American Museum of Natural History, New York City, 1 September 1971.

Publications:

Lepson, B.

"Entire Functions of Extreme Rates of Growth,"
NRL Report 7151, 30 Nov. 1970; J. of Mathematical
Analysis and Applications, Vol. 36, (1971),
pp. 371-376 (in press).

Lepson, B.

"An Interpolation Property of Entire Functions with
Non-negative Coefficients," Notices of the American
Mathematical Soc., Vol. 18, (1971), p. 524.

Noonan, J. W.

"Coefficients of Functions with Bounded Boundary
Rotation," Proceedings of the American Mathematical
Society, Vol. 29, (1971), pp. 307-312.

Noonan, J. W. and Thomas, D. K.

"On Successive Coefficients of Functions of Bounded
Boundary Rotation," Univ. of Maryland Technical
Report TR 71-13 (1971).

Papers to be published:

Lepson, B.

"Rates of Growth and Interpolation by Entire Functions
with Non-negative Coefficients," Proceedings of the
International Conference on Entire and Meromorphic
Functions, Univ. of British Columbia, Vancouver, B.C.,
Canada, June 1971 (Invited Address).

Noonan, J. W.

"Boundary Behavior of Functions with Bounded Boundary
Rotation," J. of Mathematical Analysis and Applications.

Noonan, J. W.

"Asymptotic Behavior of Functions with Bounded Boundary
Rotation," Transactions of the American Mathematical
Society (in press).

Noonan, J. W.

"Curvature and Radius of Curvature for Functions with
Bounded Boundary Rotation," Canadian Journal of
Mathematics.

Code 7104

Papers to be published: (continued)

Noonan, J. W.

"On Close-to-Convex Functions of Order β ,"
Michigan Journal of Mathematics.

Other Talks and Lectures:

Lepson, B.

"An Interpolation Property of Entire Functions
with Non-negative Coefficients," American
Mathematical Soc. Meeting, New York City.
7-10 April 1971.

Noonan, J. W.

"Coefficients of Functions with Bounded Boundary
Rotation," American Mathematical Society Annual
Meeting, Atlantic City, New Jersey, 21-24 Jan. 1971.

SPACE SCIENCE DIVISION

Code 7120

Publications for 1970 (not included in 1970 report)

Carruthers, G. R.

"Encapsulation of Helical Channel Multipliers
for Space Flight Applications," Rev. Sci.
Instr. 41, 1882 (1970).

Henry, R. C.

"Ultraviolet Background Radiation,"
Astrophys. J. (submitted for publication October 1970).

Horan, D. M. and R. W. Kreplin

"Solar X-ray Emission, March 5-10, 1970,"
contribution to a special Upper Atmosphere
Geophysics Report, November 1970.

Meier, R. R. and D. K. Prinz

"Absorption of the Solar Lyman Alpha Line by
Geocoronal Atomic Hydrogen," J. Geophys. Res.
75, 6969 (1970).

Tomblin, F. F. (Bellcomm, Inc.) and R. W. Kreplin

"Electron Intensity Variations in the Inner Belt
Following a Geomagnetic Storm," Nature 228,
988 (1970).

Weber, S. V., R. C. Henry and G. R. Carruthers

"Are There Stars Exceptionally Bright at
1500 A?," Astrophys. J. 162, L121 (1970).

SPACE SCIENCE DIVISION

Upper Air Physics Branch (Code 7120)

Publications for 1971

- Byram, E. T., T. A. Chubb, and H. Friedman
"Variability of X-Ray Emission from M-87,"
Nature 229, 544, 1971.
- Byram, E. T., T. A. Chubb, and H. Friedman
"X-Rays from Centaurus A and the Far-Infrared Background Radiation: Reply to Ramaty,"
Science 171, 500 (1971).
- Carruthers, G. R.
"Comparison of Three Films for Use in Electronographic Cameras," AAS Photo-Bulletin, 1971.
- Carruthers, G. R.
"Interstellar Molecules," Astronautics and Aeronautics, 16, 1971.
- Carruthers, G. R.
"A Narrow-Band Filter for the Lyman-Beta Wavelength Region," Applied Optics (Letter to the Editor), 10, No. 6, 1461, 1971.
- Carruthers, G. R.
"Far UV Measuring with Gas Photo-Ionization Detectors," Optical Spectra, January 1971, p.36.
- Carruthers, G. R.
"Internal-Grating Electronographic Spectrographs for the Far-Ultraviolet and X-Ray Wavelength Ranges," to be published in the Proceedings of the Fifth Symposium on Photoelectronic Image Devices, in London, England, 1971.
- Carruthers, G. R.
"Further Development of Magnetically-Focused, Internal-Optic Image Converters," Proceedings of the Fifth Symposium on Photoelectronic Image Devices, Imperial College, London, England, 1971 (to be published).
- Carruthers, G. R., and T. L. Page
"A Lunar Surface Ultraviolet Camera/Spectrograph," Sky and Telescope, submitted in 1971.
- Buckley, J. L., H. W. Moos, and R. R. Meier
"Rocket Twilight Observations of HI 12160°: Horizon Brightening at 150 KM," J. Geophys. Res. 76, 2437 (1971).

SPACE SCIENCE DIVISION

Code 7120

Publications for 1971 (Con't)

Carruthers, G. R.

"Electronic Imaging Devices in Astronomy,"
Astrophysics and Space Science. Submitted in
1971.

Carruthers, G. R.

"Far-Ultraviolet Spectra and Photometry of
Perseus Stars," Astrophysical J. 166, 349,
June 1971.

Doschek, G. A., J. F. Meekins, R. W. Kreplin,

T. A. Chubb, and H. Friedman

"Soft X-Ray Spectral Studies of Solar Flare
Plasmas," Proceedings of Conference on Cosmic
Plasma Physics, ESRIN, Frascati (Rome), Italy,
1971.

Doschek, G. A., J. F. Meekins, R. W. Kreplin,

T. A. Chubb, and H. Friedman

"Heliumlike Calcium Emission Observed During
A Solar Flare," Astrophysical J., 164, 165-180,
1971.

Doschek, G. A., J. F. Meekins, R. W. Kreplin,

T. A. Chubb, and H. Friedman

"Solar Flare Iron-Line Emission," Astrophysical
J. Submitted in 1971 and will appear in Dec 15,
1971 issue.

Doschek, G. A.

"The Solar Flare Plasma; Observation and Inter-
pretation," Proceedings of Third Symposium on
Ultraviolet and X-Ray Spectroscopy of Astro-
physical and Laboratory Plasmas, Utrecht, the
Netherlands, August 1971, to be published in
Space Science Reviews.

Fritz, G. G., A. J. Davidsen, J. F. Meekins and

H. Friedman

"Discovery of an X-Ray Source in Perseus,"
Astrophysical J. (Letters) 164, L81, 1971.

Fritz, G. G., J. F. Meekins, T. A. Chubb, H. Friedman,
and R. C. Henry

"The X-Ray Spectra of the Crab Nebula and
NP 0532," Astrophysical J., 164, L55, 1971.

SPACE SCIENCE DIVISION

Code 7120

Publications for 1971 (Con't)

Henry, R. C., G. G. Fritz, J. F. Meekins, T. A. Chubb,
and H. Friedman

"Excess Background Radiation of Soft X-Rays at
the Galactic Pole and Plane," *Astrophysical J.*,
163, L73-L77, 1971.

Henry, R. C. and James E. Hesser

"K-Line Photometry of Southern A Stars,"
Astrophysical J., 169, 633, 1971. (Abstract)

Hesser, J. E. and R. C. Henry

"Variation of Metal Abundance in Stars in
Population I Clusters," *Astronomical Society on
the Pacific*, 83, No. 492, 173, 1971.

Hesser, J. E. and R. C. Henry

"K-Line Photometry of Stars in Population I
Clusters," *Astrophysical J.*, 169, 633, 1971. (Abstract)

Horan, D. M. and R. W. Kreplin

"Solar Electron Temperatures and X-Ray Flare
Activity," *American Institute of Astronautics
and Aeronautics J. as a Technical Note*, 9,
No. 8, 1934, 1971.

Horan, D. M.

"Electron Temperature and Emission Measure
Variations During Solar X-Ray Flares," *Solar
Physics*. Submitted in 1971.

Johnson, C. Y., J. M. Young, and J. C. Holmes

"Magnetoglow: A New Geophysical Resource,"
Science, 171, No. 3969, 379, 1971.

Johnson, C. Y.

"Positive Ion Mass Spectrometer Observations
in the E Regions," *Radio Science*. Submitted 1971.

Johnson, C. Y.

"Basic E and F Region Aeronomy," *Defense Atomic
Support Agency Information and Analysis Center
(DASIAC) in a HANE Symposium Proceedings*.
Submitted in 1971.

SPACE SCIENCE DIVISION

Code 7120

Publications for 1971 (Con't)

Kahler, S. W. and R. W. Kreplin

"The Observation of Nonthermal Solar X-Radiation in the $3 < E < 10$ keV Energy Range," Astrophysic J., 168, 531, 1971.

Kahler, S. W.

"On the Existence of Solar-Flare Plasmas of $T \geq 10^8$ °K," Astrophysical J. 164, 365, 1971.

Kahler, S. W., G. A. Doschek, J. F. Meekins, and D. M. Horan

Discussion of Paper "On the Polarization and Anisotropy of Solar X-Radiation During Flares," by G. Elwert and E. Haug. Submitted 1971 Solar Physics.

Kurfess, J. D.

"Observation of Low-Energy Gamma Radiation from NP 0532," Astrophysical J. (Letters) 168, L39, 1971.

McNutt, D. P., K. Shivanandan, and P. D. Feldman

"Rocket Measurement of the Far Infrared Sky Background," Nature. Submitted in 1971.

Meekins, J. F., G. G. Fritz, T. A. Chubb, and H. Friedman

"X-Rays from the Coma Cluster of Galaxies," Nature (Letters) 231, 107 (1971).

Meier, R. R.

"Observations of Conjugate Excitation of the OI 1304 Å Airglow," J. Geophysical Res., 76, No. 1, 242, (Ltrs), 1971.

Meier, R. R. and C. S. Weller

"EUV Resonance Radiation from Helium Atoms and Ions in the Geocorona," J. Geophysical Res. Submitted in 1971.

Meier, R. R. and D. K. Prinz

"Observations of the OI 1304 Å Airglow from OGO 4," J. Geophysical Res., 76, No. 19, 4608, 1971.

SPACE SCIENCE DIVISION

Code 7120

Publications for 1971 (Con't)

Prinz, D. K. and R. R. Meier

"OGO 4 Observations of the Lyman-Birge-Hopfield Emission in the Day Airglow," J. Geophysical Res., 76, No. 25, 6146, 1971.

Rottman, G. J., H. W. Moos, J. R. Barry, and R. C. Henry

"Lyman-Alpha Emission from Arcturus," Astrophysical J., 165, 661, 1971.

Sadeh, D. S.

"Phase Variation of Very Accurate Radio Frequency Due to the Solar Eclipse," J. Geophysical Res. Submitted in 1971.

Schwentek, H., G. Hartmann, and R. W. Kreplin

"The Trend of Ionospheric Absorption During Shortwave Fade-Outs Related to the Trend of Enhancement of Solar X-Ray Flux," Radio Science, 6, No. 1, 35, 1971.

Shulman, S. D., G. G. Fritz, J. F. Meekins, T. A. Chubb, H. Friedman, and R. C. Henry

"Line Emission in the X-Ray Background," Astrophysical J., 166, L9-L12, 1971.

Shulman, S. D., G. G. Fritz, J. F. Meekins, H. Friedman and M. Meidav

"X-Ray Intensity Fluctuations in CYG XR-1," Astrophysical J., 168, L49, 1971.

Smathers, H. W., D. S. Sadeh, and T. A. Chubb

"Observations of the Crab Nebula Pulsar at 30-100 keV," Nature, 232, 120, 1971.

Taylor, R. G.

"Measurement of the 170-700 Å Solar XUV Flux on 7 March 1970," J. Atmospheric and Terrestrial Physics. Submitted in 1971.

SPACE SCIENCE DIVISION

Code 7120

Publications for 1971 (Con't)

Tinsley, B. A. and R. R. Meier

"Balmer Alpha Distributions Over a Solar
Cycle: Comparison of Observations with Theory,"
J. Geophysical Res., 76, No. 4, 1006, 1971.

Weber, S. V., R. C. Henry, and G. R. Carruthers

"Far-Ultraviolet Interstellar Absorption in
Orion and Monoceros," The Astrophysical J.
166, 543, 1971.

Weller, C. W., R. R. Meier, and B. A. Tinsley

"Simultaneous Measurements of the Hydrogen
Airglow Emissions of Lyman α , Lyman β and
Balmer α ," J. Geophysical Res., 76, 7734, 1971.

Young, J. M., C. S. Weller, C. Y. Johnson, and
J. C. Holmes

"Rocket Observations of the Far UV Nightglow at
Lyman α and Shorter Wavelengths," J. Geophysical
Res., 76, No. 16, 3710, 1971.

Mange, P.

"The Exosphere and Geocorona (Including the Polar Wind),"
Proceedings, IUCSTP Symposium, Leningrad, U.S.S.R.,
May, 1970 (In Press).

SPACE SCIENCE DIVISION

Code 7120

NRL Reports (1971)

Holmes, J. C.

"Use of Attitude Sensors to Determine the Motion
of a Free Rotator", NRL Report 7194, 1971.

Meier, R. R., and P. Mange

"Earth's Ultraviolet Halo: The Glow of Geocoronal
Hydrogen", Report of NRL Progress, February 1971, pp. 33-34

Code 7120

Talks 1970 (not included in 1970 Annual Report)

Carruthers, G.

"Far Ultraviolet Spectra of Stars in Perseus and Orion," presented at 133rd Meeting of American Astronomical Society, University of South Florida, Tampa, 8-9 December 1970.

Carruthers, G.

"Interstellar Atomic and Molecular Hydrogen from Rocket Observations," presented at National Radio Astronomy Observatory, 24 Sept. 1970.

Carruthers, G.

"Optical Observations of Interstellar Molecules", presented at University of Maryland, Seminar on Interstellar Molecules, 5 October 1970.

Chubb, T. A., and Hicks, G. T.

"Observations of the Aurora in the Far Ultraviolet from OGO-4," presented at the Annual Norwegian Scientific Meeting, Hønefoss, Norway, April 1970; abstracted Physical Norvegica 4, No. 2 (1970).

Mange, P.

"OGO-4 Satellite Observations of the Far Ultraviolet in the Atmosphere from 100 to 10,000 km," presented at Space Physics Seminar, The University of Texas at Dallas, October 21, 1970.

Meier, R.

"OGO-4 Observations of OI 1304Å," presented at the AGU Meeting, San Francisco, California, 7-10 December 1970.

SPACE SCIENCE DIVISION

Code 7120

Talks 1971 to date

Carruthers, G. R.

"Rocket Observations of the Interstellar Medium,"
University of Chicago, Chicago, Ill., March 1971;
and University of Ill., Urbana, Ill., April 1971.

Carruthers, G. R.

"Internal-Grating Electronographic Spectrographs
for the Far-Ultraviolet and X-Ray Wavelength
Ranges," Fifth Symposium on Photoelectronic
Image Devices, Imperial College, London, England,
September 1971.

Carruthers, G. R.

"Further Developments of Magnetically-Focused,
Internal-Optic Image Converters," Fifth
Symposium on Photoelectronic Image Devices,
Imperial College, London, England, September 1971.

Chubb, T. A.

"Geophysical Observations Using Gas Photoion-
ization Photometers," New South Faculty Lounge,
Georgetown University, Wash., D. C., meeting of
the Optical Society of America, National Capital
Section, February 1971.

Chubb, T. A.

"X-Ray Astronomy - Recent Results from Rocket
and Balloon Studies," American Physical
Society Mtg., Wash., D.C., April 1971.

Doschek, G. A., J. F. Meekins, R. W. Kreplin, and
T. A. Chubb

"An Analysis of Soft X-Ray Emission Line
Behavior During Solar Flares," XIV Plenary Mtg.
of COSPAR, Seattle, Wash., June to July 1971.

Doschek, G. A., J. F. Meekins, R. W. Kreplin,
T. A. Chubb, and H. Friedman

"Soft X-Ray Spectral Studies of Solar Flare
Plasmas," ESRIN Conference on Cosmic Plasma
Physics, Frascati, Italy, September 1971.

SPACE SCIENCE DIVISION

Code 7120

Talks 1971 (Con't)

Doschek, G. A., J. F. Meekins, R. W. Kreplin,
T. A. Chubb, and H. Friedman

"Soft X-Ray Spectral Studies of Solar Flare
Plasmas," Washington-Baltimore Colloquium on
Atomic and Molecular Collisions, NRL, Wash.,
D. C., March 1971.

Doschek, G. A.

"The Solar Flare Plasma; Observation and Inter-
pretation," Third Symposium on Ultraviolet and
X-Ray Spectroscopy of Astrophysical and
Laboratory Plasmas, Utrecht, The Netherlands,
August 1971.

Doschek, G. A., and J. F. Meekins

"Iron-Line Emission During Solar Flares,"
The 136th Meeting of the American Astronomical
Society, San Juan, Puerto Rico, December 1971.

Johnson, C. Y.

"Ionizing Radiation in the Night Sky," COSPAR
Symposium on D and E Region Ion Chemistry,
University of Ill., Urbana, Ill., July 1971.

Johnson, C. Y.

"Positive Ion Mass Spectrometer Observations,"
COSPAR Symposium on D and E Region Ion
Chemistry, University of Ill., Urbana, Ill.,
July 1971.

Johnson, C. Y.

"Basic E. and F. Region Aeronomy," Stanford
Research Institute, Menlo Park, Calif., August
1971.

Kahler, S. W., and R. W. Kreplin

"Observations of Non-Thermal Low Energy X-Ray
Emission Coincident with Impulsive Solar
X-Ray Bursts," XIV Plenary Meeting of COSPAR,
Seattle, Wash., June to July 1971.

Kurfess, J. D.

"Gamma-Ray Astronomy with Large Scintillation
Detectors," AAS Division of High Energy
Astrophysics - APS Division of Cosmic Physics,
San Juan, Puerto Rico, December 1971.

SPACE SCIENCE DIVISION

Code 7120

Talks 1971 (Con't)

Meier, R. R., and C. S. Weller

"A Comparison of Recent Observations of the Atomic Helium 584 Å Airglow," American Geophys. Union, Fall Annual Meeting, San Francisco, Calif., December 1971.

Prinz, D. K., and R. R. Meier

"OGO-4 Observations of the Lyman-Birge-Hopfield Emission in the Day Airglow," American Geophys. Union Annual Meeting, Wash., D. C., April 1971.

Sadeh, D. S., M. Meidav, H. W. Smathers, T. A. Chubb, and H. Friedman

"A New X-Ray Pulsar Near the Crab Nebula," 136th Meeting of American Astro. Soc., San Juan, Puerto Rico, December 1971.

Shivanandan, K.

"Infrared Rocket Astronomy & Review of Results in IR Space Astronomy," Summer School in High Energy Astrophysics, Erice, Sicily, May 1971.

Shivanandan, K.

"Infrared Rocket Astronomy," Fifth ESLAB/ESRIN Symposium, Noordwijk, Holland, June 1971.

Shivanandan, K.

"Space Science at Naval Research Laboratory," Tata Institute of Fundamental Research, Bombay, India; National Physical Research Laboratory, Ahmedabad, India; University of Malaya, Kuala Lumpur, Malaysia; University of Singapore, Singapore, Malaysia; Rotary Club, Singapore, Malaysia; Teachers Training College, Jaffna, Ceylon; Scientific and Industrial Research, Colombo, Ceylon, June to July 1971.

Shulman, S. D.

"Spectrum of the Universal Microwave Radiation From Interstellar Molecules" The 136th Meeting of the American Astronomical Society, San Juan, Puerto Rico, December 1971.

SPACE SCIENCE DIVISION

Code 7120

Talks 1971 (Con't)

Taylor, R. G.

"Measurement of the 170-700 Å XUV Flux on
7 March 1971," XIV Plenary Meeting of COSPAR,
Seattle, Wash., June to July 1971.

Taylor, R. G., and R. W. Kreplin

"Localization of Sources of Flare X-Ray
Emission During the Solar Eclipses of 18 March
1969 and 7 March 1970," XIV Plenary Meeting
of COSPAR, Seattle, Wash., June to July 1971.

Weller, C. S., and R. R. Meier

"Plasmaspheric He⁺ Distributions Derived from
Recent Measurement of 304 Å Geocoronal Radia-
tion," American Geophysical Union, Fall Annual
Meeting, San Francisco, Calif., December 1971.

Mange, P.

"Ultraviolet Exploration of the High Atmosphere,"
Pennsylvania State University, University Park,
Pennsylvania, October 1971.

SPACE SCIENCE DIVISION

Code 7120

1971
AWARDS

Incentive Award: "Solution to Personnel Safety Barrier Problem of the Detonator Block for the NRL Design Parachute Recovery System" 1971, to John Kruly.

Arthur S. Flemming Award: "Atomic and Molecular Hydrogen in Interstellar Space," Space Science Reviews 10 1970, to G. R. Carruthers, 18 Feb 1971.

NRL Research Publications Award, 1970 "Rocket Observation of Interstellar Molecular Hydrogen," Astrophys. J. 161, L81 (1970), awarded to G. R. Carruthers, 11 Feb 1971.

"Observations of Lyman- α and the Atomic Hydrogen Distribution in the Thermosphere and Exosphere, Space Research X (North-Holland Publ. Co., Amsterdam, 1970), pp. 572-581; and "Depressions in the Far-Ultraviolet Airglow Over the Poles," J. Geophys. Res. 75 6218 (1970), awarded to R. R. Meier, 11 Feb 1971

Patent Award: "Camera Tube Including Channel Electron Multiplier and Channel Storage Section." awarded to T. A. Chubb, 23 Sep 1971.

SPACE SCIENCE DIVISION

Radio Astronomy Branch (Code 7130)

Publications October 1, 1970 thru October 20, 1971

Hollinger, J. P., Hevey, R. H., Knowles, S. H.,
Sadeh, D., and Youmans, A. B.
"Measurements of Pulsar Arrival Times," Astrophys.
J. (Letters), 162, L105, November 1970.

Hobbs, R. W. and Johnston, K. J.
"Observations of Seven Compact Sources in H II
Regions at Wavelengths of 0.95, 1.65, and 2.73
Centimeters," Astrophys. J., 163, 299, January 1971.

Knowles, S. H. and Cheung, A. C.
"Further Investigations of NH₃ Inversion Radiation,"
Astrophys. J. (Letters), 164, L19, February 1971.

Hollinger, J. P.
"Passive Microwave Studies at Argus Island,"
Analyses of the NASA/Navy Review, 11-12 June 1969,
"Microwave Observations of the Ocean Surface,"
SP-152, p. 3, February 1971.

Shapiro, A., Yaplee, B. S., and Uliana, E. A.
"Radar Impulse Response of Rough Surfaces,"
Analyses of the NASA/Navy Review, 11-12 June 1969,
"Microwave Observations of the Ocean Surface,"
SP-152, p. 107, February 1971.

Hammond, Donald L.
"The Effect of Sea Roughness on the Bandwidth of
Radar Backscatter," Analyses of the NASA/Navy
Review, 11-12 June 1969, "Microwave Observations
of the Ocean Surface," SP-152, p. 137, February 1971.

Hobbs, R. W. and Waak, J. A.
"Measurement of Strong Planetary Nebulae at Short
Centimeter Wavelengths," Publ. Astron. Soc. Pacific,
83, 166, April 1971.

Hobbs, R. W. and Knapp, S. L.
"Planetary Temperatures at 9.55 mm Wavelengths,"
Icarus, 14, 204, April 1971.

Publications October 1, 1970 thru October 20, 1971 (cont'd.)

Mayer, C. H. and McCullough, T. P.

"Microwave Radiation of Uranus and Neptune,"
Icarus, 14, 187, April 1971.

Johnston, K. J., Knowles, S. H., Sullivan, W. T. III,
Moran, J. M., Burke, B. F., Lo, K. Y., Papa, D. C.,
Papadopoulos, G. D., Schwartz, P. R., Knight, C. A.,
Shapiro, I. I., and Welch, W. J.

"An Interferometer Map of the Water-Vapor Sources
in W49," Astrophys. J. (Letters), 166, L21, May
1971.

Sullivan, Woodruff T. III

"Variations in Frequency and Intensity of 1.35
Centimeter H₂O Emission Profiles in Galactic H II
Regions," Astrophys. J., 166, 321, June 1971.

Johnston, K. J.

"Photoelectric Observations of UU Piscium,"
Astron. J., 76, 455, June 1971.

Yaplee, B. S., Shapiro, A., Hammond, D. L., Au, B. D.,
and Uliana, E. A.

"Nanosecond Radar Observations of the Ocean
Surface from a Stable Platform," IEEE Trans. on
Geoscience Electronics, GE-9, 170, July 1971.

Hollinger, James P.

"Passive Microwave Measurements of Sea Surface
Roughness," IEEE Trans. on Geoscience Electronics,
GE-9, 165, July 1971.

Sullivan, Woodruff T. III

"Microwave Radiation of Water Vapor in Galactic
Sources," Doctoral Dissertation, University of
Maryland, College Park, Maryland, July 1971.

Waak, John A. J.

"An Attempt to Explain Quantitatively Observed
Variations in the Flux Densities of Seven Extra-
galactic Radio Sources in Terms of the 'Expanding
Cloud' Model," Doctoral Dissertation, Graduate
School of Georgetown University, Washington, D.C.,
July 1971.

Publications October 1, 1970 thru October 20, 1971 (cont'd.)

Johnston, K. J., Knowles, S. H., and Sullivan, W. T. III
"Observations of 1.35-Centimeter H₂O Emission in
the Southern Hemisphere," Astrophys. J. (Letters),
167, L93, August 1971.

Hollinger, J. P.
"Passive Microwave Studies," Third Annual Earth
Resources Program Review, December 1-3, 1970,
Vol. III, Hydrology and Oceanography, p. 69-1,
1971.

Yaplee, B. S., Shapiro, A., Au, B. D., Hammond, D. L.,
and Uliana, E. A.
"Nanosecond Radar Observations of the Ocean
Surface from a Stable Platform," Third Annual
Earth Resources Program Review, December 1-3, 1970,
Vol. III, Hydrology and Oceanography, p. 68-1,
1971.

Hollinger, James P.
"Remote Passive Microwave Sensing of the Ocean
Surface," Proceedings of the Seventh International
Symposium on Remote Sensing of Environment,
17-21 May 1971, Vol. III, p. 1807, 1971.

Yaplee, B. S., Shapiro, A., Hammond, D. L., and
Uliana, E. A.
"Ocean Wave Height Measurements with a Nanosecond
Radar," Proceedings of the Seventh International
Symposium on Remote Sensing of Environment,
17-21 May 1971, Vol. III, p. 1879, 1971.

SPACE SCIENCE DIVISION

Radio Astronomy Branch (Code 7130)

Talks October 1, 1970 thru October 20, 1971

Knowles, Stephen H.

"Very-Long-Baseline Interferometry of Water Sources," Seminar on Interstellar Molecules, Univ. of Maryland, College Park, Maryland, 2 November 1970.

Yaplee, B. S., Shapiro, A., Hammond, D. L., and Uliana, E. A.

"Nanosecond Radar Observations of the Ocean Surface from a Stable Platform," Oceanography Session, NASA Earth Resources Program Review, Houston, Texas, 1-3 December 1970.

Hollinger, James P.

"Passive Microwave Studies," Oceanography Session, NASA Earth Resources Program Review, Houston, Texas, 1-3 December 1970.

Johnston, K. J., Knowles, S. H., Sullivan, W. T. III, NRL; Moran, J. M., MIT-Lincoln Lab.; Burke, B. F., Lo, K. Y., Papa, D. C., Papadopoulos, G. D., Schwartz, P. R., RLE-MIT; and Welch W. J., Univ. of California-Berkeley

"Map of H₂O Line Emission Source in W49," 133rd Meeting of the American Astronomical Society, Tampa, Florida, 6-9 December 1970.

Sullivan, W. T. III, NRL and Univ. of Md., and Kerr, F. J., Univ. of Md.

"Variations of OH 18-Cm Line Emission on Time Scale of One Hour," 133rd Meeting of the American Astronomical Society, Tampa, Florida, 6-9 December 1970.

Johnston, Kenneth J.

"H α and H β Observations of 44 i Bootis," 133rd Meeting of the American Astronomical Society, Tampa, Florida, 6-9 December 1970.

Talks October 1, 1970 thru October 20, 1971 (cont'd.)

Clark, T. A., Donn, B., Jackson, W. M., NASA/GSFC;
Sullivan, W. T., NRL; and Vandenberg, N., Univ. of
Maryland

"Radio Search for H₂O Comet Bennett (1969i),"
Division on Planetary Science, American Astronom-
ical Society, Tallahassee, Florida, 1-3 February
1971.

Johnston, K. J., Knowles, S. H., Sullivan, W. T., III,
NRL; Moran, J. M., MIT-Lincoln Lab.; Burke, B. F.,
Lo, K. Y., Papa, D. C., Papadopoulos, G. D., Schwartz,
P. R., RLE-MIT; Knight, C. A., Shapiro, I. I., MIT;
and Welch, W. J., Univ. of California-Berkeley
"H₂O Line Emission from Orion A, VY CMa, and W49,"
134th Meeting of the American Astronomical Society,
Baton Rouge, Louisiana, 29 March 1971.

Yaplee, B. S., NRL and Smith, S. L., NWL
"Worldwide Deflection of the Vertical at Sea from
Satellite Radar Altimetry for Future Navy Needs,"
Gravity/Satellite Geodesy Technical Exchange Meeting,
National Bureau of Standards, Gaithersburg, Md.,
19-23 April 1971.

Knowles, S. H. and Sullivan, W. T., III
"Interferometric and Single-Antenna Observations
of the 1.35-Cm H₂O Transition in Galactic Sources,"
Radiophysics Division, CSIRO, Sydney, Australia,
23 April 1971.

Yaplee, B. S., Shapiro, A., Hammond, D. L., and
Uliana, E. A.
"Ocean Wave Height Measurements with a Nanosecond
Radar System," Seventh International Symposium on
Remote Sensing of Environment, Willow Run Labora-
tories, University of Michigan, Ann Arbor, Michigan,
17-21 May 1971.

Hollinger, James P.
"Remote Passive Microwave Sensing of the Ocean
Surface," Seventh International Symposium on Remote
Sensing of Environment, Willow Run Laboratories,
University of Michigan, Ann Arbor, Michigan, 17-21
May 1971.

Talks October 1, 1970 thru October 20, 1971 (cont'd)

Yaplee, B. S., Shapiro, A., Hammond, D. L., and
Uliana, E. A.

"Wave Height Measurements with a Nanosecond Radar,"
Electromagnetic Wave Propagation Panel, XVII
Annual Symposium of AGARD, Air Force Academy,
Colorado Springs, Colorado, 21-25 June 1971.

Hollinger, James P.

"Remote Passive Microwave Measurements of the
Sea Surface," Electromagnetic Wave Propagation
Panel, XVII Annual Symposium of AGARD, Air Force
Academy, Colorado Springs, Colorado, 21-25 June
1971.

Sullivan, W. T., III

"Time Variations in Interstellar OH and H₂O
Masers," 135th American Astronomical Society
Meeting, Amherst, Massachusetts, 24-27 August
1971.

Miller, Lee S., Brown, Gary S., RTI; and Hammond,
Donald L., NRL

"Skylab S-193 Altimeter Experiment," IEEE Third
Annual International Symposium, Washington, D. C.,
25-27 August 1971.

Schwartz, Philip R.

"Microwave Emission from Stars," IAU Colloquium
No. 15 "New Directions and New Frontiers in
Variable Star Research," Bamberg, Germany,
31 August - 3 September 1971.

Johnston, K. J., NRL; Robinson, B. J., Caswell, J. L.,
and Batchelor, R. A., CSIRO, Sydney, Australia

"Southern Water Sources Associated with OH Emission,"
Commission V, USNC/URSI Meeting, University of
California, Los Angeles, California, 21-24 September
1971.

Hollinger, James P.

"Remote Passive Microwave Sensing of the Ocean
Environment," Physics Seminar, George Washington
University, Washington, D. C., 6 October 1971.

Talks October 1, 1970 thru October 20, 1971 (cont'd)

Shapiro, A., Uliana, E. A., and Yaplee, B. S.
"Radar Pulse Shape Versus Ocean Wave Height,"
NOAA/NASA/NAVY Conference on Sea Surface
Topography from Space, Key Biscayne, Florida,
6-8 October 1971.

SPACE SCIENCE DIVISION

Rocket Spectroscopy Branch (Code 7140)

Publications - August 1970 through October 1971

Hunter, W. R. and Hass, G.

"Laboratory Experiments to Study Surface Contamination and Degradation of Optical Coatings and Materials in Simulated Space Environments," Applied Optics 9, 2101, 1970.

Hunter, W. R.

"Semiautomatic Acquisition of Extreme Ultraviolet Reflectance Data for Calculating Optical Constants," Review of Scientific Instruments 41, 1419, 1970.

Tousey, R.

"Solar Astronomy," Transactions of the International Astronomical Union, XIVA, 525-531, 1970.

Tousey, R.

"Identifications in the Solar XUV Spectrum," Proceedings of the IAU Commission 14, XIVB, 119, 1970.

Tousey, R.

"Rocket Astronomy," Encyclopedia of Science and Technology, McGraw-Hill, Inc., 647-648, 1970.

Winter, T. C., Jr. and VanHoosier, M. E.

"Schumann-Type Photographic Film Preliminary Environment Test Results," NRL Report No. 7072, 1970.

Sandlin, G. D. and Widing, K. G.

"Wavelengths and Identifications of Solar Emission Lines in the Spectral Range 145-425Å," Bulletin of the American Astronomical Society, 2, 340-341, 1970.

Prinz, D. K. and Meier, R. R.

"Absorption of the Solar Lyman Alpha Line by Geocoronal Atomic Hydrogen," Journal of Geophysical Research, Space Physics 75, No. 34, 1970.

Howard, R.A., Vanderslice, J.T. and Tilford, S.G.

"Ion Densities in the Night Ionosphere," Planetary and Space Science 18, 145-153, 1970.

Brueckner, G.E., Bartoe, J.F., Nicolas, K.R. and Tousey, R.

"Solar UV Flash Spectrum 1400Å-1960Å," ABSTRACT, Bulletin American Astronomical Society, 2, 299, 1970.

Brueckner, G.

"High Spectral and Spatial Resolution Ultraviolet Spectroscopy of the Sun in the Region 1170-1800Å," ABSTRACT, Bulletin American Astronomical Society 2, 1970.

Publications - August 1970 through October 1971

- Herzberg, G., Hugo, T. J., Tilford, S. G. and Simmons, J. D.
 "Rotational Analysis of the Forbidden $d^3\Delta_1 - X^1\Sigma^+$
 Absorption Bands of Carbon Monoxide," Canadian Journal
 of Physics, 48, No. 24, 3004-3015, 1970.
- Moe, O. K., Brueckner, G. E. and Hagyard, M. J.
 "Profile and Polarization of the Zeeman Triplet 5250.22 Å,"
 Bull. American Astronomical Society, 2, No. 4, 332, 1970.
- Benesch, W., Vanderslice, J. T. and Tilford, S. G.
 "r-Centroid Calculations for Observed and Permitted
 Transitions in N_2^1 ," Journal of Molecular Spectroscopy,
36, No. 3, 464-467, 1970.
- Ginter, M. L. and Tilford, S. G.
 "Electronic Spectra and Structure of the Hydrogen Halides,
 States Associated with the $(\sigma^2\pi^3)$ $C\pi$ and $(\sigma^2\pi^3)$ $C\sigma$
 Configurations of HBr and DBr," Journal of Molecular
 Spectroscopy 37, 159-178, 1971.
- Hunter, W. R., Osantowski, J. F. and Hass, G.
 "Reflectance of Aluminum Overcoated with MgF_2 and LiF
 in the Wavelength Region from 1600 Å to 300 Å at various
 Angles of Incidence," Applied Optics, 10, 540-544, 1971.
- Moritz, B. K. and VanHoosier, M. E.
 "CRTPAC - A Flexible High Speed Character Generator and
 Display Package," Digital Equipment Computer Users
 Society, 10, No. 4, 1971.
- Hunter, W. R., Mikes, T. L., Anstead, R. J. and Osantowski, J.F.
 "Deterioration of Vacuum Ultraviolet Reflecting Surfaces
 by the Formation of Intermetallic Compounds," Applied
 Optics, 10, No. 9, 2199-2201, 1971.
- Howard, R. A.
 "Effects of Langer Transformation on the Calculation of
 Internuclear Potential Curves," Journal of Chemical
 Physics, 54, 4252-4255, 1971.
- Michels, D. J., Tilford, S. G. and Quinn, J. W.
 "The Extreme Ultraviolet Spectrum of N IV," Journal of the
 Optical Society of America, 61, 625-631, 1971.
- Tilford, S. G.
 "Rotational Structure in the Spectra of Diatomic Molecules,"
 (Comments on) by Istvan Kovacs, American Elsevier Publishing
 Co., New York, Applied Optics, 10, 233, 1971.

Publications - August 1970 through October 1971

Tilford, S. G. and Simmons, J. D.

"Atlas of the Observed Absorption Spectrum of Carbon Monoxide between 1060 Å and 1900 Å," National Standard Reference Data Series, National Bureau of Standards, 1971.

Hunter, W. R., Cox, J. T. and Hass, G.

"Optical Properties of Evaporated Rhodium Films Deposited at Various Substrate Temperatures in the Vacuum UV from 150 Å to 2000 Å," Journal of the Optical Society of America, 61, No. 3, 360-364, 1971.

Pitz, E.

"Spectral Radiance of the Carbon Arc between 2500 Å and 1900 Å," Applied Optics, 10, 813-818, 1971.

Widing, K. G., Sandlin, G. E. and Cowan, R. D.

"On the Classification of Some Highly Ionized Iron and Nickel Lines in the 200-400 Å Region of the Solar Spectrum," The Astrophysical Journal, 169, No. 2, Part 1, 405-411, 1971.

Hunter, W. R., Cox, J. T., Hass, G. and Ramsey, J. B.

"Reflectance of Evaporated Rhenium and Tungsten Films in the Vacuum Ultraviolet from 300 Å to 2000 Å," ABSTRACT, Journal of Optical Society of America, 61, 665 (TUD14) 1971.

Tousey, R. and Koomen, M. J.

"The Relation Between the White Light and XUV Coronas on 7 March 1970," Solar Physics (Accepted for publication) 1971.

Brueckner, G. and Nicolas, K. R.

"Solar UV Flash Spectrum 1390 Å-1945 Å of the March 1970 Eclipse," Solar Physics (submitted for publication) 1971.

Tousey, R.

"High Resolution Solar XUV Observations," Space Research XII, (Accepted for publication) 1971.

Tilford, S. G. and Ginter, M. L.

"Electronic Spectra and Structure of the Hydrogen Halides: States Associated with the $(\sigma^2 \pi^2)$ $C\pi$ and $(\sigma^2 \pi^2)$ $C\sigma$ Configurations of HCl and DCl," Journal of Molecular Spectroscopy (accepted for publication) 1971.

Tilford, S. G. and Simmons, J. D.

"New Absorption Bands and Isotopic Studies of Known Transitions in Co," submitted to: Journal of Research, National Bureau of Standards, 1971.

Publications - August 1970 through October 1971

Brown, C. M. and Ginter, M. L.

"Spectra and Structure of He₂ Molecule, VI: Characterization of States Associated with 3p pi and 2s," Journal of Molecular Spectroscopy (accepted for publication) 1971.

Ginter, M. L. and Brown, C. M.

"Dissociation Energies of X doublet sigma + u (He₂⁺) and A singlet sigma + u (H₂)," Journal of Chemical Physics (accepted for publication) 1971.

Ginter, M. L. and Tilford, S. G.

"Hopfield Continuum in High Orders Using an Argon Filter," Applied Optics, (submitted for publication) 1971.

Howard, R. A.

"Energy Levels of the Rotation Vibrator," Journal of Molecular Spectroscopy, (submitted for publication) 1971.

Tilford, S. G., Howard, R. A. and Ginter, M. L.

"Fluorescence of Carbon Monoxide Excited by the 1306 Å Oxygen Resonance Line," Journal of Chemical Physics, (submitted for publication) 1971.

Bohlin, J. D., Koomen, M. J. and Tousey, R.

"Rocket-Coronagraph Photometry of the March 1970 Solar Corona Between 3 and 8.5 R_s," Accepted for publication, Solar Physics, 1971.

Talks - August 1970 through October 1971

Milone, E. F. and Schneider, W. P.

"A New Solar Atlas from Echelle Rocket-Ultraviolet Spectra," ABSTRACT, Bull. American Astronomical Society, 3, 1971.

Tousey, R.

"Possibilities for Measuring Atmospheric Extinction and Absorption with the ATM Solar Experiments in Skylab," Informal Conference on the Uses of Astronomy in the Study of Air Pollution, Project ASTRA, University of Washington, Seattle, Washington, 19 August 1971.

Ginter, M. L.

"Rydberg States of Small Molecules," INVITED PAPER, Joint U.S.-Japan Seminar on Current Problems in Spectral Studies (NSF), August 1971.

Hunter, W. R.

"Comparison of the XUV Reflectance Spectra of Evaporated Films of some Second and Third Series Transition Metals for Wavelengths less than 2000 Å," Third International Conference on Vacuum Ultraviolet Radiation Physics, Tokyo, Japan, August 1971.

Tousey, R.

"XUV Television of a Solar Image from a Rocket," Symposium on The Processing of Telescopic Images, Laval University, Quebec, Canada, 1-2 October 1971.

Hutcheson, E. T., Cox, J.T., Hass, G. and Hunter, W. R.

"Monitoring the Thickness of Thin MgF₂ and LiF Films on Al by Reflectance Measurements using the 1216 Å Line of Hydrogen," 1971 Annual Meeting Optical Society of America, Ottawa, Canada, October, 1971.

Hunter, W. R., Mikes, T. L. and Hass, G.

"Deterioration of Reflecting Coatings by Intermetallic Diffusion," 1971 Annual Meeting of Optical Society of America, Ottawa, Canada, October 1971.

Tousey, R.

"Solar Spectroscopy from Space Vehicles," Tenth National Meeting of Society for Applied Spectroscopy, St. Louis, Missouri, 18-22 October 1971.

SPACE SCIENCE DIVISION

Rocket Spectroscopy Branch (Code 7140)

Talks - August 1970 through October 1971

Tilford, S. G. and Ginter, M. L.

"High Resolution Absorption Spectra Associated with the $\pi^3c\pi$ and $\pi^3c\sigma$ Electronic Configurations in HCl, HBr, DBr, HI, and DI," Silver Jubilee of the Symposium on Molecular Structure and Spectroscopy, Ohio State University, 8-12 September 1970.

Howard, R. A. and Tilford, S. G.

"Analyses of the Schumann-Runge Band System ($B^3\Sigma_u^- - x^3\Sigma_g^-$) of O_2^{16} and O_2^{18} ," Molecular Spectroscopy Symposium, Ohio State University, 8-12 September 1970.

Bohlin, J. D.

"Apollo Telescope Mount - The First Manned Orbiting Laboratory," Harford County Astronomical Society, Harford Junior College, Maryland, 17 December 1970.

Tilford, S. G.

"The Carbon Monoxide Spectrum," Introduction Seminar Series, Institute of Molecular Physics, University of Maryland, 1 April 1971.

Sitterly, C. M.

"Infrared Atomic Spectra," ABSTRACT, Seventeenth International Astrophysical Symposium, Liege, Belgium, June 1971.

Bohlin, J. D., Koomen, M. J. and Tousey, R.

"Rocket-Coronagraph Photometry of the March 1970 Solar Corona Between 3 and 8.5 R_s ," 1971 COSPAR Meeting, Seattle, Washington, 17 June - 2 July 1971.

Brueckner, G. and Moe, O. K.

"Absolute Intensity Measurements of the UV Solar Continuum (1400-1790 Å) with High Spatial and Spectral Resolution," COSPAR/IAU Symposium on High Resolution Astronomical Observations from Space, Seattle, Washington, 28 June - 2 July 1971.

Sitterly, C. M.

"The Solar Spectrum in the Infrared and Ultraviolet Regions," Astronomy Colloquium, University of Michigan, August 1971.

APPENDIX B

.

E. O. Hulburt Center for Space Research
and
Laboratory for Cosmic Ray Physics

.

COLLOQUIA

E. O. Hulburt Center for Space Research
and
Laboratory for Cosmic Ray Physics

COLLOQUIA

.....

20 August 1970

Prof. Yehuda Yeivin, Univ. of Tel Aviv and Goddard
Institute for Space Studies
"MUON SPECTRA AND CHARGE RATIOS IN THE COSMIC
RADIATION"

15 September 1970

Dr. Richard C. Henry, Johns Hopkins University and
NRL
"RECENT RESULTS IN X-RAY AND ULTRAVIOLET ASTRONOMY"

8 October 1970

Prof. K. McCracken, Univ. of Adelaide, South Australia
and Univ. of Texas at Dallas
"SOLAR COSMIC RAYS"

22 October 1970

Prof. Donat G. Wentzel, Univ. of Maryland, Astronomy
Dept., College Park, Md.
"ACCELERATION AND HEATING OF THE INTERSTELLAR GAS BY
COSMIC RAYS"

5 November 1970

Dr. Wallace H. Tucker, American Science and Engineering,
Cambridge, Mass.
"X-RAY EMISSION FROM SUPERNOVA REMNANTS"

12 November 1970

Prof. P. J. E. Peebles, Dept. of Physics, Princeton
University, Princeton, New Jersey
"HOW DO GALAXIES FORM?"

3 December 1970

Dr. Seth D. Shulman, Research Associate, E.O. Hulburt
Center for Space Research, NRL
"THE INTERSTELLAR MEDIUM: A HIGH RESOLUTION OPTICAL
STUDY OF THE INTERSTELLAR LINE SPECTRUM OF ZETA
OPHIUCHI"

11 December 1970

Prof. Livio Scarsi, Dept. of Physics, University of
Palermo, Palermo, Sicily, Italy
"GAMMA RAY OBSERVATIONS OF THE CRAB NEBULA PULSAR"

7 January 1971

Dr. R. Grant Athay, High Altitude Observatory,
Boulder, Colorado
"ENERGY BALANCE IN THE CHROMOSPHERE-CORONA TRANSITION
REGION"

14 January 1971

Dr. John H. Hoffman, Assoc. Professor, Atmospheric
and Space Sciences, The Univ. of Texas at Dallas,
Dallas, Texas
"COMPOSITION MEASUREMENTS OF THE POLAR IONOSPHERE--THE
POLAR WIND"

28 January 1971

Mr. Harry A. Taylor, Jr., Thermosphere and Exosphere
Branch, Goddard Space Flight Center, NASA, Greenbelt,
Maryland
"SOME RECENT RESULTS OF TOPSIDE ION COMPOSITION
MEASUREMENTS"

11 February 1971

Dr. Richard L. Blake, Dept. of Astronomy and Astro-
physics, University of Chicago, Chicago, Illinois
"K X-RAY TRANSITIONS IN MULTIPLY IONIZED ATOMS: SOLAR
AND LABORATORY"

18 February 1971

Dr. Joseph Silk, Berkeley Astronomy Department, Univ.
of California, Berkeley
"X-RAYS AND THE INTERSTELLAR MEDIUM"

25 February 1971

Prof. L. Woltjer, Dept. of Astronomy, Columbia Univ.,
New York
"QUASI-STELLAR OBJECTS AND ACTIVE NUCLEI IN GALAXIES"

11 March 1971

Prof. S. Chandrasekhar, The Enrico Fermi Institute,
University of Chicago, Chicago, Ill.
"ON THE PROBLEM OF ROTATING STARS IN GENERAL
RELATIVITY"

18 March 1971

Dr. Chet B. Opal, Joint Inst. for Laboratory
Astrophysics, University of Colorado, Boulder,
Colorado
"SECONDARY ELECTRON SPECTRA FROM ATMOSPHERIC GASES
WITH EMPHASIS ON THE AURORA"

1 April 1971

Mr. Patrick S. McIntosh, Space Disturbances
Laboratory, Environmental Science Services
Administration, Boulder, Colorado
"SUNSPOT EVOLUTION AND SOLAR FLARES"

29 April 1971

Dr. A. A. Penzias, Bell Telephone Laboratories, Inc.,
Holmdel, New Jersey
"MILLIMETER WAVE OBSERVATIONS OF INTERSTELLAR
MOLECULES"

6 May 1971

Dr. Ray Weymann, Steward Observatory, University
of Arizona, Tucson, Arizona
"CURRENT RESEARCH ON NUCLEI OF GALAXIES AT THE
UNIVERSITY OF ARIZONA"

20 May 1971

Prof. Kinsey A. Anderson, Dept. of Physics, Univ.
of California, Berkeley, California
"SOLAR FLARE X-RAY BURSTS"

27 May 1971

Dr. Frank Low, Lunar and Planetary Laboratory, Univ.
of Arizona, Tucson, Arizona
"FAR INFRARED ASTRONOMY"

17 June 1971

Dr. Blair D. Savage, Washburn Observatory, Univ. of
Wisconsin
"STUDIES OF THE INTERSTELLAR MEDIUM FROM OAO-2"

15 September 1971

Dr. Herbert Friedman, Supt., Space Science Division,
NRL
"TWENTY-FIVE YEARS OF ROCKET ASTRONOMY AT NRL"

23 September 1971

Prof. J. H. Oort, Leiden Observatory, Leiden,
Holland
"RADIO STRUCTURE OF GALAXIES"

7 October 1971

Prof. A. G. W. Cameron, Belfer Graduate School of
Science, Yeshiva University, New York
"EVOLUTION OF THE GALAXY AND ABUNDANCE OF BLACK
HOLES"

21 October 1971

Dr. Allen G. Blair, Los Alamos Scientific Laboratory,
Los Alamos, New Mexico
"RECENT ROCKET OBSERVATIONS OF THE FAR INFRARED
BACKGROUND"

4 November 1971

Prof. Edward P. Ney, School of Physics and Astronomy,
University of Minnesota, Minneapolis, Minn.
"RECENT GROUND-BASED OBSERVATIONS IN INFRARED
ASTRONOMY"

18 November 1971

Prof. William A. Fowler, Kellogg Laboratory, Cali-
fornia Institute of Technology, Pasadena, California
"SYNTHESIS OF THE SUPERHEAVY NUCLEI"