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International Scientific Radio Union

Xth GENERAL ASSEMBLY

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COMMISSION V
On Radio-Astronomy

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Officers of the Commission

President . Dr. D. F. MARTYN, F. R. S., Chief Scientist, Radio Research Board, Mount Strombo, Canberra.

Rapporteurs : Dr. M LAFFINEUR, Chef du Laboratoire de Radio-astronomie, Institut d'Astrophysique, Paris.

Dr. J. L. PAWSEY, Assistant Chief, Radiophysics Laboratory, Sydney

Dr. LAFFINEUR was elected as President of Commission V by the Xth General Assembly.

List of papers presented to the Commission

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7*	Standardisation of solar noise observing equipment, India National Committee
8*	Report of the Canadian National Committee.
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Reports

Nº 304. — Report from the Chairman of Sub-Commission Va

Herewith I have the honour to inform you, that after the installation of the Sub-Commission Va on occasion of the General Assembly in Zurich (See *U.R.S.I Information Bulletin* Nº 67, January-February 1951), it was requested to the members of this Commission to send in a complete description with schemes of the apparatus for Solar-noise radio-radiation as used by them.

This request was answered by the following countries : Japan, Italy, France, Australia and Norway.

I also received from Dr. M. Martin Ryle of the Cavendish Laboratory at Cambridge, who was appointed as a member of the commission at the end of 1950, a description with sketches of the apparatus for solar noise as is used in Great Britain.

All these descriptions and diagrams were duplicated here and afterwards distributed to the other members of the sub-commission.

After joining of Dr Ryle the number of the members of the sub-commission has further extended with 3 members namely with Dr. A. K. Das, Director of the Solar Physics Observatory in Kodai-Kanal, South India, Prof .M. N Saha of the University College of Science in Calcutta, India and Mr. A. E. Covington, Micro-wave Section of the National Research Council in Ottawa, Canada.

From Dr. Das no data about the installation were received because this is not yet completed.

Mr. Covington has not yet sent in a description with schemes of the apparatus for solar-noise, as is used in Canada, I have only received regularly from him the monthly results of the Solar-radio-noise measurements

Correspondence about membership being continued with Mr. W. H. Eller, Chairman of the Department of Physics in Honolulu 14, Territory of Hawaii (U S A.), with Dr. B. F. J. Schonland, Director of the Bernard Price Institute of Geophysical Research, University of the Witwatersrand, Milner Park, Johannesburg, South Africa, and with Prof Jakko Tuominen of the Observatory, University of Helsinki at Helsinki, Finland, with the purpose of establishing an observing station for the « World-Wide-Survey ». respectively in Hawaii, South-Africa and Finland.

Attempted is still to win China for taking part in the Solar-noise measurements, but in connection with the war in Korea this attempt has lead to a failure.

The Sub-Commission Va consists now of the following members.

1 Dr J L Pawsey, Assistant Chief of the Division of Radiophysics, University Grounds, City Road, Chippendale N S W., Australia.

2 Dr M. Martin Ryle, Cavendish Laboratory, Free School Lane, Cambridge, England

3 Dr Ir M Laffineur, Institut d'Astrophysique, 98*bis* Boulevard Arago, Paris XIVe, France.

4 Mr G Righini, Osservatorio Astrofisico di Arcetri, Via S Leonardo, 75, Firenze, Italy

5 Prof Dr Y Hagihara, Tokyo Astronomical Observatory, Chairman of the National Committee for U R.S I, Mitaka near Tokyo, Japan

6 M G Eriksen, Civ Ing, Institut for Teoretisk Astrofysikk Universitetet, Blindern-Oslo, Norge

7 Dr R. Lindquist, Wave Propagation Observatory, Chalmers University of Technology, Goteborg, Sweden

8 M A. H Shapley, National Bureau of Standards, Upper Atmosphere Research Section, Central Radio Propagation Laboratory, Washington 25 D C, U S.A

9 Dr A K Das, Director of the Solar Physics Observatory, Kodai-Kanal, South-India

10. Prof M N Saha, University College of Science, Calcutta, India.

11 M A E Covington, Microwave Section of the National Research Council, Ottawa, Canada

12 M. A H de Voogt, Chairman, Engineer-in-Chief, Chief of the Division « Ionosphere and Radio-Astronomy », 6, Scheveningseweg, The Hague, Netherlands

Further the solar-noise reports are sent to Mr. S. F. Smerd, Editor « Solar Radio Noise » Radiophysics Laboratory, University Grounds, Chippendale, N. S. W Australia. for collection in the Quarterly Bulletin of Solar Activity.

Finally the concerned reports are sent to the following addresses

M. Willard H Eller, Chariman Department of Physics, Honolulu, 14, Territory of Hawaii, U S.A.

M. W. Menzel, Geschaftfuhrer der Arbeitsgemeinschaft Ionosphare der deutschen geophysikalischen Institute, Rheinstrasse 110, Darmstadt, Deutschland.

M le Directeur du Bureau Ionosphérique Français, 196, rue de Paris, Bagneux (Seine), France.

National Bureau of Standards, Upper Atmosphere Research Section, Central Radio Propagation Laboratory, Washington 25 D.C, U.S.A.

Department of Scientific and Industrial Research, Radio Research Station, Ditton Park, Slough, England.

Hereby I may remark that 2 stations on equal geographical longitude but on higher northern and southern latitude can still be of value for the investigations in consequence of the lenghtened duration of the observation in the summer season.

Concerning the sending in of the monthly results of the radio-solar-noise measurements I am informing you that reports were received from the members mentioned below

Name	Station	Fréquency Mc/s
Dr J L Pawsey	Potts Hill Sydney	600 and 1200 68 and 98
Mr. S F Smerd	Mount Stromlo	200
Dr M Martin Ryle	Cavendish Laboratory	81 5 and 175
Dr M. Laffineur	Meudon	255 and 555 (545)
Prof. Dr Y. Hagihara	Mitaka Osaka Toyokawa	60, 100 and 200 3260 3750
Mr. A E. Covington	Ottawa	2800

The reports were copied here and sent to the other members and to Dr C. W. Allen, Commonwealth Observatory, Mount Stromlo, Canberra (A.C.T.) (after September 1950 to Mr. S.F. Smerd of the Radiophytics Laboratory, Sydney).

The discussion carried on with you about the propagation of the radio-solar-noise reports among the members of the commission has convinced you and other members of the sub-commission, that my scheme of a quick mutual interchange of data between the observing stations is found to be of considerable value.

As for the inquiry into the 9 points of discussion, included in the letter of the 12th October 1951 nº 7116, circulated among the *members of the sub-commission*, which letter was sent to you by mine of the 13th of October next I send you herewith copies of the reactions received till now from Dr. J. L. Pawsey, Prof. Y. Hagihara, Dr. M. Martin Ryle and myself. These letters have been copied and sent to the other members of the sub-commission. Other comments were not received.

From several observatories the monthly results were received with a retardation of several months. Such a procedure is not advantageous for an effective comparison of obtained results.

The calibration of the sets in order to come to a trustworthy list of observations remains a very difficult job. Furthermore, observations on the same wavelength all over the world have been poor (See above list).

Changing the wavelength of a set is of course practically the same as building a new set.

Finally I may suggest some points to be dicussed by Commission V as regards the international solar-noise observations.

1 Is a quick mutual interchange of monthly results between the observatories desirable ? This point to be considered indepently of the collection and publication of the observations in the *Zurich Quarterly Bulletin* Sub-commission V*a* was not in charge of this matter.

2 Are there better and more reliable means for calibrating the sets as those now in use ?

3. Is there a possibility of using standard values of noise (temperature) of well-defined regions of the sky ? Is it possible to give a series of standard-corrections to be applied to solar-noise measurements, when the sun passes through the galactic-regions ? (To avoid this correction the Cavendish-observations are performed with the interferometer method).

4. Is it desirable and has it signification for the radio-traffic to give radio-warnings especially by the observatories situated 6-12 hours to the East ? These warnings might indicate noise-storms or disturbed conditions of the sun.

Nº 323. — Special Report Nº 3 on Dynamics of Ionized Media

A preliminary report drafted by Dr. P. L. Bhatnagor, Dr. Max Krook and Dr Donald H. Menzel (Chairman) has been submitted for discussion to Commission V.

Reports from National Committees

Australia

N° 325. — Report of the National Committee to Commission V

1 — Locations of Research in Progress

The greater part of the research in radio-astronomy in Australia is carried out by the Radiophysics Laboratory of the C.S I R O. in Sydney, the observations being taken at a number of field stations near the fringe of the built-up area The largest of these is at Potts Hill. This laboratory is concerned with cosmic and solar radio waves Theoretical work concerned with the growth of waves in ionised gases is in progress at the University of Sydney (Physics Department) and a programme of meteor observations has begun at the University of Adelaide (Physics Department). The section of the I A.U. « Quarterly Bulletin of Solar Activity » concerned with solar radio noise was edited up till 1951 at the Commonwealth Observatory, near Canberra, but this has now been taken over by the Radiophysics Laboratory. The Radio Research Board of C S I R O has also contributed.

2. — Cosmic Radio Waves

A preliminary series of observations of the atomic hydrogen spectral line at 1420 Mc/s, emitted by the galaxy was taken after receipt of information from Professor Purcell at Harvard that Ewen and he had succeeded in identifying it The Australian observations (1) showed the radiation to be distributed in a broad irregular band in the region of the Milky Way, as was expected from optical observations of the distribution of interstellar hydrogen They also showed that in certain directions, covering as much as a full quadrant around the galactic equator, the line

appears as a double line. If the source were distributed uniforml throughout the galaxy a broadcasting of the line in these directio would be expected owing to Doppler effects associated with diffe- rential galactic rotation It is probable that the double line due to galactic rotation, the source being divided into two discret parts instead of being uniformly distributed. If so the sourc must consist of two vast elongated clouds of hydrogen which a of the order of size of spiral arms of the galaxy.

During 1951, a survey of the discrete sources of cosmic radi waves was made on a frequency of 100 Mc/s (2) The 77 observe sources were examined statistically and the conclusions reache differed radically from those obtained previously by the Cambridg group following a similar survey. It was concluded that th discrete sources are not distributed at random but fall into tw distinct classes One class comprising intense sources, is concen trated in the galactic plane and these sources must therefore b at distances of the order of galactic dimensions The othe appear to be distributed at random in direction and intensit and could either be intensely powerful extragalactic bodies c comparatively feeble local ones at distances comparable wit local stars. The earlier tentative identification of two source with abnormal external galaxies favours the former hypothesi These identifications have been strengthened by more precis observations of position (3)

During this 100 Mc/s survey, and independently in the course c observations at 1200 Mc/s (4), several sources having dimensio of the order of a degree across were discovered Thus some, a least, of the discrete sources of cosmic radio waves are « radi nebulae » rather than « radio stars » This discovery is being follo wed up by observations of a number of other sources of relativel great angular size using a new interferometer of small spacin which combines the principles of the « cliff-interferometer » an « the two aerial » one (5)

In addition to such specialised experiments, observations c the distribution of cosmic radio waves at very high (1200 Mc/s) (4, 6 and very low (18 and 9 Mc/s) (7) frequencies have been taken ove parts of the sky

3. — Solar Radio Waves

The principal instrumental advance over the past two years has been the development on a wavelength of 21 cm of an aerial system with a sufficiently narrow beam, about 3 minutes of arc, to pick out individual disturbed areas on the sun (8). The system consists of a line of 32 parabolic aerials extending over a length of about 700 ft. The aerials are fed in phase from a central point. The resulting directional diagram, like that of a diffraction grating has a series of narrow maxima, each separated by 1 ½°, through which the sun passes in turn, producing a record at each passage. This equipment has shown the frequent occurrence of « bright » spots on the solar disk which move across the sun with solar rotation. Some, but not all, or these are associated with visible sunspots. When sufficient observations are available to permit the elimination of the effect of these bright patches by statistical means it should be possible to determine the residual distribution of brightness over the disk and, in particular, to see if « limb-brightening » occurs.

On longer wavelengths two series of observations are of interest. A preliminary series of observations over the frequency range 70-130 Mc/s of the spectra of bursts of solar radio waves was completed (9). New equipment to increase this range to from 40 to 320 Mc/s and to give the degree of circular polarization is partly completed. The other series consisted of observations on a fixed frequency of 97 Mc/s of the positions of the sources of bursts on the solar disk and the polarization of the waves (10). The most interesting results concern, in the case of « outbursts », the movement of the source outwards with a velocity of the order of 1000 km/sec and, in the case of « noise storms » the location of the source at a great height, e g. 0.3 solar radii, in the corona over certain sunspots The criterion as to whether or not a « noise storm » may occur appears to be that a sunspot of area greater than a certain minimum value must exist. Further, since this involves association of a noise storm with a particular sunspot, it is possible to relate the sense of rotation of the circular polarization with the polarity of the spot. The results indicate that a right-handed wave is associated with a south-seeking magnetic pole If the field in the high corona is that due simply to the spot, the wave is the ordinary wave of the magneto-ionic theory.

In addition, regular records of solar radio wave intensity have been taken on wavelengths of 3, 10, 25, 50, 150, 300 and 500 cm and the results communicated to the I.A.U. Quarterly Bulletin of Solar Activity. The most interesting result of these was the observation of a marked drop in the base level at wavelengths in the 10-50 cm region which occurred in mid-1950 with the decline in sunspot activity (11).

4. — Other Items

Theoretical work on the subject of growing waves in ionised gases has supplied a possible explanation of the origin of the high intensity components of solar and cosmic radio waves. This work is discussed in the Commission VI section of this report.

Work on meteors is in its early stages. Equipment is in operation which simultaneously measures the following parameters of a meteor echo, range, amplitude, polarization and drift velocity.

REFERENCES

1 Christiansen, Hindman, J V — A preliminary Survey of 1420 Mc/s Line Emission from Galactic Hydrogen (Submitted to *Aust. J. Sci. Res A*).

2 Mills, B. Y — The Distribution of the Discrete Sources of Cosmic Radio Radiation *Aust J Sci Res A*, **5** (June 1952).

3. Mills, B. Y — The Positions of Six Discrets Sources of Cosmic Radio Radiation. (Submitted to *Aust. J Sci Res A.*).

4. Piddington, J. H, Minnett, H C. — Radio-Frequency Radiation from the Constellation of Cygnus *Aust. J Sci. Res. A*, **5**, 17-31 (March 1952).

5. Bolton, J G. — In preparation

6. Piddington, J H, Minnett, H C. — Observations of Galatic Radiation at Frequencies of 1210 Mc/s and 3000 Mc/s *Aust J. Sci. Res. A* **4**, 459-475 (Dec 1951)

7. Shain, C A — Galactic Radiation at 18.3 Mc/s. *Aust. J Sci Res A*, **4**, 258-267 (Sept 1951)

8. Christiansen, W N. — In preparation.

9. Wild, J. P. — Observations of the Spectrum of High-Intensity Solar Radiation at Metre Wavelengths III Isolated Bursts, *Aust. J Sci. Res A*, **3**, 541-557 (Dec. 1950) IV. Enhanced Radiation, *Aust J Sci. Res. A*, **4**, 36-50 (March 1951).

10. Little, A. G., Ruby Payne-Scott — The Position and Movement on the Solar Disk of Sources of Radiation at a Frequency of 97 Mc/s I. Equipment *Aust J Sci Res A*, **4**, 489-506 (Dec. 1951) II. Noise Storms *Aust. J. Sci. Res A*, **4**, 508-25 (Dec. 1951) III Outbursts. *Aust J. Sci. J. Res. A*, **5**, 32-46 (March 1952)

11 Christiansen, W H., Hindman, J A — A long-Period Change in Radio Frequency Radiation from the « quiet » Sun at Decimetre Wavelengths

BIBLIOGRAPHY

1. Bolton, J G, Westfold, K C. — Galactic Radiation at Radio Frequencies IV The distribution of radio stars in the galaxy *Aust. J. Sci Res A*, **4**, 476-488, (Dec 1951)
2. Bracewell, R. N — Radio Stars or Radio Nebulæ? *The Observatory* (to be published)
3. Christiansen, W. N, Hindman, J V — A preliminary Survey of 1420 Mc/s line emission from galactic hydrogen Submitted to *Aust J Sci Res A*
4 Christiansen et al — Radio Observations of Two Large Solar Disturbances *Aust. J Sci Res A*, **4**, 51-61 (March 1951)
5. Christiansen, W N, Hindman, J V. — A long-period Change in Radio-frequency Radiation from the « Quiet » Sun at Decimetre Wavelengths *Nature*, **167**, 635-7 (21 Apr 1951)
6. Huxley, L G H. — The persistence of Meteor Trails *Aust J Sci. Res. A*, **5**, 10 (March 1952)
7. Jaeger, J C, Westfold, K C — Equivalent Path and Absorption for Electromagnetic Radiation in the Solar Corona, *Aust J Sci Res A*, **3**, 376-386 (Sept 1950)
8. Kerr, F. J. — On the possibility of obtaining Radar Echoes from the Sun and Planets To be published in *Proc Inst Radio Engrs*
9. Little, Ruby Payne-Scott — The position and Movement on the Solar Disk of Sources of Radiation at a Frequency of 97 Mc/s I Equipment *Aust J Sci Res A*, **4**, 489-507
10 Mills, B Y — The distribution of the Discrete Sources of Cosmic Radio Radiation *Aust J Sci Res A*, **5** (June 1952)
11. Mills, B Y — The Positions of Six Discrete Sources of Cosmic Radio Radiation Submitted to *Aust J Sci Res A*
12 Mills, B Y, Thomas, A B — Observations of the Source of Radio-frequency Radiation in the Constellation of Cygnus *Aust J Sci Res A*, **4**, 158-171 (June 1951)
13. Ruby Payne-Scott, Little, A G — The position and Movement on the Solar Disk of Sources of Radiation at a Frequency of 97 Mc/s, II Noise Storms *Aust J Sci Res A*, **4**, 32-46 (March 1952)

14. Piddington, J. H. — The Origin of Galactic Radio-frequency Radiation. *Mon. Not Roy. Astron Soc*, **111**, 45-63 (1951)
15. Piddington, J. H., Minnett, H. C — Observations of Galactic Radiation at Frequencies of 1210 Mc/s and 3000 Mc/s. *Aust J Sci Res A*, **4**, 459-475.
16 Piddington, J. H., Minnett, H C — Radio-frequency Radiation from the Constellation of Cygnus *Aust J. Sci Res A*, **5**, 17-31 (March 1952).
17. Shain, C A — Galactic Radiation at 18 3 Mc/s *Aust J Sci Res A*, **4**, 258-267 (Sept. 1951).
18. Wild, J P — Observations of the Spectrum of High-Intensity Solar Radiation at Metre Wavelengths III Isolated Bursts. *Aust. J Sci. Res. A*, **3**, 541-557 (Dec 1950). IV Enhanced Radiation *Aust J. Sci. Res A*, **4**, 36-50 (March 1951)
19 Wild, J. P — The Radio-Frequency Line Spectrum of Atomic Hydrogen and its Applications in Astronomy *Astrophys J* (to be published)

Belgium

N° 297. — Note on the activities in Belgium and in the Belgian Congo in the field of Commission V

(*Translation*)

At the I.R.S.A.C. (Institut de Recherches Scientifiques en Afrique Centrale) station of Lwiro and at the station of the Service Météorologique of Léopoldville, 6 m diameter radiotelescopes were set up respectively by the I.R.S A C and by the Observatoire Royal d'Uccle (Brussels). They were used for observations carried out for the solar eclipse of February 25, 1952, on 170 Mc/s. Reduction of results has been carried out and the analysis is being made

The Observatoire Royal of Belgium is builting near Brussels a 7.5 m diameter radiotelescope; preliminary observations will be carried out on 700 and 170 Mc/s

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Canada

Nº 8. — Report of Commission V of the National Committee

Chairman : Dr. R. E. WILLIAMSON

Canadian contributions to radio astronomy are along three main lines. The National Research Council sponsors a group at Ottawa under the direction of A. E. Covington, making solar observations, for the most part at a wave-length of 10.7 cm. Another Canadian activity in radio astronomy centres around the meteor researches of D. W. R McKinley and P. M. Millman, who use radar reflection techniques, in conjunction with photographic and visual observations. The National Research Council sponsors this programme also. A certain amount of theoretical and computational work is done at the David Dunlap Observatory of the University of Toronto, Richmond Hill, Ontario.

SOLAR NOISE WORK AT THE NATIONAL RESEARCH COUNCIL, OTTAWA

In 1946, the Radio and Electrical Engineering Division of the National Research Council at Ottawa, commenced investigations under the direction of A. E. Covington, on the emission of radio noise from the sun. Techniques and equipment which had been especially designed for radar sets were modified for use in this new field. Daily observations of the solar emission on a wave-length of 10.7 centimetres are taken with a four-foot paraboloidal reflector and a Dicke-type radiometer. These observations have been maintained regularly since 1947, and the results are communicated to « Solar Radio Noise » for publication in the « Quarterly Bulletin of Solar Activity ». The records show a decline in the level of the quiet sun that can be associated with the approaching sunspot minimum. The quiet sun level (extrapolated for zero sunspot area) has decreased from 1.18 in 1947 to 0.73 for the first half of 1951. The sunspot emission shows a good correlation with the appearance and disappearance of sunspots ; the coefficient of correlation with the sunspot area is about 0.8. The bursts of solar noise on this wavelength are not frequent and most of them occur simultaneously with a solar flare.

Prior to September, 1948, the observatory work was carried out at the Metcalfe Road Field Station of the Radio and Electrical Engineering Division. Considerable microwave radio interference was experienced at this location, and consequently a new site, free from this type of interference, was acquired at Goth Hill in South Gloucester, fourteen miles from Ottawa. A small building has been erected for the observing equipment, while the radio-telescopes have been placed outside.

Polarization studies of the 10.7 centimetres solar radiation were undertaken after the construction of a quarter-wave plate which could be placed in front of the paraboloidal reflector. The emission from the quiet sun is randomly polarized, while the sunspot emission shows a small excess of either kind of circularly polarized radiation. Burst emission likewise shows a circularly polarized component.

At the present time a ten-foot paraboloidal reflector is being constructed and will eventually be used in continuing the programme of observations started with the four-foot reflector

A 150-foot linear array has been designed and constructed for operation in the ten-centimetre band and will produce a fan-shaped beam, 0.125 degree wide in the east-west direction, and 20 degrees wide in the north-south direction. This array is made from slotted 3-inch by 1.5 inch waveguide feeding into a horn eighteen inches wide by one hundred and fifty feet long. It is mounted with the long axis in an east-west direction and can be rocked about the centre of the guide. This motion, together with the motion of the earth, will allow the whole sky to be scanned. Preliminary observations of the sun have shown that it will be possible to determine some of the characteristics of individual sunspots.

REFERENCES

1. COVINGTON, A. E. — Microwave Solar Noise Observations during the Partial Eclipse of November 23, 1946, *Nature*, 159, 405, 1947.
2. COVINGTON, A. E. — Microwave Sky Noise, *Terr Magn. Atmos. Elect.*, 52, 339, 1947.
3. COVINGTON, A. E — Solar Noise Observations on 10.7 Centimetres, *Proc. I. R. E* , 36, 454, 1948.
4. COVINGTON, A. E. — Circularly Polarized Solar Radiation on 10 7 Centimetres, *Proc. I. R. E.*, 37, 407, 1949.

5 Covington, A. E., Medd, W. J — Simultaneous Observations of Solar Radio Noise on 1 5 Metre and 10 7 Centimetres, *Jour. Roy. Astron. Soc Can.*, 43, 106, 1949.

6. Covington, A. E. — Some Characteristics of 10.7 Centimetre Solar Noise, *Jour. Roy. Astron. Soc. Can.* Part I, Vol. 43 : 16. Part 2, Vol. 43: 49, 1951.

Radio Observations of Meteors, National Research Council, Ottawa

In 1947, the National Research Council and the Dominion Observatory initiated a combined programme of meteor research, with the N.R.C. carrying out the radio and photoelectric observations and the Observatory conducting the visual, photographic and spectrographic work. The visual and photographic observations, and that part of the radio work dealing with the study of the physics of the upper air using meteors as a tool are reported elsewhere. In the field of astronomy one of the most important contributions has been the conclusion that few, if any, meteors down to the eight magnitude can be of interstellar origin. Of nearly eleven thousand meteor velocities measured by the radio Doppler method none exceeded 80 km per second. A few determinations of the complete orbits of meteors have been made by triangulating points on the ionized meteor path from three independent radar stations, yielding elliptical orbits.

Reasonably satisfactory correlation between echo signal strength and visual magnitude has been obtained down to the fifth magnitude i.e. to the limit of unaided human vision. By various extrapolation techniques the limiting sensitivity of the 200 kW radar on 33 Mc/s has been shown to be about the ninth magnitude, at least. Studies of meteor showers and of non-shower or sporadic meteors show that the non-shower meteors increase in numbers regularly with fainter magnitudes while the strong showers are lacking in either very bright or very faint meteors.

A battery of 19 photocells has been used to give rough sky plots of meteors. Relative timing accuracy between the automatic photocell record and the radar and visual records was about 0.50 second. The average sensitivity of the unaided 931-A photocell appeared to be about one magnitude inferior to that of the unaided eye.

REFERENCES

7. Millman, P. M., McKinley, D. W. R., Burland, M. S. — Combined Radar, Photographic and Visual Observations of the 1947 Perseid Meteor Shower, *Nature*, 161, 278, 1948.

8. Millman, M. P., McKinley, D. W. R — A Note on Four Complex Meteor Echoes, *Jour Roy. Ast Soc. Can.*, 42, 121-130, 1948.

9. Millman, P. M., McKinley, D. W R — Three-Station Radar and Visual Triangulation of Meteors, *Sky and Telescope*, 8, 114-116, 1949.

10. McKinley, D. W. R , Millman, P M — A Phenomenological Theory of Radar Echoes from Meteors, *Proc I R E* , 37, 364-375, 1949.

11 McKinley, D W. R., Millman, P M — Determination of the Elements of Meteor Paths from Radar Observations, *Can Jour. Res* , *A* 27, 53-67, 1949.

12. Millman, P. M , McKinley, D. W. R. — Meteor Velocities, *Observatory*, 70, 156-158, 1950

13. McKinley, D W R — Deceleration and Ionizing Efficiency of Radar Meteors, *Jour. App Phys* , 22, 202-213, 1951.

14 McKinley, Barbara, M , McKinley, D W. R — Photoelectric Meteor Observations, *Can Jour. Phys.*, 29, 111-121, 1951.

15. McKinley, D W. R. — Meteor Velocities Determined by Radio Observations, *Astrophysical Jour* , 113, 225-267, 1951

16. McKinley, D. W. R — Variation of Meteor Echo Rates with Radar System Parameters, *Can Jour Phys* , 29, 403-426, 1951.

Radio Astronomy at the David Dunlap Observatory, University of Toronto

Since the end of 1947, there has existed a loose but active cooperation in radio astronomy research between the David Dunlap Observatory of the University of Toronto and the School of Electrical Engineering, Cornell University. This resulted from the fact that one of the original planners of the Cornell University — U. S. Navy Radio Astronomy Project, Ralph E. Williamson, soon after the inception of the project, left Cornell to accept a position on the staff of the David Dunlap Observatory. Since 1948, he has held the title of consultant to the Cornell project.

The work carried out at the David Dunlap Observatory has been theoretical or computational or a combination of the two. Sponsorship for the papers listed in the accompanying bibliography was sometimes a joint one by the two institutions, and sometimes by the David Dunlap Observatory alone. As the titles in the bibliography indicate, the published work has been mostly in the interpretation and reduction of galactic observations.

At the present time, further work is in progress along two directions : one concerns the reduction of radio interferometer observations, and the other, the reduction and interpretation of a series of galactic observations made at Cornell in October, 1951, with the 200 Mc/s equipment there.

REFERENCES

17. WILLAMSON, Ralph, E. — The present Status of Microwave Astronomy *Jour. Roy. Astron. Soc. Can*, 42, 9, 1948.

18. NORTHCOTT, Ruth J., WILLIAMSON, Ralph E — Galactic Noise and the Plane of the Galaxy, *Jour. Roy. Astron. Soc. Can.*, 42, 279, 1948.

19. WILLIAMSON, Ralph E. — Concerning the Source of Galactic Radio Noise, *Jour. Roy. Astron. Soc. Can.*, 44, 12, 1950.

20. SEEGER, Charles L., WILLAMSON, Ralph E. — The Pole of the Galaxy as Determined from Measurements at 205 Mc/s, *Astrophys. J.*, 113, 21, 1951

21. WILLIAMSON, Ralph E. — Plasma Oscillations and Solar Bursts, (Abstract) *Astron. J.*, 56, 145, 1951.

SKY OR AURORAL NOISE

Correlation of the records from microwave radiometers and magnetometers have shown that radio noise may be emitted from the regions of the earth's upper atmosphere during geomagnetic disturbances. Some doubt has now been cast on observations of noise directly correlated with the aurora, but evidence magnetic disturbances. Still remains of sky noise produced by some mechanism during strong solar and magnetic disturbances.

REFERENCES

22. COVINGTON, A. E. — Microwave Sky Noise, *Terr. Magn. Atmos Elect.*, 52, 339, 1947.

23. FORSYTH, P. A , PETRIE, Wm , CURRIE, B. W — Auroral Radiation in the 3000-Mc Region, *Nature*, 164, 453, 1949

24. COVINGTON, A E. — Microwave Sky Noise, *Jour Geophys. Res.* 55, 33, 1950.

France

Nº 237. — General Report of the National Committee Commission V

(*Translation*)

It is with regret that we deplore the untimely death, since the last General Assembly of our distinguished colleague Bernard LYOT.

STUDY OF THE QUIET SUN RADIATION

During the reduced solar activity of the two recent years, French Laboratories devoted most of their attention to the observation of quiet Sun radiation.

Two eclipses, one annular, the other total, were observed. During the former on September 1st, 1951, measurements were made in Markala (French Soudan), Dakar and Paris (5, 6, 10) on 169 and 9350 Mc/s. Discussion of the results indicated the occurrence of a bright ring on the higher frequency and to a definitely ellipsoidal shape of the Sun on 1.78 m wavelength. The transmission residues during centrality are respectively 18 % on 3.12 cm and 50 % on 1.78 m.

The second eclipse of February 25, 1952, was observed simultaneously in Khartoum (Anglo Egyptian Soudan) and in Paris region (11) by means of optical and radio methods

On 55 cm wavelength (550 Mc/s) the transmission residue was 19 % and on 1.17 m (225 Mc/s) 30 %. Publication of results and detail of measurements is broadcast daily by means of Ursigrams.

STUDY OF THE DISTURBED SUN RADIATION

Theoretical and experimental studies have been carried out during the two last years : a comparison (a) of radiation on two adjoining frequencies shows the independence of bursts emitted in a narrow frequency band and the selective fade out of one of the studied frequencies : this is assumed to be due to absorbing clouds in the corona. At the same time, a study of burst aurocorrelation on a fixed frequency showed a sudden decay when the interval considered reaches a few seconds (2) According to a very satisfactory explanation of « bursts » brought forward (3, 7, 8) they would be produced ahead of the fronts of shock waves in the solar atmosphere.

The reduction of observations on 55 and 117 cm made at the Institut d'Astrophysique of Paris for 1949 (14) showed the possibility of directivity for the disturbed solar radiations for both these frequencies with gradient inversion in the northern and southern hemispheres of the Sun. Laboratory work (12) connected with such studies showed that under certain conditions, a gaseous discharge subject to a magnetic field produces non coherent oscillations at gyromagnetic frequency. This experiment seems to be of such an importance that it ought to be thoroughly studied and it is in the course of being checked in an other laboratory.

Correlation between radio solar phenomena and geophysics

It seems established that disturbed solar radiations can be related to geomagnetism by means of the following law : solar areas active from the radio point of view produce sudden and non recurrent magnetic storms while after meridian transit of inactive areas a minimum of geomagnetic activity appears. Other correlations were noted during experiments carried out in Meudon.

Milky Way radiation

The 225 Mc/s receiver of the Institut d'Astrophysique in Meudon is at present used to plot at night time an isophote map of the Milky Way on this frequency. Regular measurements of the Milky Way on decametre wavelengths are carried out at the Ecole Normale and in Meudon for ionospheric studies. The Meudon set has been improved, with the C.N.E.T. cooperation, in order to eliminate interference from telegraphic stations transmitting in the observed band. This new device should abolish the main difficulty encountered in this new method of investigating the ionosphere

BIBLIOGRAPHY

1 E J Blum, J F Denisse — Comparaison des rayonnements radioélectriques du soleil sur deux fréquences voisines, *C R*, **231**, 1214-1216, 27 Nov. 1950

2 E J Blum, J. F. Denisse, J. L Steinberg — Etude des orages radio de faible intensité. *C. R*, **232**, 387-389, 29 Jan 1951

3 E. J. Blum, J F. Denisse, J L Steinberg — Sur l'interprétation des sursauts radioélectriques solaires. *C R*, **232**, 483-485, 5 Feb. 1951.

4. J F Denisse, S Zisler, J. L. Steinberg — Contrôle de l'activité géomagnétique par les centres d'activité solaires distingués par leurs propriétes radioélectriques. *C R.*, **232**, 2290-2292, 18 June 1951

5. F Bosson, E J Blum, J F. Denisse, E Leroux, J L Steinberg — Observation de l'éclipse annulaire de soleil du 1er Septembre 1951. *C R*, **233**, 917-919, 22 Oct 1951.

6 E. J Blum, J F Denisse, J L Steinberg — Sur la forme ellipsoidale du soleil observé en ondes métriques *C R*, **234**, 1597-1599, 16 April 1952

7. J. F Denisse, Y Rocard — Excitation d'oscillations électroniques dans une onde de choc ; applications astrophysiques *J de Phys*, **12**, 893-899, Dec 1951

8 Y Rocard — Sur un mécanisme d'émission radioelectrique coronale *C R.*, **232**, 598-600, 12 Feb 1951

9. J. F Denisse. — Relation entre l'activité geomagnetique et l'activité radioélectrique solaire To be published in *Ann. de Géoph*

10 E. J Blum, J F Denisse, J. L Steinberg. — Résultats des observations d'une éclipse annulaire de soleil effectuées sur 169 Mc/s et sur 9350 Mc/s To be published in *Ann d'Astr.*

11. M Laffineur, R Michard, J. C. Pecker, Marguerite d'Azambuja, A. Dollfus, I Atanasijevie — Observations combinées de l'éclipse totale de soleil du 25 Fev. 1952 à Khartoum et de l'éclipse partielle au radiotélescope de l'Observatoire de Meudon *C. R*, **234**, 1528-1530, 7 April 1952

12 M. Laffineur, Charlotte Pecker — Emission radioélectrique due à l'effet gyromagnétique dans une décharge *C. R.*, **231**, 1446-1447, 18 Dec 1950

13. Observations de l'éclipse totale du soleil du 25 Fév 1952 Cf 11. To be published in *Ann d'Astr.*

14. M Laffineur — Contribution à l'étude du rayonnement electromagnétique du soleil sur ondes décimétriques Thesis, Paris, 4 April 1951.

Great Britain

No 118. — Report on British Work in Radio Astronomy since 1950

by A. C B. Lovell and M. Ryle

CONTENTS

I. — Introduction

This report summarises the work on Radio Astronomy which has been carried out in Great Britain since that reported to the IXth General Assembly in 1950 [1]

The work includes observations of the radio emission from the sun, the general radiation from the galaxy and from radio stars, and the radiation from extra-galactic nebulae ; observations by radio echo methods of meteors and the aurora borealis, and investigations of the ionosphere by observations of radio stars.

Most of the solar and radio star observations were made at the Cavendish Laboratory, Cambridge, most of the observations of the general galactic radiation and of the extra-galactic nebulae and all the radio echo observations of meteors and the aurorae were carried out at the Jodrell Bank Experimental Station of the University of Manchester. Investigations of the irregular structure of the ionosphere were made at both Laboratories.

It has not been possible for the work in Radio Astronomy at the Army Operational Research Group to continue except for routine automatic recording of solar radio outbursts at 4.1 metre wavelength.

II. — Radiation from the Sun

(a) *Routine Observations*

Regular observations of the intensity and polarisation of solar radiation on wavelengths of 1.7 m and 3.7 m have been maintained, providing a continuous series since December, 1946. The results have been communicated to *The Quarterly Bulletin of Solar Activity.*

(b) *Interferometer measurements of the undisturbed sun*

Observations have been made to determine the distribution of radio « brightness » across the undisturbed solar disk, using the variable aperture interferometer method devised and used by Stanier (1) on a wavelength of 60 cm. Results obtained on wavelengths of 60 cm (1) 1.4 m (2), 3 7 m (2, 3) and 7.9 m (2) show a

[1] U.R.S.I , Vol VIII, P I, p. 144-152

progressive increase in the effective diameter of the sun with increasing wavelength. It is found that of the total radiation on each of the above wavelengths, about 30 %, 45 %, 65 % and 75 % originates outside the visible disc.

A detailed comparison of the results on all four wavelengths with the distribution predicted theoretically (4) for a corona of uniform temperature shows that there are important discrepancies Attempts have been made by suitable choice of the distribution of electron density and temperature with height, to derive a model solar atmosphere which will satisfy the distribution on all four wavelengths, but no such simple model has yet been found possible. It is probable that a fuller treatment will have to include the presence of spatial irregularities in electron density (5)

(c) A new method for determining the electron density in the Corona

A new method of determining the electron density in the solar corona has been proposed which should allow direct measurements to be made out to radii where the electron density is as small as 10^4 cm^{-3} (6) It can be shown that when the radiation from a remote source passes throught a sphere whose refractive index increases with radius, there is a critical angular separation between the source and the centre of the sphere, at which radiation no longer reaches the observer The solar corona is therefore capable of occulting a distant source of radio waves, such as a radio star, as if it were an opaque sphere whose radius is considerably greater than that of the photosphere , the radius depends on the wavelength and for $\lambda = 7$ 9 m is approximately 5 R_0 By observing the position of a radio star at the time of occultation on each of several wavelengths, it should be possible to determine the electron density over a range of heights in the corona

The problem of detecting the radiation from the radio star in the presence of the more intense radiation from the undisturbed sun could be overcome by the use of an interferometer of large resolving power, but in the presence of appreciable sunspot activity, intense solar sources of small angular diameter may confuse the observations

Attempts to carry out this experiments were made in June 1950 and June 1951, when the intense radio star in Taurus passed close to the sun's southern limb Unfortunately on both occasions

unusually intense sunspot activity prevented any useful results being obtained, but it is hoped to repeat the experiment during the coming years of low sunspot activity

(d) The emission « polar diagram » of the sources of sunspot radiation

It has been known for some time (7) that at centimetric wavelengths, the enhanced radiation due to sunspots can be received with little variation of intensity whether the sunspot is in the centre of the disc, or at the limb It has also been known that at metre wavelengths, the intensity is much greater when the spot is near the centre of the disc (8) In order to compare the various theories of the intense metre-wave radiation from sunspots it is important to determine the solid angle over which the radiation escapes. The determination of this angle cannot easily be done by observations of individual sunspots, firstly because of the large random variations of intensity which occur and secondly because during the last few years there have been few periods when a sunspot could be observed individually throughout its passage across the disc

An alternative method has therefore been used, based on a statistical analysis of the daily intensity of radiation, over a period of one year for a wavelength of 60 cm, and a period of five years for wavelengths of 1 7 and 3 7 cm

The correlogram of each series of observations has been computed, from which it has been possible to derive a mean curve of the variation of intensity with the angle between the line of sight and the radius to the visible spot; this angle may conveniently be expressed in days from central meridian passage The total widths to half-power of the « emission polar diagram » are 4 days at 60 cm, 1 5 days at 1 7 m and 0 3 days at 3 7 m (9)

(e) Interferometer measurements of localised sources on the sun

By making observations with the new phase-switching interferometer (10) (see Section VII) it is possible to determine the effective position of a source of sunspot radiation with an accuracy of about 10 seconds of arc A large number of such observations have been made at times of sunspot activity during the past two years at wavelengths of 1 4, 3 7 and 7.9 m, in order to relate the sources of radiation with the visible spot groups and to observe the variations in apparent position which are found to occur (9, 10).

Four different effects may contribute to produce the apparent movements : (1) The rotation of the sun ; (2) movements of the emitting region relative to the visible sunspot ; (3) refraction of the radiation in the outer corona and (4) simultaneous reception of radiation from two or more sunspots, whose relative intensities will not remain constant.

The observations have shown two independent results ; firstly a steady day-to-day movement and secondly rapid and erratic movements within periods of a few minutes. Providing that the effects of refraction were small compared with that due to the solar rotation, the steady day-to-day movement would lead to a determination of the height of the source of radiation above the photosphere at each wavelength, but attempts to determine the height in this way have given values between 0.7 and —0 1 R_0 for a wavelength of 1.4 m and 1.0 m and 0.1 R_0 for 3.7 m. These results may be compared with those obtained at a wavelength of 3 m by Little and Payne-Scott (11). The latter authors showed that the refraction in a region having the same electron density as the undisturbed corona would be small ; they therefore concluded that their results indicated the true height of generation, although the values obtained were considerably greater than those expected theoretically.

The large range of heights obtained for all three wavelengths in the present series of observations suggests that important refractive effects are taking place in the corona above the sunspot. Photometric measurements by von Kluber (12) of plates obtained at the 1927 solar eclipse indicate that the electron density above sunspots may be considerably greater than in the undisturbed corona ; his results seem to provide the most likely explanation for the radio observations

Observations of the rapid movements of the sources show that on some days the variation may be as great as 5 minutes of arc (10), whilst on others it may be as small as 8 seconds of arc (9). It has usually been possible to relate the large motions to the presence on the disc of more than one sunspot ; the small movements may be due to variations in the excitation in different points of the emitting region, or to refraction in regions of irregular electron density above the source.

(f) Possible identification of solar M regions with coronal regions of intense radio emission

The sunspot group which crossed the central meridian of the sun on 1950 June 14, although apparently well on the decline and subnormal in flare occurrence, was associated with unusually intense, steady and prolonged emission on the metre-wavelength band (13). At the time of passage of the spot there was a marked absence of geophysical disturbances, but during the following six months there was a sequence of M-region geomagnetic storms which coincided in time with the synodic return of that particular area. It si suggested therefore that the excited, quasi-stable coronal region which gave rise to the intense radio emission subsequently became an M-region (14). (Existing optical evidence also suggests that M-regions are closely correlated with coronal phenomena)

It is also believed that the present M-region responsible for the geomagnetic storms on 1952 February 6-16, March 4-12, et. seq., may have originated from the 1952 January 15 sunspot which emitted strong radiation on the metre band from January 12-15.

III. — Radiation from the Galaxy

(a) Survey of « background » radiation and relation to galactic structure

The field of view of the 220 feet diameter paraboloid at Jodrell Bank has been surveyed at 1.9 metre by Hanbury Brown and Hazard (15). Their survey covers a 24 hour strip of right ascension between declinations 37° N and 66° N Detailed isophotes have been plotted for a strip of the Milky Way ($l = 40°$ to $130°$, $b = +12°$ to $—12°$) in terms of absolute temperature. These isophotes agree well with those of Reber (16) at 1.9 metre but show several new features. There is a local maximum of intensity at $l = 46°$, $b = +\frac{1}{2}°$ close to the intense source in Cygnus. This result confirms an analysis of this region made by Bolton and Westfold (17). Hanbury Brown and Hazard (15) suggest that this maximum may represent the radiation from a cloud of ionised gas. The isophotes also show several discrete sources near the galactic plane. The majority of these sources have not been reported previously.

The apparent width of the Milky Way has been studied by Hughes (18) at 4 metres using the 220 feet paraboloid; and by Hanbury Brown and Hazard (19) at 1.9 metre with the same instrument. It is proposed to repeat the measurements at 8 metres and it is hoped that a comparison of the three results will throw some light on the mechanism of generation of galactic noise.

(*b*) *Observations of Radio Stars*

An analysis of all the discrete sources in the field of view of the 220 feet paraboloid is now being made. Several of the sources reported by Ryle (20) have been confirmed and some new sources have been found. The celestial coordinates and the intensity of the intense source in Cygnus have been measured by Hanbury Brown and Hazard (21) at 1.9 metre and they have shown that the mean intensity of this source is changed by less than 2 % in the presence of fluctuations.

Observations with the phase-switching type of interferometer at Cambridge have been made on wavelengths of 1.4, 3.7 and 7.9 m and a number of special investigations have been made as follows :

(i) *Positional Observations*. — Observations on 3.7 m have enabled 50 radio stars to be located in the Northern hemisphere (20). The accuracy of the positions varies from about one square degree for the weaker sources, to about one square minute for the most intense sources.

In an attempt to identify radio stars with visible objects a number of special observations have been made to determine with the greatest possible accuracy the positions of four intense radio stars (22). These observations were made on 3.7 m and 1.4 m, using a number of new methods, which are described and analysed in detail in another paper (23).

The accuracy obtained for the intense source in Cassiopeia was 10 seconds of arc in R. A. and 45 seconds of arc in declination.

(ii) *Identification with visible objects*. — In the earlier survey of radio stars on 3.7 m an attempt was made to identify radio stars with a number of types of visible objects. With the exception of four of the weaker radio stars, whose positions fell close to those of four of the major extra-galactic nebulae, no significant relation was found with any notable object (20). Dewhirst, of the Cambridge Observatories, has followed the accurate positional observations described above, with a detailed investigation of faint objects near the four intense radio stars, and has photographed near the Cassiopeia source an unusual globular nebula (24).

(iii) *Parallax and Proper Motion*. — It may be shown that observations of the relative Right Ascension of a number of radio stars over an extended period, can be used to deduce a maximum value for the annual parallax and proper motion of the individual stars; long period variations of the collimation error of the system do not therefore affect the measurements (25). Two series of such observations have been carried out on the four intense radio stars mentioned above; the first on a wavelength of 3.7 m has been maintained for over a year, and the second, on 1.4 m for six months (25).

The accuracy of the first was limited entirely by ionospheric refraction. The second indicated that there was no variation greater than the accuracy of the observations. This result suggested that all four sources are more distant than ½ parsec.

(iv) *Search for long-period variations in the intensity of radio stars*. — Observations of a number of radio stars in the northern hemisphere have been maintained on a wavelength of 3.7 m practically every day for a period of over eighteen months in order to detect any intrinsic variations of intensity. It was found that of approximately 100 radio stars observed, none showed any variation greater than 0.1 mag. with any period shorter than 1000 days (26).

IV. — Radiation from Extra-Galactic Nebulae

The radio frequency radiation from the Great Nebula in Andromeda (M 31) has been measured by Hanbury Brown and Hazard (27, 28) using the 200 ft. aperture paraboloid. They base the identification of the source on its celestial coordinates, its apparent angular diameter and its intensity. The coordinates of the radio source agree with those of M 31 within 10 minutes of arc. The angular diameter was measured and is found to be consistent with that of M 31. The intensity is in reasonable agreement with that to be expected on the assumption that M 31 radiates in a similar manner to the Galaxy. In the survey of radio stars in the Northern hemisphere made by Ryle, Smith and Elsmore (20) using an interferometer at 3 7 metres a correlation was found between the position of 4 of these radio stars and 4 major extra-galactic nebulae in their field of view. They have associated radio sources with M 31, M 33, M 101, and M 51 but have failed to observe a source near M 81

Following their work on M 31 Hanbury Brown and Hazard (29) have detected radio emission on a wavelength of 1 9 metre from M 101, M 51 and NGC 4258. They have also detected the radiation from three of the major clusters of nebulae, two in Perseus and one in Ursa Major. These results have been used to test the relation between the photographic magnitude an the radio magnitude of a nebula, and indicate that there is a correlation between the two magnitude scales and that the radio magnitude of a nebula increases less rapidly than its photographic magnitude. It is hoped to check this relationship by further work on clusters of nebulae. They have also found a correlation between irregularities in the radio isophotes of the sky and the large scale irregularities in the distribution of extra-galactic nebulae.

V. — Theoretical Work on Mechanisms of emissions of Radio Waves from Sunspots and Radio Stars

Earlier discussions (30) on the emission of intense radio waves from sunspots and radio stars suggested a convenient division between « equilibrium » mechanisms (in which the intensity of the radiation never exceeded that from a black body having a temperature appropriate to the average particle energy) and mechanisms based on the coherent oscillation of a large number of electrons.

Both types of mechanism have been considered further; MacFarlane (31) and Twiss (32) have discussed new methods of generating coherent oscillations, while a general investigation of the possibilities of the escape of radiation generated by « slipping stream » mechanisms has been made by Bunemann (33, 34). He

concluded that although certain frequencies would be generated, these waves would not be able to be radiated directly from the streams; waves which could escape, on the other hand, would not be amplified, but attenuated by the slipping stream.

The problem of accounting for the acceleration of particles to a sufficient energy to account for the observed radiation from sunspots by an « equilibrium » mechanism does not present a serious difficulty, but two other problems remain (35). (*a*) If the radiation is supposed to be due to « free-free transitions », the optical depth of a body having dimensions of the order of the solar corona is quite inadequate. It seems probable, however, that for particles of high energy additional mechanisms of radiation may provide an adequate optical depth without difficulties concerning the escape of the radiation. (*b*) The second difficulty is related to the escape of high energy particles (having energies $\geqslant$ gravitational energy). The presence of a magnetic field will greatly reduce the rate of loss, as has been shown in connection with the difficulty of explaining the escape of Cosmic Ray particles from the magnetic fields of sunspots (36).

Whilst the application of similar theories to account for the radiation from radio stars is limited by the present incomplete knowledge of the physical conditions in these bodies, the tentative identification of some of the intense radio stars with diffuse nebulosities has made possible some suggestions. If these identifications are confirmed, it seems unlikely that the density or magnetic field in such bodies will be great enough to account for omission by any of the coherent oscillation mechanisms described; the existence of regions having particles of sufficient energy to radiate the observed intensity by an equilibrium mechanism would be of considerable interest from other points of view (e.g. the general origin of Cosmic Rays).

Hutchinson (37) has examined the radio emission which would be associated with the acceleration of particles to Cosmic Ray energies in localised regions having densities up to $10^{11}/cm^3$ and magnetic fields up to 10 gauss. From the observed flux of Cosmic Rays, he deduces an intensity and spectrum of the radio emission which are compatible with those found experimentally.

VI. — Investigation of the Ionosphere by Observations of Radio Stars

(a) *Measurement of total ionisation*

Accurate observations on a wavelength of 3.7 m of the times of transit of four intense radio stars, as described in Section III (*b*) (iii) have shown a refraction effect which can be accounted for by the presence at dawn and dusk, of a horizontal gradient of the total ionisation of the ionosphere By comparing estimates of the change of total ionisation derived in this way, with the normal *p'-f* curves, it is possible to deduce a figure for the total ionisation in the ionosphere. The results so far obtained indicate that approximately three-quarters of the total ionisation lies above the maximum of the F-region (38).

(b) *Study of the irregularities in the ionosphere by observations of the scintillation of radio stars*

Early experiments (39, 40, 41) showed that the irregular fluctuations of intensity and apparent position of radio stars could be ascribed to the irregular diffraction of the incoming radiation in the ionosphere At metre wavelengths, absorption can be neglected and variations of electron density will produce deviations of phase in the wavefront emerging from the ionosphere. The distribution of amplitude and phase across the ground, can then be regarded as the diffraction pattern associated with this irregular wavefield

The diffraction pattern which would be produced by such a phase-changing screen has been considered in two recent papers (42, 43) and it has been shown how the size of the ionospheric irregularities may be deduced from observations of the pattern on the ground Observations have shown that the irregularities have a lateral extent of about 5 km and a variation of total electron content of the order of 2.10^9 electrons/cm^2 (41, 44).

The observations have indicated that the irregularities are situated above the maximum of the F2 region at a height of about 400 km (43, 44). The greatly increased degree of fluctuation observed for a radio star at large zenith angles to the north, has been accounted for by increased irregularity of the ionosphere in the auroral zones (45). The observations over a range of zenith

angles from 0° to 70° have given results which can be explained by the greater slant distance between the ionosphere and the diffraction pattern on the ground (44).

Extended observations have confirmed the marked diurnal variation previously reported (41, 45) and have shown that there is little change in the diurnal variation during the course of the year (44) The occurrence of the irregularities does not appear to be correlated with other geophysical phenomena, apart from a slight increase during periods of great magnetic activity. The origin of the irregularities is not known, and it has been suggested that they may be due to the interception by the earth of interstellar matter, or by turbulence in the F2 region.

Simultaneous measurements at separated receiving points on the ground have shown that the irregularities move horizontally with velocities of the order of 100 m/sec. Observations taken at Jodrell Bank (46) during the summer months of 1951 show that between the hours 1800-0100 U.T. the F-region motion was predominently towards the West. Analysis of the results has further shown that variations in the rate of scintillation of the radio stars are due to changes in the rate of movement of the F-region irregularities and not to alterations in their size Observations taken at Cambridge (44) indicate that during the hours 0000-0500 U. T. the motion is predominently toward the East.

It has been found that the magnitudes of the lateral velocities, unlike the degree of fluctuation, are strongly related to magnetic activity, small velocities are only observed during magnetically undisturbed periods, while velocities as great as 500 m/sec have been recorded during magnetic storms (44).

An analysis of the scintillation phenomena of radio stars during a 30 month observing period has shown (47) that during aurorae the fluctuations are always rapid ($>$ 4 per minute); a more detailed analysis of a four month period indicates a correlation of about 0.65 between the fluctuation rate and the magnetic K index. On one occasion, a marked decrease in the intensity of 3.7 metre extra-terrestrial radio waves was observed during an aurora ; this decrease is attributed to the reflection of some of the incident radiation by an over-critically dense region of ionisation situated above the E layer

VII. — New Techniques

(a) *Phase-switching interferometer*

A new type of radio interferometer (10) has been developed which has a number of important advantages over earlier systems. Its use enables the radiation from a weak « point » source of radiation to be recorded independently of the radiation of much greater intensity from an extended source. It is therefore possible to use a very much greater recorder sensitivity than with earlier methods. It is, in addition, possible to use preamplifiers at the aerials and accurate stabilization of their gains is unnecessary ; the resolving power is therefore not restricted by attenuation in the aerial cables.

Besides improved sensitivity, the new system has particular advantages in the accurate determination of the position of a source ; unlike earlier systems the accuracy is not seriously affected by rapid variations of the intensity. It also has important applications to the measurement of the angular diameter and polarisation of weak sources of radiation.

The phase-switching system has been extensively used on wavelengths of 1.4, 3.7, 6.7 and 7.9 m, for the detection and location of weak radio stars, for the investigation of the scintillation of radio stars and in a number of special investigations of solar radiation.

(b) 220 *ft. aperture paraboloid*

The 220 ft. aperture paraboloid at Jodrell Bank was constructed in 1947 and from 1950 onwards it has been applied intensively to the study of galactic and extra-galactic radiation at 1.89 m. The paraboloid has a focal length of 126 feet. The primary feed to the aerial is carried on a central mast which is supported on an axle running east and west. It is possible, by tilting the mast, to move the beam of the aerial to 14 degrees on either side of the zenith, and this permits observations to be carried out in a region between declinations 67° N and 39° N. The surface of the paraboloid is formed by a system of wires which are spaced 8 inches apart and run parallel to one plane of polarisation. The profile of the mirror is maintained to within $\pm$ 5 inches of the correct

parabolic shape. The shape of the beam from the paraboloid has been measured (28) at 1.89 m by observations of the intense source in Cygnus and at 4.2 m by a series of the intense source in Cygnus and at 4.2 m by a series of aircraft flights (18). In each case the polar diagram and power gain show good agreement with the calculated parameters.

VIII. — Meteor Astronomy

(a) *Radio echo survey of sporadic meteor activity*

The detection of a radio echo from a meteor trail in a narrow beam aerial implies that the meteor radiant is located in a small sector of the sky. By making a continuous survey of the activity in two inclined sectors Hawkins and Aspinall (48) have deduced the distribution of the radiant points of sporadic meteors. From the diurnal and seasonal variation of the hourly echo rate it was found that the main concentrations of sporadic radiants were located close to the ecliptic, corresponding to orbits lying in the plane of the solar system. The distribution of radiants in ecliptic longitude was symmetrical about the apex with maxima at the apex, helion and anti-helion points. After correcting for the motion of the Earth the ratio of directly moving to retrograde meteors was found to be 10 : 1 which is in contrast with the more uniform distribution assumed in the work of Hoffmeister (49). The hourly rate observations of Hoffmeister are adequately explained in terms of the measured radiant distribution and the inference of an interstellar origin for meteors is therefore invalid When the radiant survey was combined with the measurements of sporadic meteor velocities determined in the summer daytime, the most frequent meteor orbit was found to be direct, of short period and of low inclination. The concentration of sporadic meteors round the orbit of the Earth varied in an irregular manner and showed an apparent correlation with the concentration of cometary orbits. The sporadic activity was most intense when the Sun's longitude was about 100°, during the months of June and July.

(*b*) *Radio echo measurements of the orbits of meteor streams*

(i) *The summer daytime streams.* — Combined radiant (50) and velocity (51) observations of the summer daytime meteor streams in 1948-50 have yielded orbits (52) for the four permanent members of the group. The radiant positions, velocities and the resulting semi-major axes of the orbits are given in Table I.

TABLE I

Shower	R A	Dec	Geocentric velocity	Semi-major axis
⊙ Cetids	29° 0	— 3° 7	36 7 km/s	1 3 A U.
Arietids	43° 8	+21° 9	37 7 kms/s	1 5 A U.
ξ Perseides	61° 0	+22° 8	28 8 km/s	1 7 A.U.
β-Taurids	85° 7	+17° 9	31.4 km/s	2 2 A U.

The short periods of these orbits are remarkable ; all of them lie inside the orbit of Jupiter The work was continued in 1951 with similar results (53)

(ii) *The night-time showers.* — Similar observations of the night-time streams have yielded orbital elements for the Perseid, Geminid and Quadrantid showers (54). The Perseid orbit is parabolic within the errors of measurement, and a wide range of orbits were found. The Geminid orbit is of short period and agrees closely with that found by Whipple (55). The Quadrantid orbit has been determined for the first time and is unique in being of short period at a high inclination. Evidence has been found for the existence of a core of large meteors in the region of maximum density in the streams.

(iii) *Radio echo measurements of sporadic meteor velocities.* — During the years 1948-1951 more than 1000 sporadic meteor velocities were measured (56, 57, 58, 59) the majority in experiments designed to receive meteors from the region of sky near the apex of the Earth's way. The measured velocity distribution for meteors of visual zenith magnitudes between +4 and +8 peaked near 60 km/sec. An analysis of the distributions to be expected from a random distribution of radiants and parabolic

orbits taking the collecting area of the aerials and the experimental errors into account shows that a sharp peak should be observed at about 71 km/sec It is therefore concluded that the majority of the meteors move in orbits of short periods. A study of the velocity distributions indicates that about 10 % of the meteors have velocities near the parabolic limit A few meteors had velocities in excess of the parabolic limit, but in most cases this was due to errors of measurement The results do not exclude the possibility that about 1 % have hyperbolic orbits but the evidence is by no means conclusive. Experiments in which meteors from the region of the antapex are observed showed that no instrumental cut-off was limiting the results, and no evidence was found of the greatly hyperbolic velocities observed by Opik (60). The aerials used were not sensitive to meteors from the plane of the ecliptic except within 5° of the apex or antapex and hence no evidence is available of the velocities of the ecliptical component of the sporadic meteor distribution

IX. — METEOR PHYSICS

(*a*) *Theory of radio reflections from meteor trails*

A theory (61) has been developed dealing with the dependence of the echo characteristics on the linear electron line density, α, and the plane of polarisation of the incident wave. Two qualitatively different categories of echoes are to be expected, depending on whether α is greater or less than about 10^{12} cm^{-1}. It is assumed that the initially narrow trail expands radially according to the laws of simple diffusion, hence the electron volume density varies with radius r and time t (from formation of the trail) as $exp\,[-r^2/(4Dt)]$ where D is the diffusion coefficient.

(i) $\alpha < 10^{12}$. — (*a*) Incident electric vector parallel to the trail axis (parallel scattering). The individual electrons may be regarded as free scatterers and, as predicted by Herlofson (62) the echo will decay exponentially. (*b*) Incident electric vector normal to the trail (transverse scattering). Resonant scattering may occur, increasing the maximum echo amplitude to about twice that for parallel scattering. The resonance occurs early in the life of the echo (earlier for smaller line densities) and is followed by the exponential decay (as for (*a*))

The echo amplitude, in both cases, is proportional to α, while the echo duration is independent of α, being a function only of the rate of diffusion and wavelength.

(ii) $\alpha > 10^{12}$.— The incident wave is unable to penetrate throughout the trail until diffusion has reduced the electron density everywhere to less than critical (at the wavelength used). As a result the trail reflects similarly to an expanding metallic cylinder and except initially (when the parallel reflection coefficient exceeds the transverse), the reflection coefficient is independent of the polarisation of the incident wave and is substantially constant for the echo lifetime. The echo duration and amplitude vary with electron line density as α and $\alpha^{1/4}$ respectively.

For all values of α, the duration varies with wavelength as λ^2.

These predictions are in good agreement with experiment. The echoes of class (i) are the most abundant (with durations between 0 01 and 0.1 sec. for $\lambda = 4$ m), while class (ii) corresponds to the long duration echoes (up to 100 sec. for $\lambda = 4$ m)

Simultaneous duration measurements (68) on 4 and 8 metres verify the λ^2 law, except that for very long echoes the exponent may be somewhat less than 2 (probably owing to disruption of the meteor trail through non-uniform atmospheric winds)

(b) *Correlation of radio and visual observations*

All radio echoes from visual meteors appear to belong to class (ii) of paragraph (*a*) i.e they have linear electron densities greater than 10^{12} cm Using the above theory, the results of Millman (63) for the duration of Perseid meteors as a function of visual magnitude M, and a value for the diffusion coefficient obtained from short duration echoes, it has been shown that M is proportional to log α The constant of proportionality is such that a meteor of zenithal magnitude +5 produces 10^{12} electrons per cm.

The relation between heat, light, and ionisation energy is deduced to be of the order of $1 : 10^{-2} : 10^{-3}$ and $1 : 10^{-3} : 10^{-3}$ for bright and faint meteors respectively (63*a*). The probability of ionisation per evaporated meteor atom is estimated to be about 0.2

(c) *Crossed polarisation experiment*

During major showers, experiments have been made with two aerials producing crossed polarisation (64, 64*a*) The directions of polarisation are adjusted to be parallel and perpendicular, respectively, to the meteor paths. The transmitter is pulsed, alternate pulses being received on each aerial, and the ratio between echo pulse amplitudes is measured.

Long duration echoes exhibit an almost constant ratio during their lifetimes, and, taking account of experimental errors, the true ratio is believed to be unity Most short duration echoes give peak ratios than the values observed for the long duration ones and the variation of ratio with time for a large proportion of these echoes is in reasonable agreement with theory. The average resonant ratio is estimated to be about 1.7 for a mean electron line density of 5×10^{11} cm^{-1}.

The electron line density may be estimated from the time of occurrence of the resonance, and the values so obtained are consistent with independent estimates from echo amplitudes.

(d) *Heights of occurrence of meteors*

The most probable height of occurrence of sporadic meteors, as obtained by radio techniques (65*a*), has been found to vary from 85 km for a velocity of 20 km/sec^{-1} to 110 km for a velocity of 70 km/sec^{-1}. The values for the major streams are in fair agreement with those for sporadics, with the possible exception of the Geminids (which may be somewhat lower than sporadics of the same velocity). The heights are about 5 km above those obtained visually. With recent values for atmospheric pressure versus height and with the above results, the mean radius and mass of the observed meteors (zenithal magnitude + 6 and assumed to be of stone) are $r_\infty \approx 0.05$ cm, $m \sim$ several mgm

The mean duration of short duration echoes is found to decrease with increasing height but not as rapidly as might be expected from the variation of atmospheric pressure with height. This may be due in some part to experimental limitations. The average diffusion coefficients, evaluated for various major streams, vary between 2 10^4 cm^2/sec^{-1} and 5.10^4 cm^2/sec^{-1}.

(e) *Meteor echoes and upper atmospheric winds*

Considerable departures from the theoretical echo envelopes for radio echoes from meteor trails are observed at wavelengths of 1.4 to 8.4 metres (65, 66, 67). The majority of echoes with durations exceeding 0.4 sec. (68) undergo amplitude fluctuations with periods of 0 01 to 1.0 sec , the period of fluctuation being proportional to the wavelength (67) This phenomenon may be explained by the distortion of an initially linear column of meteor ionisation by upper atmospheric winds Fluctuations of regular period are occasionally observed (68) and these are interpreted as interference between the signals from two reflecting centres in relative motion The period of fluctuation determines the relative line of sight velocities of the reflecting centres

The detailed shapes of echo pulses returned from meteor trails have been examined using very high range resolution (69) As expected the individual pulses of echoes with durations less than 0 4 sec are similar in shape to those from discrete reflecting objects, but longer duration echoes invariably show increases in width, consistent with the theory of trail distortion For an echo showing regular fluctuations, the separation of the two reflecting centres along the trail is given by the increase in width of the resultant echo pulses over the width of those from a discrete reflector Simultaneous observations of pulse widening and amplitude fluctuations show that the wind velocities at points separated by only 5-10 km differ by as much as 50 m/sec As meteors enter the atmosphere at near vertical incidence, this result may be interpreted as a variation of wind velocity in different strata between altitudes of 80 to 100 km

Uniform wind velocities can also be measured by observation of the steady drifts in range of long duration echoes These uniform winds also have velocities of the order of 50 m/sec In early December a reversal in the predominant wind direction is observed between 0100 and 0200 local time, the direction prior to 0100 being roughly from North to South, and after 0200 from South to North

X — Radio Observations of Aurorae

Radio echoes obtained from the ionisation associated with aurorae have been classified by Aspinall and Hawkins (70) as « diffuse echoes », exhibiting a spread in range (~ 100 km) and « discrete echoes » with range spreads $<$ 10 km Parallax photography by Paton (71) showed that auroral rays were located in the aerial beam when discrete echoes occurred, and this correlation

was confirmed by Lovell (72) et al. who scanned rays with a moveable, narrow-beam aerial. From the echo ranges the height distribution (73) of rays was determined and was in agreement with photographic data, while from the change in range with time, radial velocities were found to be approximately 1 km/sec. Electron densities were estimated (73) to be approximately 10^7/cc. The range spread and duration of diffuse echoes indicated that they were produced by a slant reflection from an irregular surface following the direction in space of an auroral arc

Auroral echoes have in some cases shown a 27 day recurrence (73), corresponding to the rotation with the Sun of a continuous beam of corpuscles. One such series persisted for 7 solar rotations between 1950 July 11 and December 22 and correlated with the series of « M-region » magnetic storms previously discussed by Maxwell (14) The diurnal distribution (73) of auroral echoes showed peaks at 0200 U T. and 1700 U. T The night-time peak corresponds to visual observations; the afternoon activity was produced by diffuse echoes and probably indicated the existence of a daytime arc

REFERENCES

1 Stanier, H M — *Nature*, **165**, 354, 1950
2 O'Brien, P A — In preparation
3 Machin, K E — *Nature*, **167**, 889, 1951
4 Smerd, S F — *Aust J Sci Res*, **3**, A, 34, 1950
5 Bell, C J — In preparation
6. Machin, K E, Smith, F G — *Nature*, **168**, 599, 1951
7. Covington, A E — *Proc I R E*, **36**, 454, 1948
8 Hey, J S, Parsons, S J, Phillips, J W — *Mon Not R A S*, **108**, 354, 1948
9 Machin, K E — In preparation
10 Ryle, M — *Proc Roy Soc* A, **211**, 351, 1952
11 Little A. G, Payne-Scott, R — *Aust J Sci Res*, **4**, A, 489, 1951
12 von Kluber, H — In preparation
13 Maxwell, A — *Observatory*, **71**, 72, 1951
14. Maxwell, A — *Observatory*, **72**, 22, 1952
15 Hanbury Brown, R, Hazard, C — In preparation
16 Reber, G — *Ap J*, **100**, 279, 1944
17 Bolton, J G, Westfold, K C — *Aust J. Sci Res* A, **3**, 251, 1950.

18. HUGHES, V. A. — Unpublished (*M. Sc. thesis Manchester*, 1950).
19. HANBURY BROWN, R., HAZARD, C — In preparation
20. RYLE, M., SMITH, F. G, ELSMORE, B — *Mon. Not R. M. S.*, **110**, 508, 1950
21. HANBURY BROWN, R, HAZARD, C — *Mon Not. R A. S.*, **111**, 576, 1951.
22 SMITH, F G — *Nature*, **168**, 555, 1951
23 SMITH, F G. — In preparation
24 DEWHIRST, D W. — *Observatory*, **71**, 211, 1951
25 SMITH, F. G — *Nature*, **168**, 962, 1951.
26 RYLE, M, ELSMORE, B. — *Nature*, **168**, 555, 1951.
27 HANBURY BROWN, R, HAZARD, C — *Nature*, **166**, 901, 1950.
28 HANBURY BROWN, R, HAZARD, C — *Mon. Not R A S*, **111**, 357, 1951.
29. HANBURY BROWN, R., HAZARD, C — *Phil Mag.*, **43**, 137, 1952.
30. RYLE, M — *Proc. Phys Soc* A, **62**, 483, 491, 1949.
31. MACFARLANE, G G — *Proc of Conf on Dynamics of Ionized Media*, April, 1951.
32 TWISS, R Q — *Nature*, **169**, 185, 1952
33 BUNEMANN, O. — *Proc. of Conf on Dynamics of Ionized Media*, April, 1951
34. BUNEMANN, O. — In preparation
35. RYLE, M — *Proc. of Conf on Dynamics of Ionized Media*, April, 1951.
36 FORBUSH, S. E., GILL, P, VALLARTA, M. S. — *Rev. Mod Phys.*, **21**, 44, 1949
37. HUTCHINSON, G. W. — *Phil Mag.* In the press.
38 SMITH, F. G. — In preparation
39. SMITH, F. G — *Nature*, **165**, 422, 1950.
40 LITTLE, C G, LOVELL, A C B — *Nature*, **165**, 423, 1950
41. RYLE, M, HEWISH, A. — *Mon Not. R. A. S*, **110**, 381, 1950
42 HEWISH, A — *Proc. Roy Soc* A, **209**, 81, 1951.
43 LITTLE, C G — *Mon Not R. A S*, **111**, 289, 1951
44 HEWISH, A — In preparation
45 LITTLE, C. G, MAXWELL, A. — *Phil. Mag*, **42**, 267, 1951.
46 MAXWELL, A, LITTLE, C G — *Nature*, **169**, 746, 1952
47 LITTLE, C G, MAXWELL, A — In preparation.
48 HAWHINS, G S, ASPINALL, A — In preparation
49 HOFFMEISTER, C — *Die Meteore*, Leipzig, 1937.
50. ASPINALL, A, HAWKINS, G S — *Mon. Not R A. S.*, **111**, 18, 1951.
51. DAVIES, J. G., GREENHOW, J. S. — *Mon. Not R. A. S*, **111**, 26, 1951.
52. ALMOND, M. — *Mon. Not R. A S*, **111**, 37, 1951.

53 HAWKINS, G S., ALMOND, M. — *Jodrell Bank Annals*, **1**, 3, 1952.
54. HAWKINS, G S., ALMOND, M. — *Mon Not R. A. S.* In the press.
55 WHIPPLE, F. L — *Proc. Amer. Phil. Soc*, **91**, 189, 1947.
56. ALMOND, M., DAVIES, J G., LOVELL, A. C B. — *Observatory*, **70**, 112, 1950
57. ALMOND, M DAVIES, J G, LOVELL, A. C. B — *Mon. Not. R. A. S.*, **111**, 585, 1951.
58. ALMOND, M, DAVIES, J. G, LOVELL, A C B. — *Mon Not. R. M S.*, In the press, 1952.
59. ALMOND, M. DAVIES, J. G., LOVELL, A. C. B — In preparation.
60. ÖPIK, E J — *Publ Obs Tartu*, 30, N° 5, 1940
61. KAISER, T R, CLOSS, R. L — *Phil. Mag*, **43**, 1, 1952.
62 HERLOFSON, N. — *Phys Soc. Rep Prog. Phys*, **11**, 444, 1948.
63 MILLMAN, P M. — *Jour. Roy Ast Soc. Canada*, **44**, 209, 1950.
63*a*. GREENHOW, J S, HAWKINS, G. S — In preparation
64. CLEGG, J A, CLOSS, R. L. — *Proc. Phys. Soc.*, B, **64**, 718, 1951.
64*a*. KAISER, T R, CLOSS, R. L. — In preparation
65 LOVELL, A C B. — *Phys. Soc Rep Prog. Phys*, **11**, 415, 1948.
65*a*. Unpublished results at Jodrell Bank.
66. MCKINLEY, D W. R, MILLMAN, P M — *Proc. Inst Radio Engrs.*, **37**, 364, 1949
67 GREENHOW, J S — *Phil. Mag*, **41**, 682, 1950
68 GREENHOW, J S — *Proc Phys Soc*, B, **65**, 169, 1952.
69 GREENHOW, J S — *Jour Atmos. Terr. Phys.* In publication.
70 ASPINALL, A., HAWKINS, G S — *Jr. Brit Ast. Ass.*, **60**, 130, 1950.
71 PATON, J — Edinburgh University. Unpublished work.
72 LOVELL, A C B. — Unpublished work.
73. HAWKINS, G S. — Unpublished work

India

N° 331. — Report of the National Committee to Commission V

(1) Guha used the Zwean-Kemble method for the calculation of the reflection coefficient of a barrier to obtain the reflection coefficients of the ordinary and extra-ordinary waves for a parabolic ion barrier. These results have been applied to explain the observed reversal of polarisation of microwave escaping from sunspots.

(ii) *Progress made with regard to resolutions passed in Zurich.* — Measurements on Extra-terrestrial radio noise are proposed to be started in India shortly.

REFERENCE

1. GUHA, U. C. — Reverseal of polarisation of microwaves from sunsposts, *Indian J. Phys.*, 25 (1), 8, 1951

N° 7. — Standardisation of solar noise observing equipment

INDIA NATIONAL COMMITTEE

During the IXth General Assembly of U.R.S.I., held in Zurich on September 1950, Commission V resolved that the sun be continuously observed on radio frequencies near to 200 Mc/s and 3000 Mc/s and attempts be made to fill gaps in the world chain by commencing observations in the longitudes of California and Western India at both frequencies and in Europe on 3000 Mc/s.

In this connection it is desirable that Commission V and Sub-commission V*a* of U.R.S.I. should advise on standardization of solar noise observing equipment The evaluation of solar noise flux density involves measurements of exceedingly small powers at very high frequencies. Any errors involved in the measurements will mean a serious limitation in observations specially those relating to the thermal component which is the only component received most of the time (specially so during the approaching sunspot minimum) and which forms a small part of the inherent noise power of the receiver.

From literature already published and the descriptions of equipment received from cooperating observatories it appears that the equipmental technique has reached a stage of development where it would be worthwhile to consider standardizing this equipment. For 24 hour radio observation of the sun it is considered desirable that uniform practice be adopted by all observing stations in the construction of their instruments and in the determination of constants such as received noise figure and aerial constants

For observations on 200 Mc/s and 3000 Mc/s it is proposed that Commission V may consider drawing up specifications and preparing a list of parts for standardized receiving equipment The specifications for a suitable 200 Mc/s Yagi (or any other aerial system which may have advantages over Yagi) and receiver for 3000 Mc/s reception together with necessary parabolic reflector may also be drawn up and communicated to the cooperating observatories. Specifications for suitable noise generators may also be drawn up for receiver calibration. The effective aera, directivity and gain of the receiving aerial systems should also be specified likewise.

Japan

N° 16. — Report of the National Committee

See Fasc. 1, p. 94.

N° 58. — Report of Commission V of the Japanese National Committee

by Y. HAGIHARA, *Chairman*

OBSERVATIONAL WORKS

Besides the international co-operative observations of the solar radio emission on 200 Mc/s at the Tokyo Astronomical Observatory, Mitaka, and on frequencies about 3000 Mc/s at the Atmospherics Research Institute, Toyokawa, and at the Osaka City University, Osaka, which are found in the report from the Sub-Committee for the World-Wide Network on the Solar Radio Emission of the National Committee, the following observations and experiments were carried out in Japan

I — *Tokyo Astronomical Observatory*

The solar observation on 200 Mc/s has been started in September, 1949, and those on 100 Mc/s and 60 Mc/s in September, 1950. Observations of the circularly polarized radio emission from the sun were carried out from May to November, 1951 (1) At the partial eclipse of the sun on September 12, 1950, a party was sent to Hokkaido and simultaneous observations on 100 Mc/s were conducted both in Hokkaido and Mitaka (2) A radio telescope with a parabola of 10 meter in diameter is under construction.

It will be used on 3000 Mc/s and also on other frequencies for observing both solar and cosmic radio emissions.

An interference system on 60 Mc/s with spaced aerials is also under construction.

Preliminary observations on the galactic radiation were carried out.

II. — *Atmospherics Research Institute*

A test observation on 3750 Mc/s was carried out from April to July, 1951, and the systematic observation has been started in November, 1951. Some further improvements on the receiving systems and on the method of calibration are now in progress (3, 4).

III. — *Osaka City University*

Besides the daily observation of the solar radio emission at 3260 Mc/s (5, 6), an experiment on the gas discharge tube placed in an axial magnetic field is under progress.

IV. — *Central Radio Wave Observatory*

After a preliminary observation on 60 Mc/s at the Oi station, the solar observation on 200 Mc/s for 2 hours around noon is now conducted at the Observatory. A regular observation is expected to be started sometime in 1952 at the Hiraiso Station of the Observatory. The observation at the partial solar eclipse on 200 Mc/s recorded a decrease of 35 % at the maximum phase in Hokkaido (7).

Research Activities

T. Hatanaka and his colleagues, Tokyo Astronomical Observatory (8) have derived a correlation between the burst characteristics of the solar radio emission on 200 Mc/s and the central meridian passage of sunspots of E type and F type. Echo phenomena in the solar radio bursts have also been studied both observationally and theoretically by these authors (9). They have also studied the occurrence of a noise storm statistically and found that it occurs on the days when a large sunspot is within a limited range around the centre of the solar disk. But the spot

seems to be accompanied with a strong magnetic field in such a case. Moreover a non-polarized outburst seems to occur at the beginning of a noise storm (10). A close correlation was found by T. Hatanaka, Tokyo Astronomical Observatory, Y. Sekido, Physical Department of the Nagoya University, and Y. Miyazaki and M. Wada, Science Research Institute in Tokyo, between the emission mechanism of the cosmic rays and the radio frequency radiation from the sun (11).

T. Takakura, Physical Department of the Osaka City University, investigated the directivity of the solar radio emission from the sunspots. He concluded that the radiation has no directivity on 3260 Mc/s, but on 1200 Mc/s, 600 Mc/s, and 200 Mc/s, the radiation from the sunspots in the central circle zone may be observed on the average 1.5 to 2 0 times stronger than from the sunspots in the outer zone (12).

S. Miyamoto, Astrophysical Department of the Kyoto University, suggested a mechanism of the emission of the solar radio noise by the cooling coronal prominences. He proposed a modification of the formula for the emission probability by free-free transition (13).

REFERENCES

1 S. Suzuki, N , Shibuya. — *Tokyo Astr Obs. Report*, **10**, N° 2, 1952 (in press) (in Japanese)

2 T Hatanaka, S Suzuki, F Moriyama — Rep Eclipse Committee, Science Council of Japan, 1951

3 H Tanaka, M Murase, H Jindo — *Bull Res Inst. Atmospherics*, **1**, N° 1, 1950 (in Japanese)

4. H Tanaka, T. Kakinuma, M. Murase et al — *Ibid.*, **2**, N° 1, 1951 (in Japanese)

5. M. Oda, T Takakura — *J. Phys. Soc Japan*, **6**, N° 3, 1951

6. M. Oda, T Takakura — *Rep Ion Res Japan*, **5**, N° 2, 1951

7 K Kawakami — Rep Eclipse Committee, Science Council of Japan, 1951.

8 T. Hatanaka — *Rep. Ion Res Japan*, **4**, N° 3, 1950

9. T Hatanaka — *Ibid.*, **4**, N° 4, 1950

10. T. Hatanaka, F Moriyama. — *Ibid.* (in press).

11 T. Hatanaka, Y Sekido, Y. Miyazaki, M Wada — *Ibid* , **5**, N° 3, 1951.

12. T. Takakura. — To be published in *Nature.*

13 S. Miyamoto — *Publ. Astr Soc. Japan*, **3**, N° 1, 1951

No 17. — Report from the Japanese Sub-Committee on the World-Wide Network on Solar Radio Emission

by Y. HAGIHARA, *Chairman*

This sub-committee was organized for co-operating to the world-wide observation of the solar radio emission on 200 and 3000 Mc/s in accordance with the resolution made at the General Assembly in 1950. Continual communication and exchange of results of observations are being made with the participating observers through Dr. Ing. de Voogt, Chairman, Sub-Commission V*a*. The observing stations, their frequencies, observing aerials, the person in charge, and the observing times at work are :

200 Mc/s : Tokyo Astronomical Observatory, University of Tokyo, Mitaka, Tokyo.
(139° 32′ 28″ E, 35° 40′ 18″ N)
4 × 4 horizontal beam, in equatorial mounting.
Dr. T HATANAKA.
0 h-8 h U. T. up to Jan 1952.
0 h-6 h U T. from Febr. 1952, every day.

3260 Mc/s Physics Department, Osaka City University, Ohgimachi, Osaka.
(135° 30′ 36″ E, 34° 42′ 2″ N).
Parabolic reflector of 1.5 m in diameter in altazimuth mounting.
Dr. Y. WATASE
Two or three hours, almost daily

3750 Mc/s : Research Institute of Atmospherics, Nagoya University, Toyokawa, Aichi-Prefecture
(137° 22′ 5″ E, 34° 50′ 6″ N).
Parabolic reflector of 2.5 m in diameter, in equatorial mounting.
Dr. A. KIMPARA.
0 h-8 h U. T. only during the co-operative observation undertaken by Ionospheric Research Committee, that is a month in each season of the year and for ten days at the times of occurrence of anomalous phenomena.

Observations on 100 and 60 Mc/s at the Tokyo Astronomical Observatory are also being reported. A routine observation on 3000 Mc/s is expected to be started in 1952.

Observed materials are collected by the chairman of this sub-committee and sent to the chairman of the Sub-Committee V*a* of the U.R.S.I. and also to the chairman of the Commission 40, Radio Astronomy, of the I.A.U.

Netherlands

No 283. — Report of the National Committee

See Fasc. 1. p. 99.

No 287. — Report on Dutch Research on Radio Astronomy in the period 1950-1952

by M. MINNAERT

Radio-astronomical research is being done in Holland :

I : by the « Stichting Radiostraling van Zon en Melkweg » (Radio-radiation from the Sun and the Galaxy Foundation) ;

II : by the State Central Radio Department of the P. T. T.

I. — RADIO-RADIATION FROM THE SUN AND THE GALAXY FOUNDATION (1)

The activities of the Foundation were especially directed towards three problems :

(*a*) measurements of the 21 cm radiation of the Galaxy ;

(*b*) theory of the distribution of the continuous radiation ;

(*c*) construction of a 25 metre mirror.

(*a*) *Galactic radiation at* 21 *cm* (1, 2, 3). — This radiation, due to the hydrogen atoms in interstellar space, was predicted theoretically by van de Hulst (1945) and was discovered in March

(1) *Secretary* : Dr. J HOUTGAST, Sonnenborgh Observatory, Zonnenburg, 2, Utrecht (Holland)

1951 by Ewen and Purcell. In May of the same year, Muller was able to confirm this discovery at Radio-Kootwijk. The Dutch observations were made with a paraboloid mirror of 7.50 m diameter and 1.70 m focal distance. The angular aperture of the beam was 2°8. The receptor was a double superheterodyne instrument, which was switched between two frequencies 110 kHz apart, thirty times per second by a reactance modulator. By this method, very small differences in intensity between the two frequency bands could be measured.

Tracings of the intensity of the hydrogen emission were made by fixing the position of the paraboloid relatively to the Earth, while the diurnal rotation provided a sweep across the Milky Way. By varying the height of the paraboloid, a rather systematic survey of the region near the galactic centre was possible. Since a wide spread in galactic latitude is observed, the clouds which are the source of the observed emission must be relatively close to the Earth ; in the direction of the galactic centre a maximum distance of 300 or 400 parsec is estimated. Probably the gas becomes already optically thick at a distance of 500-1000 parsec. Measurements with a slightly displaced wavelength revealed the galactic rotation of gas masses at much greater distances and confirmed by direct observation the data, calculated earlier by the astronomers for this rotation

After these measurements were made in May and June, the receiver was completely revised and improved. The switching is now made 500 times per second, and the frequency difference between which the receiver is switched has now been made variable from 100 to 600 Hz. New detailed measurements of the line profile at selected points of the Milky Way are being made.

The 21 cm line is not present in the solar radiation, which confirms that there are no neutral hydrogen atoms in the corona (4).

(*b*) *Distribution of the continuous radiation over the sky* (5). — We may provisionally assume that the continuous radio emission of the Galaxy is proportional to the mass of the ordinary stars. Oort and Westerhout have then calculated the distribution of this radiation over the sky, and found a satisfactory agreement with the observations of Bolton and Westfold at 100 kHz However

in the regions of the Galactic Poles and in the hemisphere opposite the Galactic Centre, the observed radiation is definitely in excess of the calculated radiation. It is not excluded that this is due to the total emission of all the extragalactic nebulae.

(*c*) *Construction of a 25 metre mirror.* — The construction of a big paraboloid reflector of 25 m diameter, which was planned earlier, became definitely possible thanks to a generous grant by the Netherlands Organization for Pure Research (Z. W. O.). The factory Werkspoor (Amsterdam) is working out the provisional plans. It is hoped that building will be started in 1952 and that the instrument will be completed at the end of 1953.

II. — State central radio department of the Netherlands P. T. T.

From January 1st 1951 the P T. T receiving-station at Nederhorst den Berg (52° 14′ 31″ N, 5° 4′ 38″ E) took part in the international 24-hour survey of the radio-variation of the sun (U.R.S.I.-Sub-commission V*a*). Till 8 October this was done on the frequency of 140 Mc/s ; after that date on 200 Mc/s and 140 Mc/s. The results were interchanged with the other observatories in the world. The occurrence of heavy bursts as well as the daily mean value of the received intensity is mentioned in the daily message radiated by the German Radio Station at Norddeich. (Institut fur Ionosphärenforschung)

The Physical Laboratory for cosmic ray research of the University of Amsterdam is informed by telephone directly after the appearance of heavy bursts, and monthly by letter about mean values registered during the month.

During the night the parabolic reflector is directed to a fixed point in order to make continuous galactic observations. At Radio-Kootwijk was constructed and put in daily service (15 November 1951) a fixed parabola with an « opening » of 30 m diameter and focus-distance of 7.5 m. The parabola was digged in the sand-dunes of Radio-Kootwijk ; the metallic part of the reflector consists of chicken wire-netting with openings of $\simeq$ 3 cm. The receiving set is for 6 m wave-length ; daily diagrams are compared with ionospheric conditions. It is the intention to install in addition to the 6m-set, a 21 cm-set in this parabola

The results from such a « ground » or « hole » parabola from a mechanical and electrical point of view are satisfactory.

In order ot complete the radio-noise receiving sets for the observation of circular polarisation, experiments with crossed Yagi aerials have started.

For radio-astronomical work the P. T. T. constructed an adjustable star-chart giving azimuth and altitude of celestial bodies for any time of the day. The use of such charts, in connection with tables abstracted from the Nautical Almanac, is time-saving; the accuracy is amply sufficient.

PUBLICATIONS

1 Muller, Oort — *Nature*, **168**, 358, 1951

2 Oort, Rinia, Minnaert. — *Verslagen Akad Amsterdam*, **60**, 53, 1951.

3. Muller — *Tijdschr Nederl Radiogenootsch*, **17**, 3, 1952.

4. de Jager, Minnaert, Muller — *Nature*, **168**, 391, 1951.

5 Westerhout, Oort — *Bull Astr. Inst Netherl*, **11**, 323, 1951.

Sweden

N° 269. — Report of the National Committee to Commission V

Prof Olof E. H Rydbeck

The Swedish activity in the field of radio astronomy can be divided mainly in two sections, namely an experimental and a theoretical section. The experimental work has mainly been concentrated to the Onsala Radio Wave Propagation Observatory of the Research Laboratory of Electronics of the Chalmers University of Technology. This observatory is located 24 miles south of Gothenburg (57°24′ N, 11°55′ E).

A. — Experimental activity

The installation of three reconstructed Würzburg-Riese radio telescopes (with diameter of 7.5 m) is practically completed. Two of the telescopes have parallactic mounts. The radio mirrors are at present used on fixed frequencies, the lowest of which is 150 Mc/s Solar noise has been recorded on a frequency of 150

Mc/s continuously since 1948. The shortest wave length on which solar noise recordings can be made at present is 3 cm. The low noise panoramic solar noise recorder still is in the constructional stage.

The observatory is equipped with a low noise type meteor recorder operating on a frequency of 33 Mc/s.

The Research Laboratory of Electronics under the auspices of the Swedish National Committee sent a solar noise eclipse expedition to Naples The apparatus was working on a frequency of 150 Mc/s and was equipped with interferometer type aerials, designed to facilitate polarisation measurements during the eclipse. The magnitude of the eclipse was 0.3 and the general change of the solar noise was successfully measured during the eclipse The variation was not symmetric and a fairly strong polarized component was recorded shortly after maximum phase. For further details reference is made to a forthcoming report of the radio scientific results of the expedition which will be published by the Chalmers Research Laboratory of Electronics in the Transactions of the Chalmers University.

At the Kiruna Radio Wave Propagation Observatory (67°51′ N, 20°14′ E), also operated by the Research Laboratory of Electronics, an auroral back scatter radio recorder with rotating antenna system has been in operation since the first of June 1951 on a frequency of 33 Mc/s. The recorder in syncronously run with the panoramic ionospheric recorder of the same observatory. Very interesting results have been obtained and they will be published shortly by the Research Laboratory of Electronics in the Transactions of the Chalmers University.

At the Electronics Institute of the Royal Institute of Technology in Stockholm, model experiments have been made to verify the meteor echo theory of N. Herlofsson. The experiments have been carried out on a wave length of 30 cm using a mercury gas discharge tube with a diameter of 3 cm and a length of 80 cm. The gas pressure varied between 10^{-3} and 10^{-2} mm. The results are very interesting (Romell, D., *Nature* 167, p. 243, 1951)

B — Theoretical activity

A theory of radio echoes from meteor trails has been developed by N. Herlofsson of the Electronics Institute of the Royal Institute of Technology in Stockholm. B. Lindblad Jr. of the Lund Astronomical Observatory, has statistically examined the results of meteor radar recording at the Chalmers Wave Propagation Observatory. R. Lindquist and G. Hellgren of the Chalmers Research Laboratory have analyzed the auroral radio scatter obtained with the Kiruna Observatory auroral radar. O. E. H. Rydbeck and G. Hellgren have analyzed the coupling between space charge waves on electron beams and electromagnetic radiation in ionized media with application to cosmic noise phenomena.

BIBLIOGRAPHY

1 O. E H Rydbeck, R Lindquist, I Svensson, O Perers, G Hellgren, B. Johansson — Radio Scientific Results of the Swedish Solar Eclipse Expedition to Italy Reports from the Research Laboratory of Electronics, Chalmers University of Technology, to be published

2. D Romell — Model Experiments to determine the Radio Echoes from Meteor Trails, (see also *Nature*, 167, p 243, 1951)

3. N Herlofsson. — Plasma Resonance in Ionospheric Irregularities. *Arkiv for fysik*, Band 3, N° 15

4. B. Lindblad. — A Radar Investigation of the δ Aquarid Meteor shower of 1950 Reports from the Research Laboratory of Electronics, Chalmers University of Technology, to be published

5. R Lindquist, G Hellgren — Auroral Radio Echoes recorded with a Rotating Antenna on 33 Mc/s at the Kiruna Radio Wave Observatory Reports from the Research Laboratory of Electronics, Chalmers University of Technology, to be published

6. O. E. H Rydbeck, G Hellgren —On the Coupling between Electron Beam Space Charge Waves and Electromagnetic Waves. Reports from the Research Laboratory of Electronics, Chalmers University of Technology, to be published

Switzerland

N° 5. — Report of the National Committee to Commission V

Prof Waldmeier

The Federal Observatory has published in the Quarterly Bulletin on Solar Activity a summary of the continous observations on

solar electromagnetic radiation. The following stations have forwarded their results .

Observatory	Frequency in Mc/s	Time of Observation (U T.)
Commonwealth Observatory, Canberra, Australia	200	19-06
Cavendish Laboratory, Cambridge, England	80	10-15
Cavendish Laboratory, Cambridge, England	175	10-15
Radiophysics Laboratory, Sydney, Austr	62	20-07
Radiophysics Laboratory, Sydney, Austr	98	20-07
Radiophysics Laboratory, Sydney, Austr.	600	20-06
Radiophysics Laboratory, Sydney, Austr	1200	20-06
Meudon Observatory, Paris, France	255	04-17
Meudon Observatory, Paris, France	545	04-17
National Research Council, Ottawa, Canada	2800	14-21
Laboratoire de Physique, Marcoussis, France	158	10-12
Army Operational Research Group, Byfleet, Surrey, England	73	04-20
Cornell University, Ithaca, N Y , U S.A	200	13-21

In their present form these quarterly reports are made up of four parts :

(*a*) Daily average radiation intensity.

(*b*) Polarisation.

(*c*) Variations of the radiation intensity.

(*d*) Special activity (solar flares).

The reporter has published a general account in « Radio Hélioscopie » which summarises the conference on solar electromagnetic radiation held at the IXth General Assembly of U. R. S. I. at Zurich [1].

[1] Waldmeyer, Radio-Hélioscopie, *Sci Nat*, **38**, 1, 1951.

United States of America

N° 249. — Report of the National Committee

See Fasc. 1. p 103

N° 256. — Report of the U.S.A. Commission V

The major programs in radio astronomy in the United States during 1950-52 were carried on at the Naval Research Laboratory (Washington), National Bureau of Standards (Washington), Cornell University (Ithaca, New York and Sacramento Peak, New Mexico), Stanford University (California) and Harvard University (Cambridge). Programs at the Department of Terrestrial Magnestism, Carnegie Institution, (Washington) and at Ohio State University (Columbus) are in the initial stages Independent experiments are being conducted by Reber in the Hawaiian Islands

The Naval Research Laboratory (Hagen, Haddock) has continued solar observations on 10 cm and 3 cm and has explored the 8 mm region A 50-foot steerable reflector has been mounted and is undergoing final tests N. R L sent expeditions ot the annular eclipse of September 1950 at Attu Island, Alaska, and to the total eclipse of February, 1952, at Khartoum, with programs planned to give further information on the temperature of the chromosphere

The National Bureau of Standards operated a solar patrol at about 50, 160 and 480 Mc for most of the biennium Reber has further investigated the spectral distribution of elemental bursts by observations at closely spaced frequencies, and also the frequency dependance of the decay time of bursts Several unusual outbursts were observed and discussed The solar patrol results were used qualitatively in the systematic evaluation of general solar activity activity carried on by N B S In May, 1952, the 3 Wurzbergs were dismantled in preparation for moving to a new site near Boulder, Colorado The N B S work on radio reflections from meteor ionization (Gautier, Pineo), now inactive, included work on decay rates as a function of frequency and range, the association of meteor echoes and the incidence of « Sporadic E », and the correlation of radio and visual observations during annual showers. Theoretical work at N B. S (Feinstein, Sen) has concerned both the origin of solar radio waves and the properties of meteor trails.

At Cornell University, (Burrows, Gordon, Olmsted, Owren) systematic solar observations at 200 Mc have continued, both with a patrol instrument and with a meridian interferometer. Detailed comparison of distinctive 200 Mc events and H-alpha flares has been carried on in cooperation with the McMath-Hulbert Observatory. Galactic surveys at 200 Mc are also being continued. A solar patrol is being readied at Sacramento Peak

Meteor studies at Stanford University (Manning, Villard) are largely concerned with upper atmosphere winds and so fall within the purview of Commission III Some work has been done on the length of trails by a statistical method

Enhanced radiation in the 1420 Mc hydrogen line of the galactic radio spectrum was found by Ewen and Purcell at Harvard University. Measurements of the line displacement were obtained for various parts of the sky.

At the Department of Terrestrial Magnetism (Wells, Tatel), the researches planned are in galactic radio spectroscopy A new radio telescope is being completed at Ohio State University (Kraus) for use about 250 Mc on galactic sources It is an array of 48 11-turn helical beam antennas, each 10 feet long and 15 inches in diameter, mounted on a 160 × 12 foot ground plane A Lloyd's mirror experiment from a moutain peak in the Hawaiian Islands has recently been undertaken by Reber.

Published papers on radio astronomical subjects in the past biennium are listed and summarized in the bibliography being prepared for the Xth U R S I General Assembly by Cornell University. Many of the U. S papers were presented at one of the four technical meetings of the U S Commission V during the two years

Radio-Astronomy Definitions

PROPOSAL 22 APPENDED TO THE ADMINISTRATIVE REPORT OF THE U. S. A. NATIONAL COMMITTEE (SEE FASCICULE 1, P. 113).

Term	Definition
1 Antenna Temperature (T_a)	The apparent temperature when the specified solid angle is 4π steradians. This is the total available power per cycle per second from an antenna specified in terms of the temperature of an enclosing black body which gives the same power
2. Apparent Temperature (T_d)	Of a source of radiant energy at a given frequency, the temperature of a black body subtending a specified solid angle (such as that subtended by the photosphere of the sun) and producing a flux density equal to that of the radiant source at a given point.
3 Basic Thermal Radiation	Of the sun, the thermal radiation from the quiet sun
4 Brightness Temperature (T_b)	Of a source of radiant energy, the temperature of a black body whose specific intensity equals that of the radiant source.
5. Burst	A short period increase in intensity, such as of the radiation of the sun. *Note* — Solar bursts may vary in duration from a fraction of a second to about a minute
6 Cosmic Radio Waves	Radio waves from extraterrestrial sources.
7. Discreet Radio Source	Of cosmic radio waves, a source of small angular extent
8 Enhanced Solar Radiation	The increased radiation from the sun observed particularly on meter wavelengths of hours or days duration and usually, but not always, with many bursts

Term	Definition
9. Extragalactic Radio Waves	Radio waves from beyond our galaxy.
10. Galactic Radio Waves	Cosmic radio waves originating in our galaxy beyond the solar system
11. Isolated Burst	A burst of large magnitude appearing sporadically at a time of no great activity at the frequency on which the burst is observed.
12 Median Flux Density	That value of flux density which is exceeded for half of the time during an interval of observation
13. Quiet Sun	The sun in the absence of unusual radio frequency activity such as is associated with solar activity.
14. Slowly Varying Component	Of solar radio waves, that component observed particularly at decimeter wavelengths which has maxima and minima separated by one or two weeks. *Note* — This small amplitude component is strongly correlated with sunspot areas
15. Solar Radio Waves	Radio waves from the sun
16. Specific Flux Density (S_ν)	At a point, the total power per cycle per second at a given frequency passing through an unit area perpendicular to the direction of propagation *Note* — Specific Flux Density is usually expressed in watts per square meter cycle per second
17. Specific Intensity (I_ν)	In a given direction from a source of radiant energy, the power per cycle per second per unit area normal to this direction per unit solid angle *Note* — Specific intensity is usually expressed in watts per square meter per cycle per second per steradian.
18 Specific Power (P_ν)	Power per cycle at a specific frequency.

Minutes of the Sessions

First session : Wednesday 13th August, 1952

Bussiness Session opened at 9.30 a. m. Dr. MARTYN in the chair.

I. *Sub-Commission Va-On Continuous Solar Observations.* — Mr. DE VOOGT presented a report on the past activities of the Sub-Commission. It was decided that the Sub-Commission should continue in existence and should consist of the previous members with the addition of Dr. F. G. Smith and Mr. S. F. Smerd.

The Sub-Commission was asked to draw up a report during the Assembly.

II. *Sub-Commission Vb. On Terminology and Units.* — The previous Sub-Commission was reappointed with the addition of :

Dr. J. P. HAGEN,
Dr. F. G. SMITH,
Mr. B. Y. MILLS,
Mr. F. J. KERR.

It was asked to prepare a report for submission to I. A. U. in Rome.

The possibility of setting up a joint commission with the I. A. U. on this subject was raised but it was decided not to take any action at this stage.

III. *Sub-Commission Vc. On Basic Solar Index.* — This subject was considered at the request of C. C. I. R. A Sub-Commission was appointed and requested to consider the possibility of fixing a solar index in observations of the sun at radio frequencies.

Membership :

Dr. M. LAFFINEUR (*Convener*),
Prof. S. CHAPMAN,
Dr. J. H. PIDDINGTON,
Dr. R. N. BRACEWELL,

IV. *Special U.R.S.I. Report nº 3 on «Dynamics of Ionized Media».* — The President informed the meeting that a report had been completed by Dr. MENZEL and his colleagues and a limited number of copies were available.

V. *History of Commission V of U.R.S.I.* — Dr. MARTYN was requested to act as historian of Commission V of U.R.S.I. as recommended by the Zurich, Assembly.

VI. *Cornell Bibliography of Radio Astronomy.* — Mr. GORDON reported that a supplement to the 1950 Bibliography had been prepared and that copies were being posted to those who had received copies of the original bibliography.

Second session : Wednesday, August 13th, 1952

Technical Session opened at 10.15. Dr. MARTYN in the chair.

Subject : The Sun.

The subject was introduced by Mr. W. N. CHRISTIANSEN, who offered a brief general description of solar radio emission, of his 32-element interferometer (Doc. nº 279) and of his preliminary results. This instrument operates on a wavelength of 21 centimetres and has a beam width of 3 minutes of arc. Bright patches on the sun, some of which are over sunspots, give rise to peaks in the records and these move across the sun with the solar rotation. On combining many records an apparent background is shown which is consistent with a background showing limb-brightening.

Dr. F. G. SMITH then gave an account of observations of brigthness distribution over the solar disk obtained using a two-element interferometer of variable spacing. Observations taken at four frequencies between 40 and 480 Mc/s showed a progressive increase of effective singe of the sun with increasing wave length. The brightness in each case decreased outwards without showing limb-brightening. Some observations were taken in different directions and showed no marked difference. On some occasions bright patches were observed but these cases were rejected in deriving the distributions shown.

Dr. J. L. STEINBERG described eclipse observations on 160 and 9.000 Mc/s which indicated marked lack of circular symmetry.

The observations referred to a partial and an annular eclipse observed at various stations.

Dr. J. P. Hagen described eclipse observations on various wavelengths from 8.5 millimetres to 10 centimetres at the total eclipses of 1947, 1950 and 1952. From these and other observations he derived a model of the electron density and temperature in the lower solar atmosphere.

Dr. M. Laffineur described apparatus used in simultaneous radio and optical observations of the total eclipse of February 25, 1952. The preliminary results show a nearly symmetrical distribution on the highest frequency (555 Mc/s) and an unsymmetrical distribution on a frequency of 255 Mc/s. The optical observations showed marked asymmetry of the corona which is presumably associated with the 255 Mc/s result.

Dr. J. H. Piddington described a statistical investigation carried out by Mr. R. D. Davies and himself which showed that the bright areas observed on the sun at decimetre wavelengths tend to persist after the appearance of sunspots with which they are frequently associated.

Mr. S. F. Smerd discussed the question of the electron density and temperature distribution in the solar atmosphere which would give the observed radiation. He concluded that higher electron densities than those usually assigned would be necessary. He pointed out that though such densities disagree with optical results it is possible that they exist in localized regions in the solar atmosphere. The radio observations, being dependent on the square of the density would be sensitive to the effects of such regions while optical radiation which depends on the first power of the density might not recognize them.

Third session : Thursday, 14th August, 1952

Technical session opened at 9.30 a. m. Dr. Martyn in the chair.

Subject : Dynamics of Ionized Media.

Professor Massey gave a general survey of this suject. It was based on the U.R.S.I. Special Report nº 3 prepared by Dr. D. Menzel and his colleagues et on the conference organized at the University College London by Prof. Massey in May 1951.

Dr. K. C. Westfold commented on certain mathematical aspects.

Dr. J. H. Piddington stated that a number of authors interested in the problem of e.m.f.'s induced by moving magnetic fields had neglected to take account of the effects of mechanical forces in the medium.

Dr. R. G. Giovanelli, whose paper on flares was included in those mentioned by Dr. Piddington, stated that a complete treatment including the effect of the mechanics forces mentioned was most desirable but that no adequate treatment had yet been given.

Dr. J. W. Dungey pointed out that in many cosmic phenomena effects due to rate of change of current could be neglected. One interesting aspect was that electric fields might be considered as effects of electric currents rather than in the more usual manner when the current was thought of as due to the applied field.

Dr. N. Herlofson pointed out that the problem of the reflection of a wave from a mass of ionized gas with a continuously varying electron density had not been solved in a rigorous manner. The main difficulties arose, in the case of a plane stratified medium, when the electric vector was in the plane of incidence. In the case of reflection from meteor trails solutions had been given by himself, by Feinstein and by Kaiser and Cuss. These solutions were supported by experimental evidence. Nevertheless the method of treatment was open to cristicism.

Prof S. Chapman suggested that the theory might be giving essentially correct results though not rigourous.

Dr. R. Makinson suggested that the prime difficulty might be due the use of equations applicable to a continuous medium.

Fourth Session : Monday 18th August, 1952

Chairman : Professor Schilt. (Mt. Stromlo Observatory).

Subject. — Radio emission from interstellar gas. Dr. Ewen gave a brief survey of the laboratory investigations on the 1420 Mc/s Hydrogen line and its prediction in the galactic radio spectrum by H. C. van de Hulst. He described in detail the complex equipment necessary to detect the line and the initial work at Harvard.

Professor SCHILT said that the results were of extreme importance and that the meeting was witnessing something that would open a new era in astronomy.

Mr. CHRISTIANSEN in the absence of Dr. Pawsey gave the results of a rough preliminary survey of the southern hemisphere. Four main maxima of the line intensity had been observed in the galactic plane. Splitting of the line between longitudes 170° and 250° suggested the existence of two spiral arms.

Mr. MULLER described the preliminary result of a survey of regions near the galactic plane visible from the northern hemisphere. In the Cygnus region triple splitting of the line was observed. A model of the spiral arms had been built up combining the Doppler Shift of the Hydrogen line and Professor Oorts model of the mass density distribution in the Galaxy. The spiral arms agreed in position with those deduced by Morgan from observations on O and B stars.

Professor SCHILT said he hoped that these investigations would settle the question of whether the arms in a spiral galaxy « trailed » or not. He said Mr. Muller's results indicated that there was at least one more major arm outside the Sun in our Galaxy.

In the second half of the meeting the continuous radiation from ionized Hydrogen was discussed.

Dr. SMITH briefly described previous work on the background radiation and his investigations on the « bright streak » due to ionized hydrogen close to the galactic plane suggested by Oort and Westerhout. His results indicated a wider streak than that of Oort and electron temperatures higher than 10 000°.

Dr. PIDDINGTON described the derivation of mean gas cloud densities and temperatures from the comparison of the surveys of the background radiation at different frequencies.

Mr. BOLTON said he thought that some of the differences between the surveys used in Dr. Piddington's analysis were due to limitations of aerial resolving power. Similar investigations to those of Dr. Smith indicated detailed structure in the streak along the galactic plane.

Mr. HANBURY BROWN said that results with the 220′ paraboloid at Manchester also indicated much detailed structure.

Fifth Session : Tuesday 19th August 1952

Technical session opened at 2 p. m. Mr. J. G. BOLTON in the chair.

Subject : Discrete Radio Sources.

The subject was introduced by Mr. B. Y. MILLS who outlined the progress of the last two years. Then followed a series of individual contributions.

Mr. B. Y. MILLS. An extensive survey, which covered, 90 % of the celestial sphere, indicated that the distribution of discrete sources is cõnsistent with a hypothesis in which there are two types, the first with a random disk distribution, the second with a random spherical distribution. The first must be rare objects in the galaxy, the second may be extragalactic. Several identifications have been made with extragalactic objects.

A widely-spaced interferometer, with a radio link, id being used to measure the angular size of the Cygnus source. First results suggest a size exceeding one minute of arc, but this result is not yet confirmed.

Dr. F. C. SMITH. Apparent differences in the results of surveys by Mills and the Cambridge group probably arise from differences in the aerial systems used.

A photograph from Mount Palomar shows a very diffuse object of 5′ diameter, nearly centred on the position of the Casseiopeia source. Recent measurements give a size of about 5′ for the radio source. Preliminary results indicate that the Cygnus source is resolvable, with a size of the order of 3 ½′.

Mr. HANBURY BROWN. A detailed study has been made at 158 Mc/s of the part of the sky visible from the 220 ft. aerial. Many irregularities were found in the isophotes of the background radiation. The stronger discrete source show a high galactic concentration. Several of the weaker sources have been identified with individual galaxies, and there is some evidence that some of the irregularities may be associated with clusters of galaxies.

Mr. J. G. BOLTON. An azimuth interferometer has been used in conjunction with the sea interferometer, in an attempt to measure the sizes of sources. The observed patterns proved to be highly complicated, indicating the presence of many extended objects. In some cases, the brightness distribution over an extended source has been derived.

An object of 1° diameter in Puppis has been identified with an extended patchy object in a photograph from Mount Polomar.

Consideration of the various objects now identified indicates that they are all characterized by very large velocities, and this may be significant. It should be noted that the largest intensities from the sun are also associated with high velocities.

Dr. J. W. DUNGEY. Bailey's theory is a theory which *requires* very large velocities.

Mr. C. A. SHAIN. Measurements have been made at 18.3 Mc/s between declinations —12° and —52°. Twenty five discrete sources have been detected as bumps on the records. Of these, 15 correspond with sources found by Mills at 101 Mc/s. Comparison of intensities indicates that in this frequency range the intensity varies as $\lambda^{2.7}$ on the average.

Messrs. BOLTON, MILLS, SMITH, HANBURY BROWN, SMERD, DUNGEY, KERR and WESTFOLD joined in the ensuing discussion. The main topic was the identification of radio sources with visual objects, and in particular the question wether the former are predominately objects of Population I or II.

Sixth Session : Thursday 21st August 1952

Clossing session : Dr. M. LAFFINEUR in the Chair.

After discussion between Dr. F. G. Smith, Mr. Smerd, Mr. F. J. Kerr, Dr. J. P. Hagen, Dr. J. L. Steinberg, Dr. Laffineur and others, the recommendations to be presented to the Chairman of Commission V were adopted (1).

(1) See p. 84.

Sub-Commission Reports

Report from Sub-Commission Va

1. *Recommendation.* — We recommend that the work of Sub-Commission V*a* be continued.

2. *Frequencies.* — Concerning Question N°. 9 of the Vth General Assembly of C. C. I. R. at Geneva 1951, we find that it is not practicable to use the frequencies specified for solar observations, and we suggest that C. C. I. R. should not proceed further with this question. Instead :

3. *Recommendation.* — C. C. I. R. should recommend the Frequency Allocation Authorities to provide any form of protection that may be possible to those who are measuring cosmic (including solar) radiation in the radio spectrum 10 — 30 000 Mc/s. This protection might in some cases be international ; in others it might only be possible to provide a degree of protection over a limited area.

4. *Further.* — Considering the special importance of the observations of the Hydrogen line at 1420 Mc/s, U.R.S.I. should again emphasize the necessity to preserve a band of frequencies for this work. The present work requires a bandwidth of 3 Mc/s, but it appears likely that observations of extra-galactic nebulae may be extended downwards in frequency to about 1400 Mc/s.

5. When observers are proposing to extend measurements to new frequencies, or when they propose to change from a frequency which has been used regularly, they should choose the new frequencies in consultation with the chairman of Sub-Commission Va.

6. *Accuracy and calibration.* — We consider that further efforts should be made to improve the accuracy of solar observations. We suggest :

(i) One laboratory should establish suitable standards of noise power at all frequencies used for solar observations.

(ii) Wherever possible, aerials whose gain can readily be calculated should be used.

(iii) Below 300 Mc/s, when interferometer aerials are used, the flux from the radio star in Cygnus could be used as a standard.

(iv) Below 200 Mc/s interferometer aerials should be used, so that the quiet sun may be observable against the galactic background.

(v) When equipment cannot be calibrated directly, it is essential to ensure that the overall sensitivity remains constant.

7. From experience gained during the last two years, it is clear that further efforts should be made to observe :

(i) Quiet sun radiation on the lower frequencies.

(ii) The maximum intensity of bursts on all frequencies.

8. The observational data should be submitted to Mr. Smerd as rapidly as possible. Values should be submitted at monthly intervals.

9. The assembly and distribution of Monthly Values will be continued.

We wish to express our appreciation of the work done in this report by Dr. C. W. Allen, and later by Mr. Smerd and Miss White.

Members of Sub-Commission Va

Australia. — Mr. S. F. Smerd ; Mr. Little.
Canada. — Dr. Covington.
France. — Dr. Laffineur ; Dr. Steinberg.
Finland. — Prof. Tuominen.
Honolulu. — Prof. Eller.
India. — Dr. Das. ; Prof Saha.
Italy. — Prof. Righini.
Japan. — Prof. Hagihara ; Prof. Hatanaka.
Netherlands. — Dr. A. H. de Voogt (*Chairman*).
Norway. — Dr. Gunar Erikson.
Sweden. — Dr. Lindquist.
United Kingdom. — Dr. M. Ryle ; Dr. Smith.
United States. — Dr. Shapley, ; Dr. Gordon.

Report of Sub-Commission Vb on Terminology and Units

1. *Designation of Discrete Sources.* — The following proposals are made to I. A. U.

Agreement should be reached on an international system of designation of discrete sources of cosmic radio waves, and the agreed system adopted as soon as possible.

A source should be designated by five characters, the first two giving the hours of right ascension, the third being N or S, the fourth giving the tens of degrees of declination, and the fifth the order of official classification within each coordinate mesh, e. g. 19N4A for the major source known as Cygnus A. It is recognized that existing names, based on constellations, will continue to be used as alternatives for the main sources.

Every radiating object which can be identified observationally as a distinct entity should be included in the scheme, regardless of the angular size of the object.

Reasonable agreement about the existence of an object should be required before admission to the official list. In this connection, it is proposed that U.R.S.I. should advise I. A. U. concerning the reality of each reported object.

2. *Specification of Magnitudes and Equivalent Temperature Concepts.* — The 1950 U.R.S.I. sub-committee's proposals in their sections A and B should be accepted (1). The concept of flux density should be preferred to that of temperature, except for extended objects, where « brightness temperature » should be used. The temperature concept is also of use in calibration.

A logarithmic measure of flux density should be introduced in an agreed form. Two alternative schemes are detailed in the appended notes. A choice between these two should be made at a later date.

The alternative terminology (derived from photometry) suggested in Appendix I of the 1950 U.R.S.I. sub-committee's report (2) should *not* be accepted.

(1) U.R.S.I., Vol. VIII, P. I, p. 406-408.
(2) U.R.S.I., Vol. VIII, P. I, p. 410-411.

A preference should be expressed for the M.K.S. system of units.

3. *Universal Decimal Classification.* — U.R.S.I. and I. A. U. should sponsor a classification of the subject of radio astronomy, to be forwarded to the Federation Internationale de Documentation, with a recommendation that it be incorporated in the tables of the Universal Decimal Classification.

The proposed detailed classification is as follows :

.... Radio astronomy.
.1 Theory.
.2 Apparatus.
.3 Radio waves from the solar system.
.32 Radio waves from the sun.
.311 Theory of origin.
.32 Radio waves from the moon.
.4 Radio waves from beyond the solar system (galactic and extragalactic).
.41 Continuous background radiation.
.411 Theory of origin.
.42 Radio waves from discrete sources.
.43 Line emission of radio waves.
.8 Astronomical radar.
.81 Moon echoes.
.82 Meteor echoes.

4. *Words Defining Phenomena.* — We postpone to the next Assembly the drawing up of an agreed list of words and definitions for the various observed phenomena. We affirm, however, that the word « noise » should no longer be used to describe the received radiation.

NOTES

1. *Designation of Discrete Sources of Cosmic Radio Waves.* — In an appendix to their report, the 1950 U.R.S.I. Sub-Committee on Terminology and Units in Radio Astronomy [1] proposes that a cosmic radio source should be designated by the abbreviated name of the constellation followed by a number in ordinary brackets,

[1] U.R.S.I., Vol. VIII, p. 412.

e. g. Cyg. (1). For each constellation the numbers would follow the order of discovery. The Copenhagen Observatory would be asked as a controlling office to allocate the numbers and to keep and publish up-to-date lists.

Seeger et al (1952) have pointed out that « the designation of celestial objects by constellations in as historical heritage with little but tradition to recommend it », and have proposed an alternative scheme, in which each source is designated by five characters. The first two of these give the hours of right ascension, the third is either N or S, the fourth gives the tens of degree of declination and the fifth indicates the order of official classification within each coordinate mesh, e. g. Cygnus A, whose approximate position is 19h58m, $+40\frac{1}{2}°$, becomes 19N41.

We agree that an official procedure for the designation of discrete sources should be set up as soon as possible, as the number of known sources is now large, and is growing rapidly.

The system proposed by Seeger et al appears to be the best of those yet used or proposed. We would suggest two minor modifications however :

(*a*) A change of the fifth character to a letter (e. g. 19N4A) would extend the alternation of number and letter and thus indicate clearly that the fourth and fifth characters have different meanings. Also 26 sources instead of 10 could then be accommodated in a given area without further modification of the system.

(*b*) A specific instruction should be laid down for the controlling authority in the allocation of the serial numbers. This might take the following form : Inside a given area, sources known at the inception of the scheme would be numbered according to their intensities, at a frequency of 100 Mc/s, and later discoveries according to the order in which they are reported.

Recent observational results have added a serious difficulty to the operation of any designation scheme. Formerly, the known discrete sources were all thought to have quite small angular sizes, and hence they were often referred to as « point sources » or « radio stars ». A number of extended sources have now been discovered (see Observatory, 72, p. 27, (1952), with measurable sizes, from a fraction of a degree up to several degrees. Some of these appear as distinct objects, while others may be physically associated with previously-known « point sources ».

From the point of view of a designation scheme, the discovery of extended sources raises two major questions :

(1) Should an attempt be made to indicate the type of object or any of its physical characteristics in its designation (e. g. size, intensity, spectrum, brightness distribution) ?

(2) What limits, if any, should be placed on the classes of objects to be covered by the scheme ?

We consider it would be impractical to set up any system of classification at this stage, and hence the designation of a source should be concerned only with position and serial number.

A decision must, however, be made as to the range of objects to be included. The scheme might, for example, be restricted to « radio stars » (i. e. unresolved sources) as a fairly homogeneous class. This would be unsatisfactory, however, since there is no indication that these sources are essentially different from those which have already been resolved.

We propose that no restriction should be imposed, and scheme should include every radiating object, which can be identified observationally as a distinct entity, no matter what its angular size. In cases where a complex brightness distribution is observed, each local maximum might be regarded as an individual entity. It will be seen that this proposal involves the inclusion of the galactic centre as one of the discrete sources. This may be debatable, but it seems logical to do so, since the position of the centre may be localized with sufficient accuracy to allocate it to one of the other identifiable extended sources may represent largecale features of the Galaxy, and these must be included.

If this wide definition of a discrete source is regarded as too broad, the only acceptable alternative would be a limitation based on angular size at a given frequency, for instance 100 Mc/s. Some arbitrary figure might be chosen, every source of smaller size being included in the scheme. However, the only size limitation which appears to have any basis in logic is the above mentioned (1 hour $\times$ 10°) of the oblong constellation. Then, if size defined conventionally as the angular width between halfpower points, the galactic centre would be excluded, but all other objects known at present would be included. An objection to this definition, however, is that the size of an oblong constellation varies over the sky.

Members of the solar system, e. g. the sun and the moon, should be specifically excluded. (They cannot be allocated to a zone of right ascension and declination). Also, possible « holes » in the brightness distribution are excluded, since they are not radiating objects. If any such holes are later discovered, analogous to the dark nebulae of optical astronomy, some other arrangement would have to be made for them.

While it is true, as stated by Seeger et al, that early difficulties with the observational techniques have been overcome to some extent, there is still a fair amount of disagreement about the weaker sources. This can be seen by making a comparison plot of the source positions in the three extensive surveys which have so far been reported. (These are by Stanley and Slee, by Ryle, Smith and Elsmore, and by Mills). On such a plot the stronger sources are found to agree closely in so far as the surveys overlap, but the majority of the weaker reported objects do not agree. Some of this disagreement probably arises from the use of different techniques. For example, where two weak sources are close together, different methods may lead to different types of record and hence different interpretations. Similar disagreements will probably arise with complex extended sources, and will always be present for objects at the bounds of observing possibilities.

A decision must therefore be made as to whether the controlling authority should allot a designation automatically when a new object is reported, or should wait until a fair measure of agreement is obtained between different observers. In the former case, the subsequent cancellation of numbers must be expected to occur fairly frequently.

We recommend that the controlling authority should be conservative, and allocate names only when there is reasonable agreement that an object exists in the reported position. For effective and well-informed operation of the scheme, a technical refereing committee should be set up by U.R.S.I. Commission V to guide the controlling authority in the acceptance or otherwise of observational reports.

With a system of this kind, many reported objects may not receive recognition for a considerable time, and in all cases a period number allotted by the observer using his own private scheme, or alternatively the central authority might also allocate provisional numbers, as is done in naming new comets and minor planets. These numbers might follow a system similar to, but noticeably different from, the final one. In deciding between the two types of provisional scheme, we should like the advice of astronomers who have much relevant experience.

In either case, it is presumed that any published catalogue of sources would contain, in addition to the official designation, any provisional names or numbers which may have been used by any observer. Common names now in use for the stronger sources (e. g. Cygnus A) are likely to be perpetuated in the literature.

We urge the earliest possible adoption of an agreed system, and would also stress that it is undesirable for anyone to use a proposed final system before its universal adoption, as this would prejudice later discussion.

Furthermore, once a system is adopted, unauthorized allocation of names of the agreed type must not be allowed.

2. *Specification of Magnitudes and Equivalent Temperature Concepts.* — The 1950 U.R.S.I. proposals in these two sections are generally acceptable. It is recommended, however, that the flux density concept should be preferred to the temperature concept, except for extended sources. Continued use of « apparent temperature » and « equivalent temperature », as applied to the sun, should be discouraged. The temperature concept, however, is useful in calibration of equipment.

We would like to draw attention to one shortcoming in the available terminology. The quantities used are all normally referred to a unit of bandwidth, but the terms describing them (flux density, brightness, etc.) carry no such connotation. A suitable word or phrase to convey the sense « per unit bandwidth » is lacking. « Monochromatic » (e. g. monochromatic flux density) and « spectral » (e. g. spectral intensity) are words which have been used before in rather similar connections. The suffix « υ » (e. g. S_υ, B_υ,) should be used where it is desired to stress the monochromatic characteristic.

It would often be convenient to use some logarithmic measure of flux density, e. g. in discussing the properties of a large number of discrete sources. The concept of the « magnitude » has proved extremely useful in visual astronomy, incorporating a logarithmic

scale and an agreed zero level. However, the logarithmic base 2. 512... ($=\sqrt[5]{100}$) is an awkward one and is more troublesome to use than the base 10. Also the system has the disadvantage that, at least in its most common use, larger numbers correspond to smaller intensities.

It is recommended that a logarithmic measure of flux density should be introduced in an agreed form. Agreement cannot be made at the present time between a scale. The former would have advantages in comparisons between visual and radio magnitudes, while the latter would be considerably more convenient. It is recommended that a choice should be made at the next Assembly.

Appendix I of the 1950 U.R.S.I. report suggests an alternative terminology based on photometric practices. We agree with the I. A. U. group that this terminology does not seem in any way desirable. There seems little point in distinguishing between the inward and outward flux through composite words. Thus, since « flux density » is already in use for the concept for which « radiance » is suggested all but one of the concepts are adequately served by existing terminology. The addition of the adjective « radiant » is redundant in works dealing entirely or mainly with radiation.

The exception is the concept for which « fluance » is proposed. No great need is seen for the word at present. However, it might be kept in mind as a potentially useful term, if and when the need arises.

We further agree with the I. A. U. group that a preference for the M.K.S. system should be expressed, and that the bandwidth dimension (cycle-/second or Hertz) should always be included.

3. *Radio Astronomy in the Universal Decimal Classification.* —
Radio astronomy, being a new subject, has no proper place in the Universal Decimal Classification, and the various aspects have been squeezed into the tables only by extending the meaning of existing subdivisions. Thus, « solar noise », « cosmic noise », etc., are to be found in widely scattered places, and there is no satisfactory place at all for the general subject of « radio astronomy ».

We propose that U.R.S.I. Commission V and I. A. U. Commission 40 should sponsor a classification of the subject of radio astronomy, to be submitted to the Federation Internationale de Documentation, with a recommendation that it be incorporated in the U. D. C. tables. With this end in view, we suggest that the classification set out below might be used as a basis for discussion.

We have aimed at a classification which contains a small number of clearly-distinguishable subjects of roughly comparable importance.

We have provided separate sections for « theory » and « apparatus », preferring this to the use of point-of-view auxiliary numbers, since these appear to us to be important and distinct subjects. The subject « radio waves from the sun » has not been subdivided, since the bulk of material is not yet unmanageable, but further subdivision may well be required later. It is not yet possible to distinguish completely between radiation of galactic and extragalactic origin (either for the background radiation, or that from discrete sources), and so we have kept them together in a common section.

.... Radio astronomy.
.1 Theory.
.2 Apparatus.
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.43 Line emission of radio waves.
.8 Astronomical.
.81 Moon echoes.
.82 Meteor echoes.

The above report was submitted to I. A. U. Commissions 3 and 40 during the Rome Congress in September 1952. Both Commissions made two recommendations :

1° *To submit the draft for advice to I. A. U. Commission 27,*

2° *To promote correspondance between members of Commission V interested with the draft, and between U.R.S.I. Commission V and I. A. U. Commission 40 in order to reach a final draft to be ratified by the General Assemblies of 1954.*

Both those recommandations are already being carried out.

Resolutions

1. Referring to Recommendation nº 56 (Question nº 9) of C.C.I.R., it is considered impracticable to make general use of the frequencies specified therein for solar observations; however, it is suggested that C.C.I.R. ask the Frequency Allocation authorities to give all possible protection to those engaged in radio astronomical measurements in the radiospectrum from 10 Mc/s to 30 000 Mc/s.

2. Referring to Resolution nº 20 of the U.S. National Committee it is agreed desirable to emphazise again to C.C.I.R. the importance of preserving a band of frequencies for the hydrogen line at 1420 Mc/s. At present a bandwidth of 3 Mc/s is required, but it seems probable that such observations may extend to lower frequencies, perhaps to 1400 Mc/s, in the future.

3. Referring to the statement by the Indian National Committee on « Standardization of Solar Radio Equipment » it is agreed that the precision of such equipment is still unsatisfactory. However, no specific recommendations for improvement can be made at present.

4. It is recommended that further observations be made on :

(a) quiet sun radiation at the lower frequencies.

(b) the maximum intensity of bursts on all frequencies.

5. It is recommended that observational data for cooperating observatories be submitted at monthly intervals to Mr. SMERD as soon as possible after the end of each month. The assembly of such monthly data and its general distribution to cooperating observatories will be continued.

6. The continuance of Sub-Commission (Va) is recommended.

7. It is recommended that Dr. D. F. MARTYN be appointed Historian of Commission V.

8. It is recommended that the Report of Sub-Commission V*b* (Terminology and Units) be forwarded to Commission 40 and 3 of I.A.U. for consideration at the Rome Assembly and that part (3) of the Report, bearing on the Universal Decimal Classification, be forwarded to the Fédération Internationale de Documentation with a recommendation that it be incorporated in the tables of the Universal Decimal Classification.

9. The Commission notes the valuable preparatory work by Dr. MENZEL and Professor MASSEY on the preparation of a report on the Dynamics of Ionized Media (Special Report nº 3) and urges the early collation of the United States and European contributions.

10. Special Reports :

(*a*) *Interstellar Hydrogen* : OORT (Chairman), PURCELL, PAWSEY.

(*b*) *Discrete Sources.* — BOLTON (Chairman), Hanbury BROWN (Manchester), SMITH (Cambridge).

(*c*) *The Distribution of Radio Brightness on the Solar Disk.* — CHRISTIANSEN (Chairman), HAGEN, LAFFINEUR, SMITH.

(*d*) *Meteors.* — (Covered partially by Commission III, but Commission V urges the inclusion of material on the origin of meteors).

11. *Basic Solar Index.* — The conclusions on this matter were arrived at in joint session with Commission III. The Commission stresses the value of measurements on 3000 Mc/s and supports the recommendations of Sub-Commission V*c*.

Sub-Commission V*c* on Basic Solar Index

(*a*) The Sub-Commission considers that an index of solar activity based on radio-frequency observations, although it has been the object of several important researches, cannot be considered as perfectly defined at present.

(*b*) The Sub-Commission nevertheless proposes a provisional index on the observation of two groups of phenomena :

(i) The intensity of the radiation on a frequency near 3000 Mc/s (wavelength 10 cm), whose correlation with the total area of sunspots seems well established.

(ii) The presence and intensity of noise storms connected with the appearance and activity of disturbing regions on the surface of the sun.

(*c*) The index thus be composed of the intensity of solar radiation on 2800-3000 Mc/s expressed in units of 10^{-22} watts $m^{-2}(c/s)^{-1}$.

(*d*) This number would be followed by the sign / and a number from 0 to 3 expressing the intensity of noise storms in progress between 60 and 300 Mc/s (1 and 5 m), as in Quarterly Bulletin.

(*e*) The Sub-Commission will continue its work by correspondance between its members, and endeavour to propose an observing programme in the world's observatories on the wavelength of 10 cm, following the recommendation made at Zurich. It will also encourage work on the correlation between ionospheric phenomena and various metre wave radiations within Sub-Commission Vc.