INTERNATIONAL SCIENTIFIC RADIO UNION

U.R.S.I.

Proceedings of the General Assembly

held in Zurich from September 11th to 22nd, 1950

VOLUME VIII

:: PART I ::

Published with the financial help of UNESCO

by the General Secretariat of U.R.S.I.
42, Rue des Minimes, BRUSSELS
1950

Mr. Bureau asked Mr. Rivault to give a brief account of the work described in these papers.

In paper nº 174 it is shown that an increase is cosmic radiation occurs one hour after a sudden enhancement of the mean level of atmospheric noise.

Paper nº 183 gave detailed information on sudden enhancement of atmospherics as obtained by mean level recorders.

3. Mr. Horner illustrated his paper nº 227 on the accuracy of the C.R.D.F system for locating the source of atmospherics.

4. Mr. Rivault gave a brief summary of the paper nº 145 by Mr. Carbenay extending the concept of « impulse flux » applied to the narrow sector goniometer already defined in a previous paper.

5. The formal recommendations from Commission IV [1] were read by the Rapporteurs, discussed and adopted.

6. The President closed the session at 17 30 h.

Commission V
On Radio-Astronomy

Contents

Officers

President . Dr. D F Martyn, Radio Research Board, Commonwealth Observatory of Mount Stromlo.

Secretary Dr J. L. Pawsey, Radiophysics Laboratory, Chippendale.

Rapporteurs Mr Laffineur, Ingénieur des Cadres du Centre National de la Recherche Scientifique
Dr J. L. Pawsey.

[1] See p 61

List of documents submitted to the Commission

Nº	Titles and Authors	Part
6	The position and movements on the solar disc of sources of radiation at a wave-length of about 3 metres, by R Payne-Scott and A G Little.	II
7	Solar radio frequency emission from localized regions at very high temperatures, by J H. Piddington and H C Minnett.	II
8	The derivation of a model solar chromosphere from radio data, by J H Piddington	II
9	Analyses of distribution of sources of galactic radio waves in the galactic plane, by K C Westfold	II
10	Observations of the dynamic spectrum of radio frequency bursts from the sun, by J P Wild and L L McCready	II
27	Report of the Japanese National Committee	I, p. 162
28	Results of scientific activity of the Japanese Ionosphere Research Committee, by Y Hagihara and T Nakata	I, p. 28
50	Report of Commission V on Extra-Terrestrial Radio Noise	I, p 375
70	Cosmic radio noise intensity measurements in the VHF band, by H V Cottony and J R Johler	II
71	Observations of the variable 205 Mc/s radiation of Cygnus A, by Ch L Seeger	II
72	Some characteristics of 10 7 centimetre solar noise, by A Covington	II
73	Radio pole of the Galaxy at 205 Mc/s, by Ch L Seeger and R E Williamson	II
78	Report of the Italian National Committee on Extra-terrestrial Radio Noise, by Righini	I, p 161
84	Report of the French National Committee, Chapter V	I, p 110
110	Report of the U S A National Committee	I, p 224
117	Report of the Swedish National Committee	I, p 215
129	The Chalmers Radio Astronomical Observatory, by O E H Rydbeck, H Wallman and B Stjernberg	II
130	Galactic Noise, by J G Bolton	II
131	The propagation of electron beam waves in an ionized medium, by O E H Rydbeck and S Forsgren	II
132	Survey of results of meteor recordings during 1949 at the Chalmers Observatories, by B Stjernberg	II

Nº	Titles and Authors	Part
133	Cosmic radiation and radio stars, by Alfvén and N Herlofson	II
176	Radio observations of the solar eclipse on 28-4-49, by M Laffineur, R Michard, R Servajean and J L Steinberg	II
177	Study of radio emissions from the sun on decimetre waves, by J F Denisse	II
178	Analysis of observations on the radio solar emission performed at the Meudon Observatory, by M Laffineur	II
179	Analysis of observations made at the Laboratory of the Ecole Normale Supérieure at Paris and at the Service Laboratory of the Marine Studies at Marcousis, by E J Blum, J F Denisse, J L Steinberg and S Zisler	II
200	Report of the Swiss National Committee	I, p 221
206	The solar radiation on 10 cm wave length, by M Waldmeier	II
216	Limiting sensitivities a comparison of optical and radio astronomy, by H Wallman	II
228	Report on British work since 1948 for Commission V of U R S I	I, p 144
241	The seminar of Radio-Astronomy of the Astrophysical Institute of Paris, by J Laffineur and V Kourganoff	II
247	The origin of the fluctuations in the intensity of radio waves from localized galactic sources, by A C B Lovell	II
250	Report of the Australian National Committee of Radio Science 1948-50	I, p 71
251	Electro-magneto-ionic waves, by V A Bailey and K Landecker	II
254	The Dutch Progress Report 1948-1950	I, p. 190
258	Report on work on radio-astronomy in Netherlands 1948-1950, by M Minnaert.	I, p 194
277	Interstellar meteors, by A C B Lovell	II
278	The problem of the duration and the fluctuations and the fading of radio echoes from meteor trails, by A C B Lovell	II
279	A continuous survey of meteor activity by the radio echo techniques, by A C B Lovell	II

Nº 50. — Report of Commission V : Extra-terrestrial Radio Noise

Contents

(1) Membership

The following is a list of Officers and Members of the Commission as at 8 May, 1950 :

Dr D. F. Martyn (*President*) . Radio Research Board, c/o Commonwealth Observatory, Mount Stromlo, Canberra, A.C.T.

Dr. J. L. Pawsey (*Secretary*) Radiophysics Laboratory, University Grounds, Chippendale, N.S.W.

Australia .

Dr. C. W. Allen . Commonwealth Observatory, Mount Stromlo, Canberra, A.C.T

Prof. L. G. H. Huxley : Physics Department, University, Adelaide, S.A.

Denmark

Prof. B. Stromgren . Director, Astronomisk Observatorium, østervoldgade 3, Copenhagen, K

France :

Mr. Laffineur : Institut d'Astrophysique, 98*bis*, Boulevard Arago, Paris, 14e.

M Y. Rocard : Professeur à la Sorbonne, 120, Rue d'Assas, Paris, 6e.

Great Britain ·

Dr. M. Martin Ryle : Cavendish Laboratory, Cambridge, England.

Italy :

Prof. G. Abetti : Direttore dell' Osservatorio Astronomico, Arcetri, Firenze.

Japan :

Dr. Takeo Hatanaka : Asst Professor, Tokyo Astronomical Observatory

Mr. Tetsuo Kono : Radio Wave Division Radio Regulatory Agency.

Dr Atsushi Kimpara : Professor, Nagoya University (Correspondence : c/o The Science Council of Japan, Ueno Park, Tokyo).

Netherlands :

Prof. Dr. J. H. Oort : Sterrewacht, 5, Leiden, Holland.

New Zealand :

Dr. E. Marsden : New Zealand Scientific Office, Africa House, Kingsway, London, W C 2, England.

Sweden :

Prof. O. E. H Rydbeck : Chalmers University of Technology, Goteborg.

Switzerland :

Prof Dr. M Waldmeier : Directeur de l'Observatoire Astronomique Fédéral, Sternwartestrasse, Zurich.

Prof. Dr. Fr. Tank : Directeur de l'Institut de Haute Fréquence de l'Ecole Polytechnique Fédérale, Frohburgstrasse, 174, Zurich.

Union of South Africa :

Captain P. Meerholz : c/o T.R E., Great Malvern, Worcestershire, England.

United States of America :

Dr. D. H. Menzel, Harvard College Observatory, Cambridge, Mass., U.S.A.

(2) Regular publication of solar noise data

Jointly with the President of Commission 40 of the International Astronomical Union the following letter was sent to laboratories making measurements of solar radio noise :

Dear Colleague,

The International Astronomical Union and the International Union of Scientific Radio each set up in 1948 Commissions dealing with radioastronomy We believe that the time is now appropriate to revise and extend the regular summaries of the chief characteristics of solar radio noise, now being published. Enclosed is a document describing the preliminary measures which have been taken in this respect. It is hoped that you will find it possible to participate in the proposed scheme, which will come into operation at the end of the first quarter of 1949 Any suggestions you may make with regard to improving or extending the scheme will be warmly welcomed.

In the first instance, the collected information will be published, as at present, only in the « *Quarterly Bulletin of Solar Activity* ». Consideration will be given at an early date to the question whether publication should be duplicated in the *Bulletin of U R S.I* , or some other Journal devoted to radio sciences

(s) D. F Martyn,
President Commission V, U.R.S I

(s) R. v. d R Woolley,
Chairman, Commission 40, I A U

Enclosure

Solar radio noise data
for the Quarterly Bulletin of solar Activity

The publication of solar radio-noise data in the *Quarterly Bulletin of Solar Activity* was commenced in January, 1947. The information submitted was tabulated almost without alteration, and it was left to the conferences of the I.A U. and U.R S I. in 1948 to devise methods of tabulation suitable for a uniform and progressive presentation of results. Both of the Unions have formed Commissions on radio-astronomy, and the tentative arrangements set out below have been made by agreement between the former Bulletin editor, Dr. L. d'Azambuja, and the Presidents of the respective Commissions, Dr. R. v d. R. Woolley and Dr. D. F. Martyn. It is suggested that from the commencement of 1949 the Commonwealth Observatory, Canberra, in collaboration with the Radiophysics Laboratory, Sydney, assemble the solar-noise data for publication, with Dr. C. W. Allen acting as Editor It is desirable that this arrangement be complete by the end of March 1949 so that there should be no break in the continuity of the quarterly publication.

With this in view we wish to ask ·

(*a*) Do you expect to make any regular solar radio noise observations which you might contribute to this publication ? If so, please give wavelength, nature of equipment, hours of observing, probable date of participation in scheme, etc.

(*b*) Have you any comment to make on the proposed scheme of tabulation described below ?

(*c*) If you have suitable observations can you post them as early as possible each quarter by air mail to

Dr. C W. ALLEN,
Editor « Solar Radio Noise »,
Commonwealth Observatory,
Mount Stromlo, Canberra, Australia

Tabulation of Data

The scheme of tabulation has been drawn up by conference between the Commonwealth Observatory and the Radiophysics Laboratory, while outside suggestions have also been taken into consideration. It is designed to give information on the features of solar radio-noise which are thought to be of physical importance. Every attempt has been made to enable an observer to extract the required information simply by an examination of the solar-noise recordings Many observing stations may be unable to give information as complete as the tabulation suggests, but partial information will still be useful.

The tabulations are to be made in two parts :

(*a*) Tables of hourly and daily values, and

(*b*) Lists of outstanding occurrences.

Standard forms suitable for inserting the required information will be prepared and sent to those interested

Hourly and Daily Values

Hourly values to be centred on the half-hours, U.T.

Occasional readings may be used if hourly values are not available.

The hours during which daily observations have been made should be given.

(*a*) *The Intensity Level* · to be expressed if possible in watt metres^{-2} (cycles/sec)$^{-1}$. Hourly values to be medians; i. e. the intensity which is exceeded for half the time in the (hourly) interval. Medians of the hourly values will be used for daily values. Observations with an undetermined absolute value may be useful if they are consistent.

(*b*) *The Polarisation* : to be expressed as percentage polarisation i e.

$$100 \frac{I_R - I_L}{I_R + I_L}$$

R and L will be used to denote sense of polarisation instead of + and —, and I_R and I_L are the respective power flux densities. The radio-electric (not optical) convention is adopted so that for R polarisation the vector in a fixed plane perpendicular to the ray rotates clockwise when viewed in the direction of propagation.

(*c*) *Degree of Variability* to be classified as follows :

0. No observable variability.
1. Slight variability.
2. Moderate variability.
3. Violent variability.

This classification refers to short period variability (order of seconds and minutes). It will be clear that the higher numbers 2, 3 in the scale must be used sparingly since they must cover the maximum variability ever likely to be encountered.

Special Occurrences

These will be mainly outstanding transient increases of intensity and the tabulation is designed particularly for these. However, sudden changes of polarisation, or any other occurrence the observer thinks to be important, should be reported, and adapted to the tabulation as well as possible.

The columns required are .

1. Observing station.

2. Wavelength.

3. Date.

4. Starting time, i. e. when occurrence first reaches 20 % of its maximum smoothed value.

5. Duration, counting from the start to the last time the smoothed curve is 0.2 of its maximum value

6. Type of occurrence, using the following terminology :

(i) { S : Simple rise and fall of intensity ;
C : Complex variation of intensity.

(ii) { A : Appear to be part of the general activity.
D : Distinct from (i e apparently superimposed upon) the general activity.

P : Sudden polarisation change

Other symbols may prove necessary later. Usually the groups (i) and (ii) will both be required, thus the typical burst during a noise storm would be SA, the typical outburst associated with a flare would be CD.

7 Maximum intensity — instantaneous The highest intensity during an occurrence will often come from a sharp burst This highest intensity should be recorded although it may not be a good indication of the importance of the occurrence. The unit to be watts metres^{-2} (cycles/sec)$^{-1}$ as before

8. Maximum intensity — smoothed This is intended to represent the intensity of the occurrence for comparative purposes. The observer should smooth the curve as he thinks appropriate, and measure from the highest level of the smoothed graph, to the level expected without the occurrence. Usually the smoothing period will be about 10 % of the total duration but the smoothing will be carried out roughly by eye. The unit is to be watts metres^{-2} (cycles/sec)$^{-1}$ as before. The (maximum smoothed intensity) $\times$ (duration) will give some indication of the energy emitted by the occurrence.

9. Polarisation. Percentage polarisation and the sense (R or L).

10. Remarks. Any points about the occurrence that cannot be adequately described in the other columns Any other solar or terrestrial phenomena that appear to be related to the occurrence.

1st March 1949

This scheme is now in operation. There follows a list of co-operating observatories and laboratories :

Observing Station	Abbreviation	Frequencies Used Mc/s	Normal Observing Period (Hours U T)
Commonwealth Observatory, Canberra, Australia	Can	200	00-06
Cavendish Laboratory, Cambridge, England	Cav	80 175 500	10-14 10-14 10-14
Radiophysics Laboratory, Sydney, Australia	Syd	62 97 600 1200	21-06 21-06 0-06 0-06
Meudon Observatory, Paris, France	Meu	545	04-17
National Research Council, Ottawa, Canada	Ott	2800	14-20
National Bureau of Standards, Washington, E U.A.	NBS	480 51	13-24 13-24

The following quantities are tabulated and published quarterly in the *Quarterly Bulletin of Solar Activity* .

1. *Flux* — The unit for this tabulation is 10^{-22} watts metre^{-2} (c/s)$^{-1}$.

The values can readily be converted into equivalent temperature T of the sun's visible disc by the relation .

$$\text{Flux} = 2\ 09 \times 10^{-44}\ \nu^2 T$$

where ν is the frequency in cycles per second.

2. *Polarisation* — The radio-electric (not optical) convention is adopted so that for R polarisation the vector in a fixed plane perpendicular to the ray rotates clockwise when viewed in the direction of propagation The values quoted are percentage polarisation, i e

$$100\ \frac{I_R - I_L}{I_R + I_L}$$

where I_R and I_L are the intensities

3 *Variability.* — The variability is described by indices on a scale 0 to 3 as follows ·

0 No observable variability
1. Slight variability
2 Moderate variability
3 Violent variability.

The observations from Sydney usually extend through U.T. 0 h., and hence there are observing periods at the beginning and end of the Greenwich day. When the indices differ both are tabulated, the beginning of the Greenwich day being on the left.

4 *Outstanding Occurrences*

S simple rise and fall of intensity.
C complex variation of intensity.
A appears to be part of general activity.
D distinct from (i. e apparently superimposed upon) the general activity.

The two maximum intensity columns contain, firstly the maximum instantaneous value, and, secondly, the maximum smoothed value which is more suitable for comparative purposes. The unit of intensity in these columns is 10^{-21} watts metre^{-2} (c/s)$^{-1}$. If an occurrence is observed almost simultaneously on two or more frequencies only one is tabulated in detail, and the others briefly indicated by the station, frequency and starting time.

(3) World Bibliography of Extra-Terrestrial Radio

The following correspondence has passed between the President of the Commission and the Director of the School of Electrical Engineering, Cornell University Thanks to the latter's cooperation an up-to-date Bibliography of Extra-Terrestrial Radio is appended herewith It is anticipated that supplementary issues will be produced at appropriate intervals :

27th. February, 1950

Professor C R Burrows,
School of Electrical Engineering
Cornell University, Ithaca, New York

Dear Burrows,

I have been very glad to receive the various Radio Astronomy Reports from your Department. They certainly fulfill a useful fonction.

We have had some discussion here about the preparation of a world Bibliography of Radio Astronomy on behalf of Commission V of U R.S.I , for presentation at Zurich this year as a Commission document. It seems to me that it would be wasteful to duplicate the excellent job Miss Stahr is doing.

Could I then, as President of Commission V invite your Department to prepare such a bibliography as a Commission V document for presentation at the Zurich Assembly of U.R.S.I. as part of the Commission's Report ?

Dr. Pawsey would be very happy to send you an up-to-date bibliography of all Australian work in the field, if you cared to accept this proposal. So far as I can see the proposed arrangement would not involve any change in what you are already doing, save to give the project official international status on behalf of U.R.S.I., and to ensure also that you are kept fully up-to-date on all Australian work.

If any additional expense is involved, if you let me know the approximate amount, I would try to get it met by U.R.S.I. or in some other (possibly Australian) manner. A slight redesign of the cover would be desirable — heading U R.S.I. Commission V, *Bibliography of Extra-Terrestrial Radio, prepared by School of Electrical Engineering Cornell University, etc., under U S Navy Contract, etc*

Again you might care to regard this a as continuing function on behalf of U.R.S.I , or you might care to do it only for this 1950 Assembly. No doubt you will have to get the reactions of the U S Navy.

I am looking forward very much to seeing you again at Zurich this year

With kindest regards Yours sincerely,

(*s*) D. F. MARTYN,
President, Commission V, U R S I

March 21, 1950.

Dr. D. F. MARTYN,
President, Commission 5, U R S I ,
C/o Commonwealth Observatory,
Mount Stromlo, Canberra, Australia

Dear Dr. Martyn,

The staff of the Radio Astronomy Project here at Cornell agrees heartily with your suggestion for a World Bibliography of Radio Astronomy on behalf of your Commission. On behalf of Miss Stahr and our group, it is a pleasure to accept your invitation to prepare the Bibliography as a continuing function for presentation at the Zurich Assembly as part of the Commission's report.

Dr. Pawsey's contribution of an up-to-date bibliography on all Australian work in the field will be gratefully received Available reprints of articles listed in the bibliography are desired to insure efficient preparation of the material In this regard we will appreciate the support of you and your Commission members in urging that workers in the field regularly send reprints of their articles to Bibliography of Extra-terrestrial Radio Noise, School of Electrical Engineering, Cornell University, Ithaca, New York For your convenience in communicating with the members of your Commission, a description of the proposed plan for the Bibliography is enclosed. The early receipt of com-

ments or suggestions by you and your Commission members will be appreciated. We are taking the liberty of corresponding with the workers in the field to request their cooperation in this undertaking.

The expense of publication is being investigated I expect that this item can be handled locally but will advise you if further financial support is necessary

Will you please advise us of the number of copies that your Commission will require and of the time and location of delivery of the documents ?

I look forward to renewing our cordial relations at Zurich this Fall.

Yours very truly,

(*s*) Chas. R. BURROWS.

Enclosure. — The following is a tentative description of the « Bibliography of Extra-Terrestrial Radio Noise » currently in preparation by the School of Electrical Engineering, Cornell University, Ithaca, N.Y., U.S.A , for issuance as part of the Commission's Report to the General Assembly of U.R.S I. meeting at Zurich this year.

Members of the Commission are requested to aid in the preparation of this « Bibliography » in the following respects :

(1) by communicating at their earliest convenience directly to :

Prof. M. E. STAHR,
Department of Astronomy,
Cornell University, Ithaca, N.Y., U S.A.

any comments, criticisms, or suggestions which they may care to make regarding the plans described below.

(2) by providing reprints of any papers, suitable for inclusion in the « Bibliography », which have been prepared by them or by colleagues at their institutions. Reprints should be addressed to :

Bibliography of Extra-Terrestrial Radio Noise,
School of Electrical Engineering,
Cornell University, Ithaca, New York, U.S.A

It is proposed that in scope and organisation the « Bibliography of Extra-Terrestrial Radio Noise » will be closely similar to the

« Bibliography of Radio Astronomy » and its First and Second Supplements, already issued as Reports Nos 2, 4 and 10 of the School of Electrical Engineering, Cornell University. Descriptive statements concerning the latter are contained in their Introductions. The salient features, modified for application to the Commission's « Bibliography of Extra-Terrestrial Radio Noise », are summarised below :

I. *Criteria for the Inclusion of References.* — It is proposed to give as complete a listing as possible (with the exception noted below) of papers dealing wholly or in part with the observation, prediction or interpretation, of radio-frequency radiations originating in extra-terrestrial sources. Theoretical papers of more general nature will for the most part be included if they contain any application, however slight, to one or more of these subjects. Reports of research projects will be included unless they have appeared in regularly issued and generally available publications.

II. *Abstracts* — It is proposed that the contents of all papers listed in the Bibliography will be summarised or described, in so far as their subject matter is applicable to the fields of research here considered Authors' abstracts or previously published abstracts from other sources will be used if appropriate, and in such cases due acknowledgment will of course be given.

III. *Arrangement of Material* — It is proposed that the references be arranged according to subject matter in the following categories which are not intended to be mutually exclusive but merely to indicate in each case the primary emphasis of the subject matter :

A. Galactic Radio-Frequency Radiation :
   1. Observations.
   2. Theories and Interpretations.

B. Radio-Frequency Radiation from Discrete Sources

C. Solar Radio-Frequency Radiation :
   1. Observations.
   2. Theories and Interpretations.

D. Radio-Frequency Radiation from Moon.

M. Miscellaneous.

R. Reviews.

(In any future Supplementary Bibliographies, new sections can be added and the above sections subdivided wherever such changes become appropriate as knowledge of the field advances).

The references in each catagory will be grouped according to year of publication, and within each year will be placed alphabetically by author or by title if no author is given Each reference will be assigned a number which designates the category in which it is placed, the year of publication and the position of the reference within that year, e g the fifth entry in the list of papers published in 1948 and dealing with observations of Solar Radio-Frequency radiation will be numbered C1-48-5

Following the entries in each category, reference will be made to other articles containing information pertinent to that category but listed elsewhere in the « Bibliography »

IV. *Other Features.* — It is proposed that the « Bibliography » will also contain

1. An explanatory introduction
2. An author index of all references included
3. Charts indicating the wavelengths at which radio-frequency observations of each of the following have been reported ·
   Galactic radiation,
   Radiation from discrete sources,
   Solar radiation, and possibly,
   Radiation from the moon.

On these charts reference will be made by number to the pertinent papers mentioned in the « Bibliography »

(4) Nomenclature and units

The subject of our Commission has developed rapidly in a field of science bordering on the one side astrophysics, and on the other ultra-high frequency radio. In the two latter subjects very different physical concepts and units are in common use. Hence there has been considerable diversity in the terms and concepts used in our field

It is obviously desirable to reach some measure of general agreement on these matters as soon as possible, while being careful to make provision for new developments The attached document entitled « Notes and Recommendations on Nomenclature and Units used in Radio Astronomy : I » has been prepared by the Secretary of the Commission, in consultation with radiophysicists in Australia. A second attached document « Notes and Recommendations on Nomenclature and Units used in Radio Astronomy · II » has been prepared by Dr. C. W. Allen, of the Commonwealth Observatory, Canberra ; it may be considered as giving the astronomer's viewpoint. There is considerable divergence of view evident in these two documents. No doubt other Commission Members have yet other views.

It will be our aim at the Zurich meetings to seek the largest measure of general agreement on these and kindred points.

D. F. Martyn,
President, Commission V, U R S I.

J. L. Pawsey,
Secretary, Commission V, U R S I.

8th. May, 1950.

Notes and Recommendations on
Nomenclature and Units used in Radio Astronomy : I

1. Notes on specification of magnitudes.
   1.1. Equivalent temperature concept.
2. Notes on words defining phenomena.
3 Recommendations.
   3 1. Words defining phenomena.
   3 2. Quantities and units
   3 3 Summary.

These notes relate to nomenclature in English publications dealing with « extra-terrestrial radio noise » (to use the rather cumbersome U.R.S.I. title of Commission V). Two aspects arise · firstly the choice of physical quantities (including their units and names) which are used to measure the radiation ; and secondly the names used to describe various phenomena. The current position is summarised and, in conclusion, a series of recommendations are put foward. It is suggested that these recommendations be considered as a basis for discussion of recommendations which could be formulated by Commission V of U.R.S.I.

1. Notes on Specification of Magnitudes. — Radio waves from extra-terrestrial sources are measured in terms of the power which they cause a given aerial to deliver to a given receiver. The finite bandwidth of the receiver is usually eliminated by quoting the result as « power per unit bandwidth and the mid-frequency of the received band » (1).

The magnitude of the wave can then be specified either in terms of the whole radiation received from all parts of the object, which is measured by the *flux density* (S) or in terms of the « *brightness* » (B) of the individual parts of the source. In *m.k.s.* units, which are preferred in the Radiophysics Laboratory, S is measured in watts m^{-2} $(c/s)^{-1}$ and B is measured in watts m^{-2} $(c/s)^{-1}$ $(\text{stereradian})^{-1}$. The unit of B is clumsy (2).

The alternative specification in terms of equivalent temperature yields a simpler expression.

The words which have been used for these two fundamentally distinct quantities S and B are confused. *Flux density* for S appears unambiguous but the word « intensity » has also been used. The latter word is used by certain writers in astrophysics for the other quantity B (cf. E. A. Milne : *Handbuch der Astrophysik*, Vol. III, 1930. Milne uses « specific intensity » and subsequently abbreviates to « intensity »). In this context the concept is precisely defined and valuable properties derived, e g intensity constant along a ray if no absorption or emission and refractive index constant. « Intensity » is also used in this sense in some radio-astronomy papers.

If the word intensity is to be used in a precise sense such as that used by Milne, it is obviously necessary to define it *emphatically* in order to avoid ambiguity

(1) This procedure is misleading if the spectrum shows marked variation in frequency ranges less than the bandwidth-usually about 1 Mc/s

(2) The simplification which occurs when a source of constant brightness B completely fills the aerial beam should be noted If the aerial has an effective area A and effective solid angular beam width Ω and receives a power per unit bandwidth p, then $B = p/A\Omega$ by definition However, it can be shown that for any aerial $A = \lambda^2$ (where λ is the wavelength) Hence in this case $B = p/\lambda^2$ independently of the individual values of A and Ω although the unit includes a suggestion of both.

A further possible source of ambiguity arises because an aerial normally accepts a single component of polarisation — hence the component measured should be stated. In particular, it is common practice but not universal to specify not the measured value of S or B but twice that value as an estimate of the *total power* in the two conjugate components.

1.1. *Equivalent Temperature Concept.* — This concept is used in three applications as follows :

(1) The « brightness » or « specific intensity » as used by Milne (B) of radiation from a black body of uniform temperature T is known ($B = \frac{2kT}{\lambda^2}$ for both components). Hence this temperature may be used as a measure of B. It is called the « effective » or the « equivalent » temperature (T_e). At these long wavelengths T_e is proportional to B.

(2) In the case of solar radio waves the flux density (S) is usually measured without observation of its distribution. This flux density is often specified in terms of the temperature of a black body, having the angular size of the *visible disc* which would yield the observed flux density. This temperature T_a is a particular mean value of T_e over the radio disc of the sun. It is given by :

$$T_a = \frac{\int T_e d\Omega}{\text{(solid angle of visible disc)}}$$

where $d\Omega$ is an increment of solid angle and the integration is over the whole of the contributing parts of the sun

The distribution of T_e is usually non-uniform, extends beyond the optical disc and is often dominated by one or two highly emitting small areas. Hence this mean value is a little artificial. The quantity T_a has been called « apparent temperature » by Pawsey with the idea that « apparent » infers a more artificial character than « equivalent » or « effective ». Various other names are used.

(3) The total available power per unit frequency band from an aerial (p) can be specified in terms of the temperature T of a uniform temperature enclosure surrounding it which would yield the same power ($p = kT$). This is called the « *equivalent aerial temperature* », T_a.

These three temperatures are specified in degrees Kelvin.

The specification of these three quantities, brightness, flux density and available power, in terms of temperature does not imply that the power considered is of thermal origin though it may obviously be convenient in discussing such power.

The considerations of this section are collected in Table I

TABLE I

Symbol used here	Quantity (per unit frequency band in each case)	Unit	Corresponding Temperature Expression Unit (°K)
			(of sun)
S	*Flux Density* Intensity*	watt m^{-2} (c/s)$^{-1}$	Apparent Temp (T_a)
B	Brightness	watt m^{-2} (c/s)$^{-1}$ (Ster. Rad)$^{-1}$	*Effective Temp* (T_e)
			Equivalent Temp.
	Intrinsic Intensity* Intensity		
p	*Available power*	watt (c/s)$^{-1}$	(from an aerial) *Equivalent Aerial Temp*

Words in italics are considered accepted usage
* Danger of ambiguity

2. NOTES ON WORDS DEFINING PHENOMENA. — A full satisfactory word to describe radio waves from the sun or galaxy is still lacking — « Noise » [1] is used with obvious reluctance. The alternative « radio frequency radiation » is clumsy.

Of the various terms used by different authors to describe phenomena, some are concerned with concepts which may not have reached their final form It would therefore be premature to attempt to standardise these yet, but it would be unfortunate if

[1] Its introduction is based not on normal English usage but on the technical term « noise » used in radio to describe a disturbance having an essentially continuous spectrum, e g. « random noise », « shot noise ». But too many readers naturally accept the normal acoustic implication

later authors should create confusion by using these terms with different meanings. There follows a list of some of the terms used with an indication of meanings and of some early authors using the terms.

TABLE II

Term	Meaning
1 Cosmic noise *	Radio waves from the cosmos — restricted to extra-terrestrial sources and usually excluding the sun.
2. Galactic noise *	Radio waves from a galaxy — usually ours
3 Solar noise	Radio waves from the sun.
4. Burst (McCready, Pawsey, Payne-Scott, Ryle and Vonberg)	Short period increase of radiation (duration seconds or minutes).
5 Discrete source (Bolton) Radio-type star (Bolton) Radio star (Pawsey)	Localised source of cosmic noise (less than a few minutes of arc)
Solar Noise Terms **	
6. Quiet sun (Martyn)	Sun in absence of forms of activity associated with sunspots (including all bursts, storms, etc, 8 to 12 below).
7. Basic thermal radiation	Thermal radiation from the « quiet » sun

* The word « cosmic » appears applicable in cases where the author wishes to avoid the question of where the waves originate For example, it may be said that galactic noise from our galaxy forms a part only of cosmic noise

** Some of these are simple descriptions — included here merely to make the picture complete

Term	Meaning
8 Slowly varying component	Component recognised at decimetre wavelengths, having close correlation with sunspot area, a small magnitude and peaks occurring of the order of one per month (Origin perhaps thermal).
9 Noise storm (Allen) Enhanced radiation (Pawsey, Payne-Scott)	Increase of radiation of days or hours duration, usually but not always with many bursts, showing circular polarisation (Typically found in metre wavelengths).
Storm-burst (Wild)	Typical burst during storm.
10. Outburst (Allen, Payne-Scott, Bolton, Yabsley, Pawsey)	Large increase of radiation typically associated with solar flare — usually of complex form and minutes duration.
11 Isolated burst (Pawsey)	Large burst appearing sporadically at time of no other activity Not circularly polarised. (Metre wavelengths).
12 Non-polarised burst (Payne-Scott)	Burst, not circularly polarised, observed sporadically on metre wavelengths (Appears to include 10 and 11 and probably occasional bursts of similar origin occurring during noise storms)

3. RECOMMENDATIONS .

3.1. *Words Defining Phenomena.* — It is recommended :

(1) That the title of Commission V be changed, eliminating the words « noise », which has a misleading association, and « extra-terrestrial » which is clumsy. « Radio Astronomy » is a suitable title subject to consideration of the inclusion or exclusion of meteors and the use of the radar technique in the subject matter of the Commission.

Alternatively « cosmic » seems a preferable substitute for « extra-terrestrial » and « radio waves » for « radio noise ».

(II) That a list of terms used in radio astronomy be drawn up in two parts, the first including those recommended as accepted usage and the second terms used in the literature which may not yet have reached a final form. Definitions should accompany the words.

It is suggested that « cosmic », « galactic », « solar », « burst », « quiet sun » and « basic thermal radiation » should be included in the first part (accepted usage) and the remainder of the terms of Table II in the second part (not yet final).

3 2. *Quantities and Units.* — It is further recommended .

(III) That the alternative specification in terms of power flux etc. or of temperature be retained, since each is directly applicable to certain applications, but that, in the absence of specific reasons for choice, the specification in terms of temperature be preferred. The advantages are. (1) simple units, (2) less chance of ambiguity as to whether the whole or the plane polarised component is specified (uncertain factor of 2), (3) more direct relation to measurement (standards in this Laboratory are thermal « noise » from hot and cold resistors), (4) more ready conception of intensity relative to thermal background or receiver noise. (Receiver « noise-factor » is a thermal concept).

(IV) The recommended units should be *m.k.s.* for power flux concepts and degrees Kelvin for temperature.

(V) Terminology. — The words « available power » and « flux density » be taken as accepted usage but that a ruling on the term for the third measured quantity « brightness » (or « specific intensity ») be held over until a future date In particular, the word « intensity » is now ambiguous and should not be used except with extreme care in definition or in a qualitative sense.

(VI) The words « effective temperature » or « equivalent temperature » should be used for the appropriate measure of « brightness » (or « specific intensity ») and not applied to flux density which is a distinct physical quantity.

3.3. *Summary of Recommendations* :

(I) Change title of Commission V

(II) Draw up list of terms in two parts (accepted usage and tentative).

(III) Retain both power flux and temperature modes of specification, but express preference for latter

(IV) Use *m.k.s.* units and degrees Kelvin

(V) Accept words « available power » and « flux density » but withhold decision on third quantity (brightness)

(VI) Accept words « effective temperature » or « equivalent temperature » for measure of brightness (or specific intensity).

Notes and Recommendations on Nomenclature and Units used in Radio Astronomy : II

The following terminology is suggested as an endeavour to introduce for the radiation intensity concepts words that have one clear-cut meaning. Furthermore, nearly all the terms are already in use in photometric literature (being recommended by the Committee on Colorimetry, *J.O.S.A.*, **34**, 245, 1944) where the radiation concepts have lumination analogues.

The terms suggested are :

Term	Notes	Dimensions CGS	Dimensions MKS
Radiant energy		erg	joule
Radiant density		org cm^{-3}	joule m^{-3}
Radiant flux		erg sec^{-1}	watt
Radiant efflux	Outward flux from a source	erg sec^{-1}	watt
Radiant emittance	Outward flux per unit surface	erg $s^{-1}cm^{-2}$	watt m^{-2}
Irradiance	Inward flux on to a unit surface	erg $s^{-1}cm^{-2}$	watt m^{-2}
Radiant fluance	Efflux per unit solid angle in a specified direction	erg $s^{-1}\Omega^{-1}$	watt Ω^{-1}
Radiance	Surface brightness or fluance per unit surface	erg $s^{-1}\Omega^{-1}$	watt $\Omega^{-1}m^2$

Many of these terms are new to radio astronomy and astrophysics, but their use in photometry could be extended without ambiguity. Of the completely new terms, the word « efflux » for outward flux should cause no confusion. The other new term «fluance» has been specially coined to avoid the term «intensity» which is used for this concept by the Colorimetry Committee. The word intensity is in for too general use to attempt to attach a specific dimensional meaning to it. The suggested word fluance is of course made up of the idea of flux per unit solid angle — the -ance at the end of the word calls attention to its similarity to radiance. The concept is analogous to candle power or stellar absolute magnitude.

To this Report was appended a « Bibliography of Extra-terrestrial Radio Noise » prepared by the School of Electrical Engineering, Cornell University, Ithaca, New York.

Minutes of Sessions

First (Opening) Session, Wednesday 13th. September 1950
11 00-12.15 h.

The President (Dr MARTYN) in the Chair.

Appointment of Rapporteurs. — The meeting appointed Mr. M. Laffineur and Dr. J L Pawsey.

Obituary — The Chairman expressed the sorrow of the Commission at the death of K. G. Jansky, whose discovery of extra-terrestrial radio waves founded the new science of radio astronomy. Members stood in silence to his memory. A letter will be sent by the President of Commission V to his widow.

Name of Commission. — Following the proposal of the U S. National Committee it was agreed without dissent to recommended to the Executive Committee that « Commission V » be re-named as « Commission on Radio Astronomy » and extend its scope to include such subjects as meteors, and the *moon*, when observed by radio techniques.

Activities of Commission V since the VIIIth. General Assembly — In collaboration with the International Astronomical Union solar observations on various radio wavelengths are being regularly collected for publication with other solar data in the *Quarterly Bulletin of Solar Activity.*

A bibliography of radio astronomy has been specially prepared for this meeting by the Radio Astronomy group in Cornell University. This procedure will be continued at subsequent Assemblies.

A Special Report of U.R.S.I (N° 1) has been published on our subject, by a Committee under the Chairmanship of Sir E V. Appleton.

Progress in Radio Astronomy — The President gave a brief review under the following headings .

(1) Distribution of galactic radiation
(2) The discrete sources of galactic radiation
(3) Radiation from the quiet sun.
(4) Radiation from the disturbed sun.
(5) Mechanism of emission.
(6) Meteors.

Appointment of Sub-Committees — These were appointed to report on :

(*a*) Continuous observation of solar radio emission by a chain of observatories.

Till now his has only been partially achieved Particular difficulty is caused by radio interference. It may be possible by international agreement (via I.T.U., advised by C.C.I.R.) to reserve for this purpose one or more frequency bands on which radio traffic is prohibited.

Sub-Committee consists of A. H de Voogt (*Chairman*), G Eriksen, Y Hagihara, M Laffineur, R. Lindquist, J. L. Pawsey, G Righini, M Ryle, A H Shapley, J. van der Mark

(*b*) 3rd. Special Report of U.R S I.

A Sub-Committee was set up to recommend a suitable subject for this Report, as follows · H. S. W. Massey (*Chairman*), D H. Menzel, A. C B Lovell

(*c*) *Terminology and Units* — Various documents on this important subject had been previously circulated to Commission members.

Sub-Committee : M. Laffineur (*Chairman*), J L Pawsey, M G T. Minnaert, C. L Seeger, M Nicolet

Business Session, Saturday 16th. September 1950

Chairman : Dr D. F. MARTYN.

1. *Report of Sub-Committee on subject for U.R.S.I. Special Report Nº 3* — This Sub-Committee recommended the subject of « Dynamics of Ionised Media » (See p. 404).

The Commission strongly recommended this subject to the notice of the Executive Committee, and suggested the following Committee be entrusted with its preparation :

Prof D MENZEL (*Chairman*),
Prof H S. W MASSEY (*Secretary*)
Prof H. ALFVÉN,
Prof T G. COWLING,
Dr. G K. BATCHELOR.

Power to co-opt further members should be given to the Committee

2. *Report of Sub-Committee on Terminology* (see p 406). — The CHAIRMAN commented on the excellent work of the Sub-Committee on this difficult subject and indicated that it was too detailed for summary consideration Copies will be typed and distributed to Commission Members, and will also be sent to the President of Commission 40 of I A U. for joint action

3 *World Network of solar radio observations.* — Mr. DE VOOGT reported that his Sub-Committee recommended :

(*a*) the continuation and extension of existing observations on 200 and 3000 Mc/s ;

(*b*) an attempt to overcome increasing radio interference by getting certain radio channels reserved for cosmic radio studies.

The Commission approved (*a*) and after some discussion, left (*b*) in the hands of the Sub-Committee for further consideration.

Minutes of Joint Session with Commission III (Monday, September 18th., 1950) on Solar Particles and the Earth

Chairman : Sir EDWARD V. APPLETON

Dr. D F. MARTYN gave a comprehensive account of his new theory of the mechanism of production of magnetic storms and aurorae. The speaker considered that all existing theories of these phenomena had been demonstrated to be fundamentally

unsound, with the exception of that due to Chapman and Ferraro. Unfortunately, although carefully worked out in detail, the latter theory had not yet been able to explain many of the observed phenomena, such as the morphology of the S_D variations, or the penetration of solar particles to auroral heights Dr Martyn outlined an attempt to include all major phenomena in an extension of the Chapman-Ferraro theory, using the macroscopic concepts of hydrodynamics and electrodynamics.

Professor ALFVÉN said that it was possible to apply many known principles to cosmical phenomena, but difficult to find the right ones. His own theory had been criticized, in its original form, by Cowling, but he thought suitable modifications could be made to overcome Cowling's objections. He stressed the importance of scale-model laboratory experiments, and of the application of existing knowledge of discharge phenomena in gases.

Dr MARTYN explained that on his theory the explanation of the various auroral forms involved both the bombardment of the atmosphere by high energy particles from the ring current system, about 5 5 earth radii distant, and also discharge phenomena in the atmosphere due to the completion of the current circuits.

Dr. NICOLET said that if the particles involved came from the sun, helium lines should be found in the auroral spectra his studies of this point were at present inconclusive.

Sir EDWARD APPLETON described a new phenomenon — a perturbation of F2 critical frequencies at the time of a sudden commencement.

Mr. MILLINGTON asked if atmospheric « whistlers » which arrived about 3 s after the main atmospheric pulse, and whose incidence was correlated with magnetic storminess, could be due to multiple reflections from the ring current system

An interesting discussion ensued, and it was generally agreed that this phenomenon was worthy of close study, both experimental and theoretical

Ordinary session of Saturday, September 16th., 1950

Dr. MARTYN in the chair.

The meeting was devoted to the subject of recent researches on meteors by radio methods

Dr. A. C. B. LOVELL gave a general review of the subject with special reference to the recent determinations of day-time radiants, and to observations of echoes of abnormally long persistence

Dr L A MANNING then gave an account of recent work at Stanford

In discussion Professor HAGIHARA pointed out the importance of making optical (and especially spectroscopic) measurements simultaneously with the radio ones, and indicated that these were being started in Japan.

At the conclusion of the session Professor D MENZEL showed a cine-film « Action on the Sun », taken with the coronograph at Climax Observatory. He and Professor Alfvén commented on the possible signifance of the many interesting phenomena revealed in the film

Ordinary Session, Thursday, September 21st., 1950
(9 00-12 00)

Subject : *Galactic Radio Waves.*

Dr. J. L. PAWSEY in chair.

The meeting was opened by Mr. J. G. BOLTON who outlined the history of this subject and described the research carried out in Australia by himself and his colleagues. The latter included the discovery that the fluctuations of cosmic radio-wave intensity in the constellation of Cygnus found by Hey were due to the presence of one of a new class of astronomical objects, (the discrete sources), the tentative identification of several with visible objects, measurements of the distribution of radio brightness on 100 Mc/s over the southern sky; deductions concerning the shape of the galaxy and the existence of a possible spiral arm in Cygnus, measurements of the spectra of several discrete sources, comparisons of these with that of the general background, and a discussion of the results of the hypothesis that all galactic radio-waves originate in discrete sources

Dr. LOVELL described Mr Ryle's observations of about 50 discrete sources and Smith's deduction on a hypothesis similar to that used independently by Bolton of the number of discrete sources (see paper nº 228 — British Report) It appears that spectrum measurements of the discrete sources disagree with Bolton so that further measurements are needed.

Dr. LOVELL also described observations in progress in which measurements of galactic radio waves are being made over a wide frequency range on the 230 ft. diameter paraboloid at Jodrell Bank. Such measurements are fundamental to a study of the mechanism of origin

Dr. TWISS mentioned the possibility of a contribution of extra galactic origin and Mr BOLTON pointed out that this possibility makes it impossible to decide from measurement what is the ratio of the *galactic* radiation from two points (such as the pole and centre).

Mr. WESTFOLD gave an estimate of attenuation in interstellar gas at different frequencies based on modern optical data and concluded that absorption on 100 Mc/s should be negligible. He then gave an analysis of the space distribution of sources of radio waves in the galaxy which showed similarity to that of light sources in the Andromeda Nebula. Professor MINNAERT pointed out that the Andromeda was not typical of external galaxies

In Dr. Seegar's absence, through illness, Professor BURROWS described R. E Williamson and G. L. Seegar's work on the « Radio Pole of the Galaxy » at 205 Mc/s, which showed that the observations are best fitted by taking the earth to be displaced slightly from the central plane of the Galaxy (see paper nº 73)

Dr. HERLOFSON outlined a theory of a possible mechanism of origin of galactic radio waves put forward by himself and Professor ALFVÉN which depends on the radiation of cosmic ray particles in the magnetic fields of stars in a manner analogous to that of radiation of light by electrons in a betatron (see paper nº 133)

Mr. DENISSE asked if this special mechanism involved an emission greater than the thermal value.

Mr. ROBERTS described recent work by Professor Bailey on the mechanisms of generation involving « growing waves » (see paper nº 251)

Professor MINNAERT and Dr. PAWSEY emphasised the great assistance to knowledge of the mechanism of production of galactic radio waves which would arise from a knowledge of processes responsible for the production of solar bursts

In conclusion Professor MINNAERT, *on behalf of astronomers, complimented the radio physicists on the remarkable contributions to astronomy which their researches were making.*

Ordinary Session, Thursday, September 21st., 1950 (02 00-05.00)

Subject : Solar Radio Waves.

Professor M G. J. MINNAERT in chair.

Dr. J L. PAWSEY opened the discussion with an outline of current knowledge concerning solar radio waves This leads to a division of solar noise into several classes, each with distinct characteristics, which appear to originate in different processes in the sun The classification may not be complete and the divisions between classes are in some cases not well-defined. The classification includes :

(1) A « basic » component (observed 1 m-4 m);

(2) A « slowly varying » component (observed on centimetre and decimetre wavelengths),

(3) « Noise storms » or « enhanced radiation » (observed typically on metre wavelengths);

(4) « Outbursts » (observed from centimetres to tens of metres);

(5) « Isolated bursts » (observed on metre wavelengths) (Classes (4) and (5) are each not circularly polarised and have been combined by certain authors under the title « unpolarised bursts »).

The general features of the different classes, intensity range, duration, selectivity, polarisation, area of origin and association with optical features, were outlined.

There are two theories current as to the mechanism of origin of solar noise, incoherent radiation from individual electrons similar to thermal radiation, and coherent radiation or « plasma oscillations ». Excepting for the basic component, which is thought to be due to simple thermal radiation, there has not been agreement as to which of the two mechanisms is involved in the generation of the various classes.

Up to the present there are two hypotheses, or theories, through which solar radio-wave observations may be used to investigate

physical phenomena on the sun. The first interprets the basic component as due to thermal radiation from the « quiet » sun so that it is possible to derive information about the electron temperature and density distribution in the solar atmosphere from such studies. The second, less well established, is that « outbursts » are the result of the passage through the solar atmosphere of a cloud of ejected solar particles, which are probably of the type responsible for terrestrial magnetic storms If so radio observations should provide a method of observing the initial stages of this phenomena which have so far escaped optical detection A third hypothesis concerning the slowly varying component was introduced by three authors independently during the meeting.

The meeting discussed new developments concerning different aspects of the subject under the headings given below :

Bursts. — Dr. PAWSEY outlined new observations taken by Ruby Payne-Scott and A G. Little concerning « the position and movement on the solar disc of sources of radiation at a wavelength of 3 metres » (Doc. nº 6), and by J. P. Wild and L L. McCready of « the dynamic spectrum of radio-frequency bursts from the sun » in the frequency range 70-130 Mc/s (Doc nº 10)

Mr M LAFFINEUR described simultaneous optical and radio observations on a frequency of 255 Mc/s which appeared to show a correlation between radio bursts and certain bright eruptions of very small dimensions observed in Hα light in active areas Also in a study of 120 flares which occurred at the same time as bursts of solar radio waves a majority occurred in the SW and NE quadrants. This suggests a possible directive effect in emission (Doc nº 178).

Slowly varying component. — Dr WALDMEIER described how the slowly varying component could be qualitatively accounted for on a wavelength of 10 cm by assuming it to be due to thermal radiation from « coronal condensations », regions of high temperature and density believed to exist in the corona (see paper nº 206) Similar hypotheses were independently introduced by Mr J F. Denisse (see paper nº 177) and by J. F Piddington and H C. Minnett (see paper nº 7) The latter described the spectra of the component and some indications of its polarisation.

M. Laffineur described eclipse results which indicated that the « bright spots » on radio frequencies tended to be more closely associated with « plages » than with sun spots.

Basic Component. — Mr. DENISSE described collected observations of this component and showed that they lead to chromospheric temperatures in excess of those derived optically (see paper nº 177)

Dr. WALDMEIER pointed out that the observations by Stanier of the distribution of « brightness » across the disc of the sun were inconsistent with previous calculations which indicated « limb-brightening ». However, it was possible to reconcile experiment and theory if the assigned values of electron density and temperature in the solar atmosphere were adjusted. It is clearly desirable that precise radio measurements should be made at a number of frequencies in order to put such deductions on a firm foundation.

Short business session, 21-9-50, 5 P. M.-5.05 P. M.

Dr. MARTYN read the text of resolutions (1) to be submitted from Commission V to the General Assembly (some of these had been required to be drafted since the previous meeting).

These resolutions were approved.

Reports of the Sub-Committees.

Report of Sub-Committee on « Special U.R.S.I. Report »

After considering possible subjects of special interest to Commission V which might form the subject of an U.R.S.I. report, the Committee agreed that a report on the *Dynamics of Ionized Media* would be of great value

Not only is a proper understanding of this subject highly important for the interpretation of solar and galactic radio noise, but it is also vital to the study of various phenomena in the earth's upper atmosphere including particularly the aurora, the behaviour of ion clouds produced by meteors, ionospheric turbulence and so

(1) P 63

on. Furthermore it is clearly fundamental in the mechanics of the sun's atmosphere.

Almost all of these phenomena are affected markedly by the presence of a magnetic field and the report would be concerned particularly with a discussion of the progress made up to the present in the development of methods for dealing with the flow of ionized materials when magnetic fields are present. It would also be concerned with oscillatory phenomena that may arise under these conditions.

The form of the report should follow closely that of the previous two reports in particularly emphasizing the physical principles involved. It should include an account of the reliable information at present available, with a brief description of the way it has been obtained and it should indicate clearly the directions in which more investigation is required, either to obtain new facts or to remove existing uncertainties. As far as possible it should also attempt to indicate in what way the available knowledge of the subject can be applied to the geophysical and cosmical phenomena.

The need for a coherent review of the subject is sharpened by the absence of any critical review, the bewildering varieties of approach to the problem, and the prevailing differences of opinion about the theoretical and experimental results in the field. Progress in application to problems of interest to this Union will be slow until the fundamental basis of the subject is more firmly established. It is hoped that a report on the lines indicated will assist materially in this direction

Suggested Committee :

Prof. D. MENZEL (*Chairman*).
Prof. H. ALFVÉN,
Dr. G. K. BATCHELOR,
Prof T. G. COWLING,
Dr. HERLOFSON,
Dr. A. C. B. LOVELL,
Prof. H. S. W. MASSEY,
Dr VALLARTA,
Dr. WOLF.

Report of Sub-Committee on Terminology

CONTENTS

A. — SPECIFICATION OF MAGNITUDES

Radio waves from extra-terrestrial sources are measured in terms of the power which they cause a given aerial to deliver to a given receiver. The finite bandwidth of the receiver is usually eliminated by quoting the result as « power per unit bandwidth at the mid-frequency of the received band ».

The magnitude of the wave can then be specified either in terms of the whole radiation received from all parts of the object, which is measured by the *flux density* (S) at the point of measurement over an area perpendicular to the direction of propagation, or in terms of the *brightness* (B) of the individual parts of the source. In *mks* units, which are preferred, S is measured in watts^{-2} (c/s)$^{-1}$ and B is measured in watts^{-2} (c/s)$^{-1}$ (steradian)$^{-1}$.

The words which have been used for these two fundamentally distinct quantities S and B are confused *Flux density* for S appears unambiguous but the word « intensity » has also been used. The latter word is used by certain writers in astrophysics for the other quantity B. For example E. A Milne in the *Handbuch der Astrophysik*, Vol III, 1930 uses « specific intensity », subsequently abbreviated to « intensity », for B. In this book the concept is precisely defined and valuable properties derived, e. g. the « intensity » is constant along a ray if there is no absorption or emission and the refractive index is constant. « Intensity » is also used in this sense in some radio-astronomy papers.

If the word « intensity » is to be used in a precise sense such as that used by Milne, it is obviously necessary to define it *emphatically* in order to avoid ambiguity.

A further possible source of ambiguity arises because an aerial normally accepts a single component of polarisation. Each experimenter should specify whether the stated value of S or B refers to a particular single component or to the total quantity, including both components. The total quantity has usually not been measured but estimated by doubling the single measured quantity The procedure used should be stated.

B. — EQUIVALENT TEMPERATURE CONCEPT

This concept is used in three applications as follows ·

1. The « brightness » (B) of radiation from a black body of uniform temperature T is known ($B = \frac{2kT}{\lambda^2}$ for both components). Hence this temperature may be used as a measure of B It has been wrongly called the « effective » or « equivalent » temperature T_e. It should be called the « brightness temperature » [1] T_b. At radio wavelengths T_b is practically proportional to B (Rayleigh-Jeans approximation ; for each component in a medium of unity refractive index $T_b = kT/\lambda^2$ where k is Boltzmann's constant and λ is the wavelength)

2. In the case of solar radio waves, the flux density (S) is usually specified, without observation of brightness of individual parts of the sun, in terms of the temperature of a black body, having the angular size of the photospheric disk, which would yield the observed flux density.

It is given by ·

$$T_d = \frac{\int T_b d\Omega}{\text{Solid angle of photospheric disk}}$$

where $d\Omega$ is an increment of solid angle and the integration is over the whole of the contributing parts of the sun. The distribution of T_b is usually non-uniform, extends beyond the optical

(1) Cf. Vocabulaire International de l'Eclairage (C.I.E.), 1938.

disk, and is often dominated by one or two highly emitting small areas Hence this mean value is a little artificial. Following Pawsey, the quantity T_d is called « apparent temperature » with the idea that « apparent » implies a somewhat artificial character.

3. The total available power, i. e. power delivered to a matched load, per unit frequency band from an aerial (P) can be specified in terms of the temperature T_a of a surrounding uniform temperature enclosure which would yield the same power ($P = kT_a$; k is the Boltzmann constant) T_a is called the « *equivalent aerial temperature* »

These three temperatures are specified in degrees Kelvin.

The specification of these three quantities, brightness, flux density and available power, in terms of temperature does not imply that the power considered is of thermal origin though it may obviously be convenient in discussing such power.

The considerations of this section are collected in Table I.

TABLE I

Symbol used here	Quantity (per unit frequency band in each case)	Unit	Corresponding Temperature Expression Unit (°K)
S	Flux density	watts m^{-2} $(c/s)^{-1}$	Apparent temperature of sun T_d
B	Brightness	watts m^{-2} $(c/s)^{-1}$ $(\text{steradian})^{-1}$	Brightness temperature T_b
P	Available power	watts $(c/s)^{-1}$	Equivalent aerial temperature T_a (of an aerial)

C. — Specification of Polarisation (sense of rotation)

The sense of rotation of a circularly, or elliptically, polarised wave will be defined as « right-handed » if the electric vector in a plane fixed in space and parallel to the wave-front rotates clockwise when viewed in the direction of propagation, i. e. with the source behind the observer. The opposite sense of rotation is « left-handed ».

D. — Notes on Words Defining Phenomena

A fully satisfactory word to describe radio waves from the sun or galaxy is still lacking — « Noise » [1] is used with obvious reluctance Better alternatives are « Radio waves » or « radio emission ».

Of the various terms used by different authors to describe phenomena, some are concerned with concepts which may not have reached their final form. It would therefore be premature to attempt to standardise these yet, but it would be unfortunate if later authors should create confusion by using these terms with different meanings There follows a list of some of the terms used with an indication of meanings and of some early authors using the terms.

TABLE II.

Generally Accepted Terms

Term	Meaning
1 Cosmic (radio) waves or Cosmic (radio) emission	Radio waves from extra-terrestrial sources
2 Galactic (radio) waves Galactic (radio) emission	Radio waves from our galaxy
3 Extra-galactic (radio) waves Extra-galactic (radio) emission	Radio waves from beyond our galaxy.
4 Solar (radio) waves Solar (radio) emission	Radio waves from the sun
5 Burst (McCready, Pawsey, Payne-Scott, Ryle and Vonberg)	Short period increase of radiation (duration from a fraction of a second to minutes).
6 Quiet sun (Martyn)	Sun in absence of activity associated with sunspots, bursts, storms (see below)
7 Disturbed sun (Martyn)	Sun when not « quiet » (see 6)

[1] Its introduction is based not on normal English usage but on the technical term « noise » used in radio to describe a disturbance having an essentially continuous spectrum, e g « random noise », « shot noise » But too many readers naturally accept the normal acoustic implication

Special terms used by some authors

Term	Meaning
8 Discrete source (Bolton) Radio-type star (Bolton) Radio star (Pawsey)	Localised source of cosmic radio emission (less than a few minutes of arc).
9 Basic thermal radiation	Thermal radiation from the quiet sun.
10 Slowly varying component	Component recognised at centimetre and decimetre wavelengths having close correlation with sunspot area, a small magnitude, and peaks occurring at intervals of the order of a month (origin perhaps thermal).
11 Noise storm (Allen)	Increase of radiation of days or hours duration, usually but not always with many bursts, showing circular polarisation (Typically found on metre wavelengths)
12 Storm burst (Wild)	Typical burst during storm.
13 Outburst (Allen, Payne-Scott, Bolton and Yabsley, Pawsey)	Large increase of radiation typically associated with solar flare — usually of complex form and minutes duration.
14 Isolated burst (Pawsey)	Large burst appearing sporadically at time of no « noise-storm » Not circularly polarised (metre wavelengths)
15 Unpolarised burst (Payne-Scott)	Burst, not circularly polarised observed sporadically on metre wavelengths (Appears to include 13 and 14 and probably occasional bursts of similar origin occurring during noise storms)

Appendix I

A suggested terminology for radiation concepts

The following terminology is suggested as an endeavour to introduce for the radiation intensity concepts words that have one clear-cut meaning. Nearly all the terms are already in use in photometric literature (being recommended by the Committee on Colorimetry, *J.O.S A.*, 34, 245, 1944) where the radiation concepts have lumination analogues.

The terms suggested are :

Term	Notes	Dimensions CGS	Dimensions mks
Radiant energy		erg	joule
Radiant density		erg cm^{-3}	joule m^{-3}
Radiant flux		erg s^{-1}	watt
Radiant efflux	Outward flux from a source	erg s^{-1}	watt
* Radiance	Outward flux per unit surface	erg $s^{-1}cm^{-2}$	watt m^{-2}
* Irradiance	Inward flux on to a unit surface	erg $s^{-1}cm^{-2}$	watt m^{-2}
Radiant fluance	Efflux per unit solid angle in a specified direction	erg $s^{-1}\Omega^{-1}$	watt Ω^{-1}
Brightness	Surface brightness of surface fluance per projected unit	erg $s^{-1}\Omega^{-1}$ cm^{-2}	watt$\Omega^{-1}m^{-2}$

(*) Flux density over an area perpendicular to the direction of propagation This concept applies only to small sources that subtend an angle for which the directional characteristic of the antenna is constant.

Many of these terms are new to radio astronomy and astrophysics, but their use in photometry could be extended without ambiguity. Of the completely new terms, the word « efflux » for outward flux should cause no confusion. The other new term « fluance » has been specially coined to avoid the term « intensity » which is used for this concept by the Colorimetry Committee. The word « intensity » is in far too general use to attempt to attach a specific dimensional meaning to it The suggested word fluance is of course made up of the idea of flux per unit solid angle, and « -ance » at the end of the word calls attention to its similarity to radiance. The concept is analogous to candle power or stellar absolute magnitude.

Appendix II

Designation of discrete sources of cosmic radio waves

The following suggestions are made :

1. A cosmic radio source is to be designated by the abbreviated name of the constellation followed by a number of ordinary brackets. For each constellation the numbers will follow the order of discovery As an example the designation Cyg. (1) will be given to the first discovered source in the constellation of Cygnus The boundaries of the constellations are to be taken according to the publications of Dr. F. Delporte · « Délimitation Scientifique des Constellations » and « Atlas Céleste » (Cambridge University Press 1930). The abbreviations will be those stipulated by the International Astronomical Union (*Transactions, I A.U.*, 4, p 221, 1932).

2 The Copenhagen Observatory would be asked as a controlling office to give the numbers to the newly discovered sources and keep an *up to date* list of the known objects. Any scientist discovering a radio source will be required to communicate to the Copenhagen Bureau the co-ordinates of the object, an estimate of the measured flux density, and the frequency at which the observation has been made. Information should be added concerning the possible error of the position measurement, perhaps in the form of an error ellipse ·

The Copenhagen Bureau will inform the discoverer whether the object has been previously discovered and if not will give him the designation of the source.

3 Once a year the Copenhagen Bureau will send for publication to the principal astronomical periodicals a list of radio sources with the names of the discoverers.

Commission VI
On Waves and Circuits

Contents

Members of the Bureau

President · Prof. Dr. Balth van der Pol, Director of C.C.I R.

Rapporteurs . J. Loeb, Ingénieur en chef, P.T.T , France.
Group Captain William P. Wilson, Research Engineer, B.B.C.

List of documents submitted to the Commission

No	Titles and Authors	Part
12	A variational solution to the problem of cylindrical antennas, by C T. Tai	II
13	Aperture distribution for low side lobe antennas, by H Jasik	II
14	Surface wave transmission line, by G Goubau	II
15	Some developments in the design of high performance parallel guide hybride, by H J Riblet	II
26	Planar diffraction problems, by Samuel Silver	II
45	A general theory of ultra-short wave circuits, by Sin-itiro Tomonaga	II
46	On the reciprocity of radiating systems, by T Miyazima	II
51	Summary of the U S A activities in the field of Commission VI	I, p 266
74	Parametric excitation of non-linear systems, by Hans Schaffner	II
75	Signal power spectrum and information content, by C H. Page	II
76	Dielectric tube waveguides, by R E Beam, M M Astrahan and W C Jakes, Jr	II
77	Radiation from circular current sheets, by W R Le-Page, S Seely, C S Roys and R F Harrington	II
85	Report of the French National Committee, Chapter VI	I, p 113
99	Waveguide applications of artificial metallic dielectrics, by W E Kock	II
100	Radiation from dielectric rod antennas of uniform circular cross-section, by A E Marston	II
101	Progress in the physical optics of metal plate media, by B A Lengyel	II
102	Wide angle scanning antenna research, by R C Spencer.	II
103	On the properties of standing wave and travelling wave transverse electric and transverse magnetic slots, by V H Rumsey	II