44. COMMISSION DES OBSERVATIONS ASTRONOMIQUES AU-DEHORS DE L'ATMOSPHERE TERRESTRE

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INTRODUCTION

Of the many important developments in space astronomy during the past three years perhaps the most dramatic was the voyage of the Mariner II, which passed less than 35 000 km from the surface of the planet Venus on 14 December 1962, and from which valuable measurements were made of the mass and magnetic field of Venus, of the structure of its atmosphere and of conditions in the interplanetary medium. A second event, of great importance to solar physics, was the successful launching in March 1962 of the first of NASA's 'Orbiting Solar Observatories', the first satellite to be especially designed as a stabilized platform for solar observation. Six additional satellites in this series are planned between 1964 and 1966. Striking advances in the range and quality of rocket solar spectra have also been achieved. Soft X-ray spectra have been photographed to a short-wave limit of 13·8 Å and the resolving power at longer wavelengths has been improved by as much as a factor of 10.

Broad-band rocket observations of ultra-violet stellar spectra have been improved and extended, and the Goddard Space Flight Center of NASA has also secured the first records of ultra-violet continuous spectra of early-type stars, in the range between 1100 Å and 3000 Å. Rocket observations of cosmic radio noise at frequencies as low as 0·7 Mc/s have also been carried out. It now seems reasonably certain that X-ray emission from at least one galactic source has been observed.

Although the new results obtained from observational platforms outside the Earth's atmosphere are impressive, they do not tell the whole story of progress in the field, which also includes enormous engineering efforts in the design and construction of highly sophisticated and reliable rocket boosters, spacecraft, and astronomical instrumentation for the space observatories that will begin operating during the next few years. It is to be expected that many of these preparations will be translated into astronomical results by the time of the 1967 General Assembly.

Very steady progress has been made in the development and construction of NASA's Orbiting Astronomical Observatories (OAO). Three such observatories are definitely scheduled, of which the first is to be put up in 1965. At the time of the Berkeley meeting of the IAU, astronomical observations from space vehicles had been carried out almost exclusively in the U.S.S.R. and in the U.S. The past three years have witnessed the steady growth of plans for the future European Space Research Organization (ESRO) and of active experimental programs in several countries, especially in the United Kingdom and in France. The developing

ESRO program is extremely impressive in its planning and should soon become comparable in size and importance with those in the United States and the Soviet Union. It is to be hoped that the three efforts will not be mutually exclusive, but that there will be a continuation and expansion of such international projects as the launching of the UK–1 satellite by a NASA rocket.

The subject matter of the Draft Report has been organized under seven headings: (1) Spacecraft, Instrumentation, Future Experiments; (2) Solar Ultra-violet; (3) Solar Gamma- and X-Rays; (4) Galactic Ultra-violet; (5) Galactic Gamma- and X-Rays; (6) Radio Emission, and (7) Visible and Infra-red. An earnest effort has been made to include all results of astronomical observations from space vehicles which had been published by 1 November 1963, or had otherwise come to my attention by means of preprints or correspondence. Owing in part to the great interest that space astronomy has for neighboring disciplines, identical results are frequently published in two or more journals. Hence, the content of the bibliography is somewhat selective. Furthermore, I have attempted to exclude material that seemed certain to be included in the Reports of other Commissions that deal with subject matter rather than with techniques. The Presidents of the relevant Commissions were informed of this plan in advance of the preparation of the Report. As examples of material omitted from this Report, I would mention papers dealing with the construction of models of the solar atmosphere from observations of extreme UV and X-ray emission, theoretical calculations of stellar ultra-violet radiation according to the theory of model atmospheres, etc.

The first section of the bibliography contains selected references to review articles and to the Proceedings of symposia and conferences. The first two entries refer to the Proceedings of the Second and Third International Symposia organized by COSPAR and held respectively in Florence, Italy, in 1961, and in Washington, D.C., in 1962. (**1**, **2**). References to *Space Res. IV* refer to the as yet unpublished Proceedings of the Fourth COSPAR Symposium held in Warsaw, Poland, in June 1963. The volume *Space Age Astronomy* resulted from a symposium sponsored by the Douglas Aircraft Company and held at the California Institute of Technology in Pasadena in August 1961 just before the Eleventh General Assembly. The Proceedings of the First International Conference on Vacuum Ultra-violet Radiation Physics, published as a special issue of the *Journal of Quantitative Spectroscopy and Radiative Transfer*, is of great interest not only because it contains a relatively small number of excellent articles on space astronomy, but also because it furnishes an excellent overall view of the current state of research in vacuum ultra-violet spectroscopy and its associated instrumentation. Finally, special mention should be made of the *Proceedings of the NASA-University Conference on the Science and Technology of Space Exploration* and of *A Review of Space Research*, the latter being the report of the 1962 Iowa Summer Study of the U.S. space research program. The NASA-University volumes are of interest to astronomers primarily because of the information they contain on the technology of space research.

SPACECRAFT, INSTRUMENTATION, FUTURE EXPERIMENTS

This section contains highly selected references to papers dealing with the design and construction of major spacecraft and of the astronomical instrumentation they carry. These references are necessarily incomplete both because instrumental details are frequently not published and because many of the experiments scheduled for flight are still in the developmental stage.

Orbiting Solar Observatories

The U.S. National Aeronautics and Space Administration is planning a series of seven spacecraft, under the designation Orbiting Solar Observatories, to be launched at regular intervals during the next few years. As already mentioned, the first satellite in the series, OSO–1 or S–16, was successfully launched on 7 March 1962. Successive members of the series will be designated OSO–B, OSO–C, etc. OSO–1 was designed to point continuously at the center of the solar disk with an accuracy of about 1 arc minute. In actual operation, the pointing accuracy has consistently been within ± 2·5 arc minutes in elevation and ± 1·0 arc minute in azimuth from the center of the solar disk (**75**). OSO–B will have the additional capability of carrying out raster scans, with a resolving power of 1 arc minute, over an area of 40 arc minutes square centered on the Sun. A detailed description of the OSO–1 spacecraft and a report of its performance in orbit were presented at the 1962 COSPAR meeting in Washington, D.C. (**11**). The scanning mechanism for the soft X-ray (100 Å–400 Å) spectrometer experiment of Behring and Lindsay has also been described (**12**). The spacecraft also provided data on short wavelength (1 Å–10 Å) solar X-rays, solar gamma-rays, the neutron albedo of the Earth, and the micrometeorite density at about 450 km altitude. The second OSO is expected to be launched early in 1965, and the third six to nine months later. The pointed section of OSO–B will carry the following experiments: (1) The Harvard College Observatory is furnishing a scanning spectrometer in the range 500 Å–1500 Å which may also be employed in conjunction with the raster scan to make spectroheliograms at any desired wavelength in the spectral range of the instrument (**13, 14**); (2) The U.S. Naval Research Laboratory will carry out observations of solar X-ray bursts in the 8 Å–20 Å and 44 Å–66 Å regions, together with white light observations of the outer solar corona (**15**) and spectroheliograms in Lyman-α and in He II λ304. The wheel section, which rotates with a period of two seconds about an axis perpendicular to the solar direction, will also carry four experiments, including the intensity and direction of polarized light from interplanetary space (E. P. Ney, University of Minnesota), the arrival direction and energies of primary cosmic rays, 50–1000 Mev (**16**) (C. P. Leavitt, University of New Mexico), the gamma-ray energy spectrum 0·1–5 Mev (**17**) (K. J. Frost, Goddard Space Flight Center), and ultra-violet stellar and nebular spectrophotometry in the region 900 Å–3800 Å (**18**) (K. L. Hallam, W. A. White, Goddard Space Flight Center).

Pointed experiments on OSO–C will include monochromator measurements of solar extreme ultra-violet (H. E. Hinteregger, U.S. Air Force Cambridge Research Laboratories) and studies of the spectrum of the integrated solar disk from 1 Å to 400 Å (W. E. Behring, W. A. White, W. M. Neupert, J. C. Lindsay, Goddard Space Flight Center). The following astronomical experiments will be carried in the wheel: X-ray and gamma ray astronomy (L. E. Peterson, University of California, La Jolla), gamma-ray astronomy (W. L. Kraushaar, Massachusetts Institute of Technology), solar X-rays (R. G. Teske, University of Michigan, McMath-Hulbert Observatory), and solar gamma-rays (E. M. Hafner, M. F. Kaplon, University of Rochester).

Orbiting Astronomical Observatories

The Orbiting Astronomical Observatory (OAO) provides a precisely stabilized platform on which astronomical observing equipment can be mounted. This spacecraft is 10 ft in diameter, 10 ft long, and weighs about 3600 lb. The ultimate goal of this series of satellites, of which three are scheduled to be launched at approximately yearly intervals beginning in 1965, is a pointing accuracy of one arc second (**19, 20, 21**). The first OAO will carry two major experiments, the first designed to carry out a map of the sky in four ultra-violet bands of wavelength by the Smithsonian Astrophysical Observatory (R. J. Davis and F. L. Whipple) and the second consisting of multi-color photometry at ultra-violet wavelengths from 800 Å to 3000 Å of individual stars and nebulae, by the University of Wisconsin (A. D. Code). The Smithsonian (**22, 23, 24**) plans to install four telescopes of 30 cm aperture, each with a field of view of four square degrees, to cover the spectral regions 1100 Å–1600 Å, 1350 Å–1600 Å, 1600 Å–2900 Å, and 2400 Å–2900 Å. Two types of 'uvicon' television camera tubes, developed by Westinghouse, establish the above long wavelength cut-offs. Four types of optical filters are used to establish the short wavelength cut-offs. The primary objective of this experiment, called Project Celescope, is to measure the brightness of every star that is above the equipment threshhold, in each of the four wavelength regions, to an accuracy of 0·1 magnitude. The equipment threshhold is approximately 0·04 photons cm^{-2} sec^{-1} $Å^{-1}$. It is anticipated that approximately 9 × 10^4 O-Stars, 6 × 10^4 B-stars, 1 × 10^4 A-stars, and (at longer wavelengths only) 1 × 10^3 F-G- and K-stars will exceed this threshhold. The second OAO will contain a system provided by the Goddard Space Flight Center (J. E. Kupperian and J. E. Milligan) consisting of a 36-inch Cassegrain telescope with a large aperture spectrophotometer operating in the range 912Å–4000Å, and designed to obtain absolute spectrophotometric measurements on selected stars, nebulae, and galaxies. The third OAO will also carry a large-aperture telescope and high-dispersion spectrograph with the primary objective of obtaining quantitative observations of the absorption spectrum of interstellar gas in the region between 800Å–3000Å. This is the so-called Flying Telescope Project of L. Spitzer and J. B. Rogerson, Princeton University Observatory. A communication from Dr Rogerson has up-dated material appearing on pages 542 and 547 of the *Transactions of the IAU*, Vol. **11A**. The spectrograph provides resolution of both 0·1 Å and 0·4Å. The primary mirror is now *f*/3·4 and the diameter is 80 cm. The Cassegrain focus is still *f*/20. The entrance slit subtends 0·3 arc seconds. The prototype of the satellite instrument is under construction and will be environmentally tested in summer 1964. With reference to the sounding rocket spectrometer previously described, two instruments have been prepared but are awaiting the successful operation of the necessary Aerobee three-axis attitude control system. The first launching is estimated for the spring of 1964. Princeton is also preparing for a flight, in the spring of 1964, of two photographic objective-grating spectrographs in which Schmidt optics are used to give a usable field of 10° × 10° and an effective focal ratio *f*/2·5. The spectral range of the first spectrograph is 1250Å–2080Å and of the second 1880Å–3000Å. The instrument is gimbaled and gyro-stabilized in one axis so that limit cycling of the Aerobee attitude control system will not degrade the spectral resolution, which is hoped to be in the range 1Å–2Å. The spectrograph, which has the same purpose as the spectrometer, is a back-up instrument which should operate successfully with the presently available Aerobee attitude control system.

Orbiting Geophysical Observatories

The Orbiting Geophysical Observatory (OGO) is capable of housing about 30 scientific experiments (**25**, **26**, **27**). Two types of orbits are presently planned with two satellite launchings scheduled for each, beginning in 1964. The eccentric OGO or EGO will be placed in an orbit reaching from a perigee of 170 miles to an apogee of 69 000 miles whereas the polar OGO or POGO will be launched into near Earth (160–570 miles) polar orbits. The EGO will be launched with an Atlas Agena from Florida and the POGO with a Thor-Agena from California. The OGO spacecraft are obviously intended primarily for geophysical research, but a number of projects of direct importance to astronomy have also been included in the payloads. Haddock, Walsh, and Schulte (University of Michigan) have prepared radio astronomy payloads for both EGO and POGO. The EGO experiment consists of a receiver sweeping from 2–4 Mc/s approximatley once per two seconds, primarily to investigate solar and possibly Jovian bursts as well as to explore the general noise environments. The antenna will be asymmetrical, consisting of a 9-meter extensible whip operated against the spacecraft as an electrical counterpoise. The POGO experiment is designed to survey the sky distribution of cosmic noise at 2·5 Mc/s using the theoretically predicted ionospheric focusing to obtain some directivity. The payload includes a fixed frequency receiver at 2·5 Mc/s with calibration equipment including measurement of antenna impedance and an auxiliary receiving channel at 2·0 Mc/s. The antenna will again be asymmetrical, consisting of an 18-meter extensible whip and the spacecraft body. The following additional experiments are relevant to the work of the Commission: For the first EGO, solar cosmic-rays, 10–90 Mev, K. A. Anderson, University of California; positron and gamma ray detection, T. K. Cline and E. W. Hones, Jr., Goddard Space Flight Center; galactic cosmic rays and isotope abundance with cosmic ray telescope, F. B. McDonald, and D. A. Bryant, Goddard Space Flight Center; low energy galactic cosmic ray flux, using charged particle telescope to study protons above 0·2 Mev and other nuclei at higher energies, J. A. Simpson, C. Y. Fan, and P. Meyer, University of Chicago; Lyman-α scattering in the geocorona and the interplanetary medium, P. M. Mange, Naval Research Laboratory. For the POGO, photometer airglow measurements at 6300Å, 5577Å, 3914Å, and in the near ultra-violet region, J. Blamont and E. I. Reed, University of Paris and Goddard Space Flight Center; airglow studies in the Lyman-α, far ultra-violet and 1230Å–1350Å with UV ion chamber, P. M. Mange, T. A. Chubb, and H. Friedman, Naval Research Laboratory; ultra-violet spectrometer for airglow measurements between 1100Å and 3400Å, C. A. Barth and L. Wallace, Jet Propulsion Laboratory and Yerkes Observatory.

United Kingdom Satellites

Satellites constructed by scientists and engineers in the United Kingdom are being launched by NASA in a co-operative program. The first in the series, known as UK–1, or ARIEL, or International Ionosphere Satellite, was successfully launched in 1962 (**28**). The second in the series, UK–2, which is now being prepared for launching, will include (1) a galactic radio noise study in the frequency range between 0·75 and 3·0 Mc/s and exploration of the upper atmosphere by F. G. Smith, University of Cambridge, (2) a study of the vertical distribution of ozone in the Earth's atmosphere using filtered photo-cells and a prism spectrometer in the region from 2500Å to 4000Å by R. Frith and K. A. Stewart of the U.K. Air Ministry and (3) a study of micrometeorite flux: the quantity and size of particles down to several microns studied by the holes formed in thin aluminium foil by R. C. Jennison at Jodrell Bank, Nuffield Radio Astronomy Laboratories. A successful experiment employing this technique was performed in a Skylark rocket launched from Woomera.

Advanced Orbiting Solar Observatory

The Goddard Space Flight Center of NASA has been carrying on design studies of an Advanced Orbiting Solar Observatory (AOSO) as a second generation solar observing platform (**29, 30**). The spacecraft in the OSO series are of limited capability in that the pointing accuracy is 1 arc minute, and the space and weight available for pointed experiments are relatively small, the volume being 8 × 8 × 38 in and the weight less than 70 lb. The proposed AOSO would provide 250 lb of weight for experiments occupying a volume of more than 45 cubic ft and permitting equipment as long as 10 ft. The pointing accuracy would be 5 arc seconds with a short-term jitter of no more than 0·5 arc sec/sec. The spacecraft would be capable of being pointed at any part of the Sun on command.

Project Polariscope

A program of polarimetry and photometry on stars and planets with telescopes on the ground (**31**) is being extended with preparations for flights with a balloon telescope and a Mariner polarimeter. A 28-inch telescope is nearly completed and a balloon gondola, with attitude control (± 20 arc sec), telemetry, 2 vidicons, and a photometer/polarimeter (**32**). The Wollaston-type prism is constructed of ammonium-dihydrogen phosphate (ADP). Cements for the Wollaston prism and filters near 2600Å are described by Pellicori (**33**). A new test instrument was constructed consisting of a monochromator, a collimator, a reference detector, a goniometer table, an ADP Glan Thompson polarizing prism, a telescope, and detectors for the range 1800Å–7000Å.

Project Coronascope II

A new and improved coronagraph for balloon-borne photography has been built at the High Altitude Observatory in Boulder. The instrument has an objective aperture of 3·2 cm and employs three apodized, external occulting disks at a maximum distance of 229 cm in front of the objective lens. The coronagraph is designed to photograph the K-corona from 1·5 $R_{\odot}$ to 5 $R_{\odot}$ from the center of the solar disk with a resolution of approximately 12 arc seconds. Tests of the scattered light in the system carried out in the vacuum tank of the Kitt Peak National Observatory show the stray light to have a radiance of about 10^{-9} of the mean disk of the Sun (34).

Project Sky Top

This project is a balloon-borne program of planetary astronomy being carried out by the Air Force Cambridge Research Laboratories of the U.S. Air Force under the direction of Dr J. W. Salisbury. The general research objectives are both high resolution photography and infra-red spectroscopy of the Moon and planets. The present system employs a 12-inch Cassegrain *f*/20 telescope that can track a planet to within a few seconds of arc. The present flights are designed to obtain the infra-red emission spectrum of the Moon with special emphasis on the region from 7–16 microns. The lunar spectra will be compared with the characteristic emission spectra of coarsely powdered minerals obtained in laboratory studies at AFCRL. Flights are also planned for the spring of 1964 to obtain the near infra-red spectrum of Venus. The spectrometer will be a single slit grating instrument with the output multiplexed by means of a coded disk. This flight is especially designed to measure the amount of water vapor above the Venus cloud deck. The long-range plan for Project Sky Top includes the building of a 24-inch telescope to photograph the Moon and planets at the diffraction limit as well as to obtain higher resolution spectra.

Dr R. Lüst, scientific director of the future European Space Research Organization, has commented on the present status of ESRO as follows:

'It is hoped that ESRO will come into existence at the beginning of 1964. At present there exists a so-called Preparatory Commission (COPERS). It is planned that ESRO will carry out a number of astronomical observations from rockets, satellites and space probes. So far the following number of proposals from different groups of the member states have been received:

	sounding rockets	satellites/space probes
solar astronomy	14	14
interplanetary medium	1	7
stellar astronomy	8	6
	23	27

One of the first smaller satellites will carry instruments to observe the Sun in different *UV*- and X-ray regions. Furthermore, it is planned to develop a medium-sized stabilized satellite for astronomical observations with a weight of 200 kg and a roughly circular orbit of about 300 km of altitude. Of particular interest is the planned large astronomical satellite. The detailed scientific requirements of this satellite are still under discussion, but the main objective is to obtain spectra of stars in the range of 900 Å–3000 Å with a resolution of 1 Å or better (35). As secondary instruments a broadband (X-ray) recorder and a gamma-ray telescope may be included in the payload. For the three satellite projects mentioned, preliminary design studies have been started already.'

Other Planned Experiments

One of the small ESRO satellites might be instrumented jointly by groups at Liège and Edinburgh for stellar photometric mapping of the sky in the ultra-violet and the infra-red.

The program at the Royal Observatory, Edinburgh, (H. E. Butler) also includes photoelectric, photometric and spectrophotometric observation in the region 1600 Å–3500 Å from unstabilized rockets and night-sky photography from stabilized rockets. P. Swings reports a plan to launch in 1964 a rocket containing about 50 kg of ammonia which should reach a height of 240 km. Photographic, photometric, and spectrographic observations of the NH_3, NH_2 and NH clouds will be carried out from several stations. It is hoped that this experiment, which is directed by Dr B. Rosen, will give useful information on the photo dissociation processes leading to the formation of NH_2 and NH radicals in comets. Other experiments in preparation at Liège include the launching of a rocket equipped with an ultra-violet spectrograph through an aurora and recovery of the spectrogram. Swings (**36**) has made a detailed examination of the possibilities for investigating comets by space experiments.

Dr R. L. F. Boyd has communicated plans for a number of solar and stellar studies in X-rays and in the ultra-violet which he and his group at University College London are engaged in carrying out. All of the studies at wavelengths below 100Å are conducted in co-operation with the University of Leicester (Prof. E. A. Stewardson). Ultra-violet studies of the Sun are at present concentrated on those spectral lines which are of importance to conditions in the ionosphere. Several firings are scheduled for observations of the Lyman-α lines of hydrogen and ionized helium (1216Å and 304Å). Space has been allocated both on OSO-D of NASA and on ESRO II, the latter a NASA SCOUT launching. A useful monochromator has been developed, and it is expected later to extend these observations to other spectral lines (e.g. He I 584Å). In the field of solar X-rays, future work includes the flying of a wide band 1Å–70Å (26 intervals) proportional counter spectrometer on rockets and on NASA OSO-D and a grazing incidence reflection scanning spectroheliograph on two stabilized Skylarks and on NASA OSO-E. Leicester University is independently conducting solar studies from stabilized rockets using photographic recording of dispersed X-ray spectra. Use continues to be made of the emulsion and filter X-ray recorder developed at University College.

University College plans for stellar astronomy in the ultra-violet include the launching early in 1964 of a 13½ inch rocket-borne telescope with photometers operating in three wave-bands, between 1500Å and 2700Å, to make a random scan of part of the Southern sky. This is expected to be the last unstabilized firing in connection with ultra-violet stellar studies. A further gyro-stabilized round scheduled for the same period will photograph three broad areas of the sky in a band around 1900Å. No further stellar *UV* rounds are scheduled, but current studies are aimed to obtain detailed spectra using stabilized Skylarks. The gyro-stabilized round refererd to above will also carry a large window shielded X-ray counter to obtain data on X-ray fluxes from the night sky. A cluster of three grazing incidence X-ray telescopes, covering the spectral range from 1Å to 50Å with shielded proportional counter detectors, is to be flown on NASA OAO-3 when long exposures of large numbers of selected celestial objects will be made.

C. de Jager reports three projects of interest to solar physics being worked on by the Space Research Group at the Utrecht Observatory. First, X-ray radiation of the Sun in the wavelength region between 30Å and 60Å will be measured on different occasions with Veronique and Centaure rockets. Second, an experiment has been built for measuring the primary cosmic radiation of the Sun, at first from a stratospheric balloon at about 35 km altitude and later from a rocket with parachute recovery. The first experiment will take place in January 1964. Third, good progress has been made in the fabrication of Fresnel zone plates which will be suitable as an image-forming device in soft X-rays. Proposals to fly such an experiment for solar imaging in European and American rockets have been submitted to ESRO and NASA.

At Nuffield Radio Astronomy Laboratories, several techniques have been proposed (**37**) for using the focusing properties of the ionosphere to perform spatial surveys of the radio sky at frequencies in the range 1–5 Mc/s (**38**). In particular, a system has been developed whereby a resolving power of the order of half a degree is obtained by surveying with the sharp occulting edge of the reception pattern as the satellite orbits the Earth. The system is rapidly commutated between two adjacent frequencies to remove the background radiation. J. L. Steinberg reports that a group at Meudon has been set up to design a radio astronomy experiment to be carried out by the end of 1964 on board a rocket from an altitude of 2000 km or more. The equipment will be capable of making absolute measurements of the temperature of the background sky at several frequencies between 1 and 5 or 6 Mc/s.

According to R. Lüst, three projects are at present in preparation at the Institute for Extra-terrestrial Physics of the Max Planck Institut. They are being carried out in close co-operation with Biermann. Investigations of the interplanetary medium will be carried out by means of a barium or strontium cloud with mass of the order of 1 kg which will be evaporated in the interplanetary medium (**38 bis**) (see also **38 ter**). The cloud should be ionized by sunlight, and its interaction with the solar wind will be studied and observed from the ground. Preliminary experiments were carried out in 1963 with French sounding rockets in the ionosphere. Measurements of the electron density in the interplanetary medium and observations of the *UV* radiation of comets with a *UV* spectrograph in a sounding rocket are also planned.

A. Dollfus is at present studying an instrument that will permit him to photograph the solar corona directly from a stratospheric balloon. The telescope is a small coronagraph, the lens of which is protected from direct sunlight by an occulting disk carried on a long arm. The gondola will be stabilized and automatic equipment will permit the coronagraph to point toward the Sun and to record photographs of coronal images.

T. Gold is directing the development of Project Tigris (Televised Images of Gaseous Regions in Interplanetary Space) which aims to obtain images of diffuse light-scattering regions in the solar system. By free electron scattered sunlight it is hoped that the shapes and extents of solar-ejected plasma clouds and of the associated magneto-hydrodynamical shock waves can be observed, thus leading to predictions of regions accessible to solar cosmic-rays at a given time and determination of whether magnetized bulges can become disconnected from the Sun. Observations of the corona will determine the extent of the co-rotating mass around the Sun. The main dust observations, including polarization studies, will be of the zodiacal light. Brightness contours of it and the gegenschein can be made, and any fluctuations due to interactions with gas noted. Perhaps further sources of luminosity will be discovered, such as a presently suggested diffuse dust belt surrounding the Earth. As it is thought that eventually these observations will be required continuously in connection with manned space flights, the present approach is to develop television techniques by sounding rocket. The major components of the television payload are the camera, telemetry equipment, transmitter, antenna and power supply. The camera tube of 90° lens aperture will be a ruggedized image orthicon with improved resolution and increased sensitivity in the 4000 Å–6000 Å range to detect the dominant radiation in the zodiacal light. The payload is designed to be flown to an altitude of 600 miles and pointed by using a spin-stabilized attitude-control system with an accuracy of 5°. The duration of the flight above 300 miles will be approximately $11\frac{3}{4}$ minutes. In order to use the Earth as a shield against the direct rays of the Sun, the flight must take place before sunrise or after sunset.

In order to detect celestial high-energy gamma-ray sources, to measure the incident flux and energy spectrum and to determine the angular size of the source, a large area multiplate spark chamber detector is being developed at the Smithsonian Astrophysical Observatory by G. G. Fazio for use in balloons and satellites. The principle of the detector is based on the visual representation by sparks of the positron-electron paths produced when an incoming gamma-ray photon interacts with the spark chamber plates. A television system will record a stereoscopic view of the event for transmission from the balloon or satellite. The primary problem with present gamma-ray detectors is background radiations. Use of a visual device such as the spark chamber will permit the entire photon interaction to be viewed so as to verify the nature of the particular interaction. The spark chamber detector also has a large sensitive area, a large sensitive solid angle, with ability to determine the arrival direction of a high-energy photon to about one degree. A spark chamber detector with a sensitive area of 500 cm^2 has been proposed for future flights on the Orbiting Astronomical Observatory.

Other Spectroscopic Equipment

Namioka (**39**) has carried out a careful analysis of design considerations entering into the choice of grating mountings for use in the ultra-violet region of the spectrum. A useful survey of instrumental problems in space spectroscopy, as illustrated by equipments developed at the Naval Research Laboratory, has been given by Tousey (**40**). Two other papers describe the performance of an echelle spectrograph with a resolving power approaching 200 000 (**41**), and a high resolution spectrograph for solar rocket spectroscopy in the region 2000 Å–3500 Å with a resolving power of 100 000 (**42**). A report from the Air Force Cambridge Research Laboratory (**43**) describes the construction and operation of a proportional counter spectrometer for solar X-rays between 1 Å–10 Å, to be flown in an Aerobee rocket. A photo-electric diffraction spectrometer (**44**) for recording the region of the solar spectrum near λ304 He II with an open cathode photo-multiplier (**45**) and a tracking head for illumination of the slit (**46**) was designed for flight on board the second and third Soviet spaceships, 1960, August 19–20 and December 1–2.

Components

This section of the report contains references to laboratory studies of the properties of components and materials, such as transmission filters, reflecting films, detectors, etc. A number of studies have been made in the laboratory, yielding quantitative data on middle ultra-violet transmission filters in the wavelength region 2000 Å–3500 Å (**47, 48**). Bonnet and Courtès have developed a filter with multiple and adjustable wavelength bands to study the ultra-violet solar continuum between 2000 Å and 3000 Å (**49**). Studies have also been made on interference transmission filters for the far ultra-violet (**50**).

A very useful survey discussion of the characteristics of ultra-violet photodetectors has been given by Dunkelman (**51**). Techniques especially suitable for the middle ultra-violet have also been discussed (**52**). Photocathodes with surfaces of BeO, MgO, SrF, Cs and Ni have been suggested as ultra-violet and X-ray radiation receivers, and the spectral distribution of their quantum yields derived for the region λ1000 Å–3000 Å (**45**). Measurements of the efficiency of these cathodes in the soft X-ray region have been carried out with the aid of monochromators employing concave diffraction gratings at grazing incidence and measuring absolute numbers of quanta (**53**). Hunter (**54**) has measured the sensitivity and spectral response of the tiny Bendix channel multiplier. Its spectral response is similar to that of tungsten, but its extremely small dimensions, roughly ½ mm in diameter by 3 cm long, offer intriguing possibilities for space application. The device will be used by Tousey and Purcell in the OSO-B satellite for the registration of spectroheliograms in the Lyman-α lines of H and He II, λ1216 and λ304. Other detectors consisting of small ceramic ion chambers have been constructed for the region 1050 Å–1500 Å (**55, 56**).

A discharge tube with flowing He or H giving lines of H_2, He I, He II, C II, C III, N II and O II is being used to determine the efficiency of reflecting surfaces of mirrors and gratings in the far ultra-violet (**57**). The coating of surfaces with thorium dioxide (ThO_2) significantly improves their efficiency at wavelengths shorter than 1000 Å (**58**). The phosphor $CaSO_4$–Mn is being used for the determination of the transparency of spectral devices in the region of Lyman-α (**59**). The relative intensities in two multiplets of N I, λ1492 and λ1745 have also been measured in the U.S.S.R. (**60**).

SOLAR ULTRA-VIOLET

In this and later sections, the term 'ultra-violet' will be used to refer to wavelengths between about 500 Å and 4000 Å, whereas the terms 'X-rays' or 'XUV' will apply to the region below λ500. The dividing line may also be taken as the wavelength at which normal incidence must give way to grazing incidence as a spectroscopic technique.

Rockets

Rocket spectroscopy of the Sun has enjoyed more success during the past three years than in any previous period between General Assemblies of the IAU. The beautiful results that have been obtained demonstrate that the rocket will continue to play a major role in astronomical spectroscopy from above the Earth's atmosphere for an indefinite number of years ahead, both in testing new instrumental concepts that may later be employed in satellites and in carrying out observations of solar phenomena that are not time-dependent and do not require long integration times.

A detailed study of the ultra-violet solar spectrum obtained in the U.S.S.R. in 1959 with the aid of geophysical rockets has now been published (**61**). The study lists wavelengths and identifications for more than 900 lines observed in the region 2632 Å–2900 Å with spectroscopic resolving power of 0·15 Å and also gives the absolute spectral energy distribution in the region 2470 Å–3100 Å (see also the review by Tousey (**8**)). Extremely high resolving power in the region 3500 Å–2200 Å was achieved during the flight of an échelle spectrograph by the Naval Research Laboratory on 21 August 1961 (**62**). The width at half maximum of the instrumental profile at λ2739 is 0·03 Å and is closely comparable with that of the Göttingen atlas at wavelengths longer than 3000 Å. Wavelengths have been determined to 0·01 Å. About 6400 lines have been listed from 3000 Å to 2180 Å, about half of which have been identified by comparison with the ultra-violet multiplet tables and finding list. Even with 0·03 Å resolution, there are no windows between 2600 Å and 2100 Å through which the continuum can be seen. Tousey plans to publish a line list with identifications from 3000 Å to 2180 Å, similar to the revised Rowland tables and in a second volume an intensity curve with line profiles. The instrument will be flown again in 1964 with a better échelle.

NRL spectra obtained in 1960 with a double-dispersion grating spectrograph have been employed to derive the intensity distribution in the ultra-violet solar spectrum, averaged over 50 Å intervals, in the region 850 Å–2600 Å (**63**). New spectra with greatly increased resolution were obtained on 22 August 1962, from a peak altitude of 233 km (**64**). The spectroscopic resolution over the wavelength range 2000 Å–1200 Å was approximately 0·2 Å. A second spectrograph covered the region 1250 Å–800 Å with a resolution of 0·07 Å. The new spectra are fully stigmatic and clearly show the effect of plage regions and of limb brightening.

The photo-electric scanning spectrometer, which has been developed at the Harvard Observatory for flight in the Second Orbiting Solar Observatory (OSO-B or S-17) (**65**), was flown in an Aerobee rocket on 6 September 1963. Spectral scans in the region 500 Å–1400 Å of radiation from the center of the quiet Sun show good general agreement with results obtained by other groups (**66**), but there are significant differences in relative and absolute intensities caused by the fact that the earlier measurements generally referred to radiation from active regions.

SOLAR GAMMA-RAYS AND X-RAYS

Grazing Incidence Spectra

The NRL rocket of 22 August 1962 also carried two grazing incidence spectrographs (**67, 68**) featuring the use of a thin-film aluminum filter to eliminate stray light, particularly from Lyman-α. The spectra reach a short wavelength of 170 Å, after which the aluminum filter becomes totally absorbing. The resolving power of the spectra is between 0·3 Å and 0·5 Å, and wavelengths could be determined to an accuracy of approximately 0·05 Å. The NRL spectra of

22 August 1962 clearly revealed an absorption reversal in the core of the Lyman-β line, similar to that previously observed in Lyman-α.

The pioneering work of Hinteregger (**69, 70**) in the photoelectric recording of the solar XUV spectrum in the wavelength region 1300 Å–250 Å has now been extended to shorter wavelengths (**66, 71**). The key to the successful registration of grazing incidence spectra at very short wavelengths is the reduction or elimination of scatter Lyman-α. Hinteregger (**71**) solved the problem partly by the use of a grating exhibiting a very low level of scattered light, but most importantly by evaporating a thin film of lithium fluoride on the surface of the photocathode. In this way he obtained a superb spectrum, of 0·2 Å resolving power, in the wavelength region 310 Å–56 Å during the flight on 1963, May 2. The NRL group, on the other hand, used an aluminum film filter, 1000 Å thick, and supported on an 80/inch mesh of 85% transmittance, placed 6 mm in front of the photographic film (**72**). Spectrographs embodying this technique were flown in Aerobee rockets on 1963, May 10, June 28, and September 20. Over 200 emission lines were recorded from 33 Å to 342 Å. The spectra from 33 Å to 188 Å have a resolution of 0·1 Å and a wavelength accuracy of 0·03 Å for strong lines. Many new identifications include Lyman-α of C VI at 33·74 Å and various lines of Si VII–XII and Mg VII–X, but most of the strongest lines are unidentified. It is interesting that at least 13 of the unidentified lines coincide in position with those produced from wall material in the Zeta high temperature plasma. It seems probable that many of the lines will prove to arise from Fe in intermediate stages of ionization between Fe IV and Fe XIV (**72 bis, 72 ter**).

During the same 1963 NRL flights, XUV spectroheliograms were also obtained in such lines as He II 304 Å, Fe XV 284 Å, Fe XVI 335 Å and 361 Å, Mg IX 368 Å, He I 584 Å, and O V 630 Å (**73**). In addition, spectroheliograms of a central strip seven minutes wide were obtained in H Lyman-α and β, O VI 1032 Å, 1038 Å, and C III 977 Å.

The launching of the First Orbiting Solar Observatory (OSO–1 or S–16) was an event of great importance for observational solar astronomy (**75**). The success of this satellite demonstrates the feasibility of pointing satellite instruments at the Sun with high accuracy, of having in orbit equipment that is responsive to radio commands from the Earth, and of storing and transmitting to Earth large quantities of observational data. Launched into orbit on 1962, March 7, OSO–1 performed as expected for nearly three months and more or less intermittently for more than a year thereafter. Many thousands of scans of the spectrum of solar radiation in the 50 Å–400 Å spectral range were recorded during the operating life of the satellite (**76, 77, 78**), including observations during large numbers of chromospheric flares.

During the flight of the third Soviet spaceship on 1960, December 1-2, the spectral region centered on the λ304 line of He II was recorded with a photo-electric diffraction spectrometer (**44**) and open cathode photomultiplier (**79**). Since the satellite was not stabilized with respect to the Sun, a specially designed tracking head was developed (**46**) for the illumination of the slit. The flux in λ304 was estimated as 0·5 erg cm^{-2} sec^{-1}.

Crystal X-Ray Spectra

The first measurements of the solar X-ray line spectrum in the wavelength range 1 Å–25 Å have been made by the Naval Research Laboratory (**80**) with instrumentation carried aboard an Aerobee rocket on 1963, July 25. A crystal (KAP, or potassium acid phthalate) spectrometer with a Geiger counter detector was employed to measure 13 lines in the range from 13·8 Å to 24·8 Å, including lines of O VII, O VIII, N VII and Fe XVII. The crystal spectrometer could be used as an objective grating instrument with a resolution of the order of two minutes of arc with the result that the O VII and N VII lines were revealed as radiating more or less uniformly over the entire disk, whereas most of the O VIII appeared to originate over a plage region and Fe XVII almost exclusively over the plage center.

Broad-Band Measurements

Bursts of high energy X-rays associated with solar flares have been observed both from high altitude balloons (**81–83**) and from sounding rockets. During the flare of 1961, September 28, Anderson and Winckler (**83**) measured the X-ray spectrum as a function of time by the use of scintillation counters and three three-channel pulse height analyzers set in the 20–150 Kev energy region. The bremsstrahlung X-ray bursts seemed to be quite clearly associated with type III radio radiation. Rocket measurements of X-ray spectra in the 2–20 Kev range show that the higher frequencies are intensified during sub-flares (**84**). The enhancement is attributed to line emission associated with Fe xxv and Fe xxvi. A similar 'hardening' of the X-ray spectrum during flares has also been noted from low resolution solar X-ray spectra in the band 3Å–18Å, obtained in a series of Skylark rocket flights and with the satellite S–51 (Ariel I) during the period 1959–63 (**85, 86**). The intensity of the so-called 'quiet' emission declined considerably between the times of near maximum and near minimum in the solar activity cycle. The variability of X-ray emission during the lifetime of a flare was also noteworthy and occasionally took the form of rapid X-ray 'flashes'.

In 1960, the Naval Research Laboratory launched the first in a series of solar radiation monitoring satellites, SR I, (**87**) instrumented with two ionization chambers to monitor 2Å–8Å X-rays and Lyman-α, 1216Å. A second such satellite, SR III, was launched on 1961, June 29, and carried an ionization chamber sensitive to 8Å–15Å X-rays as well as one for the 2Å–8Å band (**89**). These satellites were not equipped with data storage systems, and therefore the data were transmitted in real time. Although only a very small fraction of the data could be recorded, more than 100 X-ray events were measured from SR I alone. Fluxes in the 8Å–15Å band varied during the period 1961, June 29—November 26, from less than 0·002 to 0·4 erg cm^{-2} sec^{-1} during a 3+ flare. Although the fluxes in this wavelength band are correlated with general solar activity and with flares, the observations demonstrate that X-rays of wavelength greater than 8Å do not contribute to SID events, which seem to be caused entirely by 2Å–8Å X-rays. The SR III satellite was launched pick-a-back on top of Transit 4A, but went into orbit without separating from its partner, Injun I. The latter also contained equipment to measure X-ray fluxes in the 8Å–20Å band, but the measured fluxes seem to be about an order of magnitude smaller than those recorded by SR III (**90**).

According to a private communication from H. Friedman, 'NRL's Solar Radiation Experiment, COSPAR Satellite no. 1963–21C, was launched into orbit 1963, June 15, and re-entered on 1963, August 1. During its six weeks lifetime, fluxes were measured in the 44Å–60Å band. The intensity remained at the relatively constant level of 0·08 erg cm^{-2} sec^{-1} (assuming a 10^6 °K spectral distribution). No measurable intensity was detected by ion chamber photometers in the 2Å–6Å or 2Å–8Å bands, from which it may be concluded that the solar flux did not exceed 2×10^{-4} erg cm^{-2} sec^{-1} below 8Å'.

The pointed section of OSO-1 contained a xenon-filled ion chamber with a thin beryllium window to measure solar X-ray flux integrated over the spectral interval 0·1Å–10Å (**91**). Observations were taken for periods of two seconds every 20 seconds during the entire daylight portion of each orbit, until the tape-recorders ceased functioning on 1962, May 23. The solar X-ray flux below 11Å exhibits a slowly varying component which correlates with that of the 2800 Mc/s solar radiation. In addition to a slowly varying component, transient events lasting from 10 minutes to a few hours were frequently observed. An upper limit for the 'quiet' Sun radiation in the 20–100 Kev band of about 10^{-7} erg cm^{-2} sec^{-1} was deduced, while the corresponding value for the band 1Å–11Å was 5×10^{-4} erg cm^{-2} sec^{-1}. Aside from the transient events of relatively long duration, very rapid changes in X-ray flux also take place, the flux changing by a factor of two or more in time intervals less than one second.

In the U.S.S.R. measurements of X-ray radiation from the Sun in the region λ10Å were made with photon counters carried in rockets on 1959, July 21 (**92**) and during the total solar eclipse of 1961, February 15 (**93**). In 1959, the flux was 7·3 × 10^{-4} and 3·2 × 10^{-4} erg cm^{-2} sec^{-1} for morning and evening launchings, respectively, whereas in 1961 the value was 4·0 × 10^{-4} erg cm^{-2} sec^{-1}.

During the flights of the second and third Soviet spaceships, measurement of X-ray radiation in the region <10 Å was made with the aid of Geiger counters with windows made of Be, Al and mica (**94**). On 1960, August 19–20, the following data were obtained: 7–8 × 10^{-4} erg cm^{-2} sec^{-1} during periods of quiet Sun and 0·7–1·5 × 10^{-2} erg cm^{-2} sec^{-1} at the time of the flare at 15^h 33^m (Moscow time). On 1960, December 1–2, a flux of 2·5 × 10^{-4} erg cm^{-2} sec^{-1} was recorded. A correlation between X-ray radiation and the intensity of the coronal line Fe 5303 Å was found. This suggests that the shortwave radiation of the solar spectrum ($\lambda < 10$ Å) originates in all regions of the corona in which λ5303 is excited (**93**).

During the flight of the second Soviet spaceship on 1960, August 19–20, measurements of the total flux of solar radiation were made in the regions Lyman-α, 110 Å–44 Å, 21 Å–8 Å, 8 Å, and 1·4 Å–3 Å. In the absence of flares, the Lyman-α flux varied between 1·8 and 6 erg cm^{-2} sec^{-1}. No variations of intensity in the region 110 Å–44 Å were noted notwithstanding the presence of flares. In the regions 23 Å–8 Å and 10 Å–5 Å, the radiation during flares increased by factors of 3 and 11, respectively (**95, 96**).

The solar Lyman-α flux was also monitored from OSO-1 with equipment devised by Hallam and Young (**75**). Peak enhancements up to 6·8% were observed during bright flares.

Solar Gamma-Rays

The OSO-1 satellite carried a number of experiments designed to search for solar gamma radiation in the region 20 Kev–1 Mev (Goddard Space Flight Center), 50 Kev – 3 Mev (University of California, La Jolla), and greater than 50 Mev (University of Rochester). The Goddard results indicate that in the range 20–100 Kev the flux from the quiet Sun does not exceed 3·40 ± 0·95 photons cm^{-2} sec^{-1} whereas the California measurements yield an upper limit of 1 photon cm^{-2} sec^{-1} between 50 and 150 Kev (**75**). No bremsstrahlung bursts were observed even during solar flares. According to G. G. Fazio, a partial analysis of the Rochester data has shown no evidence for radiation of energy greater than 50 Mev from the Sun, even during the importance 3 flare of 1962, March 22, and the importance 2+ flare of 1962, March 13. The upper limit of the flux from each of these flares was estimated to be 10^{-2} photons cm^{-2} sec^{-1} and the upper limit for the quiet Sun was 2 × 10^{-3} photons cm^{-2} sec^{-1}. The sensitivity of the detector is limited by radiation produced in the spacecraft.

GALACTIC ULTRA-VIOLET

The origin of the bright nebular glow around the star Spica and in the Orion nebula, detected in 1957 by collimated photon counters sensitive between 1225 Å and 1350 Å, has been difficult to explain (**97**). It now appears that no explanation will be required, since a repeat of the 1957 experiment by the Naval Research Laboratory in April 1963 indicates that the earlier results were spurious (**98**). The intensity of the diffuse glow surrounding the star Spica has an upper limit equal to one tenth of that previously reported. There is still no explanation for the 1957 photon counter responses.

It now seems well established that O- and B-type stars have lower ultra-violet fluxes, by a factor of three or more, than those predicted from model atmosphere calculations. The evidence has come both from observations with an ingenious spectrophotometer (**18**) flown in an Aerobee rocket by Stecher and Milligan (**99**) and covering the wavelength region from λ1600 to λ4000, and from observations with broad-band photometers at a number of effective wavelengths from 1314 Å to 2985 Å. According to Stecher and Milligan, the agreement between the predictions of theoretical model atmospheres and observations is satisfactory for α Car, spectral type Fo Ia, and for earlier type stars down to λ2600. Disagreement sets in for the hotter stars below λ2400 and becomes progressively greater with decreasing wavelength.

The spectrophotometric results are confirmed generally, if not in detail by observations with broad-band photometers. Thus photometric measurements were made in 1963 by Gulledge and Packer (**100**) in a spectral band of 188 Å half width centered at 2120 Å. Stars of class B and earlier were observed to a limiting magnitude of about 3·8. Preliminary results for eight B- and one O-type stars indicate that the measured intensities are approximately one magnitude lower than the values obtained from recent stellar models of Underhill (**101**). Similar results have been obtained from Southern Hemisphere observations (**102, 103**) at an effective wavelength of 1900 Å for B-type stars from a Skylark rocket launched 1961, May 1, from Woomera. Observations on 22 early-type stars, mostly of type B, show that model atmosphere calculations overestimate the fluxes at λ1900 by a factor of two or more.

Stellar ultra-violet fluxes also show a deficiency at shorter wavelengths. At the Naval Research Laboratory, photometric measurements in two wavelength bands, 1290 Å–1350 Å and 1350 Å–1550 Å, were made on data from two Aerobee rockets flown in 1960 (**104**). Measurements were made of signals from about 50 stars in the longer wavelength interval and 80 stars in the shorter wavelength interval, all earlier than class A2. The observed far ultra-violet intensities of most B-type stars were within about one half magnitude on the low side of predictions based on blackbody computations. Two additional flights in 1963 have provided photometric data on about 200 stars with spectral bands 1040 Å–1180 Å and 1350 Å–1560 Å (H. Friedman, private communication).

Theoretical predictions of intensities in far ultra-violet spectra have been made by Gaustad and Spitzer (**105**) for a B2 star, by Osterbrock (**106**) for a gaseous nebula, and by Nikolsky (**107**) for stellar chromospheres and coronas.

GALACTIC GAMMA AND X-RAYS

Preliminary results derived from Explorer XI indicate the probable existence of a cosmic gamma ray flux of photons with energy $\geqslant$ 100 Mev with an average value of the flux equal to $5{\cdot}5 \times 10^{-4}$ cm^{-2} sr^{-1} sec^{-1} (**108**). Upper limits to the flux from various possible sources have been derived.

Considerably higher fluxes have been reported by other investigators for approximately the same energy range (**109, 110**). Dr E. M. Hafner reports that the cosmic ray group at the University of Rochester has been engaged in a study of high energy gamma-rays from astronomical sources since July 1961, both in an extensive sequence of high altitude balloon flights and in the satellite OSO-1. The photon energy range is such as to detect gamma-rays from decay neutral pions, which are expected to originate in stellar processes and in cosmic ray bombardment of interstellar material. The results analyzed so far have indicated a roughly isotropic gamma ray flux of about $5 \times 10^{-3}\gamma$ cm^{-2} sr^{-1} sec^{-1}, probably weighted toward the low end of the energy range. There are as yet no clear indications of anisotropy over the celestial sphere, nor is there evidence for a steady or transient flux from the Sun. The program is continuing.

Measurements in the range 0·1–3 Mev were also taken while the Ranger III vehicle was en route to the Moon, 1962 January 27–28. The authors found little variation with time and no response to solar activity, which was at rather low ebb at the time (**111**). The energy range includes an 'annihilation' line at 0·51 Mev which gave a yield of $10^{-2}\gamma$ cm^{-2}sec^{-1} and a 'neutron capture' line at 2·23 Mev in which the flux was $3 \times 10^{-2}\gamma$ cm^{-2} sec^{-1}.

Calculations on the opacity of the interstellar medium due to continuous absorption by cosmically abundant elements (**112**) makes it seem doubtful that very much radiation from the galaxy will reach the Earth in the wavelength region 30Å–912Å. However, the transparency of the interestellar medium increases rapidly with decreasing wavelength and at a wavelength of 3Å, for example, the transmisson is 99% through a column of material containing $1{\cdot}5 \times 10^{21}$ H atoms/cm^2. The observation of X-rays from the galaxy is important both because they give information on high energy phenomena and because they may reach the Earth from very great distances. The first positive evidence for X-rays from sources outside the solar system came from observations made in the 2Å–8Å region from an Aerobee rocket in 1962 June (**113**). The main apparent source of these soft X-rays appears to be in the vicinity of the galactic center with possible secondary contributions from two other sources. Two additional flights have now been carried out by the same authors, in 1962 October and 1963 June (**114**), as a result of which the existence of a localized galactic source of X-rays near the galactic center is considered as clearly established. Fisher and Meyerott (**115**) have also reported measurements of night-sky regions emitting photons having energies of between 1 and 20 Kev (0·5Å–10Å) from Aerobee rockets flown on 1962, September 30, and 1963, March 15. At least six regions have been identified as emitting photons, although the authors recognize the marginal character of the evidence. Fisher (**117**) is of the opinion that soft X-ray sources have been successfully identified with stellar objects rather than with emission from the interstellar medium.

Friedman reports that a collimated, large area, proportional counter was flown in an Aerobee rocket from White Sands, New Mexico, on 1963, April 29, to scan the night-sky for soft X-ray emission. A strong source was observed centered about the direction 16 hours 10 minutes right ascension at -18° declination in the general proximity of ν Scorpius. From the pulse amplitude distribution, the emission was found to occur primarily in the 3Å–8Å range. Assuming all the emission to be concentrated at about 5Å, the computed flux is about $1{\cdot}5 \times 10^{-7}$ erg cm^{-2} sec^{-1}, or just under 40 photons cm^{-2} sec^{-1}. Considering all of the uncertainties, this value is in remarkable agreement with the values of $28{\cdot}0 \pm 1{\cdot}2$ and $20{\cdot}5 \pm 0{\cdot}4$ obtained by Gursky *et al* from the 1962 June and 1963 June flights, respectively. Recent work by Ginzburg and Syrovatskii (**126**) does not support the suggestion by Clark (**125**) that X-ray emission from the center of the galaxy might result from synchrotron radiation of 10^{14} eV electrons produced by interactions of very high energy cosmic rays with interstellar matter. Friedlander (**129**), however, believes that the synchrotron mechanism cannot be ruled out because the density of high energy electrons in interstellar space may be greater than the current value. The subject of other possible mechanisms for the emission of galactic gamma- and X-rays is being actively discussed at the present time (**118-129**).

RADIO-EMISSION

The first three references in the bibliography of this section contain a general discussion of possible experiments and observations from satellites and rockets at radio frequency wavelengths (**130**), a discussion of the possibility of observing features of galactic radio emission at a frequency of 1 Mc/s (**131**), and a proposal of satellite techniques for performing a high resolution survey of the radio sky (**132**).

The interpretation of cosmic noise measurements at low frequencies from rockets and satellites is an exceedingly difficult problem, the signals being affected by the variation of radiation resistance of the antenna caused by the ionosphere and ionospheric restriction in the angular aperture of the antenna (**133**). Nevertheless, these difficulties seem to have been overcome in experiments carried out both by the University of Michigan and the Harvard Observatories. Haddock has sent the following report of the Michigan experiment: A payload was launched by rocket to an altitude of 1700 km (**134**): it consisted of a short (12·5 m) electric dipole, extended in flight, feeding three narrow-band receivers at frequencies 0·75, 1·225 and 2·0 Mc/s, together with calibration equipment for monitoring receiver performance and antenna impedance. A series of ionospheric effects was observed and good measurements of cosmic noise intensity at 1·225 and 2·0 Mc/s were possible: these were 1·0 × 10^{-20} and 2·0 × 10^{-20} W m^{-2} $(c/s)^{-1}$ sr^{-1} respectively, corresponding to brightness temperatures 2·1 × 10^7 °K and 1·7 × 10^7 °K respectively, representing average values over a hemisphere centered on the zenith at R.A. 02^h35^m; Dec. 39°. Combined with selected higher frequency measurements this shows a sharp break in the spectrum near 2·0 Mc/s which can only be accounted for in terms of interstellar absorption by ionized hydrogen, presumably in the foreground. It is inferred that the optical thickness of this gas is unity at a frequency of about 1·3 Mc/s, implying an emission measure of 4 cm^{-6} pc (assuming an electron temperature of 10^4 °K).

The ionospheric effects observed are of interest both for the planning and analysis of future space radio astronomy observations and also for space science generally. Above the peak of the ionosphere no signals originating on the bottomside were detected. Modulation of the radiometer outputs due to vehicle spin was observed throughout the trajectory. At the higher parts at 1·225 and 2·0 Mc/s, this was unrelated to the ionosphere and was presumably due to non-uniformity of sky brightness. The validity of theoretically predicted behavior of antenna radiation resistance (**135**) was verified; in particular the disappearance below the level $X = 1 - Y$ of the component associated with the magneto-ionic extraordinary wave was detected and clearly identified by the sharp drop in the received extra-terrestrial signal and the enhanced angle-dependence of the radiation resistance as manifested in the modulation of signal due to vehicle spin. This effect provides a potential method for very accurate measurement of electron density in the topside ionosphere of the Earth, or other planets, by purely passive and simple radio astronomy observations. A previously unreported phenomenon detected was the occurence of regions in the ionosphere of high noise levels at all three observing frequencies. This noise apparently occurred at each frequency in regions where the refractive index for one or the other magneto-ionic component can become infinite; it was too intense to be of thermal origin in the plasma, and is possibly due to Cerenkov emission by energetic charged particles passing through regions of high refractive index.

At Harvard, Lilley and Huguenin (**136, 137**) report preliminary observations at 4·010 and 6·975 Mc/s from three U.S. Air Force pick-a-back satellites during the spring of 1962. Although these flights were made primarily for testing purposes, several unexplained phenomena were encountered when the operating frequency approached the local plasma frequency. The apparent isotropic sky brightness, observed at 4·010 Mc/s and 6·975 Mc/s, was (1·5 ± 1) × 10^{-20} and (1 ± 1) × 10^{-20} W $m^{-2}(c/s)^{-1}$ $(sr)^{-1}$ respectively. The internal agreement between the three satellites was considerably better than the uncertainties associated with the antenna behavior at these altitudes in the ionosphere. A Blue Scout Jr. high altitude ballistic probe launched 1963 July 30 provided observations at 0·700 and 2·200 Mc/s which were far easier to interpret because of the 11 400 km apogee obtained. These measurements yield an apparent isotropic sky brightness of (3 – 6) × 10^{-20} at 0·700 Mc/s and (0·7 – 1·4) × 10^{-20} at 2·200 Mc/s. Several bursts of unconfirmed origin were observed during the three hour flight, including a two order of magnitude enhancement at 0·700 Mc/s. There is a distinct possibility that the entire flux observed at 0·700 Mc/s was not of galactic origin. A satellite containing radio telescopes at 2·2 Mc/s and 4·010 Mc/s with a 1200 km circular orbit is planned to be orbited before the XIIth General Assembly.

The following report on results of Venus microwave measurements from Mariner II was prepared by A. E. Lilley (**138**). The Mariner II spacecraft was instrumented with a two-channel microwave radiometer operating at wavelengths of 13·5 and 19·0 mm. The radiometer's total weight was 22 lbs. Its average power consumption was 4 watts; its peak power consumption was 9 watts. The radiometers were of the crystal video type; the Dicke switching technique was used. Comparison horns, oriented to avoid pointing toward Venus and the Sun, provided reference temperatures. The radiometers operated with a common antenna having a diameter of 48·5 cm. During the 110-day flight 23 noise calibrations were made, and thus the gain, base-level, and time constant performance of the radiometers could be monitored en route. The microwave radiometer beams first made contact with the planet Venus on 1962, December 14, at $18^h\ 59^m$ GMT (spacecraft time). During the next 35 minutes three scans across the planetary disk were obtained. The approximate angular extent of each scan was: scan 1, 10°; scan 2, 15°; scan 3, 10°. The altitudes at mid scan were: scan 1, 40 200 km; scan 2, 37 750 km; scan 3, 35 850 km. Scan 1 was located on the dark side, scan 2 was located near the terminator, and scan 3 was located on the light side. Estimates of the peak brightness temperatures of the three scans follow. (The temperatures are based on calculations which account for the effects of the antenna beam and the post-detection time constant.) For scan 1 (dark side), 460 °K; for scan 2 (near terminator), 570 °K; for scan 3 (light side), 400 °K. The errors of the quoted temperatures are estimated to be 15 %. The results suggest a limb darkening, an effect which presents cooler temperatures near the edge of the planetary disk. The ionosphere model of Venus, which permits earthlike temperatures, appears to be ruled out by these observations. On the other hand, the observed limb darkening is consistent with a model of the Venusian environment which has high temperatures originating deep in the atmosphere or at the surface of the planet.

VISIBLE AND INFRA-RED

Among the many advantages of extraterrestrial observations of astronomical sources, the one that has been most exploited has been the observation of ultra-violet and X-radiation. More attention is now being devoted to the opportunities for observations in the visible, with greatly reduced sky brightness and atmospheric scintillation, and in the infra-red where the transparency is greatly improved even at the altitudes of high-flying aircraft (**139**). Observations from high altitude can also assure the success of eclipse expeditions (**140–142**).

High-altitude investigations of the total solar eclipse of 1961, February 15, in the Soviet Union included observations from an aircraft at a height of 10 km with a diffraction spectrograph and image converter (**141**) and rocket observations of the corona made with an electrophotometer of 8 arc minutes resolving power (**142**). The observations indicate the presence of inhomogeneities in the corona between 9 and 35 solar radii which are not greater than 370 000 km in diameter.

The High Altitude Observatory at Boulder, Colorado, has continued its program to investigate the feasibility of coronal observations from balloons. Successful flights with an externally occulting coronagraph mounted on the Stratoscope-I guiding frame were made on 1960 September 10 and October 3, (**143**). Sky brightnesses were recorded photographically and photoelectrically at a number of scattering angles and effective wavelengths. Photographic observations at scattering angles from 1·67° to 2·8° with a low dispersion spectrograph covering $\lambda\lambda 0{\cdot}37$–$0{\cdot}79\mu$ were also carried out. The results are of interest not only for those planning future observations against the sky background, but because they give information on the rate of meteoric infall. Calculations based on the 1960 observations show that it may eventually be possible to observe the solar corona out to six radii from the Sun's center with a balloon-borne, externally occulted coronagraph.

The technique of apodizing the occulting disk, in which the diffraction pattern about the gaussian image point of a lens is modified by varying the transmission across the lens, has brought large gains in the reduction of stray light in externally occulted coronagraphs (**34**). This principle is being applied both in Project Coronascope at the High Altitude Observatory and in the small coronagraphs which have been constructed by the U.S. Naval Research Laboratory to study the F and K coronas at times other than during a solar eclipse. The optical system combines a Lyot-type coronagraph with objective lens of 25 mm diameter and

300 mm focal length together with an external occulter in the form of a disk, placed 20 inches in front of the objective lens, with a fine sawtoothed serrated edge. The use of the toothed wheel as an apodizer has been discussed by Purcell and Koomen (**15**). In the photo-electric version of this instrument, the corona is scanned in a spiral, from about 3 to 10 solar radii from the center of the Sun, the light intensity is measured with a photomultiplier, and the signal is recorded through telemetry. Measurements are made in both radial and tangential polarization. This instrument is being prepared under NASA auspices for flight in the second Orbiting Solar Observatory. Two such instruments were flown in Aerobee-Hi rockets in June 1963 together with similar coronagraphs, employing photographic recording of the corona. Records obtained on 1963, June 28, with both instruments, appear to have recorded the corona from $R = 3$ to $10\ R_{\odot}$. The data are being studied. There is clear-cut evidence of many slow-moving particles in the space surrounding the rocket, and probably coming from the rocket. The extent to which they contributed to the observed coronal brightness is under study.

Dollfus has placed in operation a new aerostatic installation to transport instruments to altitudes of 30 km in the stratosphere (**144**). The new installation consists of a group of inflatable balloons each carrying a weight of about 30 kg; the balloons are traversed diametrically by a central cable and placed one above the other. In 1960 and 1961 he carried out a series of five flights by this technique, transporting instruments weighing about 200 kg to an altitude of 30 km. With the aid of these balloon installations, Dollfus has identified zones of atmospheric friction responsible for atmospheric turbulence and stellar scintillation. He has examined the scintillation of the stars and its rapid variations with altitude in the course of nighttime ascensions in a free balloon. Automatic cinematography from the gondola of the balloon cluster viewed from below permits the identification of deformations of the installation taking place in zones of sudden horizontal friction in the atmosphere. The scintillation of the stars seems directly caused by the existence of these zones of friction.

An infra-red radiometer on board Mariner II carried out measurements of the radiation temperatures of 'small regions' of the surface of Venus at $8{\cdot}4\mu$ and $10{\cdot}4\mu$ (**145, 146**). The temperatures agree with broad-band Earth-based measurements in the region 8–13μ. Furthermore, the infra-red emission from Venus shows definite limb darkening and is equal in intensity on the bright and dark sides of the planet.

M. Schwarzschild reports that Stratoscope II, a 36-inch balloon-borne telescope, was flown for the first time in the night of 1963, March 1, for the purpose of obtaining infra-red spectra of Mars (**147**). A number of technical difficulties were encountered during the flight. Nevertheless, some spectral tracings of Mars were obtained which showed that the water vapor content of Mars is not likely to exceed 40 microns. A second and fully successful flight occurred on 1963, November 26, during which the infrared spectra of Jupiter and of seven red giant stars were secured (News Notes, *Sky and Telescope*, **27**, 16, 1963).

The observations of Glenn, Carpenter, and other astronauts of a luminous band or layer about 100 km altitude have been attributed to the night-glow layer (**148**). Link (**149**) believes that the observations can be equally well explained on the basis of the elevated absorbing layer previously adduced by astronomers from observations during lunar eclipses and from other analogous phenomena.

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Addendum

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