44. ASTRONOMICAL OBSERVATIONS FROM OUTSIDE THE TERRESTRIAL ATMOSPHERE (OBSERVATIONS ASTRONOMIQUES AU-DEHORS DE L'ATMOSPHERE TERRESTRE)

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Introduction: Commission 44 in a Changing Space Astronomy Environment

R.M. Bonnet

It can be considered as very satisfactory and a sign of good health that, as early as 1961, and since then, the question of the role of our Commission was discussed and in particular the overlapping activities with those of COSPAR and of other IAU Commissions were put into focus. It is the opinion of some members of our Commission that an analysis of whether a partial merging of Commission 44 with COSPAR Working Group 3 should be considered. Such an organizational scheme might offer the advantage of a greater flexibility and of a closer cooperation between IAU and COSPAR in space astronomy with the guarantee that duplication is prevented. Similar schemes do exist in other ICSU organizations.

In analyzing the past activities in space astronomy we see that most national and international programmes have naturally proceeded from the early, rudimentary and exploratory rocket type experiments to the most sophisticated space observatories, the Space Telescope being the ultimate example. This evolution has immediate consequences on the way the community of astronomers is involved in the space programmes, and also on the sort of tasks Commission 44 should consider as primordial. With the launch of Copernicus, and especially IUE, the non space astronomy community became more and more deeply involved in the utilization of space observatories and in the analysis of their data, either through guest investigator programmes or as users of a general facility. One prime role of our Commission is therefore to inform the scientific community of the currently planned or future space programmes of the various national and international space agencies. For that purpose in particular, our Commission initiated in 1976 the distribution of a Commission News Letter under the editorial responsibility of Y. Kondo. Four issues of the News Letter have been published as of now but it is not sure whether it will be possible to continue its publication in 1979 and proceed with this essential activity.

A new era is coming. New transportation systems are being designed and will become operational in the next decade. Although it is not too strong to state that the Spacelab is far to-day from fulfilling its promises of the early 70's, of a cheap and economic way of carrying a wide panoply of astronomy instruments into space, ranging from the rocket type to the most sophisticated ones, its unfortunate evolution should not prevent space astronomers from analyzing their future programmes, trying whenever possible to influence the future developments to be done toward a more economic system. Instruments like recoverable, re-usable free flyers such as the Space Telescope cannot be considered as too far remote a dream due to the advent of concepts like the Space Shuttle and revisitable space stations which are under development in the US and USSR. Commission 44 should thereby serve as a discussion platform to astronomers who should clearly express what their needs and preferences are so that they can be incorporated in due time in the development phase of the large space programmes not forgetting however the financial limit-

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ations. Probably the most interested people in these discussions are those sientists who do not belong to nations with a space programme of their own, because they have less possibilities to get their voices heard.

Future space astronomy programmes are now, in more and more countries or organizations, discussed in full perspective in comparison with ground-based programmes. One other role of our Commission is to coordinate space and ground-based astronomy programmes. In that respect, the coordinated campaign to observe X-ray binaries conducted during 5 years under the responsibility of, again, Y. Kondo and sponsored jointly by Commissions 22 and 44 can be considered as extremely successful and its initial objectives can be considered as satisfactorily attained. Thanks to the initiatives of a number of dedicated workers, the additional objective of organizing special campaigns, set forth at Grenoble in 1976, have also been achieved and such efforts must be continued in the future. Here also the Commission 44 Newsletter can play an important role.

In the past three years, space astronomy has been subject to an intense activity. Copernicus, launched on 21 August, 1972 has continued operating successfully and is still in operation as of now. OSO-8, launched on 21 June, 1975 was successfully operated until 30 september, 1978. HEAO-1, launched on 12 August, 1977 will operate until March 1979. I.U.E., launched on 26 January, 1978 is promised to a brilliant future and has already provided the astronomy community with a tremendous wealth of scientific data and HEAO-2 which is in orbit now since the 13th of November, 1978 seems to accomplish its programme according to the most optimistic expectations. The European satellite COS-B launched on 9 August, 1975 is also still operating and has made a break through in a new type of astronomy, uncovering a new spectral range, and discovering new sources. The French-Russian cooperation has been proceeding extremely well and the successful detection of gamma-ray bursts onboard Cygne-II MP and Cygne-III in coordination with other space instruments provides a remarkable contribution toward the analysis of these phenomena. Finally, the successful series of ISEE-1, -2 and -3 launched beteewn 1977 and 1978 provides a unique way to understand the interplanetary medium and the solar corona.

Analyzing this impressive series of success one is immediately stroke by the ability of the satellites and their instruments to operate over periods of time much longer than their designed lifetime. This is the consequence of the higher reliability and quality of subsystems. It results in more data becoming available and of course more to reduce. It therefore implies that more efforts should be devoted both financially and in terms of scientific manpower to data analysis. One action our Commission might undertake would be to trigger the interest of more scientists to get involved in the data analysis and to convey more clearly to the various national and international agencies the concern of the scientific community that more support is needed.

Looking ahead now, we may be satisfied that ambitious programmes are approved and well underway in various agencies. These are in particular HEAO-C, SMM, (NASA), EXOSAT (ESA), the Solar Polar Mission, the Space Telescope, two projects done in cooperation between ESA and NASA, the Spacelab -1 and -2 payloads, IRAS, in cooperation between the Netherlands, the U.K. and the USA, UFT, in cooperation between France and USSR, etc...

Various other projects are very good candidates for future selections. These are :

- the Solar Optical Telescope (SOT) and the Hard-X-ray Imaging Instrument (HXII) on Spacelab later hopefully followed by a Grazing Incidence Telescope on Spacelab (GRIST) and, maybe, a Solar Probe and a Solar Cycle and Dynamics Mission (SCADM) in the area of Solar Physics;
- the Gamma-Ray Observatory (GRO), the Advanced X-Ray Astrophysics Facility (AXAF), an American or European Extreme Ultra-Violet Explorer and several

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Spacelab facilities like LAMAR and EXPOS instruments, in the area of High Energy Astrophysics;
- the NASA Cosmic Background Explorer (COBE), the German project GIRL, and an ESA Large Infrared Telescope on Spacelab (LIRTS), a cryogenically cooled 1 m IR telescope (SIRTF) also on Spacelab, plus a 3 m telescope onboard a C 5 A aircraft, in the area of infrared astronomy.

In addition, new disciplines which in the past were not considered as potential new starters, are entering the field of space astronomy. This is in particular the case of Astrometry which ESA is seriously considering to get involved in through the HIPPARCOS Project.

No doubt that the results that will come out of these future projects will provide the substance of future Commission 44 reports.

The report covering the period from 1976 to 1978 follows below and is separated in 4 chapters each one covering a particular spectral interval followed by a 5th chapter on solar physics and 2 appendixes on IUE and HEAO-1. These various contributions have been written by members of our Commission and they focus more on technical aspects and on the main or unpublished results rather than on a more refined analysis which may be found in the reports of other Commissions such as 10, 12, 16, 17, 29, 34, 36, 42 & 48. In addition, review and survey articles may be found in the following references:

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1. Radioastronomy from Space

J.L. Steinberg

Since the discovery of galactic free-free absorption of low frequency cosmic radio waves, space radioastronomers know that they cannot see very deep into space. On the other hand, even if cosmic localized sources are observable, their detailed study requires very large space antennas or arrays whose construction does not seem likely in the foreseeable future except if they come up as a by-product of some large scale application project.

In the last few years, only one satellite has been operated which was devoted entirely to low frequency radioastronomy: RAE-2 which orbits the Moon and carries occultation observations of discrete sources and maps the sky. All other low frequency radio astronomy experiments were part of scientific payloads on Hawkeye-1 and 2, IMP-6, Voyager-1 and -2 and ISEE-3; scientists and engineers have now demonstrated that they can integrate sensitive radio receivers in very complex payloads. At the time of writing, there are few results published about Voyager-1 and -2 and ISEE-3 data and this is normal since their launch is rather recent. New results have been published from earlier experiments, for instance the STEREO missions which operated at frequencies where simultaneous observations can be made from the ground.

A. GALACTIC RADIO EMISSION

RAE-2, while orbiting the Moon, was screened for part of its orbit from the Earth radio radiation. It was also fitted with the same X-shaped antennas as RAE-1, which were made of four 229 meter long booms which provided some gain and space resolution (1 steradian at 10 MHz). It operated for 3 years of which 340 days were

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free enough of spurious effects (thermal motions of the booms, terrestrial radiation or leakage of man-made interference through the ionosphere) to be used to obtain detailed radio spectra in four cardinal directions (both galactic poles, center and anticenter) and contour maps of the galactic radiation (Novaco and Brown, 1978).

The spectra confirm the sharp cut-off below 250 kHz due to free-free absorption by galactic electrons.

The galactic brightness distributions between 9 and 1.31 MHz are essentially in agreement with the disc-halo models deduced from previous ground-based and space (RAE-1) observations. Emission from the Southern polar region is lower than that from the Northern polar region, probably due to the longer path length. Some features are seen in absorption and some others in emission but the contrast is low. At the lowest frequencies, the radiation path is limited to the solar neighborhood. The only dominant feature might be due to the local magnetic field in the Galaxy.

B. EMISSION FROM THE PLANETS

RAE-2 has also been used to search systematically for occultations of the planets (Kaiser, 1977) in the range 25 kHz-13.1 MHz using elaborate processing techniques. Only the Earth and Jupiter have given positive results. The discovery of an emission from Saturn has not been confirmed yet.

I. Jupiter Radiation

Simulaneous (stereoscopic) observations from the Earth and the Soviet probe Mars-7 have provided the first direct evidence of the directivity of Jupiter decametric (burst) emission at 30 MHz (Poquerusse & Lecacheux, 1978). This important result seems to be confirmed by Voyager-1 and -2 observations which will undoubtedly yield many more results about the directivity of fine structures in time and frequency.

II. The Earth Kilometric Radiation (TKR)

The study of TKR is on the borderline between astronomy and geophysics but some processes can be studied in our magnetosphere which can be effective in other planets, most probably in Jupiter.

It has been established that the TKR is associated with the occurence of auroral arcs and magnetospheric substorms (Kaiser & Alexander, 1977). Using Moon occultation observations from RAE-2 at 250 kHz, the source of TKR has been found in a sector centered on the 21-22 hours meridian (Alexander & Kaiser, 1976). And in all reported cases the source is found at geomagnetic latitudes between 75 and 85 degrees, frequently in the dayside cusp and sometimes at geocentric distances up to 20 R_E in the dayside, much higher than the plasma level at 250 kHz (at $R \simeq 2 R_E$) (Alexander & Kaiser, 1977).

TKR can be observed between 100 and 600 kHz with a variable frequency for the peak intensity and a relative bandwidth of about 100%. The flux level increases with substorm activity; the peak intensity is usually found near 250 kHz; this peak frequency decreases with increasing auroral activity (Kaiser & Alexander, 1977).

The detailed study of the spectrum of the radiation (Gurnett & Green, 1978) shows cut-off frequencies corresponding to an emission in the right hand mode of propagation; but no direct polarization measurements are available yet; some will certainly be made with the Voyager instruments but no position measurements will be available simultaneously. There is also a large uncertainty in the geocentric distance of the TKR sources; a large distance can be interpreted either as due to refraction and scattering in the magnetosphere (Alexander, Kaiser & Rodriguez,

1978) or by systematic position errors due to the use of a spinning dipole to localize a polarized source as suggested by Boischot, Harvey & Lecacheux (1978).

C. EMISSIONS FROM THE SOLAR CORONA AND INTERPLANETERAY SPACE

Radio waves cannot propagate in the corona and interplanetary medium unless their frequency is higher than the local plasma frequency which decreases with increasing heliocentric distance. Waves of frequencies higher than 15 MHz or so can be studied from the ground and yield information on phenomena taking place below 5-10 solar radii heliocentric. Simultaneous observations from spacecraft and the Earth have produced directivity data. At lower frequencies, multispacecraft observations have produced 2-dimensional positions.

I. High Frequency Stereoscopic Results

The solar corona can be studied by radio methods using radio burst sources as tracers. Each burst is characterized by the apparent position, size and shape of its source, its intensity, spectrum, polarization and so on; all these parameters can be measured from the ground in the meter and decameter wavelength range i.e. in a range of altitudes of 0.2 to 2 solar radii.

These intense solar emissions are produced by non-thermal mechanisms involving injection of energy from outside the radiating plasma volume. In the case of the most frequent bursts such as Type I and III, this energy is brought in by fast electrons but the conversion mechanism of the kinetic energy into radio energy is largely unknown although many theories are available; it is quite sure, however, that the emitted frequencies must be close to some resonant frequency of the medium if the conversion mechanism is to be efficient enough. As long as the mechanism is not elucidated, it is difficult, for instance, to infer coronal magnetic fields from type I observations. On the other hand, propagation effects such as refraction, scattering on electron density inhomogeneities and occultation or absorption could bring information on coronal structures which cannot be measured optically.

Waves emitted near a resonance frequency are likely to undergo strong refractive effects and even focussing or beaming whose existence can only be guessed from statistical center-limb counts, if the beam is not always radially oriented. Occultation by coronal structures can also produce angular cut-offs and therefore apparent directivity of the emission. Directivity can be detected only from simultaneous observations in two different directions.

Studying type III's at 169 MHz with STEREO-I on the Soviet probe Mars-3 yielded unexpectedly high directivities which have been interpreted by occultation effects by coronal overdense sheets based on filament chains; such chains were detected earlier from their thermal radio radiation. A model has been built (Hoang & Steinberg, 1977) which can account for all the available observations: scattered image size, relative positions of the fundamental and harmonic components and directivity.

The first observations of type III's at 30 and 60 MHz with STEREO-5 on Mars-7 and on the ground have provided evidence of ionospheric intensity scintillations of solar bursts (Poquerusse & Steinberg, 1978). These ionospheric intensity scintillations can be invoked to strengthen the arguments against a purely collisional damping mechanism (Poquerusse, 1977) and to eliminate objections raised against the fundamental-harmonic interpretation of type III pairs.

Stereoscopic observations at 169 MHz provided in 1974 the first direct evidence of the high directivity of individual type-I's: an upper limit of 25° could be placed on the 3 db beamwidth of these events. Time delays between the observation of an event at the Earth and on board the space probe have also been used (Bougeret, 1978). The following results have been obtained:

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- the measured beamwidth yields an upper limit to the total rms angular deviation of a radio ray launched at the source through the inhomogeneous corona: the total scattering power thus obtained cannot account for an apparent diameter of a source larger than 0.7 to 1' if we assume that the apparent source is the scattered image of a point source;
- time delay measurements confirm the existence of a small number of type I sources within a storm center; this fact is quite compatible with the very inhomogeneous structure of the corona above active regions, and also with a small size of the primary source;
- some type I source have been found to radiate up to 60° away from the radial direction;
- these observations, added to earlier statistical knowledge of type I's, are compatible with the following new model of a storm center;
- type I's are produced in overdense, very inhomogeneous, fibrous regions in the vicinity of active centers;
- they radiate in a narrow beam whose axis is less than 20° away from the axis of the loop. When type I's are seen on the limb, their source is high on the loop so that their beam can be oriented towards the Earth; their radiation must reach the Earth above other loopy regions so that they will be seen, on the average, higher than in the center, as observed;
- if their apparent size is larger than 1' or so, scattering by multiple reflections on overdense fibers can be invoked as a mechanism which broadens the scattered image while preserving the directivity (Bougeret & Steinberg, 1977).

The gyroresonance theory of Mangeney & Veltri (1976) is more compatible with these observations than others, but it implies rather large magnetic fields in coronal arches.

II. Low Frequency Multispacecraft Results

The most frequent radio bursts observed in interplanetary space are type III's produced by 10-100 keV electrons ejected from the Sun and guided along magnetic field lines. At each radial distance, the electrons induce plasma waves which are scattered into electromagnetic waves at the local plasma frequency and its first harmonic. The local plasma frequency and thus the electron density at the type III source can be determined if we know whether we are observing the fundamental or the harmonic.

The measurement of the direction, size and polarization of a low frequency source from a spinning spacecraft has been reviewed by Boischot, Harvey & Lecacheux (1978). From a spinning spacecraft fitted with a spin plane dipole, only the azimuth of a source (around the spin axis) can be found if the received radiation is randomly or circularly polarized. More information can be obtained if one uses a dipole which is tilted to the spin axis of an angle different from 0 and 90°.

Using two spacecraft fitted with spin plane dipoles and spinning around mutually perpendicular axis, Baumback, Kurth & Gurnett (1976) showed that type III trajectories do not deviate from the ecliptic plane by more than 30°. Fitzenreiter et al. (1977) used IMP-6 whose spin axis is perpendicular to the ecliptic and RAE-2 occultation observations; they have given at least one example of type III electrons crossing the ecliptic at 0.8 AU from the Sun. Both of these teams had to use an electron density model (that deduced from the RAE-1 measurements) to interpret their data and find positions at each frequency.

But if it is accepted that type III's observable from the Earth's neighborhood are not far from the ecliptic, multispacecraft triangulation can yield a density model. Weber et al. (1978) used Helios-1 and -2 as well as the Moon orbiter RAE-2. The difference between the times of observation at the various spacecrafts has also been used. The main results obtained are the following:

- simultaneous observations of plasma waves and type III radio radiation have demonstrated that the burst emission takes place, in general, at the harmonic of the plasma frequency (Gurnett, Baumback & Rosenbauer, 1978);
- localizations by triangulation and from time delays are found to agree if propagation effects are properly taken into account by ray tracing (Weber et al. 1978);
- the electron density distribution in the interplanetary medium deduced from type III radio mapping is in agreement with the extrapolated coronal density distribution at solar minimum (Weber et al., 1978).

More results are likely to come from Voyager -1 and -2 and ISEE-1 and -3.

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2. Infrared Space Astronomy

R. van Duinen

Infrared astronomy is a rapidly growing discipline and is now contributing substantially to various fields in astrophysics. A detailed review of the contribution made by infrared astronomers over the last three years to astrophysics is clearly beyond the scope of this report. Instead I will attempt to identify the general trends which are evident in the developement of space infrared astronomy. Also, I will mention some new developments which may be expected to contribute to astronomy in the next few years. Finally, I will briefly review future experiment plans that are presently being discussed, some of which will come to fruition in the near future.

A. SCIENTIFIC OBJECTIVES

In the reporting period the flow of results from space infrared astronomy has been particularly broad. The use of aircraft is fortunately not limited to the Northern Hemisphere, various examples of observations of sources in the Southern sky may be found below. Evidently airplane observers have been able to further improve their instruments. As a result the scientific returns from aircraft observations have been impressive.

Balloon platforms are becoming more reliable as carriers of infrared equipment. Over the airplane the balloon environment offers conditions of lower emissivity and higher transparency of the atmosphere, this advantage should be more fully exploited.

Sounding rockets have carried the first infrared sky survey telescope. The publication of the improved version of the AFGL survey was an important event.

The increase in sensitivity of infrared photometric systems onboard aircraft and in balloon gondola has allowed us to move from observing the very brightest sources to the realm where weaker objects can be detected and -in some cases-be mapped. As an example, compact H II regions probably fuelled by a single O star have recently been studied extensively with the C-141 airplane (NASA's flying infrared "Kuiper Observatory") by the University of Chicago group at far infrared wavelengths. Some of the compact sources are believed to be pre-main sequence stars on the basis of their infrared to Lyman α luminosity ratios (Harley et al. , 1978). To appreciate the progress in sensitivity one should recall that only a few years ago infrared observations of H II regions were limited to the very bright giant complexes that are excited by a cluster of early type stars. Similarly, as a result of improvement in the photometric instruments simultaneous observations in a number of infrared wavelength bands have become possible. Such observations allow the study of detailed dust temperature and dust opacity distributions in H II regions and associated molecular clouds and in the Galactic Centre. Examples of such studies can be found in the work performed by the Caltech group, again using the Kuiper Observatory (Gatley et al., 1977); Werner et al., 1976).

Far infrared photometric observations of planetary nebulae and possible precursors of such objects have been reported by the University of Chicago group. These multicolour data seem to indicate that typical dust temperatures in these objects are higher than the 30-50 K, typically found in dusty H II regions.

Emission line stars have also been observed in the far infrared by the University of Arizona group. The data seem to indicate the presence of cool ($\sim$ 50 K) dust around these objects.

An upper level on the far infrared emission of the Crab Nebula has been observed which is consistent with the small amount of dust evident from optical extinction (Harvey et al., 1976, Harvey et al., 1978a).

Mapping of molecular clouds has in some cases resulted in discoveries of new far infrared sources which are either powered by an embedded hidden heat source, or the result of a dust density enhancement heated by a nearby star. Examples of such objects are the new sources found in the Ophiuchus molecular cloud and the W33 region (Fazio et al. 1976; Wright et al., 1978) by the MIT balloon group, and in the Cepheus cloud by the Groningen balloon group. The Ophiuchus source has been mapped by the Arizona group using the Kuiper Observatory (Harvey et al., 1978b).

Of the two categories mentioned, the S140-IR source is probably an embedded young object, based on observations by the University of Arizona group (Harvey et al., 1978c) and by the Groningen-Meudon group (Rouan et al., 1977). The far infrared sources in the Carina region are examples of infrared sources heated by a nearby hot star (Harvey et al., 1978d), as is IRS1 in ρ Ophiuchus.

Detailed association of the dust temperature in molecular clouds -as deduced from observations with multiband far infrared photometers- with the kinetic gas temperature from CO observations yields information on the physical conditions in such dense objects. Infrared observations that contribute to such studies are now available from the Meudon-Groningen Caravelle telescope on sources like S140 and S88. Similar data have been obtained by the Groningen balloon system on S187 and S255, and Cep A (Koppenaal 1978).

Like the progress in Galactic observations on discrete sources is largely due to improvements in sensitivity of photometric systems, the same improvements have led to a modest increase in the number of extragalactic objects that have been observed in the far infrared. Most of these observations have again been performed with the Kuiper Observatory -the data concern the far infrared emission of nuclei of Galaxies (Telesco & Harper, 1977) ; it is interesting to note that the disk emission of the Galaxy M83 has been detected by the smaller Meudon-Groningen telescope (Viallefond, 1978). Observation of far infrared disk emission in combination with observations of the gas provide insight in star-formation rates and mass luminosity ratio's. Similar astrophysical objectives are the basis of observations of diffuse Galactic emission such as recently have been reported from balloon systems by the University of Arizona, Japan, Saclay and Meudon-Groningen airplane groups (Wijnbergen, 1978; Maihara et al., 1978; Serra, et al., 1979; Serra et al., 1978a; Serra et al., 1978b; Low et al., 1977).

The diffuse emission measurements suffer from instrumental problems and apparent differences between results of different observers still exist. It also appears that the theoretical interpretation is not without difficulties; the usual model of reradiated ultraviolet radiation absorbed by dust is contested by one that requires additional contribution from molecular clouds heated by embedded young stars. Other extragalactic photometric observations concern far infrared mapping of the 30 Dor region in LMC and the detection of the giant H II region NGC604 in M33.

Spectroscopy in space infrared astronomy has only recently given the first results. The UCL balloon group has performed high resolution observations on bright H II regions on a number of forbidden lines in abundant ions such as O III and N II after the first discovery of some of these lines by the Cornell group from the NASA Lear jet (Ward et al., 1976). Similar observations with the Fourier spectrometer used in the UCL balloon system have been performed by the Meudon-ESTEC collaboration in the Kuiper C-141 Observatory (Baluteau et al., 1976). Attemps have been made to discover the 28.6 micrometer H_2 line, both with airplanes and balloons, but no positive detection has so far been reported although the predicted line intensities should be within reach of present day low emissivity system.

Near infrared airborne specroscopy has discovered the presence of spectral emission features which have so far eluded definite identifications but which may hold a key to the problem of the chemical composition of interstrellar dust grains. The UCSD group has found such features around 7 micrometers mostly in the spectra of planetary nebulae with the Kuiper Observatory (Willner et al., 1978a; Willner et al., 1978b). A French group has probably detected the ice band at 43 micrometers in a low resolution spectrum of Orion.

Planets have been observed with infrared spectrometers to obtain data on the atmospheric structure and composition.

B. FUTURE EXPERIMENTS

Future work on the short term will largely be a continuation of the present lines of research. It may be expected that the main emphasis of infrared observations will be on spectroscopy of H II regions and molecular clouds on the one hand, while higher sensitivity photometric observations will result in accurate mapping of galactic and extragalactic sources in various well defined bands. A general problem for the planning of infrared observations is the lack of a high sensitivity all sky survey, especially at the longer wavelengths. By 1981-1982 the IRAS survey will be conducted in four bands between 8 and 120 micrometers at a detection level of a few tenth of a Jansky. The IRAS survey by 1981 and the use of that satellite in additional observations will dominate the field for some time and provide guidance for future observations (Van Duinen, 1977).

On the longer term numerous plans exist in the various space agencies. The use of Spacelab as a platform for infrared observations is imminent. The first cryogenically cooled infrared telescopes that will fly in the Shuttle in 1981 are from the Arizona/MIT collaboration and a cosmic background experiment from ESA. Possibly the third cooled instrument to be used in Shuttle in 1983 is a 50 cm diameter cryogenic telescope from the FDR to perform photometry and spectroscopy on astronomical sources and in the Earth atmosphere.

Other proposals being studied for infrared astronomy include a large uncooled telescope (2.5 diameter) either in Spacelab or as a free flyer-mainly by ESA- and an 1 meter class cryogenic telescope again either in Spacelab or as a free flyer (by NASA).

The longer term plans involve an IRAS type cryogenic telescope for observation of the cosmic background and a similar size telescope for spectroscopic work as a follow-up of the IRAS survey.

Technological developments that are important to infrared astronomy involve multidetector arrays, cryogenic systems for long life time and spectroscopic instruments for resolution in the 10 000 to 100 000 range based on Fabry-Perot and heterodyne techniques.

C. FUTURE OBJECTIVES

It is immediately clear that key features of theoretical models of some astronomical phenomena would never have been discovered without the painstaking efforts of airplane observers and balloonists. The dominating role of dust in the energy balance of H II -and starforming region- is an example. Another one is the dominating energy output in the far infrared of certain galaxies, which is now firmly established; a full understanding of this phenomenon requires a much larger number of galaxies to be observed. In the years to come space infrared astronomy may be expected to play a crucial role in the understanding of fragmentation and star formation in molecular clouds. Especially on the problem of the formation of low mass stars vital contributions may be expected from observations in this wavelength range. The few far infrared forbidden line spectroscopic results obtained to date apparently are difficult to reconcile with similar observations, obtained from the ground both in the near infrared and in the visual. Whether this is the case because the infrared lines arise in yet different regions or because of observational effects is not clear and an important problem to solve by more observations. In the middle infrared and in the near infrared solid state features have been detected which so far seemed to have escaped identification but which may help to unravel the secrets about the composition of interstellar dust grains. Air, balloon and ultimately shuttle and satellite infrared research is needed to fully explore the rich potential of observations in this wavelength range.

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3. Ultraviolet Astronomy

A. K. Dupree

This last triennial period has been an active one with substantial and continued interest in the acquisition and analysis of ultraviolet observations of extra-solar objects and the interstellar medium. Energetic programs of rocket and balloon-borne cameras and spectrographs complemented the many satellite experiments -the OAO series (OAO-2, Copernicus), ANS, TD-1, Prognoz-6, and Voyager in addition to the International Ultraviolet Explorer (IUE) that was launched in January 1978. This latter satellite is discussed by R. Wilson in Appendix 2 of this report. Further plans for ultraviolet instruments are noted below.

Highlights of these years include ultraviolet imaging and spectra of extragalactic objects, and extensive studies and analysis of stellar spectra including transient sources. With ultraviolet spectroscopy now possible down to V $\sim$ 15, our reach includes more diverse categories of objects and studies of the interstellar medium, to much greater distances than previously attainable.

A. HIGHLIGHTS OF RECENT RESULTS

A characteristic of the last three years has been an extension of spectroscopic and photometric observations to more distant objects and to those that are relatively weak emitters in the ultraviolet spectral region. The first direct observation of the ultraviolet spectrum of a quasistellar object, 3C273, was made by Davidson, Hartig & Fastie (1977) with a moderate resolution (1015A) rocket-borne 40cm diameter telescope and spectrograph. The emission-line spectrum of 3C273 is similar to the spectra of high redshift QSO's, but no absorption is observed spectroscopically and with the International Ultraviolet Explorer (Davidsen & Hartig, 1978; Boksenberg et al., 1978).

The ultraviolet scanning spectrometer of Princeton University on board Copernicus has continued to produce a wealth of new material. Further study (Jenkins, 1978a, b) on the extent of coronal gas in the galaxy indicates the presence of discrete regions of hot gas uncorrelated with the presence of target stars. Interest is particularly keen on problems concerning mass loss in early hot stars of spectral type (Snow & Morton, 1976; Hutchings, 1976; Marlborough, 1977; McCluskey & Kondo, 1976) and variability in the ultraviolet emission that may in some cases suggest fundamental changes in the structure of the wind (York et al., 1977; Snow, 1977; Marlborough, Snow & Slettebak, 1978; Lamers & Morton, 1976; Lamers & Rogerson, 1978; Abbott, 1978).

The 5 channel ultraviolet grating spectrophotometer on the ANS Satellite has investigated variability in specific objects also: Wolf-Rayet stars (Burton et al., 1978) and planetary nebulae (Gilra et al., 1978) as well as more extended studies of the colors of certain stellar groups, for instance, Ap and Am stars (van Dijk et al., 1978) and other diverse objects: Helium spectrum variables (Molnar & Wu, 1978); selected extra-galactic objects, NGC 4151 (Wu & Weedman, 1978); planetary nebulae (Pottasch et al., 1977, 1978); close binary systems (Wu, 1976), Nova Cygni 1975 (Wu & Kester, 1977) and a transient X-Ray source, A0620-00 (Wu et al., 1976. P. Wesselius also communicates that 70 percent of the material obtained with ANS -20000 observaions on 4000 objects- has been reduced and it is antiticipated that a first version of a catalogue will be available at the time of the IAU General Assembly in 1979.

Spectroscopy in the near ultraviolet (λλ 2000-3400) has been carried out by a Balloon-borne Ultraviolet Stellar Spectrograph (BUSS) and early results have been kindly communicated by C. de Jager and Y. Kondo. This instrument was developed at the L.B. Johnson Space Center in the USA together with the Space Research Laboratory, Utrecht, the Netherlands (Hoekstra et al., 1978). The 1978 flights were partially supported by the University of Brussels and the University of Mons, Belgium. The two-axis stabilized telescope has a diameter of 40 cm. The echelle spectrograph is used with a SEC vidicon detector to yield a spectral resolution, $\lambda/\Delta\lambda$ of 3×10^4. The instrument was launched from Palestine, Texas, USA two times in 1976 and twice in 1978. A total of 81 spectra of 58 stars was recorded. Detection and identification of spectral features in selected stars has been carried out with specific emphasis on the mass loss implied by the line profiles (Hucht et al., 1978a, b; Lamers et al., 1978; Morgan et al., 1977; Stencel & Hucht, 1978), and the presence of chromospheric emission features (Kondo et al., 1976a, b).

Ultraviolet monochromatic fluxes at λ 2740 and λ 2275 have been obtained for numerous stars with photometers installed on the USSR Cosmos 215 satellite (Dimov & Terez, 1976). Comparison of these measurements with those made by other instruments shows satisfactory agreement (Zvereva & Eerme, 1976) for about one half of the sample. A most recent ultraviolet scanning spectrometer is a collaborative effort between the Laboratoire d'Astronomie Spatiale in Marseille, France and the Crimean Astrophysical Observatory, USSR. This instrument, borne on a Prognoz-6 satellite was launched in September, 1977 to study the integrated sky background, the geocorona, and galactic and extragalactic fields. The photoelectric scanner records a spectrum from λλ 1100-1900 with a bandwidth of 200A, and a field of view of 6° in diameter. First results of the mean ultraviolet spectrum are contained in Zvereva et al. (1978), and Hua et al. (1978).

An ultraviolet objective prism spectrograph (S-019) was carried aboard the U.S. NASA Skylab mission. Images were obtained of 188 starfields from λλ 1300-5000A (O'Callaghan et al., 1977) and many cool stars with hot secondary companions were discovered (Parsons et al., 1976).

B. CATALOGUE PUBLICATIONS AND COMPENDIA

Compendia of ultraviolet spectra have been published from several instruments. These include a catalogue by Snow & Jenkins (1977) containing spectra from λλ 1000-1450 of 60 O and B stars observed by Copernicus at a resolution of 0.2A. High resolution spectra (about 0.05A from λλ 907-1443; 0.1A from λλ 1426-1650; 0.4A from λλ 1408-3196) from Copernicus have been pulished of selected early-type stars: Alpha Lyr (Faraggiana et al., 1976); Zeta Oph (Morton & Underhill, 1977); Tau Sco (Rogerson & Upson, 1977), and Alpha Aql and Alpha CMi (λλ 2100-3200 only) (Morton et al., 1977).

Results from the sky survey telescope (S2/68) on the European Space Research Organization satellite TD-1 are contained in two volumes, One, the Ultraviolet Bright Star Spectrophotometric Catalogue (Jamar et al., 1976) includes 1356 stars principally of early spectral type (O, B, and A) for wich absolute fluxes are tabulated at 20A intervals over the regions λλ 1380-2540 and at λ 2740, a photometer channel. A subsequent volume (Thompson et al., 1978) extends to 31215 stars by combining the spectrophotometric channels and tabulating the fluxes in three broad bands of 330A width, centered at λ 1565, λ 1965, and λ 2365 in addition to the photometer channel at λ 2740. All stellar spectral types are represented; the tabulation contains down to V $\sim$ 9, and about 10 percent have $\gtrsim$ 9.

Far ultraviolet broad-band (λλ 1050-1600 and λλ 1230-1600) imagery of selected objects with about 4 arc-minute resolution has been accomplished by Carruthers and collaborators with instruments based on an electrographic Schmidt camera. Catalogues of selected target fields obtained from the lunar surface (Page et al., 1978), of imagery of nebulosities in Cygnus (Carruthers & Page, 1976) and imagery and spectrography of the Large Magellanic Cloud (Page & Carruthers, 1978) are published. Additional rocket-borne electrographic cameras have obtained images λλ 1000-2000 of extended regions such as the Orion Nebula and the Andromeda galaxy with about 30"arc angular resolution (Carruthers & Opal, 1977, Carruthers et al., 1978).

C. FUTURE PLANS

The US National Aeronautics and Space Administration is preparing the launch of a Far Ultraviolet Space Telescope (FAUST) aboard the Spacelab I mission scheduled for 1981. This instrument was developed by the Laboratoire d'Astronomie Spatiale (LAS) and the French Space Agency (CNES) and will be a joint experiment of the Space Sciences Laboratory at the University of California at Berkeley and LAS Marseille (Riviere & Deharveng, 1978). This instrument will observe faint (V $\sim$ 17) astronomical sources in the 1200-3000A spectral band. The basic instrument is a Wynne telescope with an effective area of 150 square cm, a field of view of 7°5, and an imaging capability of about 2 arc minutes. The detector system has an ultraviolet image intensifier with film recording. Spectroscopic observations can be made using a calcium fluoride objective prism. Spectral resolution varies from 30 to 200A depending on wavelength.

Space Telescope (ST) is a U.S. NASA program to launch in 1983 a 2.4 meter-diameter telescope containing complementary focal plane instruments. A spatial resolution of 0.1 arc seconds over periods of 10 hours is anticipated; wavelength coverage ranges from 1100A to 10000A. Five science instruments were selected in 1977 for inclusion on the mission. These descriptions were taken from material kindly provided by N. Roman, C.R. O'Dell, and J.F. Drake :

- A Wide Field/Planetary Camera (WF/PC) developed at the California Institute of Technology.
  This is a broad band imaging instrument designed to provide high angular resolution over the widest possible field of view in many wavelength bands from λλ 1000-10000.
- A Faint Object Camera (FOC) provided by the European Space Agency.

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It will produce images with the highest spatial resolution of any instrument on ST. The wavelength range is anticipated as λλ 1200-8000A.

- A High Speed Photometer/Polarimeter (HSP) provided by the University of Wisconsin.
  It is designed to measure colors with coarse spectral resolution, but high time resolution on a 1 msec scale, and with high accuracy in absolute intensity. The HSP will also measure light polarization in the visual UV spectal region.
- A Faint Object Spectrograph (FOS) developed at the University of California at San Diego.
  This spectrograph will cover the wavelength range λλ 1140-10000 at modest spectral resolution ($\lambda/\Delta\lambda \sim 10^2-10^3$).
- A High Resolution Spectrograph (HRS) developed by the Goddard Space Flight Center.
  It will operate from λλ 1100-3200 at very high spectral resolution of 0.01-0.02A.

D. SPACE TELESCOPE SCIENCE INSTITUTE

NASA has concluded that the scientific operation of the Space Telescope should be managed by an "independent" Institute.

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4. High Energy Astronomy

R. Giacconi

A. INTRODUCTORY REMARKS

Astronomical observations in X-ray astronomy have undergone an explosive growth in the past few years. Data from UHURU, ANS, Ariel, OSO-8, Copernicus and most recently the HEAO-1 mission have enormously expanded the scope of X-ray astronomy. In drafting this report, one is confronted with discussing X-ray emission from a great variety of objects in which X-rays may be the result of completely different mechanisms and spanning in luminosity from 10^{28} to 10^{45} erg sec^{-1} in the 0.1 to $\sim$40 keV range. Normal stars, dwarf novae, RSCVn systems, hot white dwarfs, flare stars, U Gem systems, globular clusters, binaries containing neutron stars and black holes, nuclei of active galaxies, the intragalactic gas in clusters of galaxies and possibly a diffused extragalactic medium have been studied in their X-ray emission.

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At the moment a few hundred X-ray sources are known. It is expected that in a few years, as we move to the use of focusing X-ray telescopes, this number will grow to thousands or tens of thousands. It may well be that X-ray astronomy results should in the future no longer be reported within the constraints of high energy astronomy, but rather as part of subject oriented reports. These remarks are meant as an explanation of the very cursory treatment given to each topic in this report.

Although gamma-ray astronomy has had a more difficult beginning than X-ray astronomy, the number of discrete gamma-ray sources discovered by SAS-2 and particularly Cos-B, now stands at more than two dozen after analysis of only a fraction of the results. It is clear now that high energy astronomy promises substantial contributions to the understanding of some of the most fundamental current problems in astrophysics, such as the physics of collapsed systems, the nature of the energy source in active nuclei or the dynamics and evolution of clusters.

B. LOW LUMINOSITY GALACTIC X-RAY SOURCES

The number of low luminosity galactic X-ray sources has increased to more than two dozen in the past three years. The sources range from isolated hot white dwarfs (HZ 43, Fiege 24, Sirius B(?), normal stellar coronae (α Cen, Vega, η Boo), stars with very active coronae (RS C Vn), flare stars (Uv Ceti), interacting winds and stellar surfaces (Algol), and finally accretion onto white dwarfs (AM Her, steady; U Gem, impulsive). A wide variety of physical phenomena lead to the observed X-ray emission. Intrinsic luminosities range from 10^{27} to 10^{32} erg $cm^{-2}sec^{-1}$ with temperatures between 10^5 to 10^7°K. Most of the data come from rocket experiments, the soft X-ray experiment on ANS and from the GSFC experiment on HEAO-1.

Computations of X-ray emission from stellar coronae heated by acoustic waves (de Leore and de Jager, 1970; Landini & Fossi, 1971) had predicted detectable X-ray fluxes from nearby stars. However, the detection of Capella (Catura et al., 1975) and Algol (Harnden et al., 1977) is at odds with the predictions; only some of the systems appear to have "normal" stellar corona. Detection of Vega (α Lyr) and η Boo ρ by Topka et al. does not clarify the situation. The detection of Ux Aries by Walter et al., 1978, may indicate the existence of a class of G Giant X-ray sources to which Capella may belong. Both Capella and Ux Aries belong to the class of RS C Vn systems and several others have been detected by HEAO-1. (See, for instance, review by G. Garmire, 1978).

The original observation of the Sirius system (Mewe et al., 1975) could not resolve the origin of the observed X-ray and clarify the role of photospheric emission from the white dwarf. The detection of HZ 43 with SAS-3 (Hearn et al., 1976) and of Feige 24 (Margon et al., 1976) shows that emission occurs from white dwarfs in non-interacting binary pairs and that the X-ray emission is from the atmosphere of hot white dwarfs.

Soft X-ray flares have been observed from YZ C Mi and Uv Ceti by ANS (Heise et al., 1975) and models explaining the emission as scaled up solar flares appear appropriate. Systems conceptually similar to the hard X-ray binaries such as Her X-1 or Cyg X-1, but containing a white dwarf rather than a neutron star or black hole, may be represented by the dwarf novae, such as SS Cyg (Rappaport et al., 1974) and RX And (Henry et al.,1975). Mason et al., 1977), with HEAO-1 detectors have observed intense-soft (kT $\sim$ 0.04 keV) X-ray radiation from U Gem peaking 1 or 2 days after the optical outburst. On June 1, 1975, an X-ray flare in the vicinity of λ Sco was observed during 30 min with high temporal resolution (Beigman et al., 1976a), with the grazing incidence X-ray telescope RT-4 onboard Salyut 4.

Upper limits for X-ray flux for a number of stars (Beigman et al., 1978) and also the limit $\gtrsim$ 0.2% for the pulsating component of the supernova Vela-X (Beigman et al., 1975) were obtained.

The AM Her system has been intensively studied following discovery by Hearn et al., 1976, and its optical identifications by Berg & Duthie, 1977. The system is apparently composed of a dwarf M star and a magnetized white dwarf. Optical polarization data reveal a 2 x 10^8 Gauss field (Tapia et al., 1977). Mass accretion onto the white dwarf produces X-rays up to 60 keV (Swank et al., 1978). The system is unique with respect to other low luminosity sources because the accreting white dwarf is endowed with a large magnetic field. The detection of a source apparently associated with the Orion Nebula (den Boggende et al., 1978) raises interesting questions since compact objects may not have had time to evolve in this very young region of stellar formation unless they are derived from very massive stars.

C. CLASSICAL X-RAY BINARIES

The classical X-ray binaries (Her X-1, SMC X-1, Cen X-3, etc...) are known to contain neutron stars. Measurements of mass yield 1.2-1.8 $M_{\odot}$ and a study of the changes in intrinsic pulse period for 7 X-ray pulsars indicates good correlation with the expected response to accretion torques for neutron stars (Rappaport et al., 1977).

The observation of Her X-1 with Salyut 4 in the initial phase of a 35 day cycle revealed an unusually small flux in the region $\approx$ 0.25 keV (Beigmnan et al., 1976b). It could possibly result from the delay of soft X-ray radiation.

No substantial new information has been obtained on candidate black hole objects, such as Cyg X-1 or Circ X-1, except the tantalizing discovery of 12 millisecond quasi-periodic pulsations from Cyg X-1 from Friedman et al., 1978

Better understanding of the nature of transient X-ray sources has been achieved by the discovery of 3.6 s pulsation (Cominsky et al., 1978) from the hard transient X-ray source 4U0115+63. The identification with a heavily reddened, early type star (Johns et al., 1978) has permitted the determination of the orbital parameters for this system. The results show that the large orbital separation, large eccentricity $\varepsilon \sim 0.3$ and/or the small radius of the companion star result in episodic rather than continuous mass transfer onto the compact object (probably a neutron star) (Rappaport et al., 1978).

The study of the X-ray pulsar 4U1626-67 by Rappaport et al. revealed a 7.7 s period. A model involving a binary system containing a neutron star and very low mass companion has been proposed by Joss et al., 1978. Joss & Rappaport propose that this model could also explain the bulk of the unidentified galactic bulge sources, such as Ser X-1, Agl X-1, etc. The model follows the suggestion by Whelan & Iben, 1973, and Gursky, 1976, that such systems may be the descendent of a cataclysmic variable system where a degenerate dwarf accretes matter until reaching the Chandrasekhar limit, then producing a type 1 supernova and leaving a remnant neutron star or black hole.

D. X-RAY BURST SOURCES

X-ray bursts from a source in the globular cluster NGC 6624 were discovered by Grindlay et al. in December 1975 with the ANS satellite. Two years later some 30 or more bursters are known (Lewin & Joss, 1977). They are strung along the galactic equator and most of them are within 35° longitude from the galactic center. At least three are located in globular clusters (possibly many more) and some have been identified with faint blue stellar objects (McClintock, 1977). A typical burst rises in less than a few seconds and lasts several seconds to minutes. The observed peak intensities in bursts are of 10^{-8} to 10^{-7} erg $cm^{-2}s^{-1}$. At $\sim$ 10 Kpc this implies a luminosity of 10^{38} - 10^{39} erg sec^{-1}. The bursts are sometimes emitted at approximately regular intervals of hours to days, as first reported by Clark et al., 1976. This is an important distinguishing characteristic from gamma-ray bursts where such behavior has not been observed. Most burst sources appear to have active and inactive periods. At least eight burst sources are known to exhibit a persistent flux of X-rays.

Significant spectral changes occur during bursts. In most cases the spectra appear to soften during the decay. If the burst emission is associated with a black body (Swank et al., 1977; Hoffman et al., 1977), temperatures of 3 x 10^7°K are derived. The effective radius of the region can be computed to be of $\sim$10 100 km. The rapid burster MXB 1730-335 is unique in producing both normal "Type I" bursts (every four hours) and distinctly different "Type II" bursts at a rate of 4000 bursts day. The energy contained in each Type II burst can vary by two orders of magnitude and is found to be proportional to the time interval to the next burst. The rapid burster is located in a globular cluster.

Models of X-ray burst sources fall into two classes: instabilities in the accretion of matter onto a compact object (white dwarfs, neutron stars or black holes), and thermonuclear flashes in matter accreting onto a neutron star.

Within the first category of models, accretion onto compact objects of $\sim$ $1M_\odot$ in binary systems has been proposed by many authors (see review by Lewin & Joss, 1977). Grindlay & Gursky, 1976, and Grindlay, 1978, have proposed accretion onto a $\sim 100M_\odot$ black hole from the interstellar medium. Thermonuclear flash models require that the neutron star be located in a binary system. No direct evidence of the association of burst sources with binary systems has yet been found (Grindlay et al., 1978).

E. SUPERNOVA REMNANTS

Most of the new results concern the detection of new X-ray emitting supernova remnants in the energy range 05-2 keV and the study of structure in some of them.

The NRL group, in particular, has detected X-rays from three remnants: MSH 14-63 (Naranan et al., 1978), and two remnants in Cygnus (Gull et al., 1977; Snyder et al., 1978; and Davidsen et al., 1977).

A picture of the Cygnus Loop in the 0.15-1 keV band has been obtained by Rappaport et al., 1978, in a rocket flight using X-ray focusing optics with a resolution $\sim$ 1-2 arc minutes. Correlation with optical structures is under way.

F. X-RAY SOURCES IN THE NUCLEI OF ACTIVE GALAXIES AND QUASARS

The 2-10 keV X-ray luminosity of galactic nuclei ranges from $L_x < 10^{36}$ erg s^{-1} for our own galactic nucleus to Lx $\sim 10^{46}$ erg s^{-1} for quasars. X-ray spectra often appear hard and may be represented by power law continua. More sensitive hard X-ray (> 10 keV) observations are needed to test or retest prediction (Lightman & Rybicki, 1978) that a "universal" hard spectrum (with $\alpha \simeq 1.0$) through $\sim$ 100 keV energies may be found for these sources. The X-ray luminosity and gamma-ray luminosity may exceed the total emission from the nucleus at other wavelengths, as in the case of NGC 5128, NGC 4151 and 3C273. X-ray variability of days and less has been observed. Such high luminosity coupled with rapid variations suggest that the X-rays originate close to the power source in these galactic nuclei.

Twenty-six X-ray emitting Seyferts have by now been identified in the 2A and 4U catalogs and in SAS-3 and HEAO-1 experiments. Lx in the 2-10 keV band covers the range $10^{42.5}$ - 10^{45} erg s^{-1}. Variability is observed on time scales possibly as short as 12 min in NGC 4151. Lx appears correlated with the optical continuum power as well as with the power emitted at 2.2 μ, 3.5 and 10 μ. Lx also appears correlated to the strength of Hα and the FWZI of Hβ. Lx does not appear correl-ated with radio power or with the strength of optical emission lines. This appears to suggest that X-rays arise in the dense core region of < 0.1 pc size. Five of the Seyferts were first discovered by X-ray measurements. All X-ray emitting Seyferts appear to be of type 1 except perhaps M82 and NGC5506, but see below.

Contribution of the Seyferts to the 2-10 keV X-ray background appears to range from 6 to 20%, assuming no evolution.

Six BL Lac-type galaxies are now identified with X-ray sources. They appear to have a similar range of luminosity and variability as the Seyferts. The spectrum of Mk 421 has been detected at 0.25 keV, indicating absence of a cut-off (Hearn et al., 1978).

Two new QSO's have been detected by spectroscopy of candidate sources in the X-ray error box. MR 2251-178, discovered by Ricker et al., 1978, and QSO 0241+622, discovered by Apparao et al., 1978. The latter is the brightest and nearest known QSO.

A new class of sources of very great interest is that of the emission line galaxies containing now some 8 objects: NGC 7582 and NGC 2992, discovered by Ward et al., 1978; 1334-30 by Schnopper et al., NGC 2110 by Bradt et al., and NGC 5506, M82, NGC 1365 and NGC 5264 in the 2A and 4U surveys.

The X-ray luminosity from these objects is found to be between 10^{41} to 10^{43} erg s^{-1} in the 2-10 keV range. Some of them could be classified as Seyferts Type 2; but most seem to be only characterized by narrow emission lines indicating perhaps a smaller degree of mass motions than in the Seyferts. Their possible contribution to the extragalactic X-ray background is not well understood.

It is suggestive to consider (at least from the X-ray point of view) that the phenomena occurring in these objects may represent a link between those in normal galaxies and those observed in Seyferts, QSO's and BL Lac objects.

G. CLUSTERS OF GALAXIES

X-ray sources associated with clusters of galaxies constitute the largest single class of identified extragalactic objects, with approximately 50 identified in the 4U and Ariel 5 catalogs (Forman et al., 1977; Cooke et al., 1977). Inverse Compton scattering of the microwave background photons by relativistic electrons, thermal bremsstrahlung emission from a hot thin plasma and emission from multiple compact sources have been proposed to explain cluster X-ray emission.

On the basis of several lines of evidence it now appears virtually certain that the dominant fraction of X-ray radiation originates from thermal bremsstrahlung from a gas at T $\sim 10^8$K in a diffuse intracluster medium. Spectral data show the presence of a continuum with an exponential spectrum as would be expected in thermal bremsstrahlung (TB) emission, as well as a spectral feature at $\sim$ 7 keV, which is interpreted as due to K-line emission of Fe XXV and Fe XXVI ions at $\sim 10^8$K (Mitchell et al., 1976; Mushotzky et al., 1978). However, extended radio halos in a number of X-ray clusters (e.g. A2319, Grindlay et al., 1977) suggest that a fraction of the 2-10 keV flux, and any hard X-ray emission is due to inverse Compton scattering.

The fact that a strong anti-correlation (Melwick & Sargent, 1977) exists between cluster X-ray luminosity and the fraction of spiral galaxies in the cluster can readily be understood in the TB model. The containment of the electrons in radio tails and the tentative detection (Gull & Northover, 1978) of a cold shadow cast on the microwave background are also strong confirmation for the existence of a hot intracluster medium. The mass of the gas contained within the core region is of order of that contained in the galaxies and falls short by factors of $\sim$ 2-10 from providing the virial mass required to bind either the galaxies or the gas itself (Kellog et al., 1973).

The temperature of the gas ranges from 2 to 20 keV with most values between 4 and 10 keV. The iron line equivalent width for the 8 clusters, in which it has been observed, is consistent with that expected at the measured temperature of the gas, assuming approximately solar elemental composition (Mushotzky, 1978). Attempts to quantify the relation between the luminosity of the cluster and optically observed parameters and characteristics have not been very successful. Solinger & Tucker (1972) suggested that $Lx \propto \Delta V^4$ if $M_{gas} \sim M_{virial}$, and kT independent of ΔV; and $L_x \propto (\Delta V)^5 \exp|-A/\Delta r^2|$, if $kT \propto \Delta V^2$.

No distinction between these relations is yet possible. No more successful have been the attempts to relate T to either cluster richness R (Jones & Forman, 1977) or central galaxy density N_0 (Bahcall, 1977). On the other hand, the total luminosity Lx has been more convincingly related to cluster richness R and $\bar{N}_0$.

Enhanced emission within the core in the neighborhood of the central galaxy NGC 1275 has been observed in Perseus. This component is < 4 arc min and contains about 1/4 of the intensity (Cash, Malina & Wolff, 1976; Gorenstein et al., 1977). A plausible explanation is accretion onto NGC 1275 (Cowie & Binney, 1977). Virgo shows on the small scale (< .1 Mpc) emission compatible with the "well" model in which the X-ray emitting gas is bound to the potential of M87. On a larger scale ($\sim$ .5 Mpc), emission presumably due to the cluster as a whole, has recently been detected (Lawrence et al., 1978; Jones Forman, 1977; and Forman et al., 1978). Evidence for larger scale structures of order of 10 has been presented by Murray et al., 1977, and Forman et al., 1978). In particular, the latter describes UHURU results which tend to support the existence of extended massive halos of $\sim$ 5 Mpc surrounding clusters. The total mass contained in these halos would be of order $10^{15} - 10^{16} M_\odot$, providing sufficient mass for closure of groups of clusters.

H. GAMMA RAY ASTRONOMY

At present both diffused gamma radiation and discrete sources ($\sim$ 20) have been detected. The diffused component has been studied by SAS-2 in the range above 35 MeV. It appears to consist of two components: one which is clearly of galactic origin, correlated with galactic latitude, 21 cm measurement and the continuum radio emission; the other, apparently isotropic with a steeper energy spectrum (2.85 (+0.50, -0.35) differential power law index) between 35 and 150 MeV. For a review, see Fichtel, 1977. Cos-B has detected 24 high energy discrete sources at energies > 50 MeV. Four sources are currently identified with pulsars (including PSR 0531+21 and PSR 0833-45). The most remarkable feature in these objects appears to be the presence of two gamma-ray peaks in the pulse, often uncorrelated to the optical or radio appearance and separated by a constant fraction of the period, $\sim$ 0.4. In some of these objects the gamma-ray luminosity represents a large fraction of the available energy provided by loss of angular momentum of a neutron star.

3C273 has been identified with a gamma-ray source. It is the only high latitude gamma-ray source so far observed at $\sim$ 100 MeV (though Cen A is detected at $\sim 10^{11}$ eV) and the identification, although based on poor location accuracy, appears very likely. Poor location accuracy makes it difficult to identify any of the remainder of the gamma-ray sources. Somewhat surprisingly SN remnants do not appear well correlated with gamma-ray source positions. Suggestions of possible connections with molecular clouds and O and B associations have been advanced. Gamma-ray sources do not, in general, appear to be strong 2-6 keV X-ray sources (possible self absorption?) which raises problems for many models of the underlying energy source. The correlation with 30-100 keV X-rays has not yet been fully investigated. Gamma-ray sources appear poorly correlated with strong radio sources.

Gamma-ray lines studies, now beginning in earnest, promise to open up a very interesting line of research. A 0.511 MeV gamma-ray line detection due to positron annihilation from the galactic center has recently been reported by Leventhal et al.

I. NEW RESULTS ON COSMIC RAYS IN THE LAST TWO YEARS

I. Observations

The spectrum of electrons at high energies (above 10 GeV) is very steep hinting that the confinement time of cosmic rays is long. This observation is in agreement with accurate results on the isotropic composition of beryllium which indicate that the confinement time of cosmic ray is more than 20 million years. Time delay between nucleosynthesis and acceleration is larger than 1 year, as seen from recent precise elemental abundances.

The isotopic composition of Ne, Mg, Si and Fe in cosmic ray sources is compatible with solar system values (although there is some discussion about Ne22 observations). At present there is no compelling evidence that cosmic rays are made out of freshly synthetized material.

The variations of composition with energy in the range 5-100 GeV are well explained by a propagation effect with a mean free path which decreases as the energy increases. While the source composition is energy independent (at higher energies: from air shower observations, hints of FE enrichment).

Gamma-ray observations indicate that cosmic rays are not homogeneously distributed in the galactic disk. Also observations of the gamma-ray spectrum due to diffuse interstellar medium permit the determination of the electron spectrum in the region approx. 100 MeV. The result implies that the effects of solar modulation are important. Anisotropies in the cosmic ray flux at energies above 10 eV have been detected.

II. Theory

The spectrum of cosmic rays is well explained if cosmic rays are accelerated by shock waves from supernovae. Diffusion effects have been developed and can fit most of the data. The gradient of cosmic ray in the ecliptic plane has been measured to greater distances. Results imply that the boundary of the solar cavity is much further than 17 A.U. Measurements slightly above the plane indicate that the perpendicualr gradient is large, especially for the anomalous component.

Solar cosmic rays emitted from medium and large flares tend to have always the same composition. In very small flares cosmic rays tend to be enriched in heavy elements and also sometimes in He 3 (these contributing remarks courtesy of Drs. C. Cesarky & L. Koch, Saclay).

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5. Space Solar Astronomy

R. M. Bonnet

Activity in space solar astronomy for the period extending from January 1976 to January 1979 has been very intense. It is presented below, like in the previous report, experiment by experiment.

A. SKYLAB

Most of the results obtained with Skylab are described in the reports of Commissions 10 and 12 to which the interested reader is referred to. The work has been supported essentially in the United States but also through guest investigators in Europe, Japan, etc... Specialized Workshops have been organized by NASA and the NCAR in the US.

It would be outside the scope of this report to describe the fundamental contribution of the ATM instruments to our understanding of Solar Physics. These contributions bear mostly on deepening our knowledge of:

1) the Energy Balance of the Chromosphere and the Corona over active and quiet regions, and coronal holes (see Withbroe & Noyes, 1977; Withbroe, 1977; Zirker, 1977, Kopp & Orall, 1977; Cheng et al., 1978);
2) the structure of the corona as observed in X-rays and in white light, and in particular the existence of loops interconnecting separate active regions and their relationship with the underlying magnetic field (Svetska et al., 1977) and of X-ray bright points and their relationship with super-granulation (Howard et al., 1978);
3) the physics of flares (Svetska, 1978; Feldman et al., 1978);
4) the density structure and dynamics of the chromosphere and the corona (Doschek et al., 1978, Feldman & Doschek, 1977; Doschek & Feldman, 1977-1978, Feldman et al., 1976, Doscheck et al., 1976).

B. OSO-8

The last of the NASA Orbiting Solar Observatory was launched on 21 June, 1975 and successfully operated for more than 39 months, until it was switched-off on 30 September, 1978. During this period, the two pointed instruments and two in the wheel have been observing the sun continuously in the far ultraviolet and in the X-ray regions.

The two pointed instruments possessed high spatial and spectral resolution capabilities and were particularly suited for the study of velocity fields and periodic motions.

The LPSP instrument (Artzner et al., 1977; Bonnet et al., 1978) detected for the first time oscillations in the two optically thick h and k Mg II lines, simultaneously with H and K Ca II. Between the two ions the correlation is very good, and the periods vary from 150 s to 280 s; supergranular cells show shorter periods than do network and plage regions (Artzner et al., 1978).

The oscillations have also been detected in Lyman α despite their very small amplitude. A search for velocity oscillations of both 300s and shorter periods has been made in the line of O VI at 1032, but no oscillatory power has been detected so far in this line, within the limit of ± 3 km/s.

As a first order step, Ly α and Ly β H I quiet sun profiles, are better represented if the partial redistribution hypothesis is used and if, for the core of the lines, macroscopic turbulent velocities of about 20 to 30 km/s are introduced. There is still a disagreement however in the wings at distances larger than 1A from the core (Gouttebroze et al., 1978).

Plage profiles were observed from both OSO-8 and the ground and were used to test active region models characteristic of the sun during the rising slope of the cycle (Pecker et al., 1977). When compared to quiet sun profiles, they show a higher intensity, and a lower contrast between the core and the two emission peaks but nearly the same peak separation.

Sunspots were extensively studied (Hosinsky et al., 1977; Scharmer et al., 1977) and the temperature gradient is found to be steeper over the umbra than in quiet sun regions (Yun et al., 1977).

Several observations made in the penumbra of sunspots show very strong ejections of matter with velocities of 50 to 80 km/s. A broad absorption feature appears first in the wings of Ca II and Mg II, and then decreases in the middle temperature range producing significant depletion in the red peak of the Ly α line.

Both quiet and active prominences have been observed with the LPSP instrument. Active prominences have complex velocity structures which increase to the periphery and reach 20 km/s in Ca II and Mg II lines. The shape of the lines suggests a turbulence velocity in the range 20 to 30 km/s. The brightness in Ly α, Mg II and Ca II are comparable with previously observed and computed ones (Vial et al., 1979). A first attempt to observe prominences simultaneously from space and the ground was made in the frame of a systematic programme of observation in coordination with Oslo, Meudon and Pic du Midi observatories during two periods in 1978.

The O VI line (1032A) can also be observed with the LPSP instrument. Several sets of plage observations show very strong Doppler shifts ranging from − 25 to + 30 km/s. Impulsive events produce similar velocities.

The LPSP instrument has successfully observed a classical two-ribbon solar flare on 19 April, 1977, in McMath region 14726 (Skumanich et al., 1977). This flare gave rise to a low intensity long-lived, class C-2, X-ray event. All flux curves, except for the soft X-rays (1.5-12 keV), show superposed "bursts". The Lyman α flux appears to decay slowly in a fashion similar to the soft X-rays while the Mg II flux decays more rapidly similar to the moderate X-rays. At flare maximum the portion of the flare ribbon, assumed to be 5" wide, crossing the 6" slit was 110 times brighter in integrated Ly α (± 1A) and 45 times brighter in integrated Mg II (± 1.4A) than the quiet sun. Line profiles of Ly α, O I λ 1305, and for the first time, Mg k, h have been obtained from pre-flare through maximum into the late-cooling phases. Two components are clearly recognized, more so in Mg II than Ly α. One is to the red by 16 km s^{-1} of the rest position, the other at a blue shift of 50 kms^{-1}. The latter may be the signature of the "blow-off" of the flare heated chromosphere and is present from the beginning as a weak signal which reaches maximum visibility at maximum phase. At this time its FWHM is 50 km $^{-1}$ while that of the red component is 90 km $^{-1}$.

The LASP instrument (Bruner et al., 1977) investigated the 300 s photospheric oscillations and the motions driven by them in the chromosphere and at the transition zone level through the analysis of time resolved Si II (1817A) and

C IV(1548A) profiles, either for the quiet network or in active regions. The Si II emission lines formed at about 1200 km give a positive evidence for acoustic waves propagating radially with a velocity near the sound speed, but the amplitudes of the waves seem too small to contribute significantly to the energy balance in the upper chromosphere. Fourier analysis of time series also seems to give evidence for scattering of acoustic waves by chromospheric inhomogeneities at frequencies above 10 mHz and for aperiodic solar fluctuations at frequencies below 2.9 mHz (Athay & White, 1977). The observed fluctuations in the C IV line position corresponding to rms velocities of about 2.3 km/s in active regions and 5.7 km/s in quiet regions are too low to explain coronal heating of acoustic waves, although there is evidence for the occasional existence of acoustic waves at transition zone temperatures. The data are however consistent with heating mechanisms based on energy transport by magnetohydrodynamic waves (Bruner, 1978).

A search for frequency dependence of phase velocities of waves in the solar chromosphere for periods ranging between 100 s and 1000 s has been undertaken for lines of Fe II, Si II, C II, Si IV and C IV. The phase delays and the derived propagation times increase with increasing frequency in the range 2 to 5 mHz. Little power is found for frequencies above 5 mHz (Chipman, 1977).

Modelling of the upper atmosphere was also undertaken using the C IV line and the C II resonance lines at 1335A. A marginally significant increase in the width of the C IV line with intensity was detected and a contrast ratio of 13:1 with the extreme extending to 50:1 was measured between network and cell. The measured average width of 0.22A (FWHM) of the C IV line is in good agreement with earlier work (Bruner & McWhirter, 1978). The center-to-limb analysis of the C II resonance lines indicates the existence of a temperature plateau at 16 500 K with about 25% more material than found in previous models.

C IV 1548 profiles also reveal red-shifted brightenings in the transition region above active regions and sunspots. In these events, the intensity rises by factors of up to 5 in less than ≃ 30 s. These events indicate that the emitting material is moving downward at velocities of up to 30 kms/s. The increase in line intensity and the amount of motion are consistent with the interpretation of these events as pressure waves propagating down magnetic flux loops (Bruner & Lites, 1978).

The Lockheed Mapping X-Ray Heliometer (Wolfson et al., 1977) has also been successfully operating since the launch. It responded to radiation from plasma of temperatures higher than 2 10^6 K, had a time resolution of 20 s, and a spatial resolution of 2-3 arcmin. It provided essentially continuous coverage of solar activity via one-dimensional collimators and proportional counter detectors. The temperature and emission measure evolution of the hot flare plasma were studied in many small events and an exponential growth was found for the emission measure during the rising phase of the events. The emission temperature evidenced a slow decrease throughout all the phases except the very beginning of the events. Temperatures above 10^7 K are required for these subflares to occur (Datlowe, 1977). Other data on flare observations are also available in Mosher et al., 1978., and in Avery et al., 1977. Temporal and spatial relationships of activated filaments, soft X-ray production and H α flares have also been made and no striking correlation was found. Filament activity itself is not directly responsible for any dramatic effects in X-rays (Acton & Mosher, 1978).

The Columbia University instrument contains two Bragg crystal spectrometers operating between 1.5 and 7.0A. The good spectral resolution ($400 \leqslant \lambda/d\lambda \leqslant 1500$) and high time resolution (10 s) coupled with their high sensitivity have made it possible to observe active regions under quiescent and flare conditions and both lines and continuum have been observed.

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The spectrometers have enabled detailed studies of the development of flare temperatures and emission measures to be made.

The line spectrum consists of emission from H- and He- like ions together with their related satellite line systems. Several satellite lines in the 1s .(2$\frac{s}{p}$) - 1snp(2$\frac{s}{p}$), n > 2, series in Si XII have been studied for the first time and their temperature dependence is consistent with formation by the dielectronic recombination process.

In some flares, a decrease in the S XV forbidden intercombination line ratio occurs at the start of the event and lasts for approximately 1 min. If this is interpreted as a density enhancement then an electron density > $10^{14} cm^{-3}$ is indicated (Parkinson et al., 1978).

C. SALYUT-4

The Orbiting Solar Telescope (OST-I) (Bruns et al., I), with a stigmatic spectrograph (Bruns et al., 2) was installed in 1975 on board of the Orbiting Station "Salyut-4". The stigmatic spectra of active regions were obtained wetween 970 and 1430 A, with a spatial resolution of 3"-5", and a spectral resolution of 0,3A). Intensities of 145 emission lines in spectra of two flares and flocculi have been obtained. Spectral lines of ions are much more enhanced in these spectra up to 20 times as compared with those of quiet sun than the lines of neutral atoms (enhanced in 1,5-3 times).

Examination of Ly α and Ly β profiles of weak flares and flocculi shows that the wings of these lines are mainly broadened by Stark-effect and by radiation damping. At the level where the wings originate $n_e \gtrsim 2.10^{13} cm^{-3}$; the column density of hydrogen in ground state $N_I \simeq 4.10^{20} cm^{-2}$ and kinetic temperature $T_{kin} \gtrsim 15\ 000°K$. In the active regions considered n_e is 10-100 times larger, N_I is 10-100 times smaller and ionization is $10^2 - 10^4$ times stronger than that of the quiet chromosphere.

The examination of Doppler shifts of lines observed in flocculi shows that the regions of opposite polarities of photospheric magnetic field are connected by loops. Plasma moving along these loops from one side of flocculae to the other can reach velocities $\gtrsim$ 100 kms/s^{-1}. "Turbulent" velocities of plasma, derived from the width of line profiles can reach 80-100 km/s^{-1} (Bruns et al., 3).

D. INTERCOSMOS AND OTHER SOVIET PROGRAMS

"Intercosmos 16" was launched on July 27, 1976. The satellite was equipped in particular with an U.V. spectrometer made by the Sweden Space Corporation with cooperation of the Crimean Astrophysical Observatory (USSR). It covered the spectral range 1200-1500A and could measure linear polarization (Stenflo et al., 1976). Data analysis shows that the average limb polarization in Ly α at 1216A is smaller than about 1%. (Stenflo et al., 1977).

The work was being continued on the evaluation of X-ray spectra obtained with the satellites "Intercosmos 4, 7, 11" and rockets "Vertikal". Detailed study of spectra in the region of resonance lines of Mg XII and Fe XXVI ions was carried out; a large number of the so-called "satellite" lines as well as the K and K lines of lower ions were detected and identified. Experimental wavelengths obtained coincide with the calculated values with an accuracy of ± 4.10^{-4}A. For a number of solar flares the temperature of the hot plasma core was measure ($6-30.10^6$K), its temporal variation was followed and spectral line Doppler shifts were found which are indicative of plasma motions with velocities up to 600 km/s (Aglizki et al., 1978; Kononov et al., 1978; Yakimets et al., 1977).

The results on polarization of the flare radiation may be found in Somov & Tindo, 1978; Tindo & Somov, 1977-1978.

The detailed analysis of X-ray events in the region 2.5-30 keV and γ rays observed by the series of satellites "Prognoz" during the period 1970-1974 was finished (Problemi solnechnoy activnosti i cosmichescaya systema Prognoz, Moskva, 1977).

E. OTHER SOLAR SATELLITES

Kanno & Nishikawa (1978) used the data of OSO-4 and OSO-6 to study U.V. absorption by spicules. Glencross (1978) continued analyzing the X-ray data obtained with the UCL package on OSO-5, and noted the surprising fact that the average flux and the frequency of flaring fell considerably before large outbursts.

The analysis of extreme UV and soft X-ray data on flares as observed by the GSFC spectroheliograph on OSO-7 was continued (Neupert, 1977).

A comprehensive analysis of the TD-1A observed X-ray flares was completed by Hoying et al., 1976, and a model was constructed that explains the soft-hard X-ray emission as well as the microwave radiation of a few flares (Böhme et al., 1977).

F. ROCKET EXPERIMENTS

Rocket experiments have been continuing at a fairly high rate especially in the U.S. Outstanding results on the ultraviolet spectrum between 1175 and 1714A were obtained with the High Resolution Telescope and Spectrograph of NRL (USA). A spatial resolution, better than one arcsec, together with a spectral resolution of 0.05A were determining factors in uncovering many new features at the temperature minimum level and in the transition region, with Doppler velocities of 10 km/s in the network, dominated by redshifts while more homogeneous areas show outblowing material, and very broad non-Gaussian profiles of subarcsecond elements in the network and plages.Blue-shifted jets seem to originate from these events exhibiting projected velocities up to 200 km/s (Brueckner et al., 1977). Very intense downflows of more than 100 km/s are observed in transition region lines above the umbra of sunspots. Emission lines of H_2 have also been observed by Jordan et al., (1978) on these spectra.

The scientific analysis of the data from rocket-spectrometer flights at the Center for Astrophysics (Harvard) has resulted in the publication of an atlas of the center and limb solar spectrum in high spectral resolution for the wavelengths between 2252A and 3196A (Kohl et al., 1978a). These data have resulted in the determination of the photospheric abundance of boron, of numerous spectral line profiles in absolute specific intensity units, (Kohl & Parkinson, 1976; Kohl, 1977) and semi-empirical values for residual solar irradiance in the earth's atmosphere down to 28.7 km (Cann et al., 1978).

A Lyman alpha coronograph has been built at the Harvard-Smithsonian Center for Astrophysics to measure the spectral line profile and absolute intensity of resonantly scattered coronal Lyman alpha radiation (Kohl et al., 1978b).

The 1974 University of Hawaii rocket flight had yielded spectra of 15 mA spectral and 7 arcsec spatial resolution in the wavelength range 2680-2930A. An atlas of quiet sun disk center has been published (Allen et al., 1978). These data have been used with ground-based measurements from KPNO to more firmly establish the solar tin abundance (Allen, 1978a). Inspection of the films revealed three faint emission lines deep in the wings of the Mg II h and k wings (Allen & McAllister, 1977) ; their behavior strongly resembles that of their counterparts in the Ca II H and K wings. The appearance of the Mg I resonance line (2852A) core was found to differ strongly between a sunspot and the surrounding plage (Allen & McAllister, 1978b).

The improved University of Hawaii spectrograph was flown at Withe Sands in August 1976. These 1976 spectra (1770-2020A) show bright emission lines of Si II and III, S I and C I. Also present are about 130 other emission lines (mostly due to Fe II) and about 3000 absorption features. Detailed analyses of line profiles of Si II λλ 1808A, 1816A and 1817A (Finn & McAllister, 1978), of S Iλλ1807A and 1900A (Doherty & McAllister, 1978a), and of C I λ 1930A (Doherty & McAllister, 1978b) have been conducted. Highlights of these studies are that the transition zone temperature rises deeper into the atmosphere than provided by the model of Vernazza, Avrett and Loeser, and the S I data illustrate the presence of residual coherence in the photon scattering process. Observations of S I, Mg II, Ca II, and C I were combined to derive a simple model of the height variation of the macroturbulence field.

Absolute disk intensities and center-to-limb data from the French Veronique rocket spectrograph launched in 1973 have been analyzed and published (Samain, 1978a). The analysis of the UV continuum shows that a model with a temperature minimum at 4300 K is consistent with the existence of departures from local thermodynamic equilibrium for the main absorbers, i.e.: Si I, Mg II, Fe II, provided the temperature gradient of the model is slightly modified in the vicinity of the temperature minimum. The sources of continuous opacity have been analyzed by Samain and a complete discussion may be found in his thesis (1978b).

K. Nishi analyzed the data of observation obtained by a scanning spectrometer mounted on the K-10-11 rocket launched on September 24, 1975. The observed values of center-to-limb variation were consistent with their previous ones (1630A ∿ 1740A) and those obtained by Samain (1740 ∿ 2000A), but differed from the calculated values derived from the HSRA model (Nishi et al., 1976).

X-ray pictures and spectra of the sun were obtained with the Astro-1 rocket experiment of the national federal rocket programme of Germany. The rocket was launched in Spring 1974. From pictures obtained in the light of two emission lines the distribution of temperature and emission measure could be determined (Briel, 1976).

The X-ray pictures of former German rocket experiments have been analysed (Kramer et al., 1978).

A U.K. rocket payload was flown successfully at the beginning of 1978 with instrumentation designed specifically to determine the coronal helium abundance by measurements of the resonance scattering of the He II 304A line. The data are currently being reduced. A development of this instrument has been selected by NASA to be flown on the Spacelab-2 flight.

A NASA Astrobee rocket, carrying a joint Leicester-A.S. and E. payload designed to measure the emission and temperature structure of an X-ray bright spot was launched in February, 1977.

G. BALLOON EXPERIMENTS

Solar faculae were observed from a 10cm aperture balloon-borne telescope launched on September 19, 1973 and September 2, 1976. The life time of facular granules with the average size of 2" near the limb was statistically estimated to be 4 ± 1 hour and they fluctuated in intensity with a time scale of approximately 20 min. Their centre-to-limb variation indicates that the facular granules are about 1000 K hotter than the photosphere at the optical depth of around 0.1 at 5000A (Hirayama, 1978).

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The work underway at the Genova Observatory was continued and resulted in the measurement of the absolute solar brightness temperature in the far infrared, between 85 and 250 μm using lamellar-grating interferometer and a black-body calibration source. The spectral resolution was $0.2cm^{-1}$ (Rast et al., 1978).During the first two flights in 1975/1976, a flat temperature profile between 60 cm^{-1} and 110 cm^{-1} was observed with a minimum of 4530°K + 100°K - 150°K in agreement with the S model of Vernazza but in contradition with the UV results of Samain (see above).

H. CONCLUSION

Now that OSO-8 has been switchedd off, apart from a few rocket and balloon experiments, there is no space solar instrument in activity before the launch of SMM at the end of 1979 and probably a Soviet satellite with a similar mission. After SMM the next major event will be the launch of Spacelab 2 in 1981 which will carry 3 solar instruments : a new version of the NRL, HRTS, a Lockheed instrument to measure solar magnetic and velocity fields and a U.K. instrument to study the abundance of helium relative to hydrogen in the corona.

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Appendix n°1

NASA High Energy Astronomy Observatory (HEAO) Program

H. Friedman

HEAO-1 carries four sets of instruments to cover the spectral range from 0.15 keV to 10 MeV. Each instrument gains markedly in sensitivity over earlier experiments in its class by virtue of the large size made possible by the 3000 kilogram payload launch capability of the Atlas Centaur rocket. The spacecraft was inserted in a circular orbit at 440 km at 22.75 degree inclination on August 12, 1977. In its first six months HEAO-1 completed a full sky survey. As it approached the one-year mark, a substantial program of discrete pointings was interspersed with the second round of sky survey.

The A-1 instrument is composed of seven modules of large area proportional counters, prepared by the Naval Research Laborotary (H. Friedman, P.I.), which are used to map the entire sky for sources (0.25 keV to 20 keV) down to the confusion level of 1° x 4° collimators. Another set of proportional counters, A-2, designed by the Goddard Space Flight Center (E. Bolt, P.I.) and the California Institute of Technology (G. Garmire, P.I.), with the collaboration of the University of California, Berkeley and the Jet Propulsion Laboratory, studies the diffuse X-ray background (0.15 keV to 60 keV). Positions of sources are determined to a precision approaching 5 arc seconds by a modulation collimator proportional counter instrument. A-3, built by the Massachusetts Institute of Technology (H. Bradt, P.I.) and the Smithsonian Astrophysical Observatory (H. Gursky, P.I.). A-4 is a set of scintillation phoswich detectors assembled by the University of California, San Diego (L. Peterson, P.I.) and the Massachusetts Institute of Technology (W. Lewin, P.I.), which extends the range of studies into the region of hard X-rays and low energy gamma rays. All of the instruments are distinguished by their large size compared to similar devices flown in earlier programs.

A. A-1 INSTRUMENT

The principal objective of the A-1 instrument is to obtain a high sensitivity map of the sky. To this end the spacecraft is maneuvered in a uniform scan mode. Proportional counter modules 1 to 6 are mounted on the -Y face of the 6 meter long spacecraft and module 7 on the +Y face. The Z axis, through the short 2.5 meter dimension of the spacecraft, points to the sun. Since the spacecraft is carried with the earth about the sun, the Z axis advances one degree per day in the ecliptic plane. The detectors looking outward perpendicular to the Z axis make two revolutions per hour, thus scanning great circles which are meridians of ecliptic longitude. Modules 1 to 4 perform the basic scan with 1° x 4° fan beam fields of view, the short dimension being in the roll direction. Three scans are completed each orbit and a new strip of sky is covered each day. Near the ecliptic, sources remain in view for 8 days, and at higher ecliptic latitudes the duration increases, so that the two ecliptic poles are scanned every rotation. Modules 5 and 6 have 1° x 0.5° fields to help resolve source confusion and module 7 has an 8° x 2° field to provide longer transits in which to observe rapid variations.

The choice of telemetry mode determines observable time scales. In the mode most often used, the instrument transmits five spectra, with timing resolutions of 320 and 640 milliseconds. For the study of rapidly varying sources, 5 millisecond integrations are transmitted plus a single spectrum. When the satellite is over a ground station, a high bit rate mode can transmit in real time with a resolution of a few microseconds.

HEAO-1 spends most of its time scanning high galactic latitudes where the number of sources grows more rapidly at fainter flux levels than it does in the plane. Thus, A-1 should see more extragalactic objects than the previous surveys. The results thus far indicate that the A-1 catalog will exceed 1000 sources, most of which will be extragalactic.

B. A-2 INSTRUMENT

The A-2 instrument gives first priority to determining the spectrum and isotropy of the diffuse background. Six counters cover the range from 0.15 keV to 60 keV and the collimator grids are designed to provide two fields of view in each counter. The diffuse X ray background should scale directly with solid angle whereas energetic particle backgrounds should not. Results of the first six months of operation lead to the conclusion that the diffuse spectrum is a close fit to a thermal spectrum at a temperature of about 450 million deg K. A further conclusion is that the integral of clusters of galaxies fits a thermal continuum with a temperature of about 60 million degrees Kelvin. Clusters constitute the main contribution of discrete sources to the integral background below 10 keV, but cannot supply more than about 10 percent of the diffuse background. Above 10 keV, Seyferts are the most important discrete sources. The recent detection of radiation in the gamma-ray region from the Seyfert NGC 4161, and possibly from 3C 273, suggests that Seyferts may be the most important contributors to the background radiation at higher energies than surveyed by the A-2 experiment. If the diffuse flux observed by the A-2 instrument, up to 60 keV, is primarily produced by hot, intergalactic gas uniformly filling the universe, the density would be about equal to the critical value for a closed universe.

A-2 will contribute substantially to the catalog of X-ray sources, especially those in the very soft X-ray range. HZ 43 should be typical of hot white dwarfs. Nine RS CV_n binaries have been identified as soft X-ray sources (4×10^{30} - 10^{33} erg/sec, 10^7K). Algol is an example of a semi-detached binary ($\sim 10^{31}$ erg/sec, 2-6 keV). W UMa and VW Cephei (10^{29} erg/sec) are examples of

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contact binaries. SS Cygni and Am Her are soft X-Ray/cataclysmic variables. Even the stellar coronae of nearby F and G dwarf and subgiant stars appear to be detectable.

C. A-3 INSTRUMENT

The A-3 instrument has significantly increased understanding of several X-ray sources by obtaining precise positions for them. For example, the X-ray nova, Nova Ophiuchi 1977, was positioned so rapidly that it was possible for optical observers to locate it before it had faded away. Precise positions have been found for many faint sources in the galaxy such as the Rapid Burster and the new black hole candidate GX 339-4. As the mission advances, the accumulation of additional pointing and scanning time will allow positioning of fainter objects, including those outside our galaxy. Already positions and angular sizes for several cluster sources have been found and one X-ray source associated with an active galaxy, Centaurus A, has been determined precisely enough that one can say the X-ray source lies at the center of the galaxy.

D. A-4 INSTRUMENT

The A-4 instrument has been studying high energy emission from binary pulsars and active galaxies. The cyclotron feature in Hercules X-1, first seen by the Max Planck Institute, has been confirmed with the A-4 instrument, and they have further found another cyclotron feature in a recurrent transient pulsar, 4U 0115+63. In this instance the spectral feature appears to be absorption. A-4 has also worked with the Helios Satellite to determine the location of a gamma burst to an accuracy of 0.4 square degrees. Such measurements may eventuallly make it possible to determine the origin of gamma bursts.

E. HEAO-B

As of the time of this summary, HEAO-B is scheduled for launch in November, 1978. It will have about 10 times the sensitivity of HEAO-I for discrete X-ray sources and is to be operated as a guest observatory for a large segment of the astronomical community as well as for the consortium that conceived it. The consortium institutions include: the Center for Astrophysics-Harvard College Observatory/Smithsonian Astrophysical Observatory; the Center for Space Research, MIT; Columbia Astrophysical Laboratory, Columbia University; and Goddard Space Flight Center, NASA. The Principal Investigator, R. Giacconi, will be Director of the Observatory. Principal Scientists are E. Bolt, G. Clark, H. Gursky and R. Novick.

The basic part of the HEAO-B instrumentation is a nested Wolter-type mirror, 60 cm in diameter with an effective field of view of 75 arc minutes. There are four focal plane instruments: a High Resolution Imaging System (HRI) and an Imaging Proportional Counter (IPC); a Solid State Spectrometer (SSS); and a Focal Plane Crystal Spectrometer (FPCS). An objective grating spectrometer and a filter spectrometer are located just behind the mirror and can be inserted into the X-ray beam to be used with the imaging detectors. Finally, there is a Monitor Proportional Counter coaligned with the telescope with the capability for high time resolution studies.

The telescope effective area is energy dependent, $\sim 300 cm^2$ below 3/4 keV, $\sim 200 cm^2$ at 2.4 keV, and $\sim 50 cm^2$ at 3.5 keV. The predicted resolution is 1 to 1.5 arc seconds blur circle radius within 3 arc minutes of the axis, and ~ 1 arc minute at 20 arc minute off-axis.

HEAO-C, the final mission in the program, will be devoted to cosmic ray astrophysics and is scheduled for launch about one year following HEAO-B.

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Appendix n°2

The International Ultraviolet Explorer

R. Wilson

The International Ultraviolet Explorer (Boggess et al., 1978a) was launched successfully on 26 January 1978, from Cape Canaveral, Florida. The satellite was developed to provide a general facility for observing ultraviolet (UV) spectra of astronomical sources over the wavelength range from about 1150 A to 3200 A. The project has been a joint undertaking in which the US National Aeronautics and Space Administration (NASA) provided the spacecraft, the optical and mechanical components of the scientific instrument, the US ground observatory and spacecraft control software, the UK Science Research Council (SRC) in collaboration with University College London (UCL) provided the television cameras used to record the spectroscopic data; and the European Space Agency (ESA) provided the solar arrays and the European ground observatory. The image processing software was developed jointly by NASA and the SRC's Appleton Laboratory. The satellite has been placed in geosynchronous orbit over the Atlantic Ocean and is operated for 16 hr each day, for NASA sponsored observers, from the US ground observatory located at the Goddard Space Flight Center (GSFC) near Washington, D.C., and for the remaining 8 hr by ESA for ESA and UK sponsored observers, from the European ground observatory located near Madrid.

The main characteristics of the scientific instrument and its in-orbit performance are summarised in Table 1. The 45 cm telescope can image a source in either of two spectrographs (short or long wavelength) each of which has a selection of two entrance apertures (small or large) and two dispersions (low or high). The high dispersion mode uses an echelle grating operating at high order ($\sim$ 70-120) which is crossed by a diffraction grating for order separation, thereby presenting the detector with a compact two-dimensional format. The low dispersion mode is obtained by simply flipping a plane mirror in front of the echelle leaving only the diffraction grating as a dispersing element. The dectectors are ultraviolet cameras which are based on a uv-to-visible image converter (UVC) fibre -optically coupled to a secondary electron conduction (SEC) vidicon tube. The design is such as to retain the high quantum efficiency and solar-blind characteristics of the Cs Te photocathode of the UVC and to exploit the long integration times possible with the SEC.

The geosynchronous orbit allows continuous real-time control which is used to give an increase in system capability and scientific efficiency. The observer is present at the observatory ground station where control is based on a large real-time computer software system to process commands and telemetry. The first step in an observation is to slew the telescope to the desired object which can be done to $\sim$ 2 arcmin. The target will thus be present within the 16 arcmin field of the telescope which is viewed by an image dissector tube and transmitted to the ground for display. The observer then identifies the target and nominates a guide star; the target is then placed in the desired aperture and maintained there by the same image dissector tube acting as a fine error sensor (FES). On completion of the exposure, the camera is read and the spectral image transmitted to the ground where a quick-look display enables the observer to judge the quality and content of the data. The observation can be repeated or the next one initiated as need be.

The synchronous orbit has a futher advantage in that the unconstrained area of the sky accessible to observation is much greater than for low-orbit astronomical satellites or for ground-based observatories. A penalty is that observations must be conducted in sunlight and this requires the telescope to have an efficient baffle system. This has been demonstrated to be fully effective and observations are possible at all angles greater than 45° from the sun. Hence, except for the less serious restrictions which are caused by the bright earth and moon, about 80% of the celestial sphere is accessible to observation by IUE. Thus, long exposures are possible and variable phenomena can be studied for longer intervals than with other astronomical facilities.

The geosynchronous orbit is elliptical and the satellite enters the upper part of the earth's radiation belt for a few hours near perigee. The radiation levels encountered (due to the trapped electrons) vary considerably and, at worst, restrict camera exposures to about 15 minutes. However, for 40% of the orbits, the radiation level is negligible. Outside the belt, long exposures have been made which show that background levels can be tolerated for exposures in excess of 10 hours.

During the commissioning phase which terminated on April 2, 1978, a number of important activities were carried out (Boggess et al., 1978b) After insertion into mission orbit, the various sub-systems were switched on in a series of operations which terminated in 3-axis stabilisation and star acquisition. At that point, without orbital optimisation or calibration, a set of high priority targets were observed as a precaution against premature failure of the system. These covered many areas of astronomy and the results have been reported in Nature (Heap et al., Linsky et al., Grewing et al., Dupree et al., Boksenberg et al., Lane et al., 1978). They will not be summarised here since a more up-to-date account of IUE observations appears in the main body of this report. Following those observations, the system was optimised (e.g. the telescope was focussed and the camera settings optimised for its observing and prepare sequences) and its performance assessed. The main performance parameters are listed in Table 1 and, by and large, the system is operating at its design levels. Finally, the system was calibrated for wavelength by using standard stars set up by OAO-II, TD-1 and ANS observations. The sensitivity is indicated in Table 1 by the magnitude limits for "blue" objects (e.g. hot sub dwarfs, unreddened early type stars in Magellanic clouds, some Seyferts and QSO's etc.) depending on an exposure range of about 1-5 hours. The calibration data inputs to the data processing system which reduces the observations of all users to a point where astrophysical analysis can begin. At the time of writing, this system is less than perfect, and steps are in hand to improve it. Observers have exclusive rights to their data for six months but after that period they are deposited in data banks held by the three participating agencies and are made available on request, to the international community.

Since 3 April 1978 IUE has been operating as a guest observer facility and the three agencies have allocated about one year ot time to proposals involving about 200 astronomers from 17 countries. A second invitation to propose in bids for the second year of operation has resulted in about 400 proposals being received by the three agencies.

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Table 1

IUE SCIENTIFIC INSTRUMENT

CHARACTERISTIC AND PERFORMANCE

Telescope	Type	Ritchey-Chretien
	Aperture	45 cm
	Focal ratio	F/15
	Acquisition Field	16 arcmin
	Image quality	3 arcsec (70%)
	Pointing accuracy	< 1 arcsec
Spectrographs (2)	Type	Echelle x Grating or Mirror x Grating
	Entrance Slots	3 arcsec circle or 10 x 20 arcsec ellipse
	Detectors	UVC/SEC Vidicon Camera
	Wavelength Range	1150-3200A
	High dispersion Resolving Power	$1.2 - 1.5 \times 10^4$
	High Dispersion Resolution	0.1A - 0.2A
	Low Dispersion Resolving Power	200 - 400
	Low Dispersion Resolution	6A - 8A
Sensitivity	(Blue Objects)	
	High Dispersion	$m_v < 8-10$
	Low Dispersion	$m_v < 13-15$

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