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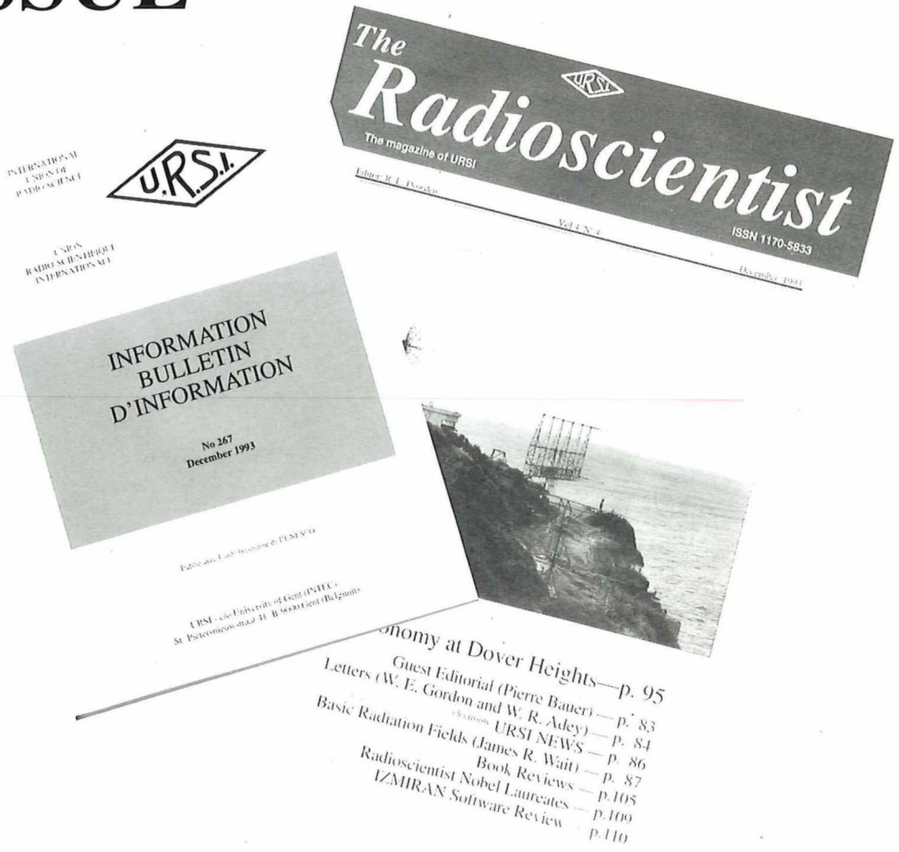
# FIRST COMBINED ISSUE

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**Oliver Lodge**
**Bianisotropics in Belarus**

URSI – c/o University of Gent (INTEC)
St-Pietersnieuwstraat 41 – B-9000 Gent (Belgium)

# *The* *Radioscientist*

# INFORMATION BULLETIN D'INFORMATION



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The **International Union of Radio Science (URSI)** is a foundation Union (1919) of the International Council of Scientific Unions as the direct and immediate successor of the Commission Internationale de Télégraphie Sans Fil Scientifique (TSFS) which dates from 1913.

The *Radioscientist & Bulletin* is an amalgamation of the URSI *Information Bulletin* established in 1938 and the *Radioscientist* established in 1990. The *URSI Bulletin* occupies the first part of the *Radioscientist & Bulletin* beginning on the following page. The *URSI Bulletin* issue number given on the cover and on each page is a continuation of the stand-alone URSI *Information Bulletin* . The *Radioscientist* occupies the rest of the issue following the *URSI Bulletin*. Both the *Radioscientist* and the *Bulletin* sections have their own pagination: that of the *Radioscientist* is reset annually while that of the *Bulletin* is reset at each issue. The volume number of the *Radioscientist & Bulletin* is a continuation of the stand-alone *Radioscientist* (the *URSI Bulletin* did not use volume numbers). Citation of articles in the *URSI Bulletin* section should have the form: *URSI Bulletin,* No. 268, pp 4-7, (1994) while those for the *Radioscientist* section should have the form: *The Radioscientist* Vol. 5, pp 43-51, (1994).


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The *Bulletin* section contains, as in the past, the official resolutions and recommendations of URSI, reports of URSI Member Committees, Commissions, Working Groups, meeting reports and announcements, and lists of scientific symposia and meetings. Contributions in these categories should be submitted to the Editor (Secretary General).

The *Radioscientist* section consists of feature articles, research notes and reviews, book and software reviews, Letters to the Editor, news and views. All opinions are those of the authors and/or of sources identified with each article. Articles with no author identified in this section can be attributed to the Editor. Contributions in these general categories, in French or English, and in any of the fields of the URSI Commissions, are invited and should be submitted to the Editor (*Radioscientist*).



COVER: The final (December, 1993) *URSI Bulletin* and the final *Radioscientist* as separate issues are shown here to mark the beginning of this combined magazine. During its long life (56 years), the *Bulletin* has had many forms and formats, including the A4 one to which it returns in this issue. Until recent years it was typed onto A4 paper and photo-reduced to A5 for printing. The *Radioscientist* was first issued as a trial at the Prague GA in 1990 as the successor of *URSI NEWS*. The latter was first issued in 1988, initially as a single folded A4 sheet inserted in the *Bulletin* .

1 - 3 : 1994

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# INFORMATION BULLETIN D'INFORMATION

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# INFORMATION BULLETIN D'INFORMATION

# Contents

# EDITORIAL

This issue of the Bulletin is the first which I have the privilege to edit as newly elected secretary general of URSI.

First of all, I would like to pay tribute to my predecessor Professor Jean Van Bladel, who for 14 years devoted a lot of time and attention to the Bulletin. It will be difficult to maintain the high standards which Jean Van Bladel set, not only concerning the Bulletin but especially with regard to the function of secretary general.

As decided in Kyoto and announced in the previous Bulletin, the Radioscientist and the Bulletin are now published under a single cover with Professor R. L. Dowden as editor of the Radioscientist section. Starting from this issue, The Radioscientist & Bulletin will have a wider circulation, since it will not only be sent to the Member Committees and URSI officials, but also to all registrants of the Kyoto General Assembly and the scientists accepted as URSI correspondent.

Finally I would like to emphasise that the Bulletin is very much a team effort and that it is a pleasure for me to collaborate on this with Professor Peter Van Daele, assistant secretary general and Inge Heleu, administrative secretary.

PAUL LAGASSE

Ce numéro du Bulletin est le premier que j'ai le privilège d'éditer en tant que secrétaire général de l'URSI.

En premier lieu je voudrais rendre hommage au Professeur Jean Van Bladel, qui durant 14 années s'est dévoué pour l'édition du Bulletin. Ce sera difficile pour moi de maintenir le haut niveau de Jean Van Bladel, non seulement par rapport au Bulletin, mais surtout en ce que concerne la fonction de secrétaire général.

Ainsi qu'il a été décidé à Kyoto et annoncé dans le Bulletin précédent, le Radioscientist et le Bulletin seront publiés à partir de maintenant sous la même couverture, avec le Professeur R.L. Dowden en tant qu'éditeur de la partie Radioscientist. Le nouveau Radioscientist & Bulletin aura une distribution plus importante, du fait qu'il sera envoyé non seulement aux Comités Membres et aux officiels de l'URSI, mais aussi à tous les participants de l'assemblée générale de Kyoto et aux scientifiques acceptés comme correspondants de l'URSI.

Pour conclure je tiens à attirer l'attention au fait que le Bulletin est le résultat d'un effort d'équipe et que c'est un plaisir pour moi de pouvoir collaborer avec le Professeur Peter Van Daele, secrétaire général adjoint et Inge Heleu, secrétaire administrative.

PAUL LAGASSE

# NEWS FROM THE MEMBER COMMITTEES

## IRELAND

The URSI Sub-Committee, Royal Irish Academy, held a one-day symposium on 23rd November 1993.

The Sub-Committee was established in 1982 as part of the National Committee for Engineering Science. In order to promote the various fields of radio-science within Ireland a policy of hosting a symposium every 1 to 2 years has been followed. It is the intention of the Sub-Committee to encourage contact between universities and industries. The one-day symposia have achieved considerable success in this regard.

The particular symposium was the sixth and attracted a total of 96 participants which included 14 speakers. It did not have a specific theme except that a topic was required to be on radio-science as per the commissions of URSI. The venue was the Library/Meeting Room in Academy house in the centre of Dublin. (The Library contains a distinguished collection of books, records and documents. Sir William Rowan Hamilton was President from 1837 to 1846.)

Dr Brian Austin, University of Liverpool, was the guest of the Royal Irish Academy and Trinity College Dublin. He opened the symposium with a very stimulating one-hour lecture, titled SMALL ANTENNAS: A QUEST FOR THE LIMIT. Most participants probably remembered antenna theory for its extensive use of mathematics. Dr Austin emphasised that his entire lecture required just a single equation. There was considerable praise for the clarity of his ideas and lecturing style.

The programme consisted of 13 other presentations of 20 minutes each. While the time factor was very restricted, speakers confined their presentations to summaries and conclusions. A number of topics were based on research work under a programme on advanced technology in telecommunications funded by EOLAS; Irish Science Technology Agency. Due to developments in business radio services over the previous 10 years there was an emphasis on radio communications.

Five presentations concerned research work being undertaken at our universities. They covered such diverse areas as low profile microstrip antennas, diversity antenna systems, microwave equipment for television services in the band 2.5 to 2.68 GHz, spread spectrum local area networks and bipolar transistors for cordless telephones. The remaining topics were from state organisations or telecommunications companies. They included items on modems, digital television, DECT & GSM.

European Space Agency (Mr K Galligan) gave a presentation on the new SATSOUND stereo outside broadcast terminal which should reduce the difficulties encountered in satellite communications.

Copies of the presentations and papers will be available on request from the Royal Irish Academy.

BRIAN P MCARDLE

## COMMISSION F

## WAVE PROPAGATION AND

## REMOTE SENSING

### Report on Scientific Sessions at the Kyoto General Assembly

*Commission F organized 12 sessions covering developments in fundamental aspects of wave propagation and interaction with the environment as well as applications in remote sensing and telecommunications systems.*

The Commission Tutorial on observations of the ocean surface by space-borne Synthetic Aperture Radars (SAR) was presented by R K Raney. He presented the fundamentals of SAR and various effects that influence the quality of the observations. Civilian SAR systems have not been optimized for ocean surface observations. Nevertheless, the directional wave spectral information derived from SAR observations is comparable to the best data available from other sources. Further progress in the field is expected through combination with observations from other instruments.

Session F1 on Ground-based and Spaceborne Probing of the Atmosphere (Convener: M Chandra) contained 8 invited papers. Reported at the session were the "State of the art" develop- ments in the field of ground-based and spaceborne radar/radio- meters for probing the atmosphere. Ground-based radar observations are used for (macroscopic) modelling of the spatial structure of raincells as well as (microscopic) analysis of particle composition and population distributions. Investigations presented revealed that convective raincell shapes can be adequately described by exponential profiles. Very detailed analysis of the atmospheric scattering proper- ties relevant to rain-radar design were examined. These consi- derations led to the recommendation that the most complete space-borne radar should, ideally, be multiple frequency with some polarisation capabilities for improving signal to clutter contrast. Fundamental aspects of rain observations from the ground and from space were discussed and the development of spaceborne a radar for the Tropical Rainfall Mission was presented. Weather observations using radars and the accuracies involved continue to be a subject of study. Radar observations of rain scatter are used for interference modelling.

Ground-based passive microwave sensing of the atmosphere is an important tool for the prediction of propagation effects for low-availability satellite communication systems. The concept of spaceborne MIMR (Multi-frequency-Imaging-Microwave radio- meters) was shown to bring new capabilities in retrieving atmospheric parameters including snow, sea-ice and precipita- tion.

Session F2 on Remote Sensing of Ice (Convener: R K Raney) contained 10 invited papers.

A large variety of techniques is used for the monitoring of sea ice. The monitoring includes type classification, determination of the structure and its variation with season. Subjects presented ranged from theoretical models for assessment of the feasibility of active and passive remote sensing techniques to a discussion of experimental data obtained. Polarimetric scattering observations are a possible tool for the reconstruction of sea ice parameters. SAR observations from ERS-1 and JERS-1 were presented and discussed.

Session F3 on Attenuation due to Gases, Rain, Clouds and Fog (Convener: C J Gibbins) contained 7 invited papers, covering most aspects of absorption and dispersion at microwave and millimetre-wave frequencies by atmospheric gases and hydrometeors in the form of rain snow, fog and clouds. Modelling of attenuation by atmospheric gases is now a mature science and high precision is achieved for frequencies up to 1000 GHz by the MPM model developed by H Liebe. Modelling and experiments were reviewed. Ordering of all the material presented in the literature sometimes presents problems. Attenuation due to clouds and (light) rain has recently gained importance as a parameters in Earth-Satellite link design in relation to low-availability systems. This presents new challenges for the integration of climatic information in propagation prediction models. Multi-frequency observations, both active (radio beacons, radar) and passive, sometimes covering a wide range of frequencies were reported to yield very interesting results for detailed modelling of attenuation parameters.

Session F4 on Refractive Effects on Terrestrial radio Paths; Prediction and counter-measures (Convener: L Martin) contained 6 invited papers.

The study of refractive mechanisms on terrestrial radio paths is directed towards the development of prediction models as well as countermeasures for signal disturbances on radio relay links. Results of the application of the mode theory and of the parabolic equation method were reported. Detailed experimental studies showed that ray tracing may also provide a valid statistical model. Statistical evaluation of available methods has shown that further progress can be made in the accuracy of the prediction of system design parameters.

Session F5 on Remote Sensing of Land, especially Vegetation (Convener: T LeToan) contained 7 invited papers. Much research effort has been put in modelling of backscatter

from rough soil and vegetation. Discrete electromagnetic scattering models are used to understand and predict scatter mechanisms. Progress in the use of incoherent scatter and radiative transfer models was reviewed. Experimental studies for the classification of vegetation type and estimation of vegetation cover were reported. New results from polarimetric and interferometric SAR measurements were presented. Simulations of scatter from vegetation were used for the study of frequency dependence of signal distribution. Passive remote sensing of the earth's surface has made substantial progress. It was shown that multifrequency radiometric measurements combined with infrared observations are useful in identifying crops and moisture conditions of the surface.

Finally, the combination of active and passive remote sensing data was shown to have good potential for further development of scatter and emissivity models.

Session F6 on Depolarization due to Rain, Ice and Surface Scattering (Convener: Y Karasawa) contained 8 invited papers. Rain and ice depolarisation occurring on earth-satellite paths have been studied intensively both experimentally and theoretically. Cancellation methods were presented and shown to be able to produce substantial improvement in crosspolar discrimination. Measurements of dual-polarised satellite beacon signals are presently studied in order to characterize the relative importance of rain and ice depolarisation. Results of multi-frequency and dual-polarisation radar observations of rain and melting layer and their comparison with theory were presented. From such observations and the resulting knowledge of particle population characteristics, prediction models of depolarisation effects on fixed and mobile-satellite systems have progressed in their development.

Session F7 on Remote Sensing of the Sea Surface (Convener: W Alpers) contained 8 invited papers. Processing of wave mode image spectra obtained with ERS-1 produced statistics of significant wave height of a quality that is comparable to altimeter results. Further SAR studies presented include an analysis of internal waves using interferometric techniques. The combination of measurements using C-band and Ku-band scatterometers for further development of models for the extraction of wind data was addressed. The quality of wind data extracted from active microwave instruments was reported to be very high. One paper addressed the utility of fully polarimetric radiometry for the determination of wind direction.

Session F8 on Climatic Parameters in Radiowave Propagation Prediction (Convener: M P M Hall) contained 10 invited papers. General methods for the prediction of the occurrence of various characteristics of the propagation of radiowaves in the lower atmosphere have been developed in the past decade. The extent to which these characteristics may vary from one climate of the world to another is an essential study for the planning of radiosystems. The parameters involved concern, in particular, the characterisation of rain and refractivity. In this context the problem of global mapping of climate parameters was addressed. Regional factors in the prediction of attenuation are studied in relation to rainfall rate statistics and information on cloud cover and cloud type. Attention is now focused on the acquisition of propagation statistics from tropical areas. Several papers reported such results from various areas in the world. Large-scale information on climate may become available for global mapping studies in the next few years. This subject is one of the high-priority items for study in liaison with the ITU.

Session F9 on Imaging the Subsurface (Convener: A Q Howard) contained 9 invited papers.

Radars for subsurface probing, in particular borehole radars, have evolved substantially in the past few year, in particular through the use of advanced signal processing tools. Work presented included measurement results as well as theoretical analyses of wave propagation through inhomogeneous surface structures. A large variety of inversion techniques under study for the extraction of surface structure parameters from borehole radars was discussed.

Session FC1 on Dynamic Propagation Effects and Adaptive Counter Measures (Convener: A Dissanayake) contained 7 invited papers devoted to propagation effects on satellite links and techniques for counter measures. One paper described a novel technique of realizing adaptive equalizers with neural networks for digital mobile radio applications. There were two papers dealing with propagation dynamics derived by monitoring satellite beacon signals. Characteristics of propagation impairments discussed included: fade rates and durations, frequency scaling, and separation of tropospheric scintillation and rain fading. The main theme of four of the papers was impairment amelioration suitable for satellite communication applications. Considerations were given to: site diversity combined with frequency diversity, up-link power control, adaptive TDMA, adaptive coding and satellite resource sharing.

Session FC2 on Propagation Statistics, Low Availability and System Reliability (Conveners: J P V Poiares Baptista and H Fukuchi) contained 7 invited papers covering new concepts, data and models for the design of communication systems. Two contributions reported also on the actual trade-off design of future systems.

In particular, the following was presented and discussed:

- Concepts for the specification of requirements to optimize the cost effectiveness of communication systems based on return period and risk.
- Propagation characteristics at 30 GHz using Olympus for the design of low margin systems.

- New radio meteorological/climatological data using radioson- des, and data with a global coverage from the initialisation of numerical forecast algorithms.
- A scintillation model based on the inversion of actual beacon measurements. Results from its application to digital systems showed bit error rate degradation.
- Year-to-year variability of propagation characteristics and its impact on digital microwave broadcasting satellite systems.
- New telecommunication system design using ultra small aper- ture terminals. Site diversity and snow attenuation were also presented.

On practically all subjects covered by the invited papers of the oral presentation sessions, contributed poster papers were presented in the general Poster Session. A total of some 30 poster papers were presented.

G. BRUSSAARD

# EXCERPTS FROM THE KYOTO G.A. PROCEEDINGS

## REPORTS OF MEETINGS : BOARD OF OFFICERS

*Summary Report*

The Board of Officers met on three occasions, respectively on 23 August, 1 and 3 September.

During the 23 August meeting, which lasted from 8.40 to 12.50, miscellaneous items were discussed (such as the possibility of starting a Bulletin Board system, and the pros and cons of the mock-up version of the joint Bulletin-Radioscientist presented by Professor R.L. Dowden). Most of the time, however, was devoted to an overview of the agenda of the Council. Professor E.V. Jull gave some general information on the Young Scientist Programme.

During the second meeting, which lasted only one hour, the following assignments (involving, in particular, the new Board) were agreed upon for the next triennium :

Dr. P. Bauer :
Member of the Long Range Planning Committee and Liaison with the IGBP Committee

Professor J.B. Andersen :
Chair of the Long Range Planning Committee

Professor P.J.B. Clarricoats :
Treasurer and Member of the Standing Publications Committee

Professor E.V. Jull :
Member of the Standing Committee on Young Scientists, Chair of the Awards Committee, Member of the Long Range Planning Committee

Professor T. Okoshi :
Chair of the Standing Committee on Future General Assemblies, Member of the Standing Committee on Young Scientists

Professor T.B.A. Senior :
Chair of the Standing Committee on URSI Membership, responsible for issues related to the Republics of the former Soviet Union.

Professor J. Van Bladel :
Member of the Standing Committee on Young Scientists and Developing Countries

Professor P. Lagasse :
Secretary of the Long Range Planning Committee

Professor H. Matsumoto :
Coordinator of the Scientific Programme for the XXV General Assembly.(The French Committee, in consultation with the President will appoint an Assistant Coordinator of the Scientific Programme.)

The Board appointed Professor P. Van Daele as Assistant Secretary General for the next triennium. Professor Van Daele's name had been submitted by the Secretary General, Professor P. Lagasse.

Professor J. Van Bladel, the outgoing Secretary General, proposed to wrap up the financial matters relating to the Kyoto General Assembly and effectively to transfer all other financial and practical authority to the incoming Secretary General at the start of the fourth quarter of 1993.

He also indicated his willingness to edit the Proceedings of this General Assembly, the September and December issues of the Bulletin and the reprinting of the Statutes and the Brochure. The Board gratefully accepted this proposal.

The third meeting, on 3 September, lasted two hours, and was attended by the new Board. Some of the items under discussion were :

- the possibility of concentrating the technical sessions of the General Assembly into a six (consecutive) days programme. The Committee on Future General Assemblies was asked to report on this proposal, by 1995;
- the practical organization of the Network of Correspondents;
- the production of the first joint Radioscientist/Bulletin in March 1994;
- the conclusions to be drawn from the Round Table Discussion and the meetings of the Coordinating Committee;
- the budget to be allotted to the Commissions ($12,000 for the next triennium, possibly to be raised later if finances permit);
- new guidelines for the sponsorship of meetings;
- the relationship between URSI and supranational agencies such as ESA;
- the financial support to URSI's representatives in ICSU Committees.

## Reports of Meetings : Council

*Summary Report*

The Resolutions and Recommendations adopted by the URSI Council were reproduced in the December issue of the Information Bulletin.

The Council met on Tuesday 24 August (9.00 to 16.45), Friday 27 August (18.10 to 20.05), Tuesday 30 August (18.05 to 20.05). Wednesday 1 September (17.05 to 18.35) and Friday 3 September (14.10 to 15.45).

1. Membership of the Council

President : Prof. E.V. Jull
Secretary : Prof. J. Van Bladel

Representatives of Member Committees (alternate representatives are mentioned between parentheses) :

Argentina : Professor S.M. Radicella
Australia : Professor D.J. Skellern
Austria : Dr. G. Kirchengast
Belgium : Professor P. Delogne
Brazil : Professor P. Kaufmann
Bulgaria : Professor B. Shishkov
Canada : Dr. G.Y. Delisle (Professor P.H. Wittke, Dr. St. Maurice)
China CIE : Professor S. Feng
China SRS : Professor Yinn-Nien Huang
Czechoslovakia : Dr. A. Tlamicha
Denmark : Professor. E. Ungstrup
Egypt : Professor I.A.M. Salem
Finland : Professor V.I. Lindell
France : Professor P. Degauque
Germany : Professor H.J. Albrecht (Dr. K. Dorenwendt)
Greece : Professor J.G. Fikioris
Hungary : Professor K. Géher
India : Dr. A.P. Mitra
Ireland : Professor S.S. Swords
Israel : Dr. J. Shapira
Italy : Professor F. Carassa
Japan : Professor S. Adachi
Netherlands : Professor F.W. Sluijter
New Zealand : Professor J.E. Titheridge
Nigeria : Professor G.O. Ajayi
Norway : Professor D. Gjessing
Poland : Professor S. Hahn
Portugal : Professor H.C. Neto
Russia : Professor V.V. Migulin
South Africa : Dr. A.W.V. Poole
Sweden : Professor S. Ström (Dr. V. Scuka)
Switzerland : Professor M. Ianoz (Professor F. Gardiol)
Thailand : Mr. P. Chooncharoen
United Kingdom : Professor P.J.B. Clarricoats (Professor A.D. Olver)
USA : Professor C.M. Butler

Honorary President W.E. Gordon, the members of the Board, the Chairs and Vice-Chairs of Commissions, the Chair of the Scientific Committee and the Assistant Secretary General attended in an advisory capacity. Observers from Korea, Turkey, Peru, representatives from the Japanese organizers and various URSI officials also attended the meetings, partially or totally.

2. Approval of the Agenda

The agenda had been split into two parts, termed A and B. In Part B were grouped items which could be approved automatically, unless there were questions, in which case they could be discussed more extensively and shifted to Part A. The Council approved the list of items in Part B as proposed, hence the agenda was approved in its original form. The subdivision in Parts A and B, a new procedure, worked well, and increased the efficiency of the deliberations of the Council.

3. Formation of Temporary Committees

(a) Ad hoc Group to recommend final revision of the Statutes

Prof. P.J.B Clarricoats (U.K.)
Prof. P. Degauque (France)
Prof. J.E. Titheridge (New Zealand)
Prof. J. Van Bladel (for the Secretariat)

(b) Drafting Committee
Prof. L.W. Barclay (U.K.)
Dr. P. Bauer (France)
Prof. A.D. Olver (U.K.)
Prof. J. Van Bladel (for the Secretariat)

4. Organization of the XXIV General Assembly

President Jull thanked all these involved with the organization for their very efficient work. The Local Organizing Committee had set up a most impressive organizational structure, which took excellent care of the needs of the 1045 regular registrants and 201 student registrants (among whom 113 Young Scientists).

Vice-President J.B. Andersen, Coordinator of the Scientific Programme, discussed the Programme in very general terms. He thanked the Associate Coordinator, Professor H. Matsumoto, for his decisive contributions. The abstracts of the invited and contributed papers were collected directly by the Japanese Organizing Committee, a method which worked out extremely well in practice.

A the last meeting of the Council, on 3 September, President Jull asked the Council to express its thanks to our Japanese colleagues for their unparalleled efficiency and courtesy in the organization of the General Assembly, both administratively and scientifically. The Council responded by giving a spontaneous and well-deserved applause to our Japanese hosts, who spared no effort to ensure the remarkable success of the Kyoto event.

5. Proposal to increase the number of Vice-Chairs of Commissions

Professor Clarricoats presented a proposal made by the URSI Committee (Panel) in the U.K. to increase the number of Vice-Chairs to two. The increase work load which Universities and Laboratories have recently put on the shoulders of their staff seriously decreases the time which the Vice-Chairs can devote to their task. In quite a few cases this task includes the editorship of the Commission contribution to the RRS (Review of Radio Science). This led to the wish to double the number of Vice-Chairs, the understanding being that this new feature would not place any additional financial burden on URSI. An added advantage of the proposal would be to involve additional persons in the affairs of the Union.

The Council asked Professor Clarricoats to gather the reactions of the Commissions to the U.K. proposal, and to report his findings to the Council. This consultation took place, and resulted in the withdrawal of the U.K. proposal.

6. Election of Board of Officers, and of Chairs and Vice-Chairs of Commissions

The results of the elections were as follows :

(a) Board of Officers :

President :
Dr. P. Bauer (France)

Vice-Presidents :
Prof. J. B. Andersen (Denmark), Prof. P.J.B. Clarricoats (U.K.) (Treasurer), Prof. T. Okoshi (Japan), Prof. T.B.A. Senior (U.S.A.)

Secretary General :
Prof. P. Lagasse (Belgium)

Professor E.V. Jull remains a member of the Board as Past President.

(b) Chairs and Vice-Chairs of Commissions :

| Commission | Chair | Vice-Chair |
|---|---|---|
| Commission A | U. Stumper | M. Kanda |
| Commission B | D. Olver | C.M. Butler |
| Commission C | P.H. Wittke | B.G. Evans |
| Commission D | T. Itoh | R. Sorrentino |
| Commission E | V. Scuka | M. Hayakawa |
| Commission F | R.K. Moore | M.P.M. Hall |
| Commission G | K. Schlegel | B.W. Reinisch |
| Commission H | F. Lefeuvre | V. Fiala |
| Commission J | Y.N. Parijskij | R. Booth |
| Commission K | P. Bernardi | J.C. Lin |

The Chair and Vice-Chair of the Scientific Committee on Telecommunications are respectively Professor L.W. Barclay and Professor P. Delogne.

7. Admission of Member Committees. Resignation of Member Committees.

The Council unanimously accepted the application to membership of the Academies of Sciences of Russia, the Ukraine and Uzbekistan, of the Korean Advanced Institute of Science and Technology, and of the Scientific and Technical Research Council of Turkey (see Resolution U.2). It also accepted the applications to associate membership of the Academies of Belarus, Chile and Kazakhstan (see Resolution U.3), and confirmed the associate status of the Committee in Peru (see Resolution U.4).

The Council also decided that the Committee in Iraq should be considered as having resigned from the Union, given the delays experienced in the payment of its annual contribution (see Art. 9 of the Statutes). The Council hopes that Iraq will soon be able to rejoin URSI's ranks.

8. Membership

Professor T.B.A. Senior, Chair of the Standing Committee on URSI Membership, gave a comprehensive summary of the history of the "individual membership" problem, and continued with a survey of the activities of his Committee during the last triennium. He also discussed the report of his Committee, which recommends an extension of the "correspondent" concept with respect to the Prague version. The

Council approved the report (see page 76 of the Proceedings, and Resolutions U.5 and U.6).

Professor Senior subsequently showed a sample of a possible "Correspondent" card. This led to a few questions concerning the potential advantages of possessing the card, and the possibility of identifying the Commission of main interest to the Correspondent by means of the card.

The Committee in New Zealand had proposed to create a category 1/2 (with dues corresponding to one half the basic unit of contribution). Professor Titheridge explained that the idea was to help economically weak territories join URSI at a higher level of participation than that of Associate Member. The Council briefly discussed the problem, but ultimately decided to refer the question to the Membership Committee.

9. Finances

Treasurer Bauer thanked his predecessor Dr. Albrecht for the way he handled URSI's financial affairs. He presented a few viewgraphs, and made the following comments :

(a) the ratio of scientific to administrative expenses evolved favourably during the triennium, in particular thanks to the support provided by the University of Ghent.
(b) the assets being comfortable, there was a strong probability that the amounts given to the Commissions could be significantly raised above their present level, which is $10,000 per triennium.
(c) the annual accounts should show more clearly, in the future, the amounts devoted to the Young Scientists Programme.

Dr. Bauer also noted that the contributions were now expressed in Belgian francs (BEF), which introduced a favourable amount of stability in the expenses incurred in Belgian francs (which are mainly connected with administrative and publications items).

The Council approved the accounts of the Union for the triennium 1990-2. It also approved the report of the Finance Committee (see Resolution U.7, and the report on page 73of the Proceedings). The Council considered the two budget models prepared by the Committee, and decided to choose Model A. The unit contribution for 1994, 1995 and 1996 will therefore remain at the level of the past triennium, i.e. BEF 30,000 (Model B proposed to raise the unit to BEF 35,000).

10. XXV General Assembly

There were three invitations before the Council, from the Member Committees in China (CIE), Egypt and France. As a result of the vote, the XXV General Assembly will be held in Lille, France, from 28 August to 5 September 1996 (see Resolution U.25). The Coordinator of the Scientific Programme will be Professor H. Matsumoto, assisted by Dr. Hamelin, Associate Coordinator.

11. Future General Assemblies

The Council first discussed the desirability of changing the statutes with respect to the selection of future venues. The main issue was the possibility of selecting a venue six years in advance. Some of the comments made were as follows :

(a) in certain countries facilities can be booked six years in advance, but a financial commitment may be delayed until much later (e.g. two years ahead of the meeting). Reservations could therefore be cancelled without penalty if a bid were not successful. In other countries this system would not work.
(b) some Unions experience increasing difficulties in obtaining bids for their General Assembly.
(c) to change the statutes in an even more flexible way than proposed in the preparation of the Council, it was suggested to modify Art. 67g to read "to decide the year and place of future Ordinary General Assemblies".
(d) if a venue is chosen six years ahead of time, one actually goes over to a six year system (unless the rules are changed along the way).
(e) remembering that proposing for 2002 in 1996 implies that key persons must start working in 1995 (at the latest), the bid would imply that most of these key persons would still be available and active seven years later.

The Council was clearly sympathetic with the need for certain Member Committees to have a lead time of six years, but thought that the problem should be referred to the Standing Committee on Future General Assemblies, given the complexity of the factors involved (see Resolution U.10). The Council reached the same decision concerning two other items. The first one was the choice between a scientific programme concentrated in one week (e.g. Monday to Saturday) (solution I), or the present system, with a weekend in the middle of the programme (solution II). Some of the arguments pro and con were :

(a) Many people like a concentrated programme, which reduces the time invested in the Assembly, and encourages participants to stay the whole length of the meeting.
(b) In favour of solution II is the fact that a General Assembly is not a "run of the mill" scientific meeting, but one in which the contacts between people who rarely meet, or belong to different disciplines, are encouraged by the rather extended meeting period. Solution I would strongly change the nature of the General Assembly from that point of view.
(c) This argument clearly weakens solution I, but a way out could be found by programming a large number of poster sessions, a solution which would facilitate the contacts between participants.

The second item was the time of the year in which a General Assembly is preferably held. The answer to that question is not evident. Several factors are involved :

(a) the time schedule of the Universities
In the U.S. the academic year has a tendency to start earlier and earlier in August. The period from 20 August to, say, 10 September is therefore unfavourable. In other countries examination periods extending to 15 July may be an obstacle.

(b) conflicts with other important Conferences, which often have a fixed schedule. The European Microwave Conference, for example, is traditionally held around 10 September.

12. Publications

Professor P.J.B. Clarricoats, Chair of the Standing Publications Committee, presented a general survey of URSI's Publications Programme to the Council. He insisted on the great importance, for the image of our Union, of the RRS (Review of Radio Science) and MRS (Modern Radio Science) volumes. He expressed warm thanks to the editors of these volumes, Dr. Stone and Professor Matsumoto, but noted that the work involved had been of such magnitude that measures should be taken to lighten the burden put on the editors.

Professor P.J.B. Clarricoats also noted that the vast information present in our scientific programme should ideally be saved, and made available to the general public. He realized that publishing full Proceedings would not be a realistic proposition, but suggested that individual Commissions might be willing to take steps better to disseminate the work presented in their sessions.

Dr. R. Stone said a few words about the 1993 RRS. He mentioned the high quality of the contributions, and expressed a desire to receive feedback from the URSI community on the way the RRS should develop in the future. Professor Degauque, who had been involved with the production of the diskette, mentioned that the references were not submitted in a standard form, which created much additional work for the sub-editor. He thought that the vast work involved could only be justified if the diskette proved to be really useful. Dr. W. Stone proposed to appoint a separate editor for the diskette, and to impose more stringent requirements on the referees.

Vice-President R.L. Dowden answered questions concerning the agreements which had been signed with periodicals wishing to carry the URSI logo. The Council thought that a maximum number of URSI Scientific Commissions should be involved in the areas covered by those periodicals. It also wished to modify the text of the typical agreement by adding a clause allowing URSI to terminate the agreement, for example when a deterioration in the quality of the periodical is observed.

The Council later heard the report of the Publications Committee (see page 77 of the Proceedings) and approved this report.

13. Scientific Committee on Telecommunications

Professor L.W. Barclay presented the report of the Committee (see page 80 of the Proceedings). A lively discussion followed, devoted, in particular, to the relation SCT-Commissions. The following points were made :

(a) this relation must be smooth ; the independence of the Scientific Commissions must be respected;

(b) the SCT must not do anything which Commissions can do better;

(c) it was noted that Commissions already have joint scientific sessions at General Assemblies. The SCT might intervene to bring more cohesion to the programme when more than two Commissions are involved. This would, of course, only hold for topics which concern Telecommunications.

The Council approved the report of the Committee, and in particular the part devoted to Commsphere 94. There was some discussion, however, about the establishment of an e-mail system for rapid communications between members of the "Joint Task Group on the Mobile and Personal Communications Channel". Professor Shapira sees the proposed system as a model for the fast exchange of science, but agreed that there would be some financial implications. Support of such expenses is not traditional URSI policy, and the point was referred to the Board of Officers for further study.

14. Approval of reports

The Council approved the following reports (in addition to those mentioned previously) :

- the report of the Working Group on Time Domain Waveform Measurements;
- the report of the Long Range Planning Committee ;
- the report of the Standing Committee on Developing Countries;
- the report of the Standing Committee on Young Scientists;
- the report of the Inter-Union Commission on the Allocation of Frequencies to Radio Astronomy and Space Science (IUCAF).

## REPORTS OF MEETINGS : COORDINATING COMMITTEE

*Summary Report*

The Coordinating Committee met on two occasions, on 23 August and on 3 September 1993. The members discussed a large number of topics of interest to the Commissions. Some of these were also included in the agenda of the Council, and the Summary Report of the Council shows the results of the discussions in that body. The main points raised at the Coordinating Committee's meetings are given below.

1. Scientific Programme of the Kyoto General Assembly

Professor J.B. Andersen, Coordinator of the Scientific Programme, expressed his appreciation for the cooperation and the excellent work performed by Professor H. Matsumoto as Associate Coordinator of the Scientific Programme. For the Kyoto General Assembly a total of 1600 papers were received, out of which 1331 were accepted. Statistics concerning the papers are given in the following table.

| Commission | Invited Paper | Contributed Oral | Contributed Poster | Total Accepted | Withdrawn | Total Presented | Rejected | TOTAL |
|---|---|---|---|---|---|---|---|---|
| A | 58 | 3 | 1 | 62 | 0 | 62 | 2 | 64 |
| B | 26 | 74 | 50 | 150 | 7 | 143 | 112 | 262 |
| C | 43 | 61 | 24 | 128 | 1 | 127 | 17 | 145 |
| D | 38 | 47 | 8 | 93 | 2 | 91 | 19 | 112 |
| E | 86 | 0 | 17 | 103 | 1 | 102 | 29 | 132 |
| F | 85 | 0 | 31 | 116 | 5 | 111 | 16 | 132 |
| G | 52 | 20 | 137 | 209 | 2 | 207 | 15 | 224 |
| H | 37 | 60 | 151 | 248 | 3 | 245 | 1 | 249 |
| J | 76 | 20 | 47 | 143 | 4 | 139 | 2 | 145 |
| K | 32 | 22 | 34 | 88 | 1 | 87 | 29 | 117 |
| YS | 0 | 0 | 18 | 18 | 1 | 17 | 0 | 18 |
| TOTAL | 533 | 307 | 518 | 1358 | 27 | 1331 | 242 | 1600 |

The use of Kyoto as a single address for the General Assembly papers has proven to be very beneficial from the organizational point of view.

2. Young Scientist Programme

President Jull thanked the Japanese organizers of the General Assembly for providing funding and support for a large number of Young Scientists. The efforts made by the Commission Chairs, and especially by Professor Matsumoto, for integrating the scientific contribution of the Young Scientists into the General Assembly programme were also greatly appreciated. Overall the General Assembly's Young Scientist Programme was a success ; there was a strong competition and the standards were high: 120 applicants were selected out of a total of 224. The URSI Young Scientist Programme has grown over the years into a major effort. It is the largest programme of its kind within ICSU. This strongly increases the visibility of URSI and represents a very worthwhile investment in the future of Radio Science.

President Jull thought that the size of the group should be maintained and not further increased. The French Organizing Committee plans a Y.S. budget of $80,000, with a target of 120 Young Scientists, depending on the availability of funds. The answers to a questionnaire made clear that the inclusion of the Young Scientists papers in the regular sessions was generally appreciated by these young colleagues.

3. Post Mortem of the General Assembly.

This particularly important discussion was led by Professor J.B. Andersen, who based his remarks on the outcome of a questionnaire which had been distributed to session chairs. Some of the main reactions were :

(a) General lectures
The general lectures received very high marks, indicating the interest and the need for continuation of this programme;

(b) Tutorials
The number of attendees to the tutorials was larger than at previous General Assemblies, which for some tutorials resulted in crowded rooms, a problem to be avoided in the future. The lectures were given very good marks;

(c) Scientific sessions
A variety of reactions were received on the scientific sessions, going from "best of several years" to "disappointing in quality". There were also mixed responses on the ratio invited versus contributed papers;

(d) The giant poster session
The giant poster session received a large number of positive reactions and many attendees appreciated the large interaction it encouraged. The number of posters was larger than originally foreseen, due to some shifts from the oral presentations. Some of the answers to the questionnaire indicated that too many posters were presented in too short a

time. The suggestion was made to have separate poster sessions for some of the Commissions wishing to accommodate a particularly large number of posters;

(e) Joint scientific sessions
A participant expressed the opinion that "Joint Sessions" were not always really integrated, since in many cases each participating Commission would receive its own time slot, and organize it without due reference to the contributions of the other Commissions. It was suggested that, in the future, papers should be chosen with greater integration in mind;

(f) The programme in general
The reactions on the weight of the programme varied from "just right" (not too light) to "too heavy". It became clear during the meeting that some of the Commissions would have problems to compress the scientific programme into a single week;

(g) Publications distributed at the General Assembly
The size of the whole package (abstracts + Review of Radio Science + Modern Radio Science) has become a problem. A proposal to publish the Abstracts separately per Commission, in order to help solve the weight problem, was not approved, since it would weaken one of the main aims of the General Assembly, namely interaction and integration. The Publications Committee was asked to examine, together with the Local Organizing Committtee in Lille, the possibility of mailing the publications ahead of the Assembly, totally or partially;

(h) Overall impression
The overall impression of the General Assembly was very positive. The programme was deemed a success, and the work of the Local Organizing Committee was unanimously praised.

A few additional organizational items were discussed :
- the possibility of having "Late News" papers in predefined slots;
- the desirability of extending the period in which posters are available, and this without requiring the continuous presence of the authors;
- the desirability of having conveners present invited papers in their own session;
- the possibility of giving conveners advance information on the status of registration, the idea being to predict "no-shows" among the speakers;
- the desirability of a very rigid, universally-adhered-to time structure for the scientific sessions. In favour is the ease with which participants could plan moving from one session to another. Against the plan is a certain lack of flexibility, e.g. in moving papers from a regular session to a poster session. After some discussion it was tentatively proposed to adopt a 20 minute slot for regular papers, and 40 minutes for invited papers;
- the optimum length of the Scientific Programme

A proposal to concentrate the Programme in six consecutive days was discussed, but not all Commissions had broached the topic in their Open Meetings. Six of them did, and four were in favour of the proposal, while two thought that six days would be insufficient to cover their needs (see also the Council report).

4. Guidelines for the Programme of the Lille General Assembly:

The Programme will be based on the structure which worked well in Kyoto. Professor H. Matsumoto intends to send out a questionnaire to all Commission Chairs to collect relevant information. The same general timetable will be used as for Kyoto, viz.

It was felt most important to respect these dates and to have the "First announcement" out before the summer of 1995!

5. Sponsorship of meetings in 1993-1996

The Secretary General read the list of proposals for sponsorship put together on the basis of the information available from the Commission Open Meetings. This list will be submitted to Board and Council. Financial support is provided from various sources, but in particular by the triennial budget put at the Commissions' disposal. This budget was $5,500 in 1987-1990, and was raised to $8,000 in 1990-1993. It was further increased to $10,000 in 1992, to give greater flexibility in supoprting colleagues from Eastern Europe. Dr. Bauer mentioned that the planned Commission budget for 1993-1996 was $12,000, with a possible increase to $15,000, finances permitting.

6. Commission Secretariat

A retiring Commission Chair expressed concern about the fate of the important information about Commission affairs which he had collected in his files. He suggested the creation of Commission archives, and the appointment of a (semi-professional) Secretary to manage these archives, and ensure a reasonable amount of continuity in the activities of the Commissions. The consensus of those present was to leave such a decision to the individual Commissions.

# EXCERPTS FROM THE KYOTO G.A. PROCEEDINGS

## REPORTS OF MEETINGS : ROUND TABLE DISCUSSION

*Summary Report*

*The Round table discussion was held on Friday 3 September 1993 from 8.30 to 11.00. It was attended by some 50 persons.*

Prof. J. B Andersen opened the meeting and welcomed the participants. In a short introduction he outlined the purpose of the meeting as being an open discussion between the Commissions on the scientific role of URSI. He also stressed the different goals of URSI in the field of international radio science research. The different Commissions were then asked to present their views.

***Commission A (Presented by Dr. U. Stumper)***

Although it was stated that the "Terms of reference" of Commission A had not been changed, research on certain topics will be reinforced. It is expected that results of this increased research will be discussed at the next General Assembly. A recommendation had been proposed in the field of basic units for linking the mass unit to fundamental constants.

In an overview of the activities at the Kyoto General Assembly, it was mentioned that in total 8 joint sessions were organised with other Commissions. A strong interest exists within Commission A for future collaboration with Commission K.

Commission A will be represented in several international bodies, and will sponsor several conferences.

During a short discussion after the presentation, a suggestion was made by Professor R.K. Moore on the organization, at the next General Assembly, of a joint session sponsored by Commissions A and F on radar measurements in space.

***Commission B (Presented by Professor F. Gardiol)***

The over-all interests of Commission B on "Fields & Waves" cover theory, techniques and concepts. Three areas of interest are identified:
1) propagation (free space & guided);
2) scattering (reflection & diffraction);
3) antennas (guided & free).

The tools which are used for the research include mathematics and computation. Both analytical and numerical techniques are used for validation in both the frequency and the time domains.

Commission B is involved in the organization of several conferences, mostly in collaboration with the Antennas & Propagation Society of IEEE.

During the discussion after the presentation, Professor P. Degauque asked questions on the relation between Commission B and the Antennas & Propagation Society of IEEE. Professor Gardiol answered that there is no official relation, but that cooperation follows out of mutual membership of individuals in both Commission B and the Antennas & Propagation Society.

Professor J.B. Andersen expressed his concern on the limited presence of members of Commission B at sessions of other Commissions. Professor Gardiol agreed with this point of view, but emphasized the fact that joint sessions with other Commissions were held at the Kyoto General Assembly. Dr. F. Lefeuvre also clarified the interest of Commission H in the activities of Commission B, since similar tools are used by both Commissions. He envisages more interaction in the future.

***Commission C (Presented by Professor P. Lagasse for Professor P.A. Matthews)***

An overview was presented of the different sessions and joint sessions organized by Commission C at the Kyoto General Assembly, illustrating the wide range of topics covered by that Commission.

Related to this wide range of activities and the many international conferences in the field, it is felt that the URSI General Assembly can not be considered as the first forum for presenting new results. URSI nevertheless has a role to play in organizing and providing overviews and tutorials in the field.

In the discussion after the presentation, a question was raised by Dr. P. Bauer on the links between Commissions C and J. Dr. R.K. Ekers replied that, in the past, joint sessions were organized, but this had not been the case at the present General Assembly. A further discussion, involving most of the Commissions, led to the conclusion that indeed in some areas URSI is not considered as the first forum to present new results. How to deal with this fact is an important consideration for the future.

***Commission D (Presented by Dr. J. Hénaff)***

Dr. J. Hénaff explained the difficult role of Commission D within URSI due to the large range of subjects, although different key areas in electronics and photonics could be identified.

Commission D has several connections with other Commissions and uses these connections to avoid overlapping sessions at the General Assembly. The Commission also

organizes, in collaboration with other Commissions, ISSSE and is involved in the organization of several other Symposia. Suggestions were made to organize various sessions on different joint topics.

On a question raised by Professor Andersen during the discussion after the presentation, Dr. Hénaff agreed that URSI is not the first forum for new scientific results in the field of Commission D. To deal with this problem, more tutorials should be included. Professor D. Skellern emphasized that the sessions of Commission D were a success, with many experts presenting overviews on different topics.

***Commission E (Presented by Drs. J. Hamelin and V. Scuka)***

In an overview of the scientific interests of Commission E, Dr. J. Hamelin identified the different research topics and the structure of Commission E, based on 7 working groups. The activities at the Kyoto General Assembly were presented through a brief outline of the different sessions and joint sessions in which Commission E was involved.

Commission E did not organize symposia on its own, but was involved in the organization of different joint symposia.

Dr. V. Scuka (new Chair) continued the presentation by outlining the plans for future activities and interests.

In a comment after the presentation, Professor M. Ianoz emphasized the interaction between Commissions B and E. It was again stated that URSI is a good place to present reviews of the different fields of interest. On a question raised by Professor J.B. Andersen, the work of these working groups was further clarified. During the General Assembly, they assist in the organization of different sessions, but also continue to work in the interval between General Assemblies. They are a place of cooperation on a limited number of subjects, and are not only a body for exchange of information. The system results in a fast exchange of information on new research, thanks to personal contacts.

***Commission F (Presented by Professor R.K. Moore)***

In his presentation Professor R.K. Moore clarified the structure of the different sessions organised by Commission F at the present General Assembly. All oral sessions consisted of invited papers, together with some good reviews. All contributed papers were presented as posters at the large joint poster session. It is felt by Commission F that this structure of organizing sessions is a good solution for the General Assembly.

Several topics of interest for Commission F during the next triennium were then outlined; they include radio wave propagation and remote sensing.

Every third year Commission F organizes an Open Symposium, but it is also involved in the organization of several other meetings. Within the fields of interest of Commission F important new results are presented at these Symposia, while invited papers and reviews generally make up the largest part of the General Assembly.

***Commission G (Presented by Professor A.W. Wernik)***

The structure of Commission G, as presented by Professor A.W. Wernik, consists of 4 working groups which hold several meetings in the period between General Assemblies. The Commission is also involved in 3 inter-commission working groups and 2 inter-union working groups. Commission G has sponsored 9 symposia and 12 are already planned for the future. At the Kyoto General Assembly, 8 sessions were organized, together with 5 joint sessions with other Commissions.

Commission G also issues newsletters to communicate within the Commission itself. It is strongly recommended that the official members of the Commission should be more actively involved in the work of URSI.

Commission G feels that, during future General Assemblies, stronger emphasis should be put on the radiocommunication aspects of its work. Some outstanding problems have been identified by means of a questionnaire and through the sessions held at Kyoto.

In a short discussion after the presentation, in answer to the comment that some of the topics identified by Commission G are not specific for URSI, it was stated that Commission G attracts people from other organizations, and in that fashion is able to put them in contact with URSI.

***Commission H (Presented by Dr. R.F. Benson)***

In his presentation Dr. R.F. Benson outlined the work of Commission H at the Kyoto General Assembly and clarified the different topics of interest to the Commission.

***Commission J (Presented by Dr. R.K. Ekers)***

Dr. R.K. Ekers presented the highlights of the work of Commission J at the Kyoto General Assembly. The Commission clearly understands that URSI is an international forum suitable for discussions of radio techniques in several areas of astronomy. At the General Assembly, however, not the whole field of astronomy could be covered.

On the inter-Commission relations, it was stated that joint sessions are not necessary to have interaction between the different Commissions, since people do attend tutorials of Commissions other than their own.

In the discussion after the presentation, Professor D. Skellern agreed with this point of view, but the number of sessions

at the General Assembly must be reduced to increase this interaction, which of course is not stimulated if tutorials do overlap with other sessions.

*Commission K (Presented by Professor P. Bernardi)*

The speaker presented a brief overview of the (short) history of Commission K. Several research topics were identified, together with the already existing connection and relation with other Commissions, such as A and B. In the future collaboration is envisaged with Commissions C and E.

After the individual presentations by the different Commissions, Professor J.B. Andersen opened the general discussion.

Professor D. Skellern started it by discussing the work of the Coordinating Committee in setting up the different sessions at the General Assembly. He strongly felt that more care should be taken in the future to avoid overlap of sessions. If this overlap at the Kyoto General Assembly was due to the short time which was available at the Brussels meeting of the Coordinating Committee, then this meeting should be lengthened. In his comment Dr. P. Bauer emphasized that a similar round table discussion should be held at the Coordinating Committee meeting to be held in Brussels in April 1995.

In his comment Professor E.V. Jull expressed his satisfaction with this interesting round table discussion, which should be continued at future General Assemblies. He also emphasized that **scientific** aspects are to be discussed, and not aspects related to the **organization**.

Professor J.B. Andersen closed the meeting at 11.00.

# REPORT OF THE STANDING COMMITTEES

## The Standing Finance Committee

The Finance Committee met on 25 and 30 August 1993 under the chairmanship of Professor Geher.

1. Accounts for the years 1990-1992

The Treasurer, Dr. P. Bauer, presented the balance sheets and other data pertaining to the Union's financial condition and activities during the 1990-92 triennium. The Committee expressed its satisfaction with the general financial health of URSI, which was strong.

2. Review of BEF and US$ accounting bases

The practice of utilizing the BEF (Belgian francs)as the monetary basis, but with dual accounting in BEF and US$, has been successful and the Committee recommends that it continue. An earlier proposal that the ECU be adopted as a monetary basis was discussed and the Committee deems this, in light of recent developments, to be unwise. The balance sheets in BEF and those in US$ were reviewed and the Committee found that each provided useful information that would be difficult to discern from either alone.

It was pointed out that the dual system allowed desired flexibility to nations in the payment of dues. (Approximately 75% of the 1992 dues were paid in BEF, with the balance in US$).

Dr. Bauer recommended that accounting of funds for the Young Scientist and Scientific Programmes each be more explicit so that income and expenditures of each may be more readily understood. The Committee endorsed this recommendation.

3. Changes in the former USSR

The USSR paid dues in category 6. Since 1993, Russia has paid according to category 5. Other countries have applied for membership according to the categories below : Ukraine (3), Uzbekistan (3), Turkey (1), Korea (2).

4. Annual contributions

Two models, A and B, have been proposed by the Treasurer to forecast future financial balance sheets (see Treasurer's report). Model A is based upon a contribution unit of BEF 30,000 ($860) and B, upon a contribution unit of BEF 35,000 ($1,060). The models show surplus and deficit projections through the 1994-1996 triennium. Due to the present good financial health of URSI, and due to the level of the current assets, the Committee recommends adoption of Model A for the immediate future. The contribution unit of BEF 30,000 appears adequate to cover expenses for the next triennium.

The Committee views the present level of cash reserves and assets to be such that a percentage of income from investments, which is more easily predicted than is that from dues, be distributed to Commissions and the Scientific Committee. The percentage is to be determined by the Secretary General and the Treasurer so as to keep the real

value of URSI assets constant in time. In addition, a percentage of income should be earmarked for the Young Scientist Programme.

5. Corresponding and individual members

In Prague the foundation for a network of correspondents was established. At the present meeting approximately $30 of the registration fee is earmarked to support this plan, with the attendees of the Kyoto meeting to be designated "correspondents". In addition, one may become a correspondent between assemblies by paying a pro rata fee.

The Committee recommends that a questionnaire be distributed after the plan has been in place for two years. The questionnaire is to be designed so as to determine the effectiveness of the programme.

6. Acknowledgement

The Committee thanked Dr. Bauer and commended him for outstanding performance as URSI Treasurer.

7. Other

a. The table of 1993 dues payments was discussed.
b. The Committee discussed three questions posed by Vice President Dowden in a letter to Prof. Van Bladel and a related proposal by Prof. Titheridge of the New Zealand Member Committee. Both the proposal and the questions pertain to the minimum level of dues of a country. The Committee deferred comment in order to await a recommendation by the Membership Committee.

C.M. BUTLER

## THE LONG RANGE PLANNING COMMITTEE

The Committee met on 25 August 1993, with President E.V. Jull in the Chair.

The following items were discussed :

1. Individual Membership

The work and conclusions of the "Standing Committee on URSI Membership" were presented by Professor T.B.A. Senior. Based on those considerations and after extensive discussions, the following slight modifications to the resolution U7 of the URSI Council in Prague were proposed :

i any scientist attending a General Assembly or an URSI symposium will become a correspondent for a three year period, a special fee being included in the registration fee;
ii individual scientists not able to attend a General Assembly will be given the possibility of being included in the Network of Correspondents for a 3-year period by applying directly to the URSI Secretariat and by paying the special fee;
iii the Board can decide to waive this special fee upon request by the scientist;
iv correspondents participating in the Network will receive the Radioscientist-Bulletin and a numbered card allowing reduced registration fees at conferences;
v they will have no voting rights, but will be allowed to express their views in the Commissions on matters of a scientific nature.

2. Information - communication in the 90s

After a presentation by Professor W.E. Gordon and extensive discussions it appears that practically all Commissions contribute to the scientific foundations of the general theme "Information - Communication". By paying special attention to this theme in future URSI symposia and General Assemblies, and by fostering inter-Commission cooperative work on this subject, it should be possible for URSI gradually to increase its role in this important field. A more detailed proposal for discussion by Council and the Coordinating Committee will be prepared by Professors W.E. Gordon and L. Barclay.

3. Eastern Europe and CIS scientists

In view of the complexity of the matter it was proposed that it should become the responsibility of one of the Vice-Presidents.

4. Sponsorship of meetings

It was proposed that the Commissions should take responsibility for indicating how and whether URSI is properly represented and involved in URSI sponsored meetings.

5. Committee members for 1993-1996

It was proposed that the President should chair the Committee and that the Secretary General and the Past President should be members. Professor W.E. Gordon and Professor J.G. Lucas are willing to serve on the Committee. It was also proposed to add a Young Scientist to the Committee.

E.V. JULL

# REPORT OF THE STANDING COMMITTEES

## The Standing Committee on URSI Membership

The Committee noted that the following changes in URSI Membership have taken place since the last General Assembly :

(1) the membership of the former USSR has been replaced by Russia (Category 5), Ukraine (Category 3), Uzbekistan (Category 3), Belarus (Associate Member) and Kazakhstan (Associate Member);
(2) new members are Korea (Category 2), Turkey (Category 1) and Chile (Associate Member), and the associate membership of Peru was confirmed;
(3) the membership of South Africa was changed from Category 3 to Category 2, and Iraq is no longer a member.

One of the charges to the Membership Committee was "to propose ways of bringing URSI to the attention of radio scientists in territories which have not yet decided to adhere to the Union" and one way to do so is through some form of Individual Membership. The Committee has given considerable thought to the matter. The concept was discussed at the Commission B International Electromagnetic Theory Symposium in 1992, and influenced in part by ideas expressed at that time, together with some possible ground rules for Individual Membership. These were described in an Open Letter sent to all Member Committees in February 1993, and seven responses were received, most (but not all) giving cautious support. An abbreviated version was also published in the March 1993 Bulletin. In view of the responses, the Committee does not feel that there is enough support for the idea of Individual Membership to justify pursuing it at this time, but many of the same objectives can be achieved through the Network of Correspondents.

The establishment of the Network was approved at the Prague General Assembly. Financial support is provided by a portion of the registration fee at an Assembly, as was done at Kyoto, but to see how the Network might operate, the Board authorized its establishment on a trial basis starting in 1992, i.e. before Kyoto (see the December 1992 Bulletin for a description). As a result of discussions with the Long Range Planning Committee, it appears that the aim of bringing URSI to the attention of more radio scientists can be achieved by a slight modification to the originally-approved Network. To this end, the following modification to Resolution U.7 of the URSI Council in Prague is proposed (see Resolution U.5) :

(1) any scientist attending a General Assembly or an URSI Symposium will become a Correspondent for the three-year period following the Assembly, financed by a special fee included in the registration fee;
(2) other scientists may seek inclusion in the Network of Correspondents for the same three-year period by applying directly to the URSI secretariat and paying the special fee;
(3) on request, the Board may decide to waive the fee for a scientist in (2);
(4) scientists participating in the Network will be issued a numbered card allowing reduced registration fees at certain URSI-sponsored symposia and conferences, and will receive The Radioscientist Bulletin;
(5) Correspondents will have no voting rights, but will be allowed to express their views in the Commissions on matters of a scientific nature.

It is believed that (1) and (3) above are a reasonable first step in seeking to bring URSI to the attention of radio scientists who are presently not able to attend a General Assembly or an URSI Symposium. Information about the Network and the opportunity to apply for inclusion will be disseminated as widely as possible. A simple application form will be developed and enclosed in a future Bulletin.

It is recommended that the Membership Committee carefully monitor the operation of the Network during the next triennium, and propose any further modification necessary to improve its effectiveness.

T.B.A. Senior

## The Standing Publications Committee

The Committee met on 27 August 1993 under the Chairmanship of Professor Clarricoats and discussed the following items :

1. Bulletin and Radioscientist

The Committee recommends to Council the merger of the Bulletin and Radioscientist under the joint Editorship of Professors Dowden and Lagasse who will be aided by Associate Editors.
The Commissions will be encouraged to contribute through a specific statement printed in the preface of each issue.

The Editorial policy will be such that material for the Radioscientist will be refereed, as at present, with the Editor executing the final responsibility for publication. The volume of material will be subject to such constraints as imposed by financial considerations.

The publication will be circulated to URSI Member Academies for distribution to their existing lists of radioscientists. Effort will be made to reduce duplication in distribution.

The Editors will seek advice from ISBN to ensure adequate indexing.

2. URSI News

Professor Dowden will investigate the feasibility of producing an e-mail version of URSI News and will advise the radioscience community through the Bulletin/ Radioscientist.

3. Review of Radio Science and Modern Radio Science

The Committee recommends that the above publications be published separately rather than as a merged entity.

Dr. Stone agrees to continue as Editor of "Review of Radio Science " while the choice of the Editor for Modern Radio Science will be determined by the organising committee for the 25th General Assembly.

Dr. Stone seeks proposals for an Assistant Editor for "Review of Radio Science " who should be appointed by the URSI Board. He has made arrangements with Commissions to furnish the Commission Editors.

P.J.B. CLARRICOATS

## THE STANDING COMMITTEE ON YOUNG SCIENTISTS

URSI does not limit its support of Young Scientists (Y.S.) to the implementation of the ambitious attendance programme at General Assemblies. Important funds are also earmarked for the period between General Assemblies. In 1991 URSI provided support for the attendance of 14 Y.S. at URSI-sponsored or co-sponsored conferences. The URSI commitment to this was $11,000. In addition, the attendance of 26 Y.S. from developing countries at the College on Theoretical and Experimental Radio Propagation at Trieste was partially supported by URSI.

In 1992, the attendance of 53 Y.S. at URSI organized or co-sponsored conferences was assisted by URSI or conference funds. Of these 53 Y.S., 25 were from developed countries and 10 from developing countries. Eighteen were from Eastern Europe, the Ukraine and Russia. Total amount of support provided was $42,500.

For the participation of Y.S. in Kyoto, it should be noted that a total of 223 applications have been received from 46 countries of which 96 are from developed countries, 69 from Eastern Europe and C.I.S. and 58 from developing countries. About 193 of these applicants are suitable for URSI Y.S. Awards. Of these 90% have papers submitted for a regular session of the General Assembly Scientific Programme. The others have not requested their papers be included in the regular sessions. Arrangements have been made at Kyoto by the Japanese organizers to accommodate and provide registration fees and living expenses for 120 Y.S. at a cost of about $600 each. In addition they have $10,000 for Y.S. travel support. URSI has about $40,000 available for Y.S. travel support (most of these funds are from URSI's own budget).

The Committee intended that almost all Y.S. should present their papers in a regular session. This factor was to be of importance in the selection process. Other factors will be the ranking provided by the Member Committees and, for the industrialized countries, the membership category of the Committee. Special effort is being made at this General Assembly to assist Y.S. from Eastern Europe and the C.I.S. Also, as at all General Assemblies, young colleagues from developing countries are especially to be encouraged.
It is against this background that the Committee met on 26 August 1993, and discussed the following items :

*1. Review of 1990-93 Activities*

The Chair reviewed URSI Y.S. activities in the period since 1990 and also the arrangements for the programme in Kyoto, many details of which had already been distributed to Council. It was noted that the scale of this programme is now such that it occupies much of the time of the Secretariat in the eight months prior to the General Assembly, and that it is the largest programme of that kind within ICSU.

*2. Recommendations for 1990-93*

In view of the above the Committee felt that it might not be advisable at present to attempt to enlarge the scale of the programme further, but rather to try to maintain its current level of funding. For Kyoto this is, approximately :

| | | |
|---|---|---|
| Accommodation & living | (Japan) | $78,000 |
| Travel expenses | Japan | $10,000 |
| | URSI & ICSU | $35,000 |
| | Other sources | $5,500 |
| | | $128,500 |

*3. Sources of funding*

Dr. Reddy suggested that letters be sent to each of the Member Committees requesting that they seek sources of funding within their country for the travel costs of their Y.S. One may not always be able to count on the high level of support provided by the local organizers at Kyoto. Dr. Reddy felt that it would be possible to do this in India for Indian Y.S. He drafted a letter which the Chair agreed to sign after minor revisions.

It was pointed out that the task of providing support would be much simplified if an URSI Y.S. Foundation existed. An amount of about $200,000 would provide sufficient funds for the present level of activity.

E.V. JULL

# REPORT OF THE STANDING COMMITTEES

## The Standing Committee on Developing Countries

The Committee met on 30 August under the chairmanship of Professor S.M. Radicella. Were also present : Professor G.O. Ajayi, Professor S. Feng and Dr. B.M. Reddy.

The Committee discussed the following points :

1. Status of the Handbook on Radio Propagation

The Chair reported on the current status of the Handbook, which is devoted to satellite communication. Many chapters had been written and submitted, while some were still expected. After a thorough discussion, the following decisions were taken :

(i) Professor Pontes of Brazil is to be requested to contribute two chapters;

(ii) Professor Ajayi of Nigeria accepted to contribute two chapters;

(iii) Professors Radicella, Feng, Ajayi and Dr. Reddy will constitute the editorial board under the coordination of Professor Ajayi;

(iv) A meeting of the editorial board is to be held in Delhi, India in January 1994 for about four days to finalise the preparation of the Handbook. URSI support is requested for the meeting expenses.

2. Training activities and meetings co-sponsored by the Standing Committee / Relation with the reorganized ITU

The discussion was based mainly on the report to the URSI Council presented by Professor Radicella. The Memorandum of Understanding between ITU, URSI and the ICTP in Italy was commendable and should be encouraged. This is to ensure that developing countries benefit from the reorganization of the ITU, and particularly from the new activities of the Telecommunication Development Sector.

S.M. Radicella

# REPORT FROM THE SCIENTIFIC COMMITTEE

A meeting of the Scientific Committee on Telecommunications was held on Friday 27th August. The meeting was attended by 17 persons.

1. The meeting reviewed the work done in establishing SCT.
2. The commissions were asked to consider the study topics already identified by the ITU-R members, and also to consider the topics which have been the subject of joint sessions at this General Assembly. The object of this process is to identify if the interest in any topic is sufficient for the establishment of new Task Groups or Joint Task Groups.
3. The continuation of the Joint Task Group on "the characterization of the mobile and personal communication channel" (chaired by J. Shapira) was confirmed.
4. The meeting took account of the discussions within the Long Range Planning Committee concerning future developments in information transfer and communications, and proposed ways of taking this matter forward.
5. The SCT made the following proposals:

5.1. The Coordinating Committee should coordinate and oversee the programs of the commissions and of the intercommission working groups, directed towards "information / communication beyond 2000" at each of its meetings.

5.2. The SCT should promote the establishment of Task Groups and Joint Task Groups where inter-Commission or Commission / ITU-R Study Group expertise is necessary for the study of relevant topics.

5.3. A session on future telecommunications should be included in the programme of the ISSSE. Consideration should also be given to the inclusion of such sessions at conferences which are URSI-sponsored.

5.4. The SCT should organise, with the active cooperation of the Commissions, COMMSPHERE-94 during the forthcoming triennium. This conference is devoted to future telecommunications and information transfer. Key Topics for inclusion in Commsphere-94 include: satellite mobile communications and coordination and integration with terrestrial cellular systems; mobility and flexibility in the communications networks; radio astronomy and the electromagnetic environment.

5.5. Future General Assemblies should include one or more sessions on the subjects sponsored by the SCT. Taking advantage of the presence of experts at the General Assembly a first planning meeting has been held anticipating the approval of COMMSPHERE-94. If approved, this conference could be held in Israel in December 94. This provides a geographic spread with ISSSE (San Francisco) and the next General Assembly.

6. To support the activities of the SCT it would be advantageous if some funding could be made available

6.1. to assist some scientists to attend COMMSPHERE. This will need to be considered when an application for sponsorship of this conference is made;

6.2. to assist in the establishment of an E-mail system for rapid communication between members of the Joint Task Group on the Mobile and Personal Communications Channel.

L. W. Barclay

## COMMISSION G

### Newsletter No. 210-G Dec. 1993

Following the tradition of the two former Commission G chairmen I will issue newsletters from time to time. They should inform you about the work in the commission and should also be a forum for discussion of Commission G items. These newsletters will not only be distributed among the national representatives of Commission G, but will be send also to all colleagues who have accepted any duties within the commission (like Working Group Chairman/ Vice-Chairman, Convenors etc.). The current distribution list is attached to this newsletter. Please check your address, FAX, E-mail number etc and send any correction or addition to me. (note from the secretariat: distribution list available at the secretariat). Those of you who had the chance to attend the XXIV URSI-General Assembly in Kyoto in September will confirm that this was an excellent scientific meeting and superbly organised by our Japanese colleagues. The URSI officers will try their best to make also the GA in 1996 which will be held in Lille/France an equal success.

### 1. Tentative programme for the 1996 GA

The major item of this newsletter will therefore be the tentative programme for the coming GA. In Kyoto the Vice-Chairman, Prof. Bodo Reinisch, and myself received more than a dozen suggestions for session topics - much more than we can establish. We decided not to increase the number of sessions (compared to the Kyoto GA where 8 G-sessions, 3 GH-sessions, one CFG- and one HEF-session were held), since we got the message from discussions with many colleagues that this number was already regarded as the upper limit. We therefore had to select from the received suggestions. We based this selection mainly on the relationship of the topics to our terms of references (see attached). We have been criticised by URSI officials that some of the topics on recent GAs were too little related to these TORs and that URSI does not want to compete with IAGA or COSPAR in choosing topics that deal with very general aspects of, for instance, solar-terrestrial relationships. On the other hand we also tried to represent a broad spectrum of ionospheric topics and to avoid repetitions. In the overall spectrum of scientific activities of the GA, also the commission tutorial and the contributions to the Review of Radio Science 1993-96 should be taken into account.

We also did not always accept the suggestions for convenors of the suggested sessions. Since URSI is a world wide community, we tried to establish some international balance in the convenorship. So, we hope that some of you will not be too disappointed when your suggestion does not appear in our tentative program. Since our program always attracts many colleagues form the Commission H (and vice versa!) we tried to coordinate it accordingly. To facilitate this we prepared a cross table of possible overlap.

### Commission G Sessions

G1 Ionospheric models and indices (Bilitza) G2 Ionospheric HF-propagation and telecommunication (Reinisch) GF3 Stratosphere-mesosphere-ionosphere studies using the GPS system (Hoeg) G4 Observations and modelling of high latitude E- and F-region plasma structures (Shirochkov)

G5 Computer aided processing of ionograms and ionosonde records (Wilkinson) G6 Radio Tomography of the ionosphere (Leitinger) G7 Open session and latest results (Matuura) G8 Panel discussion : the future of coherent and incoherent scatter radars (Röttger)

Joint Session with Commission G

HG1 Computer simulation of multiple scale processes in space plasmas (Chanteur)

HG2 Effects of lightning and VLF waves on the ionosphere (Rycroft, Nunn) HG3 Coupling of plasma processes in ionospheric modifications by high-power HF waves (Sa Basu, Bernhardt)

HEG1 EM coupling between the ground (including seismic activity) and the upper ionosphere and magnetosphere (Molchanov, Parrot, Fraser-Smith) HGCJ1 Turbulence and wave analysis for non-Gaussian signals (Krasnoselskikh, Wernik)

### Commission H Sessions (provisional)

H1 Whistler-mode waves and their effects on the radiation belt (Smith, Inan)

H2 Active experiments in space by in-situ and remote sensors experiments (Raitt)

H3 Plasma wave observations by multiple spacecraft in geospace (Kimura, Taylor, Lefeuvre)

H4 Non linear theory and computer simulation on waves and particle in geospace plasma (Matsumoto, Abdalla)

H5 Open session and latest results (Lefeuvre)

**Possible Overlaps**

| | G1 | G2 | GF3 | G4 | G5 | G6 | G7 | G8 |
|---|---|---|---|---|---|---|---|---|
| H1 | x | x | x | x | x | x | | x |
| 2 | x | x | x | x | x | x | | |
| 3 | x | x | x | | x | | | |
| 4 | x | x | x | | x | | | |
| 5 | | | | | | | | |
| HG1 | x | x | x | | x | | | |
| HG2 | x | x | | | x | x | | |
| HG3 | x | x | x | x | x | x | | |
| HEG1 | x | x | | | x | x | | |
| HGCJ1 | x | x | | | | | | |

## Commission G-Tutorial

B. M. Reddy : The equatorial ionosphere

Planned contributions for the review of Radio Sciences 1993-96:

HF-Commission (T. B. Jones)

Imaging Riometers (P. Stauning)

Polar Patches and Blobs (G. Crowley)

Since I already mentioned that the program is tentative, we are still open for suggestions and comments (including the overlap-table). I am looking forward to receiving your contributions, but please keep in mind that the total number of sessions will not be increased.

## 2. Activities between the GAs

You all probably know that URSI can sponsor workshops or symposia with special topics related to our TORs which may taken place between GAs. Several categories of sponsorship exist which mainly depend on the amount of money that URSI provides. We have already received 17 requests. Some of the respective meetings already have a long tradition (like for instance the IRI Workshop and the Beacon Satellite Workshop) other are still tentative, some may not materialise at all.

**Funding was already arranged for**

1. IRI Workshop, Trieste, Italy (Oct. 93)
2. Workshop on Electromagnetic Scattering from Gases and Plasma, Aussois, France (March 94)
3. STEP Symposium, Send, Japan (June 94) 4. COSPAR (two sessions), Hamburg, Germany (July 94)

If anybody wants to apply for sponsorship please sent me a note with the necessary dates (topic, place, time, expected number of participants) as soon as possible. Please keep also in mind that the URSI funds are very limited. Usually it is in the range of US$500-1000 per meeting.

## 3. Terms of References of Commission G

The Commission deals with the study of the ionosphere in order to provide the broad understanding necessary for radio communications. Specifically, it includes the following areas :

a. Global morphology and modelling of the ionosphere;
b. Ionospheric space-time variations;
c. Theory and practice of radio propagation via the ionosphere;
d. Application of ionospheric information to radio communications.

To achieve these objectives, the Commission cooperates with other URSI Commissions, corresponding bodies of the ICSU family (IUGG, IAU, COSPAR, SCOSTEP, etc.) and other organisations (ITU, IEEE, etc).

## 4. Use of ionospheric data

As a follow up of our questionnaire on the future of ionospheric studies we already asked you for information on the usage of ionospheric data/results. Unfortunately very few responses have been received so far, and therefore we would like to ask you again:

1. Do you know or feel that there is a need for ionospheric information in your country?
2. Who are the users of ionospheric information?
3. What kind of information do they use and need?
4. Do you have in your country an ionospheric information and/or prediction service?

There is no real deadline for the answers. We will be happy to receive your reply at any time within the year (1994).

Finally I wish you all a peaceful and successful year

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# UTC TIME STEP

### on the 1st of July 1994

A positive leap second will be introduced at the end of June 1994. The sequence of dates of the UTC second markers will be:

| | | | | |
|---|---|---|---|---|
| 1994 June | 30 | 23h | 59m | 59s |
| 1994 June | 30 | 23h | 60m | 00s |
| 1994 July | 1 | 0h | 0m | 0s |

The difference between UTC and the International Atomic Time TAI is: from 1993 July 1, 0h UTC, to 1994 July 1, 0h UTC : UTC-TAI = -28 s from 1994 July 1, 0h UTC, until further notice : UTC-TAI = -29 s

Leap seconds can be introduced in UTC at the end of the months of December or June, depending on the evolution of UTC-TAI. Bulletin C is mailed every six months, either to announce a time step in UTC or to confirm that there will be no time step at the next possible date.

MARTINE FEISSEL

## 1993 International Reference Ionosphere (IRI) Workshop

The 1993 IRI Workshop was held at the International Center for Theoretical Physics (ICTP) in Trieste, Italy from October 19 to 22, 1993. It continued the series of meetings organized by the COSPAR/URSI Working Group on IRI to advance specific aspects of the model. With this year's workshop the group has begun the difficult task of establishing quantitative descriptions of ionospheric variability. IRI currently provides monthly average values for the undisturbed ionosphere. The intend is to also predict the expected standard deviations and to issue warnings when the occurrence probability for specific ionospheric irregularities (e.g., Spread-F, Sporadic-E) is above certain critical levels.

The Workshop was co-sponsored by COSPAR, URSI, and ICTP. 47 participants from 20 countries attended the 42 presentations spread over 4 days and 9 sessions. Excellent support before, during and after the meeting was provided by the Local Organizer, S. Radicella, and his team at ICTP. During the morning of the first workshop day a special session was held in celebration of Karl Rawer's (the first Chairman of IRI) 80th birthday. His colleagues, co-workers, and students described Rawer's many contributions to ionospheric physics in particular his leadership in advancing the capabilities of the ionosonde instrument to study ionospheric dynamics and his important role in guiding the development of insitu instruments (the German/US satellites AEROS A and B carried four experiments from his group). The laudatio was given by B. Reinisch (U. Mass. at Lowell). On the evening of the second workshop day a special computer session was held to familiarize the participants with the PC version of IRI and related software.

As a result of this workshop several improvements and extensions will be incorporated into the next version of the IRI model. Most importantly, it was decided to open IRI to regional F-peak models (e.g., for the European or Asian sector). Other new feature include: (i) an explicit representation of the auroral oval, (ii) total electron content as a new parameter, and (iii) improved models for the electron temperature in the topside and for the ion composition below 300 km. A D-region task group will compare their data and results to come up with a joint recommendation for an improved D-region model. Another interesting outcome of this workshop is the plan to convene a special task force at ICTP for a study of the F1 region and the E-F region variability; if successful this approach may be the venue for future improvements of critical parts of the model.

### *D-Region*

Four groups are currently involved in D-Region modelling for IRI; all four presented status reports at this meeting. Singer's (Germany) effort focuses on the most characteristic D-Region point, NmD, where a sharp change in gradient signals the transition from molecular to cluster ions. He deduced an improved seasonal and solar cycle dependence for NmD based on his long record of radiowave propagation measurements on several frequencies. Friedrich (Austria) uses the neutral density as scaling parameter and developed his model with about 80 rocket profiles measured by Faraday rotation/differential absorption and insitu probes. Both authors find discrepancies up to a factor of 10 with the current IRI model below 80 km; agreement is much better at higher altitudes. Comparisons with the results of the theoretical model by Kopp (Switzerland) and his colleagues come to similar conclusions. Danilov (Russia) and his team studied D-Region variability with more than 60 rocket profiles. He suggests distinction of three disturbance levels related to conditions of strong and weak Winter Absorption Anomaly (WAA) and of stratospheric warmings. Collaborative efforts between the four teams were initiated in Trieste, with the goal of a joint recommendation for an improved description of seasonal and solar cycle variations in the next IRI update. [task lead: Singer, Friedrich, Kopp, Danilov]

### *Bottomside F Region*

Two characteristic points are currently used to define the IRI bottomside profile shape: (A) NmF1 is the electron density of the F1 ledge that is clearly seen in ionograms (F1 cusp), but that is difficult to identify in incoherent scatter radar measurements; the change in gradient at this point seems to be correlated to the transition from atomic to molecular ions; the F1 feature exhibits a strong solar dependence and disappears for large solar zenith; (B) h0.5 is the height where the density has decreased to half the F2 peak value; IRI actual uses the ratio h0.5/hmF2 often called the G-factor.

Ionosonde data presented at this meeting showed that the F1 parameter modelling needs to be revisited, in particular the latitude dependence and the critical upper limits (of solar zenith angle) for F1 occurrence. The group strongly endorsed a proposal by Radicella (ICTP) to invite a team of experts to ICTP for a one-month empirical and theoretical modeling study of the F1 feature. This team would also work towards a quantitative description of ionospheric variability in the E-F region based on the preliminary efforts presented during the workshop (Mosert de Gonzalez, Argentina). [task lead: Radicella, Bilitza, Reinisch]

Mahajan (India) investigated the diurnal variation of h0.5 with more than 2000 profiles from the incoherent scatter facility in Arecibo, Puerto Rico. His results can be used to extend the G-factor formula to low latitudes; the current formula is based on mid-latitude ionosonde measurements (Gulyaeva, Russia). [task lead: Anderson, Gulyaeva, Mahajan].

*Topside and Plasmasphere*

Work continues on a new topside model using a (magnetic) field-aligned coordinate and ISIS topside sounder data. Responding to popular demand the IRI group decided to add the total ionospheric electron content (TEC) as a new IRI output parameter. TEC will be obtained by numerically integrating the IRI electron density profile with a user-specified upper height limit. [Bilitza]

Kimura (Japan) presented a diffusive equilibrium model for the plasmaspheric electron density distribution based on observations by the Akebono satellite. If consolidated with the work by Rycroft (U.K.) and colleagues, this new study could lead to a reliable plasmaspheric extension of the IRI model. [task lead: Oyama/Kimura, Rycroft]

*Mapping of E and F Peak Parameters*

IRI mapping efforts are closely coordinated with the activities of the URSI Working Group on Ionospheric Informatics (WGII). An accurate global representation of the F peak height, hmF2, remains as one of the most pressing mapping issue for both groups. Most models (including IRI) make use of the well-known anti-correlation between hmF2 and the propagation factor M3000 that is routinely scaled from ionograms. This method, however, tends to underestimate the very large peak heights observed close to the magnetic equator. Regional maps based on parameterized drift observations may be required to alleviate this problem. [task lead: Anderson, Reinisch, Bibl]

Discussions also focussed on the issue of E and F1 peak height modeling. Commonly used formulas date back to the early seventies and should be checked with newer ionosonde and incoherent scatter data. WGII agreed to add hmE and hmF1 to the parameters studied under itUs Verification of Ionospheric Models (VIM) effort. The compilation of insitu rocket measurements presented by Gupta (India) could be of help at low latitudes. [Bradley, Mahajan, Paul]

Several papers dealt with methods and results of regional mapping of F peak parameters. Regionals maps exists for certain parts of the globe (e.g., Australia, China, Europe). They have proven to represent the regional ionosphere much better than the global models. It was decided that future versions of the IRI model should accommodate regional models in addition to the global CCIR and URSI maps for the F peak parameters. As a test case the Chinese regional maps will be incorporated into IRI (Dai, China/ICTP). A good candidate are also the PRIME maps for Europe (Mikailov, Russia); PRIME is the Parameterized Regional Ionosphere Model for Europe project (Bradley, U.K., Chair). Through regional models it may be also easier to introduce storm effects into IRI, since the ionospheric documentation of the different storm phases may vary from region to region. PRIME, for example, intends to publish maps for the different storm phases which could than be readily implemented into IRI. [Dai/Radicella, Mikhailov/Cander]

The next version of IRI will also include a representation of the auroral oval. As a start this will the Holzworth parametrization of the Feldstein ovals for different magnetic activity. The IRI user can thus be alerted to regions in which to expect higher variability. At equatorial latitudes occurrence statistics for Spread-F are required to flag the time periods of very high variability. Spread-F maps established by Maruyama (Japan) with ISS-b topside sounder data may serve this purpose. [Maruyama, Matuura]

*Plasma Temperatures and Ion Composition*

Oyama (Japan) compared the IRI electron temperature model with the data obtained by his electron temperature probe on the Hinotori satellite. The measurements at the Hinotori altitude of 600 km show distinct early morning and late afternoon maxima currently not reproduced by the smoothed IRI curves in this altitude range. Incorporation of global Te maps established with the Hinotori data will help to alleviate this problem and is now planned for the next edition of the IRI model. [Oyama, Bilitza]

An improved model for the ion composition below 300 km was presented by Danilov (Russia); this Danilov&Smirnova model will replace the older Danilov&Semenov model implemented in IRI-90. Use of the new model leads to more reliable transition heights (molecular to atomic ions) which is one of the most important parameter in the bottomside ionosphere. [Danilov, Bilitza]

An evaluation of the different formulas for the ratio between molecular and cluster ions was identified as one of the most important tasks in modeling the D-region ion composition for IRI. The current IRI formula is based on Danilov's (Russia) assessment of a large number of rocket measurements. Kopp (Switzerland) has presented a formula based on his photochemical computations. Friedrich and Torkar (Austria) have established a correlation between the neutral density and temperature at the transition height from molecular to cluster ions. Of interest for future IRI work is the suggestion by Danilov (Russia) to represent the ratio between the two dominant cluster classes: proton-hydrated and non-proton-hydrated cluster ions. [Danilov, Friedrich, Kopp]

*Membership and Meetings*

We mourn the death of our dear colleagues C. Serafimov (Bulgaria) and J. Buchau (U.S.A.). Serafimov was a member and strong supporter of the IRI Working Group from early on. Buchau was an invited speaker at several IRI Workshops including the present workshop. Their expertise and friendship will be sadly missed by all of us. Four

# REPORTS ON URSI-SPONSORED MEETINGS

new members were accepted into the Working Group: B. Ward, DSTO, Salisbury, Australia; K.K. Mahajan, NPL, New Dehli, India; W. Hoegy, NASA, GSFC, USA; M. Mosert de Gonzalez, Universidad Nacional de Tucuman, Argentina. An IRI Newsletter will produced and distributed by K. Oyama (Japan) starting this summer. The presentations from the IRI sessions during the World Space Congress in Washington, DC (1992) have been submitted to Pergamon Press for publication in an upcoming volume of Advance in Space Research. A.P. Mitra and K.K. Mahajan (India) have invited the group to hold the 1995 IRI meeting at NPL in New Dehli, India most likely in early January; the topic will be the low-latitude and equatorial regions in IRI.

DIETER BILITZA

# ANNOUNCEMENTS OF URSI-SPONSORED MEETINGS

## 1994 URSI COMMISSION-F MICROWAVE SPECIALIST SYMPOSIUM ON MICROWAVE REMOTE SENSING OF THE EARTH, OCEANS, ICE AND ATMOSPHERE

May 18-20, 1994, Lawrence, Kansas, USA

The 1994 URSI Commission-F Microwave Specialist Symposium on Remote Sensing will be held in Lawrence, Kansas during May 18-20, 1994. Contributed papers are solicited describing original work on microwave remote sensing. The topics of interest are listed below, but any paper dealing with the application and utilization of microwaves for remote sensing will be considered. The conference language will be English.

Topics to be adressed include:

1. Active and passive microwave sensing of:
   - land surfaces
   - vegetation
   - sea ice
   - soil moisture
   - cultural targets
   - continental ice
   - ocean waves
   - atmosphere
   - other ocean features
2. Microwave remote sensing systems, including
   - imaging radar
   - scatterometers
   - earth- and ice-probing radars
   - altimeters
   - radiometers
3. Calibration of microwave remote sensors
4. Special sessions will be devoted to ERS-1 radar results

Young Scientists Travel Stipends

Limited funding is available for partial support of the travel expenses of young scientists (less than 35 years of age at the time of the meeting). To qualify for the young scientist stipends, the applicant must be the first author.

For further information, please contact:
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## PHYSICS AND ENGINEERING OF MILLIMETRE AND SUBMILLIMETRE WAVES

June 7 - 10, 1994, Moscow, Russia

This International Symposium is sponsored by the International Union of Radio Science ( URSI ) and the Russian Fund of Fundamental Investigations.

Working languages : English and Russian

The programme of the Symposium includes invited reports of leading scientists and poster presentations on the following topics:

1. Theoretical problems of Radiophysics:
**1.1 Electrodynamics of Open Structures:**

- Scattering and Diffraction;
- Analytic and Numerical techniques;
- Inverse problems;
- Time - domain methods;
- CAD of millimetre-wave and wave circuits 1.2 Electromagnetic phenomena in solid-state structures:
- Low-dimensional systems;
- High-frequency electron phenomena in HTS; - plasma of solids ( waves, instabilities, nonlinear effects ); 2. Passive and active devices;

- Vacuum - electron devices;
- Diffraction electron devices;
- Solid-state sources, multipliers;
- Detectors and Mixers;
- Antennas;
- Transmission lines and components (printed circuits, waveguides, quasi optical systems ).

**3. Propagation of mmand sub-mm waves:**

- Absorption and radiation of atmosphere, remote sensing of atmosphere; - Scattering and radiation of sea and earth surfaces, objects; - Fluctuation processes and coherence of **mmand sub-mm** waves near sea and earth surfaces;

**4. Application of mmand sub-mm waves:**

- Scientific instruments;
- Radar systems ( active and passive );
- Telecommunications;
- Target recognition;
- Remote sensing of natural environment; - Application of **mmand sub-mm** waves in medicine, biology and ecology;

For further information, please contact:

Dr. G. Khlopov, the Organising Committee Co-Chair
Institute of Radiophysics and Electronics
Ukrainian Academy of Sciences
12, ac Proskury st., Kharkov, 310085 Ukraine
Fax : (7-0572) 44-11-05 / Tel : (7-0572) 44-85-74
e-mail: ire%ire.kharkov.ua@relay.ussr.eu.net

## Bioelectromagnetics Society Annual Meeting BEMS

12-17 June 1994, Sheraton Hotel, Copenhagen, Denmark

The Bioelectromagnetics Society is pleased to announce that it will hold its Sixteenth Annual Meeting, June 12-17, 1994 at the Sheraton Hotel in Copenhagen, Denmark. This meeting is sponsored by Commission K

Papers and posters will deal on the interaction of electromagnetic energy (from zero Hertz through the visible light frequencies) with biological systems. Areas of interest include, but are not limited to:

*Bioelectromagnetic Phenomena*

Biotechnology Dosimetry
Diagnostic Applications Epidemiology
EM Properties Of Biological Materials

*Exposure and Measurement Instrumentation High Intensity Field Phenomena*

Human Exposure Assessments Safety Standards
In Vitro Studies Tissue Healing And Bone Repair
In Vivo Studies Mechanics Of Interaction
Medical Applications Therapeutic Applications
Magnetic Resonance Imaging

The technical Program Committee (TPC) is chaired by James Lin, Vice President/President-Elect. Local arrangements for the meeting are being made by William Wisecup, Executive Director and the Local Arrangements Committee. The Technical Program includes workshops, minisymposia, student paper competitions and exhibits. An award will be given for the best student paper presented at the meeting.

The deadline for submission of abstracts was January 7, 1994.

For further information, contact :

James C. LIN, BEMS
120 West Church Street, Frederick, MD 21701, USA
Tel. +1 301 663 4252 / Fax +1 301 663 0043

## 11th International Beacon Satellite Symposium

11-15 July 1994, Aberystwyth, Wales, UK

The Symposium is the 11th meeting of the URSI Beacon Satellite Group. Members of the IAG Special Study Group 4-140, concerned with tomography of the atmosphere by geodetic measurements, will also participate.

The range of topics will cover all aspects of beacon satellite activity with special emphasis on ionospheric tomography, use of GPS observations, ionospheric efects in geodesy and radio astronomy, and ionospheric variability. Facilities will be provided for a poster session and rooms will be available for small working groups and informal meetings.

Programme Committee

Dr. L. Kersley (UK)
Dr. R. Leitinger (Austria)
Mr. J.A. Klobuchar (USA)
Dr. T. Spoelstra (Netherlands)

Local Organising Committee
Dr. Len Kersley (Chairman)
Dr. Eleri Pryse
Dr. Ian Walker
For further information please contact:

BSS94
Department of Physics, The University of Wales,
Aberystwyth SY23 3BZ, Wales, UK
Tel: + 44 970 622 802/Fax: + 44 970 622 826
e-mail: bss94@aber.ac.uk

## 30TH COSPAR MEETING

### Symposium C.4 : IRI - The High Latitudes in the International Ionosphere Hamburg, Germany, 20-21 July 1994

**Scope:**

Improvement of the description of ionospheric parameters at high latitudes is of highest priority for future updates of the International Reference Ionosphere. Comparisons are encouraged of IRI with ground and space data and theoretical values from the auroral and polar region. Other topics of the meeting will be general comparisons of IRI with new measurements and studies which initiate improvements of all parameters included in IRI.

The meeting will be comprised of invited and contributed papers.

For further information contact:
Dr. W. Singer
Institute of Atmospheric Physics
Schloßstrasse 4-6, 18221 Khlungsborn, Germany
Tel: +49 38293 6855 / Fax: +49 38293 6850

### Symposium D4.1 : Active Experiments in Space Plasmas Hamburg, Germany, 20-21 July 1994

**Scope**:

Active experiments continue to provide powerful diagnostic tools for understanding complex space plasma processes in the ionised regions of the Earth's atmosphere. Experiments involving injection of waves at frequencies ranging from VLF to HF, a variety of charged particle beams and releases of chemicals are conducted all over the world, from ground- rocket- or satellite-based platforms. New improved ground-based facilities are currently being built and first experiments involving in situ injection of VLF waves (i.e. WISP rocket) have now been realised. Examples of relevant topics are VLF-HF wave injection from ground and space, TSS, CRRES (satellite and rocket) and APEX missions.

For further information contact:
Prof. U. Inan
Electrical Engineering Department
Stanford University, Durand 321/STARLab,
MC-4055 Stanford CA 94305, USA
Tel: +1 415 723 4994 / Fax: +1 415 723 9251

### Symposium C1.3 : Processes active at the Ionosphere-Magnetosphere Interface Hamburg, Germany, 16 July 1994

**Scope:**

The ionosphere is a major source of matter for exosphere and magnetosphere. In turn, the ionosphere and plasmasphere are profoundly influenced by inputs from the magnetosphere. for the plasmasphere, the roles played by photoelectron heating, Coulomb interaction with ring current, wave-particle interactions, thermal conduction and plasma flow, require study, particularly under disturbed conditions. Questions also arise on the importance of the various ion acceleration mechanisms and how these relate (in the plasmasphere, auroral and cusp ionosphere) to temperature anisotropies, for example. Observations by radar and satellites (HINOTORI, CRRES) and theoretical studies contribute.

For further information contact:
Prof. R. J. Moffett
Dept. of Applied and Computational Mathematics
University of Sheffield
P.O. Box 597, Sheffield S10 2UN, United Kingdom
Tel: +44 742 824434 / Fax: +44 742 824292

## IV SUZDAL URSI SYMPOSIUM ON ARTIFICIAL MODIFICATION OF THE IONOSPHERE

August 15-19, 1994, Uppsala, Sweden

A first announcement will be distributed shortly.

For further information, please contact :

Dr. Bo Thidé
Swedish Institute of Space Physics
S-75591 Uppsala, Sweden
Tel: + 46 18 30 36 00 / Fax: + 46 18 40 31 00
e-mail: bt@irfu.se

# ANNOUNCEMENTS OF URSI-SPONSORED MEETINGS

## EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION

September 26-30, 1994, Firenze, Italy

SCOPE AND OBJECTIVES

The European Conference on Optical Communication (ECOC) is the major European conference on the technology and use of optical fibres for communications and related systems. In line with its predecessors, the 20th ECOC will provide an international forum for the presentation and discussion of significant new results and of the progresses of research, development and applications of optical communications. Emphasis will be on original, not previously published, contributions for oral presentation and poster sessions. Invited speakers will review current topics emphasising those with a likely impact on emerging fibre systems technology. Post-deadline papers will present new contributions and latest results.

The aim is to cover optical communications and related fields including the following representative topics:

*Fibres, Cables and Fibre Components*
- Fibres, cables, connectors.
- Materials and coatings.
- Strength and mechanical fatigue.
- Splitters, couplers, isolators, mode converters, multiplexers, WDMs and filters.
- Fibre-based lasers, amplifiers and superluminescent sources.
- Hybrid and monolithic integrated waveguide components.

*Integrated Optics and Optoelectronic Integrated Circuits, Devices, Components and Modules*
- Optical sources, detectors, amplifiers, modulators, switches.
- Integrated devices, modules and systems.
- Nonlinear and parametric processes.
- Modelling and characterisation techniques.
- Fibre-waveguide coupling packaging.

*Photonics*
- Optical interconnects.
- Photonic switching, signal processing and computing.
- Optical neural network.
- Optical logic devices, optical memories, ultrafast optics.
- New photonic functions.

*System Technologies*
- Transmitter/receiver design and performance.
- Coherent optical transmission.
- Soliton transmission and non-;linear propagation.
- System aspects and applications of optical amplifiers.
- Analogue and digital multiplexing techniques.
- Direct detection, sub-carrier multiplexing, wavelength division and coherent systems.
- Cable television distribution technologies.
- Theory and modelling of lightwave systems.
- Optical sensor systems.
- Optical free space communication.

*Networks and Switching*
- Telecommunications and cable television networks.
- Local, metropolitan and wide area networks.
- Network architectures and protocols.
- Passive optical networks and loop systems.
- Customer premises optical networks.

SPECIAL EVENT:

At ECOC '94 a joint session will be organised, in cooperation with the "Photonics in Switching" topical meeting, which will highlight the progress in this area.

OFFICIAL LANGUAGE

English will be the official language of the Conference. No simultaneous translation will be provided.

SUBMISSION OF PAPERS

The deadline for submission of papers is March 30, 1994. The conference programme will include a session of post-deadline papers. The papers should reach the ECOC TPC Chairman before August 31, 1994. The acceptance of the post-deadline papers will be announced during the conference.

For further information, contact:

ECOC'94 Conference Secretariat
Franco Bertoldi
Instituto Internazionale delle Comunicazioni
Genova Via Pertinace, Villa Piaggio
I-16125 Genova, ITALY
Tel +39.10.2722383
Fax +39.10.2722183

# ANNOUNCEMENTS OF URSI-SPONSORED MEETINGS

## 1994 Asia-Pacific Microwave Conference (APMC '94)

December 6-9, 1994, Tokyo, Japan

The sixth Asia-Pacific Microwave Conference (APMC'94) will be held at Nippon Convention Center (Makuhari Messe), Japan on December 6-9, 1994. This conference is organized and sponsored by the Institute of Electronics, Information and Communication Engineers (IECE) of Japan, and is co-sponsored by IEEE-MTT-S Tokyo Chapter and is cooperatively sponsored by IEEE MTT-S and URSI Japan Committee.

The main conference topics are listed below:

1. Solid State Devices and Circuits
2. GaAs FET, HEMT, HBT and other Devices
3. Low-Noise Devices and Techniques
4. High-Power Devices and Techniques
5. Microwave and Millimeter Wave Monolithic Circuits
6. High-Speed Digital Circuits
7. Microwave Measurement for Gigabit Devices
8. Opto-Electronic Techniques
9. Microwave and Millimeter Wave Packaging
10. Passive Devices and Circuits
11. Microwave Superconductivity
12. Electromagnetic Field Theory
13. Ferrite Devices
14. Microwave Acoustics
15. Millimeter Wave and Submillimeter Wave Techniques
16. EMC/EMI
17. Scattering and Propagation
18. Microstrip Antennas
19. Measurement Theory and Techniques
20. Computer Aided Design
21. Microwave and Millimeter Wave Systems
22. Microwave Terrestrial, Satellite and Mobile Communication Systems
23. Microwave Industrial Applications
24. Microwave Medical/Biological Applications
25. Phased and Active Array Techniques
26. Remote Sensing

However the above topics should not be considered as the total limits of the conference scope.

Time table:

| | |
|---|---|
| Paper submission deadline : | June 10, 1994 |
| Accepted paper notification : | August 10, 1994 |
| Advance programme delivery : | September 10, 1994 |
| Advance registration deadline : | October 31, 1994 |

For further information please contact:

Prof. Shizuo Mizushina, Chair Steering Committee
c/o REALIZE INC.
2-16-13 Yushima, Bunkyo-ku, Tokyo 113, Japan
Tel: + 81-3-3815-8590, Fax: + 81-3-3815-8939

The URSI Scientific Committee for Telecommunication announces : **COMMSPHERE 95**

## URSI International Symposium on Future Telecommunication and the Electromagnetic Environment

23-26 January 1995, Eilat (by the Red Sea), Israel

COMMSPHERE is an international forum of concerned leading scientists, experts and administrators, for discussion of the future of telecommunications and other Electromagnetic radiation usages in view of the growing congestion of the spectrum.

The conference is structured for 3 days plenary sessions and discussions, half a day multiple workshops and a poster session, and a summary plenary session. Extended summaries will be published at the symposium.

Plenary sessions will consist of both contributed and invited papers. One page summaries should be sent to the secretariat no later than July 1, 1994. Authors will be notified by September 15, 1994. Photo ready manuscripts are due December 1, 1994.

Industries and organizations interested in supporting the conference and/or displaying innovative achievements, should contact the secretariat.

SESSIONS

* Integrated wireless access networks
  Organizer : Prof. Moshe Sidi, EE Faculty, Technion, Haifa, Israel 32000.
  + Services and networks
  + Air interface trade-offs
    Spectral efficiency, cost commensurate with the service, power levels and interference, cell size vs. infrastructure
  + Network architectures
* MSS, LEO and other communication satellites - systems, interference and coordination.

Organizer : Mr. Jacques Dutronc, Head of Future Systems Studies, Eutelsat, Tour Maine-Montparnasse 33, avenue du Maine, 75755 Paris, Cedex, France
Tel. : 33-1-45-38-47-75, Fax 33-1-45-38-47-98
+ Systems and services
+ Network architecture
+ Interconnection with cellular systems
+ Interference and spectrum sharing
+ Terminal standards
+ Regulations, transborder licensing & coordination

* Communication for the developing countries - needs, accumulated experience and opportunities.
Organizer : Prof. S.M. Radicella, International Centre for Theoretical Physics, ICE/ICTP, P.O. Box 586 (Via Beirut 7), TRIESTE, I-34100, ITALY, Tel. (39) 40 2240 331, rsandro@dec3100a.ictp.trieste.it
+ Survey of communication needs in developing countries
+ Experience accumulated - case studies
+ Future plans and opportunities

* Radio astronomy and the EM environment
Organizer : URSI Commission J
+ Tutorial of Radio Astronomy science and tools
+ Radio astronomy coordination with communications and other EM activity

* Spectrum management policies and the future of telecommunications
Organizer : Prof. R.D. Parlow , US Department of Commerce, Nat. Telecom. & Inf. Admin. /Room 4099A, 14th and Const. Av. NW WASHINGTON DC 20230 USA, Tel. (1)202-482 1850
+ Spectral allocations policies and their impacts
+ Spectral coordination and monitoring

WORKSHOPS

* Wave oriented space-time signal processing
Organizer : Prof. L. B. Felsen

* Radiation Hazards of Personal and Cellular Communication / Organizer : Prof. Paolo Bernardi

* Advanced and appropriate technology for telecommunications in developing countries
Organizer : Prof. S.M. Radicella

Conference Chairman : Joseph Shapira

Organizing committee : L. Barclay, P. Delogne, J. Shapira

Local organizing committee
Chairman : Dr. Rafael Kastner, Department of Electrical Engineering - Physical Electronics, Tel Aviv University, Tel Aviv 69978.

Organizational support : Mr. Rafael Hoyda, Head, EM Spectrum branch, Israel Ministry of telecommunications, 9 Ahad Haam Str. Tel Aviv Israel, Tel. 972 3 5198 281

Conference secretariat :
KENES, P.O. Box 50006, Tel Aviv, Israel
Tel. : 972 3 514 0014
Fax : 972 3 517 5674 or 972 3 660 325

## EMC Zurich '95

March 7 - 9, 1995, Zurich, Switzerland

The 11th International Zurich Symposium and Technical Exhibition of Electromagnetic Compatibility will be held in March 1995. It will again be hosted by the Federal Institute of Technology in Zurich, Switzerland.

Symposium Organisation:

Prof Dr P Leuthold, Zurich (Symposium President); Prof Dr W Zaengl, Zurich; Prof Dr F L Stumpers, Eindhoven (Vice-Presidents); Dr G Meyer, Zurich (Symposium Chairman); Prof Dr C R Paul, Lexington (Technical Program Chairman); Dr B Szentkuti, Berne (Technical Program Vice Chairman); H A Kunz, Luterbach (Exhibition); Dr U Kaiser, Fribourg (Publicity); Prof Dr M Ianoz, Lausanne (Joint Events) – to be extended.

Programme:

Approximately 130 papers organised in thematic sessions; tutorial lectures; workshops; open meetings. The lectures will be published in a symposium proceedings.

Language:

The official language of the symposium is English.

Exhibition:

60 – 70 booths

Events:

Technical excursions; social program.

Place:

The symposium will be held at the Swiss Federal Institute of Technology. Zurich is a nice modern city in the centre of Europe and within easy reach of many renowned alpine tourists resorts.

Information:

Dr Gabriel Meyer, Symposium Chairman
ETH Zentrum – IKT, CH-8092 Zurich, Switzerland
Tel. : +411 632 2790 / Fax ; +411 262 09 43
e-mail: gmeyer@nari.ikt.ethz.ch

# ANNOUNCEMENTS OF URSI-SPONSORED MEETINGS

## 1995 International Symposium on Electromagnetic Theory

23-26 May 1995, St.Petersburg, Russia

The 1995 URSI Commission B Symposium will be held from 23 to 26 May 1995 in St.Petersburg, Russia. This will be the 15th Electromagnetic Symposium which has been organised by URSI. If you are interested in electromagnetic theory and its applications, you are invited to offer a contribution and participate in the Symposium.

The triennial symposium on electromagnetic theory is organised by Commission B (Fields and Waves) of the International Union of Radio Science (URSI). It will cover progress in all areas of electromagnetic theory. Contributions are requested describing original work in the following topics :

Antennas
Canonical problems
Complex and random media
Guided waves and microwave circuits
High frequency techniques
Inverse problems
Mathematical methods and ill-posed problems
Non-linear media
Novel numerical techniques
Numerical differential and integral equations
Numerical hybrid methods
Parallel processing techniques
Periodic structures
Rough surfaces
Scattering and diffraction
Transient phenomena
Theoretical electromagnetics

A synopsis should be mailed to arrive no later than 15 September 1994. It must be limited to one sheet of paper utilising both sides if desired. Multiple sheets will not be handled. Synopses should summarise the intended contents of the paper so that the Technical Programme Committee can evaluate the technical contribution of the paper. Authors are requested to start the first side with the title, followed by the names of authors and a contact address, fax and e-mail number (if available). Please send 5 copies of the synopsis.

All synopses must be received no later than 15 Sept. 1994.

Address for synopses for authors outside the former Soviet Union:

Prof. A D Olver, Dept. of Electronic Eng.
Queen Mary & Westfield College
Mile End Road, London E1 4NS, United Kingdom
Fax: +44 81 981 0259, E-mail: a.d.olver@qmw.ac.uk

Address for synopses for authors in the former Soviet Union:

Prof. V S Buldyrev, Dept of Math. Physics
Institute of Physics, University of St.Petersburg
1 Uljanovskaja Ave, Petrodvoretc 198904, Russia
Fax: +7 812 428 6649 or +7 812 428 7240
E-mail: bvs@onti.phys.lgu.spb.su

Synopses will be evaluated by the Technical Programme Committee and authors will be informed of the result in early November. To avoid the problem of a small minority of authors who submit papers but do not attend the Symposium, at least one author per paper will be required to register by 1 March. March 1 is also the deadline for the camera-ready copy of the full paper to be received in London or St.Petersburg.

A number of URSI Young Scientist Awards will be available. Please indicate when submitting a Synopsis that you wish to be considered for an Award.

Please distribute this Call for Papers widely and make copies as required. To be included in the mailing of the final programme, fax or e-mail your name and address to one of the contact addresses.

Timetable for the Symposium :

| | |
|---|---|
| 15 September 1994 | Final date for submission of Synopses |
| November 1994 | Notification of accepted papers and details of format full paper |
| 1 March 1995 | Pre-registration for at least one author |
| 1 March 1995 | Final date for receipt full paper |
| 23-26 May 1995 | Symposium |

Technical Programme Committee :

A D Olver (UK) - Chairman
C M Butler (USA) - Vice-Chairman

| | |
|---|---|
| S Adachi (Japan) | J Arnold (UK) |
| V Buldyrev (Russia) | P Edenhofer (Germany) |
| F Gardiol (Switzerland) | G James (Australia) |
| R Kleinman (USA) | I Lindell (Finland) |
| M Ljalinov (Russia) | D R Wilton (USA) |

St.Petersburg Organizing Committee :

V S Buldyrev - Chairman
V E Grikurov - Secretary

The working language for the Symposium will be English. Papers will be presented in both oral and poster sessions. Some topics may be chosen exclusively for the poster format.

# OTHER MEETINGS BROUGHT TO OUR ATTENTION

## 1994 International Display Research Conference
## International Workshop on Display Materials
## International Workshop on Active-Matrix LCD's

October 10-13, 1994, Monterey, California

The Society for Information Display
The Advisory Group on Electron Devices
in cooperation with the IEEE Electron Devices Society
organize this conference and these workshops at the Hyatt Regency Hotel, Monterey, California.

The 14th Annual International Display Research Conference (IDRC'94) and the International workshops on Display Materials and Active-Matrix LCD's will be held in Monterey, California (located 90 miles South of San Francisco) on October 10-13, 1994.

Research and fundamental development aspects of display technology and related human-interface issues will be emphasized. Leading contributors to display research are encouraged to attend for an intensive exchange of ideas through formal and informal discussions stimualted by the natural beauty of the scenic Monterey Peninsula. In keeping with this emphasis and tradition, there will be no commercial exhibition of equipment. Authors are encouraged to bring operating displays to the author interview sessions which will be scheduled to facilitate direct discussions between attendees and authors of presented papers. Parallel sessions will be minimized.

New phenomena and concepts are one of the distinguishing features of this conference - IDRC is an ideal forum for presenting new concepts in display technology and for discussing their potential impact. Increased emphasis will be placed on electronic display materials and active-matrix LCD's through the Internationa Workshops to be held on October 10-11, 1994. The first day of the Workshops consists of invited papers and discussion sessions. Contributed Workshop papers will be included in the first day of the main conference, October 11-13, 1994. A unique format has been developed which will afford attendees the opportunity to participate in either the Workshops, the IDRC or both.

For further information please contact:

International Workshop on Display Materials
Dr. Zvi Yaniv, Workshop Chairman
Advanced Technology Incubators
1-313-737-9132

International Workshop on Active-Matrix LCD's
Prof. M.K. Hatalis, Workshop Chairman
Lehigh University
1-215-758-3944

Or for general information:
Ralph Nadell
Palisades Institute for Research Services, Inc.
201 Varick Street, Suite 1006
New York, NY 10014, USA

## 3rd International Conference on Intelligence in Networks (ICIN)
## 3eme Colloque International sur L'Intelligence dans les Reseaux

11 - 14 October 1994, Bordeaux, France

Sponsored by ITU, the International Telecommunication Union

Organized by SEE , IREST, ADERA

Supported by France Telecom

Contact address :
Sectretariat :
ADERA, B.P. 196
F-33608 PESSAC CEDEX, FRANCE
Tel. (+33) 56 15 11 56 or (+33) 56 15 11 58
Fax (+33) 56 15 11 60

# OTHER MEETINGS BROUGHT TO OUR ATTENTION

## International Conference on Spacecraft Propulsion

November 8-10, 1994, Toulouse Labège, France

The Centre National d'Etudes Spatiales (CNES, the French Space Agency) and the European Space Agency (ESA) are organizing this conference.

This is the first time a conference has been organised on this subject by two European space organisations. It will provide specialists with an opportunity to review recent progress in propulsion engineering and technology, and to share experience.

The symposium is organised as a set of technical sessions covering chemical and electric propulsion of spacecraft, excluding launch vehicles.

Chairperson:
A. Letraublon
CNES, Toulouse, France

Please send abstracts (French or English) to
Corinne Leroy
Carte Blanche
19 Rue Mahuziès
81100 Castres, France
Tel: + 33 63 723 100
Fax: + 33 63 723 032

The deadline for submission was 30 April 1994.

## Second Regional Geodesy and Geophysics Assembly in Africa

November 14-25, 1994, Ibadan Nigeria

International Commission for earth sciences in Africa (ICESA)
Commission Internationale pour les sciences de la terre en Afrique (CISTA)

The scientific Programme consists of several scientific sessions, including:

- Geodetic and Gravity Network and the African Plate
- Geomagnetic, Electromagnetic Induction and the African Plate
- Seismology and the African Plate
- Surface and Groundwater Sources in Africa
- Meteorology in Africa
- Atmospheric Physics and the Ozone Layer
- The Oceans and the African Plate
- Volcanism in Africa
- Pre-Cambrian Evolution and Metallogenic Provinces in Africa
- Rift Systems in Africa
- Appropriate Technology for Geophysical and Astronomical Instrumentation in Africa
- Satellite Data Acquisition and the Earth Resources of Africa
- The Energy Resources of Africa from below and above the Earth
- Satellite Communication System in Africa and the International Decade for Natural Disaster Reduction

*Timetable:*

Second announcement : April 28th, 1994

Deadline for receipt of abstracts : May 28, 1994

Deadline fior return of preliminary registration forms: August 15, 1994

Payment of registration fees / accomodation : August 15, 1994

Deadline for submission of full papers : November 15, 1994

Publication of refereed proceedings : July 15, 1995

*For further information, please contact:*
LOC of ICESA Scientific Assembly
ICESA International Secretariat
P.O. Box 22383
University of Ibadan Post Office
Ibadan, Nigeria

# ANNUAL REPORT OF IUWDS FOR 1993

by Richard Thompson, IUWDS Chairman
IPS Radio and Space Services
PO Box 5606
West Chatswood NSW 2057 Australia
Tel: + 61 2 414 8325 / Fax + 61 2 414 8331
Telex : AA20663 / e-mail: richard@ips.oz.au

## 1. Introduction

The International Ursigram and World Days Service (IUWDS), a joint service of URSI, IAU and IUGG and a permanent service of the Federation of Astronomical and Geophysical Data Services (FAGS), provides rapid information to the world community to assist in the planning, coordination and conduct of scientific and other work affected by the sun-earth environment.

Three basic mechanisms have been selected to accomplish this program. Firstly, IUWDS prepares the International Geophysical Calendar each year. This calendar gives a list of "World Days" which scientists are encouraged to use for carrying out their experiments. the calendar is prepared for IUWDS by the World Data Center-A Solar Terrestrial Physics in Boulder, USA. The calendar is distributed widely to the scientific community and is also published in a number of Journals and other publications.

Secondly there is the International Ursigram Service for assisting those who need a specific state of solar activity, earth atmosphere or magnetosphere at the time of their experiment. Both programs are designed to be very flexible and can be easily adjusted to fit the needs of the scientific community.

Thirdly IUWDS arranges Solar Terrestrial Prediction Workshops bringing together scientists, solar terrestrial forecasters, and users of forecasts to advance the science of forecasting. Such workshops were held in Boulder (1979), Meudon near Paris (1984), Leura near Sidney (1989), and Ottawa (1992). Each workshop resulted in a collection of papers - the Workshop Proceedings - being published and becoming important reference material for the field.

In addition, on behalf of COSPAR, each month IUWDS summarises the status of satellite orbits around the earth and of space probes in the interplanetary medium in the Spacewarn Bulletin. Future launches are announced, actual launches are reported, new satellites receive an international designation, decays in the earth atmosphere are predicted and announced, and finally series of satellites useful for international participation are listed. This bulletin is produced by the World Data Center-A for Rockets and satellites located at the Goddard Space Flight Center in Greenbelt, USA.

The present solar cycle proved to be very active in its early stages, both in terms of sunspot number and in the frequency of severe disturbances to the sun-earth environment. This activity, combined with the increasing sensitivity of modern technology, has emphasised the relevance and importance of the services co-ordinated by IUWDS.

## 2. The International Ursigram Service

The International Ursigram Service operates through a number of Regional Warning Centers (RWC) scattered all around the world. Warning Centers are located in Beijing (China), Boulder (USA), Moscow (Russia), Paris (France), New Delhi (India), Ottawa (Canada), Prague (Czech Republic), Tokyo (Japan), Sydney (Australia) and Warsaw (Poland).

In its own geographic area, each RWC collects all the data and reports available concerning the state of the sun-earth environment. In some cases, these come from observatories operated directly by the Regional Warning Centre. In many cases, they are gathered from regional scientific institutes and universities.

These data and reports are coded according to the IUWDS code book and distributed daily, on request to users and to other RWCs. data exchange is generally via a daily, or more frequent, message sent either by electronic mail, facsimile transmission or telex. Electronic transfer of data is also used to relay larger image files.

Information transmitted through the IUWDS network is analysed by Regional Warning Centres which produce a number of "summary" reports and forecasts. The "Geoalert", a forecast of solar-geophysical conditions for the next few days, is a particularly important one of these reports. each RWC prepares its own forecast ("Geoalert") and sends it to the World Warning Agency (WWA) in Boulder each day. The WWA then issues a Geoalert which is distributed worldwide each day at 0300 UT through the IUWDS network. Many RWCs also relay the WWA Geoalert to users within their own region.

## 3. Publications

The International Geophysical Calendar is distributed free of charge throughout the world. the present distribution is approximately 2000 copies produced at nominal cost.

The Spacewarn Bulletin is also distributed free of charge throughout the world and the information is now available through an electronic bulletin board system.

The Geoalerts and the abbreviated Calendar records are published monthly in "Solar and Geophysical Data" pro-

duced and distributed by World Data Center-A for Solar Terrestrial Physics in Boulder, USA.

The daily Geoalerts and URSIgram messages, distributed daily by telex, are "real-time" information. these are obsolete after a few days and only a summary is printed as the IUWDS Alert Periods" in the Solar-Geophysical Data Books published by World Data Center-A. However, the production and distribution of Ursigrams is a very important part of the current expenses of the RWCs. This expense is borne by the host institutions.

The IUWDS Code Book has been updated and reprinted in a loose leaf format. Further updates occur on a regular basis as new codes are introduced or existing ones are changed. The updates are supplied to RWCs for distribution as required.

## 4. IUWDS Activities during 1993

4.1. Proceedings of the Ottawa Solar Terrestrial Predictions Workshop in 1992

Work has continued on the collection of papers from the IUWDS Solar Terrestrial Predictions Workshop held in Ottawa during 1992. This work has been done by Hruska from the Ottawa Regional Warning Center, Heckman from WWA in Boulder, and Shea and Smart from the Geophysics Directorate of the US Philips Laboratory. The Proceedings are being printed and will be available in early 1994.

4.2. The Next Predictions Workshop

The strong interest in Solar-Terrestrial Predictions Workshops have encouraged IUWDS to continue to arrange these meetings. IUWDS has accepted an offer from the Tokyo RWC to host the next "Predictions" meeting in Japan. This meeting is likely to be held in the Tokyo area during 1996.

4.3. Data Exchange

Exchange of data within IUWDS has undergone a dramatic change over he past few years. Whereas information was previously transferred between centres in coded format by telex, all centres now have access to rapid exchange of larger volumes of information via electronic data networks such as Internet. This resulted in a greater diversity of data exchange with each centre able to send information and forecasts to all other centres. the range of information being exchanged is also increasing with greater emphasis on raw or image data. In addition there is an increasing amount of valuable data available from electronic bulletin boards, both from IUWDS and non IUWDS sources.

Several IUWDS centres have been given special access to daily X-ray images of the sun produced by the Japanese Yohkoh satellite. These proved extremely valuable by providing information on the size and the location of solar coronal holes which are an important source of solar terrestrial disturbance. The images have also given advance notice of the return of larger, potentially flare-producing, regions to the visible face of the sun.

4.4 Wider Membership of IUWDS

Discussions are taking place on increasing the membership of IUWDS to include a wider geographical spread. In particular, IUWDS would like to include membership from areas such as South America and South Africa.

Negotiations have taken place on expanding the membership of IUWDS in regions, such as the Czech Republic, where several institutes are interested in its activities.

4.5. IUWDS Code Book

A new version of the IUWDS Code Book was produced during 1993 and distributed to Regional Warning Centres and other interested parties. The code book is the basis by which a wide range of solar, geomagnetic and ionospheric observations are compressed into a computer readable format. The work in updating the code book was coordinated by the Boulder Centre.

4.6. Search for a New Name for IUWDS

IUWDS is seeking a new name which better expresses the diversity of the information provided by the service. many suggestions have been made and a decision will be made at the next IUWDS Steering Committee meeting.

4.7. Next IUWDS Steering Committee Meeting

The next meeting of the IUWDS Steering Committee will be held in conjunction with the COSPAR Congress in Hamburg, Germany in mid 1994.

The present list of IUWDS officers and representatives is as follows:

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# The Radioscientist

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The Editor reserves the right to accept, reject, defer and/or edit any material and all material submitted. Accepted papers are not necessarily published in the immediately-following issue.

# THE EDITOR'S PAGE

## Editorial

Welcome to this very first issue of the new *Radioscientist & Bulletin*! You will find the "look and feel" is much the same as the old *Radioscientist* though there are some things different quite apart from the size (already over twice) which is intended to be about 80 pages eventually. These are explained on the *Radioscientist & Bulletin* masthead (page ii, inside front cover).

The role of the seven listed Associate Editors is to invite articles for publication. Unsolicited contributions are best sent direct to me since all material has to come to me in the end any way. Exceptions are the Associate Editors for Reviews who will be pleased to hear from anyone wishing to review books (you get to keep the book!). Please remember that all *Bulletin* contributions (reports from Commissions and Member Committees, notices of forthcoming meetings, etc) must be sent to the URSI Secretary General. Any such material sent to me will be passed on to him.

All articles in the new *Radioscientist* are refereed (1-3 referees, depending on content) — even book reviews are checked by the Review Editor. Articles invited by the Associate Editors are accepted by them, when in final form, on the recommendation of referees they appoint. The refereeing process can take considerable time so there is little point in setting deadlines for authors. Contributions are welcome at *any* time, but may not be published in the next possible issue. Previously published material, or material simultaneously submitted elsewhere, *must* be identified by the author who needs to present an adequate case for republication. If the case is accepted, written copyright releases are then required.

Two articles submitted for this issue were withdrawn by the authors who were unable or unwilling to meet the requirements of the referees. Articles will not be rejected merely because they are controversial — I can think of three in this issue which might upset someone — but we, the editors, cannot be held responsible for the opinions and statements by authors which go unchallenged by the referees.

**Scanning the issue:** This looks like being a bumper year for historical articles on turn-of-the-century radio. The first, in this issue, is on Oliver Lodge. Future issues will include the cooperative work of Marconi and Fleming and the work of the Canadian, Fessenden.

*N Rays* ... by Karl Stephan was previously published in the *IEEE Antennas and Propagation Magazine* (**35**, #3, June, 1993). I know of two instances in very recent times, which I would not dare identify, where scientists have achieved publication of similar "science".

The two papers on chirality by Fedorov and by Guerin *et al.*, respectively, one theoretical and one experimental, were chosen from those presented at the Gomel meeting in October, 1993, by Associate Editor Ari Sihvola who also wrote the introduction. Chirality is a hot topic in electromagnetism and you will see more in the next issue.

The *INSPIRE* project shows how high-school students can be fired up by, and do real research in, radioscience for little outlay. Anyone interested in extending the principles to other parts of the world is welcome to write to the author (who, by the way, is Co-editor of the *electronic URSI NEWS*).

Is anyone out there in a position to "test drive" radioscience equipment and write up the results for the *Radioscientist* as an independent? Included in this issue is a description of the IPS–71 ionosonde. The author is also the maker, but any competitor is welcome to describe *their* product in a similar way on these pages.

**Richard L Dowden**

## Letter to the Editor

I was fortunate enough to have received a 1993 URSI Young Scientist Award which provided me with the opportunity of attending and presenting a technical paper at the recent General Assembly held in Kyoto, Japan, 25 August – 2 September 1993. Without the financial support provided by this award, it would not have been possible for me to attend this conference. I would like to express my gratitude to all those involved in making this award possible. I would especially like to thank the Secretary General, Professor J Van Bladel, and the President of URSI, Professor E V Jull, for their efforts on behalf of the Young Scientist program. I also wish to express my appreciation to the Japanese organisers of the Assembly who provided all the Young Scientist awardees free room and board in Kyoto. My stay at the Higashifama Youth Hostel in Kyoto was very enjoyable and provides a unique opportunity to interact with other Young Scientists from all around the world. Finally, I would like to acknowledge the supplemental financial support provided by the US National Committee of URSI to help defray the cost of travel to the General Assembly.

**Douglas H Werner**

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# N Rays, Super-Dielectrics, and Microwaves Faster than Light: Improbable Discoveries in Electromagnetics

**Karl D Stephan**

*Department of Electrical and Computer Engineering, University of Massachusetts, Amherst, MA, USA.*

When a researcher publishes experimental results that challenge generally accepted physical laws, one of two things can happen. If other experimenters confirm the discovery, the discoverer receives glory and honour as the trailblazer into a new field of knowledge. But if independent experiments fail to confirm the researcher's unorthodox claims, the wheels of the scientific method eventually roll on by, to leave the alleged discovery in the dust of history. Essential in either case is a good-faith attempt by independent workers to verify the claimed results. In this article, I will describe two historical incidents of false "discoveries" by sincere, reputable researchers in electromagnetics. I will show how each case was finally resolved by a visit to the researcher's own laboratory. And I will conclude by describing the ongoing controversy surrounding recent claims that, under certain conditions, microwave signals can travel faster than the speed of light in a vacuum.

## 1. Blondlot and the N rays

When Roentgen discovered X-rays in 1895, he set off a flurry of activity in the scientific community. His was a truly fundamental discovery, verified and enlarged upon by many researchers, including a professor of physics at the University of Nancy named René-Prosper Blondlot [1]. It was Blondlot who showed that the mysterious penetrating rays were, in fact, electromagnetic in character. But the great honour of the newly established Nobel Prize in physics, for 1901, went to the groundbreaking Roentgen.

In the fall of 1903, Blondlot announced the discovery of "a new ray, which he called N ray, with properties far transcending those of the X rays" [2]. (I have been unable to discover his reasons for choosing the letter N.) Unlike X rays, whose generation required expensive evacuated tubes and high-voltage induction coils, N rays were emitted by ordinary metals, or so Blondlot claimed. Here was a triumph every French citizen could be proud of, and French scientists lost no time in getting on the N-ray bandwagon. Within weeks the French Academy's premier scientific journal, *Comptes rendus*, was publishing paper after paper on N rays. These rays were apparently shown to enhance the eye's ability to detect light in a dim room. Living tissues, including the human body, were alleged to emit N rays. Jean Becquerel, the son of the famed discoverer of radioactivity, Henri Becquerel, claimed to show that N rays were conducted along wires. He did this by passing a wire over the skull of an anaesthetised human subject, while he watched for variations in brightness of a luminous thread at the other end of the wire. By the following summer, at least fifty papers on N rays had been published, although most of them came from the busy pens of only three researchers: Blondlot himself, Jean Becquerel, and an expert in hypnotism named A. Charpentier. Blondlot's fame seemed assured when the French Academy announced that he would receive its 20,000-franc Lalande prize for the discovery of N rays [3].

Outside France, however, all was not well. The rays seemed to have a curious respect for the French border. They refused to venture beyond it, even as far as the neighbouring country of Germany. All the papers confirming the N rays were by Frenchmen. The Kaiser, not content to be upstaged by French scientists, had commanded a Professor Rubens, of Berlin, to come to Potsdam and demonstrate the new rays. But Rubens, along with colleagues in England and the United States, had failed utterly to reproduce any of the results claimed by Blondlot and his countrymen. It is at this point that my source for this history enters the picture. As with most histories, this one was written by the victor. The uncomfortable but necessary task of getting to the bottom of the N-ray controversy fell to Professor Robert W. Wood, of Johns Hopkins University, from whose biography this story is taken.

Wood was a well-known experimental physicist. His careful research, describing anomalous spectra in the vapours of sodium and other elements, challenged the received spectroscopic wisdom of the day, and led theorists along paths that converged, two decades later, in the theory of quantum mechanics. In September of 1904, Wood was in Cambridge, England, attending a meeting of the British Association for the Advancement of Science. After the meeting, an informal conference was called to discuss "what was to be done about the N rays" [4]. Blondlot had, by that time, gone so far as to measure lines in the N-ray spectrum, by using a block of solid aluminium as a prism. Wood might not know much about N rays, but he knew all about spectroscopy. The group in England concluded that the only way to find out what was really going on was for someone to visit Blondlot, and witness the experiments first-hand. Wood was reluctant at first, but agreed to go after Rubens told him, "...you are an American, and you Americans can do *anything*..." [5] (and get away with it, presumably.) The rest of the story is best told in Wood's own words:

"[I met] Blondlot by appointment at his laboratory in the early evening. He spoke no English, and I elected German as our means of communication, as I wanted him to feel free to speak con-

fidentially to his assistant....

"He first showed me a card on which some circles had been painted in luminous paint. He turned down the gas light and called my attention to their increased luminosity when the N ray was turned on. I said that I saw no change. He said that was because my eyes were not sensitive enough, so that proved nothing. I asked him if I could move an opaque lead screen in and out of the path of the rays while he called out the fluctuations of the screen. He was almost 100 per cent wrong and called out fluctuations when I made no movement at all, and that proved a lot, but I held my tongue....

"But the crucial and most exciting test was now to come. Accompanied by the assistant, who by this time was casting rather hostile glances at me, we went into the room where the spectroscope with the aluminium lenses and prism was installed. In place of an eyepiece, this instrument had a vertical thread, painted with luminous paint, which could be moved along in the region where the N-ray spectrum was supposed to be by turning a wheel having graduations and numerals on its rim....Blondlot took a seat in front of the instrument and slowly turned the wheel. The thread was supposed to brighten as it crossed the invisible lines of the N-ray spectrum. He read off the numbers on the graduated scale for a number of the lines, by the light of a small, darkroom, red lantern. This experiment had convinced a number of sceptical visitors, as he could repeat his measurements in their presence, always getting the same numbers....I asked him to repeat his measurements, and reached over in the dark and lifted the aluminium prism from the spectroscope. He turned the wheel again, reading off the same numbers as before. I put the prism back before the lights were turned up, and Blondlot told his assistant that his eyes were tired. The assistant had evidently become suspicious, and asked Blondlot to let him repeat the reading for me....As soon as the light was lowered, I moved over towards the prism, with audible footsteps, but *I did not touch the prism.* The assistant commenced to turn the wheel, and suddenly said hurriedly to Blondlot in French, "I see nothing; there is no spectrum. I think the American has made some *dérangement*." Whereupon he immediately turned up the gas and went over and examined the prism carefully. He glared at me, but I gave no indication of my reactions. This ended the seance, and I caught the night train for Paris." [5]

When Wood surreptitiously removed and replaced the prism, he revealed the subjective nature of the experimental results. Clearly, the brightening effect appeared only when the experimenter knew it should appear, not when the physical environment was supposed to produce it. The following day, Wood wrote a letter to *Nature*, in which he expressed "...a very firm conviction that the few experimenters who have obtained positive results have been in some way deluded" [5]. His letter also describes photographs submitted by Blondlot as evidence for the brightening of electric sparks illuminated by N rays. Wood pointed out that even these photographs were exposed by the hand of the experimenter, whose subconscious desire to astound the world must have subtly altered the exposure time to intensify the right images.

The publication of Wood's letter pricked the N-ray balloon. A semi-popular French journal, *La Revue Scientifique*, published a translated version of the letter, and asked a broad cross-section of French scientists to submit their opinions on N rays. N rays lost, forty to six. When Blondlot attended the annual meeting of the French Academy the following December, he found that he was receiving the Lalande medal, not for N rays, but "for his life work, taken as a whole" [7].

This story has a sad epilogue. While Wood went on to greater fame, receiving many awards for his work in spectroscopy and colour photography, Blondlot's scientific life was over. He eventually became insane, and Wood's biographer speculates that the exposure of his last "discovery" might have contributed to his descent into madness. But by all accounts, he was in full possession of his faculties during the N-ray experiments, and no one ever accused him of bad faith. While Wood could have debunked the N rays more diplomatically, he deserves credit for investigating the matter until it was resolved in an objective, scientific fashion.

## 2. Joffe and the super-dielectric

We now move ahead to 1927. The Marxist government of the Union of Soviet Socialist Republics had survived for a decade, but not without severe economic disruptions and widespread food shortages. Under pressure to prove to the capitalist world the superiority of communist industrial and technological methods, in October, the Communist Party's Central Committee ordered the drafting of a master Five-Year Plan for the economy, the first of many. Any invention that would help the Soviet Union reach its ambitious goals for industrial development would be prized by the leadership, and its inventor rewarded handsomely. As in France after the German discovery of X rays, a sense of national prestige at stake pervaded the scientific community of the USSR.

It was in this tumultuous time that Professor Abram Fedorovich Joffe, of the Polytechnic Institute of Leningrad, discovered something that he believed would revolutionise the electric-power industry. Joffe was already well known for his research in the physics of crystals. On the strength of his reputation, he obtained a hearing at the Massachusetts Institute of Technology, and travelled to Boston to give a seminar on his theory.

His host was a faculty member named Vannevar Bush, to whose autobiography I owe much of the following information [8]. No mere ivory-tower researcher, Bush always had his nose in the air for practical applications of new ideas. A few years earlier, he had played an essential role in the founding of Raytheon Corporation, and he would later head the US Office of Scientific Research and Development, during World War II. Joffe was a guest at Bush's home, where he impressed Bush as "...dignified, genial, modest, generously inclined, intellectually honest beyond any doubt" [9]. This favourable impression was to play an important

role in what followed.

Joffe spoke at MIT on theories of electric conduction in solids, a poorly understood area at a time when quantum mechanics was still in diapers, so to speak. Bush describes the lecture thus: "[Joffe] expounded his theory, and then, to my amazement, told how it could be applied to make an insulating material of far greater dielectric strength than existing materials. This woke me up in a hurry, for, if what he described was correct, it would revolutionise the design of electric machinery and power cables" [10]. Bush acted quickly. He got in touch with some investor friends of his, who took out an option to buy the American-patent rights to the invention. Before returning to the USSR, Joffe provided Bush with test results and other documents confirming his discovery.

The next thing to do, of course, was to see how well the results could be duplicated. Over the next several weeks, Bush set up experiments to check Joffe's results. They failed! Bush was in a quandary. He asked himself, "What next? Was I to question the great Joffe? Where had I made my error? The result was that I went to Russia to check on the spot" [11]. Bush went straight to Joffe's institute in Leningrad. After listening to Joffe in more detail and studying his experiments, Bush realised that the theory was just plain wrong. But how could a fallacious idea survive repeated tests and examination by a group of otherwise-rational individuals? Bush found a clue to the mystery one day, as he stood talking to Joffe in a corridor. Here is how he describes it:

"An oldish man with full beard and piercing eyes came bounding up the stairs two steps at a time. When he came behind Joffe he froze in position and waited, until I called Joffe's attention to him. Then he showed some samples and a sheet of computations, and talked about them excitedly. Joffe evidently said something kind to him, for he beamed and then bounded down again to his cubicle. Fanaticism, utter devotion! The sad fact was that, whenever a worker obtained a result that supported the theory, he reported it with exultation. If he obtained a contrary result, he knew he must be wrong.... [Joffe] was isolated from criticism by his very eminence, and hungry for the give and take which is an essential part of real progress." [12]

Bush found himself in a delicate situation, which he pondered as he rode with Joffe on the train back to Moscow. To cause Joffe to lose face before the world-scientific community was unpleasant in any case. But in the highly charged political atmosphere of the Soviet Union, a fall from grace could have painful, even fatal, consequences. Bush had a frank discussion with Joffe on the train, pointing out errors in his reasoning. True to his character, Joffe generously admitted his mistakes, and thanked Bush for finally providing the independent, objective evaluation he had needed for so long. Before his departure from Moscow, Bush offered to keep his report on Joffe's work quiet until Joffe could move on to other things. In contrast to Blondlot, whose reputation was irreparably damaged by the N-ray affair, Joffe changed direction successfully, and enjoyed a lengthy and honourable career in solid-state research, gaining membership in the USSR Academy of Sciences, and receiving the Stalin Prize in 1942.

But just as Wood had to visit Blondot's laboratory, Bush had to go halfway around the world to see Joffe's isolation, and how it worked to engender the same kind of entirely innocent but effective self-deception that produced N rays. Armchair theorising wouldn't do.

## 3. Ishii and the "c/cos$\theta$" effect

We now come to a controversy that, as April of 1993, has not yet been resolved, at least to the satisfaction of all. The central figure is Thomas Koryu Ishii. A full professor at Marquette University, in Milwaukee, Wisconsin, he has a distinguished record of over 300 publications, spanning a period of thirty-five years. According to a recent biographical note [13], he has performed research in "...millimetre-wave and microwave ferrite devices, thermionic and solid-state devices, circuit components and transmission lines, and applications of microwaves, millimetre waves, and quantum electronics." He is the author of a book on microwave engineering that has gone through two editions [14]. And for his contributions to engineering education, he received the IEEE Centennial Medal Award, in 1984. Clearly, here is someone who knows whereof he speaks, whether it concerns microwaves, solid-state physics, or a host of related topics. It was this distinguished individual whom I met, on a rainy fall day in September of 1989 at the Dragon Spring Hotel, on the western edge of Beijing.

That week, I was attending the Second International Symposium on Recent Advances in Microwave Technology, and the first paper in the session that day was on "Wavefront Detection of Non-TEM Microwaves," presented by Prof. T. Koryu Ishii [15]. I confess that after a lapse of three years, I cannot recall many details of Ishii's talk. What I do remember, however, is receiving the distinct impression that he claimed to be measuring microwave signal propagation that was faster than the speed of light. "Surely that isn't what he meant," I said to myself.

During the discussion period that followed, at first it seemed that our polite Chinese hosts were reluctant to pursue such a potentially embarrassing line of inquiry. But finally, someone in the audience asked Ishii point-blank whether he was claiming to measure signals that travel faster than $c$, the speed of light in a vacuum.

Yes, came the response, that is exactly what he meant.

"Didn't he realise what implications this had for little things like the theory of relativity?" the questioner wanted to know.

Yes, Ishii understood that there might be far-reaching consequences of his work, but there the experiment was, and he stood behind it.

Later on during the conference, Ishii and I went on some tours together. I believe we were among the first tourists to gain admission to Tiananmen Square, after the events of the previous June. He appeared to be very modest and unassuming, and not at all like someone who was single-handedly attempting to overthrow ninety years of received wisdom in physics. Somehow I could not bring myself to ask him more about his singular paper.

It turned out that the talk I witnessed was not the first time Ishii had attempted to bring his ideas on the speed of microwave signals to the attention of a sceptical technical community. As far back as 1985, he had written a paper called "Theory of Delay Time Reduction in Deep Space Communications," and submitted it for presentation at a conference in Amman, Jordan [16]. This work was apparently not accepted, when the conference committee realised the one thing that the title could mean. In the 1989 edition of his microwave-engineering textbook, he devoted three pages to the rather unorthodox, but still legitimate, idea of the phase velocity of electromagnetic waves in free space [17]. Defining a direction at an angle $\theta$ to the direction of wave propagation, he observed that the apparent velocity of the wavefronts, along the defined direction, is the phase velocity, $v_p = c / \cos\theta$, where $c$ is the velocity of light. As $\theta$ increases from zero, the phase velocity rises beyond the speed of light, an apparent contradiction of Einstein's theory of special relativity. But Ishii, perhaps not wishing to break with the rest of the world quite yet, stopped short of claiming that any intelligence could be transmitted at velocities greater than $c$.

Clearly, by 1989 he had lost any such inhibitions. The following spring, it appears that Ishii and a graduate student of his, named George C. Giakos, gave a series of seminars at Marquette University that must have made the Beijing talk look tame by comparison. These seminars had tantalising titles, like "Paradoxes in Electromagnetic Field Propagation" [18], "Non-Prearranged and Prearranged Communication" [19], "Ultra-Relativistic Microwaves in Open Space" [20], and "It Moves Faster than Light" [21]. At the same time, they were submitting articles on their discoveries to refereed technical journals. After what was undoubtedly a rocky review process, their papers finally began to be accepted for publication.

In January of 1991, *Microwave and Optical Technology Letters* published "Anomalous Microwave Propagation in Open Space" [22]. The scope of this article does not permit an exhaustive discussion of the technical details, which are, in any case, best evaluated from the primary sources, but the essence of their experiment was quite simple. They generated an X-band microwave pulse and transmitted it from one waveguide horn to another, measuring the transit time with a detector and a time-domain reflectometer (TDR). As long as the horns faced each other coaxially, the measured delay from transmitter to receiver was within a couple of percent of the expected speed of light. But when they moved one horn laterally with respect to the other (see Figure 1), they reportedly saw *no* increase in the delay time, for offset distances ranging from 15 up to 40 cm. This was observed despite Pythagoras' insistence that the distance from one horn to the other was increasing. Therefore, if the angle between the transmitting horn's axis and the direction to the receiving horn is $\theta$, then the observed velocity of the pulse is not $c$, but $c / \cos\theta$. Hence, the phenomenon I have chosen to call the "$c / \cos\theta$ effect." Eventually the effect breaks down, but over a limited distance, they claimed to have measured a microwave signal propagating at speeds exceeding $c$ by as much as ten percent, as Figure 2 shows.

The readers of *Microwave and Optical Technology Letters* (MOTL) barely had time to catch their breath before a second revelation took place. The next month saw the publication, in the same journal, of "Energy Propagation with Phase Velocity in a Waveguide" [23]. This paper described pulse measurements in a waveguide with slotted-line segments. It purported to show that, in contradiction to every commonly accepted authority, the pulses travelled along the waveguide at the phase velocity, not the group velocity. This time they measured speeds as high as $5 \times 10^8$ m/s, or some 67% faster than $c$ (see Figure 3).

MOTL enjoys a somewhat-limited circulation, so the next publication they selected was perhaps chosen with readership in mind. The table of contents of the August, 1991, issue of the trade journal, *Microwaves and RF*, has a section on "Design Features." Among such articles as "Proper Design Yields Efficient Digital Transmitters" and "SAW Filters Aid Communications System Performance," one finds the title, "Transmit Radio Messages Faster Than Light" [24]. This publication added little to the MOTL papers in the way of experimental results, but some theory was adduced to explain the phenomenon. We refer the reader to the original article for details of the theory. It seems to hinge upon the appearance of a constant, $\delta$, the origin of which is not entirely clear.

Giakos and Ishii's more-recent publications on this topic have been in the *IEEE Microwave and Guided Wave Letters*. They presented both their waveguide and free-space results in a single paper, entitled "Rapid Pulsed Microwave Propagation" [25], in which photographs of the TDR-pulse displays are reproduced. Their TDR appears to be primarily an analog instrument, and it apparently requires that the user move a marker along the displayed pulse until the marker coincides with the pulse's leading edge. What exactly constitutes the leading edge is a judgment call by the user. Nevertheless, the photographs are there.

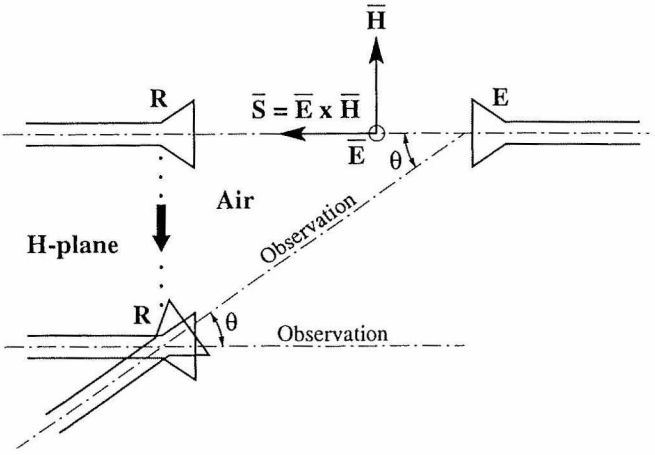


*Figure 1. Ishii and Giakos' waveguide-horn experiment, for which they claim no increase in pulse delay occurs over a range of angles, θ. E denotes the transmitter and R the receiver (after Giakos and Ishii [22]).*

The publication of "Rapid Pulsed Microwave Propagation" provoked a spate of rebuttals, some of which the Editor collected and published in the May, 1992, issue [26, 27, 28]. Both the "Comments," and the "Response" letters by Giakos and Ishii [29, 30, 31] make interesting reading. Only one correspondent bothered to try reproducing the waveguide experiment, without success. The others mounted theoretical attacks, to which Giakos and Ishii responded with more assertions about the repeatability and reliability of their experiments.

After reading these verbal battles, I called Ishii and asked him if anyone had seriously tried to reproduce his work. He was the same polite, serious gentleman I remembered from my visit to Beijing. When I asked him again, "Do your experiments show that signals travel faster than light?" he replied in the affirmative. His only condition was that a signal be defined as a "change of field." He put me in touch with Dr. Jon C. Freeman, of NASA's Lewis Research Centre, as someone who had tried to duplicate his results experimentally. Ishii claimed that if Dr. Freeman's experimental data were "processed correctly," they confirm his (Ishii's) results. In both a telephone call and an extensive letter, Dr. Freeman informed me that his data do not confirm anything except what has been known for years: microwave pulses in a waveguide travel at the group velocity, not the phase velocity, and certainly slower than *c*. In some brief experiments of my own, at the University of Massachusetts, I obtained results similar to Dr. Freeman's.

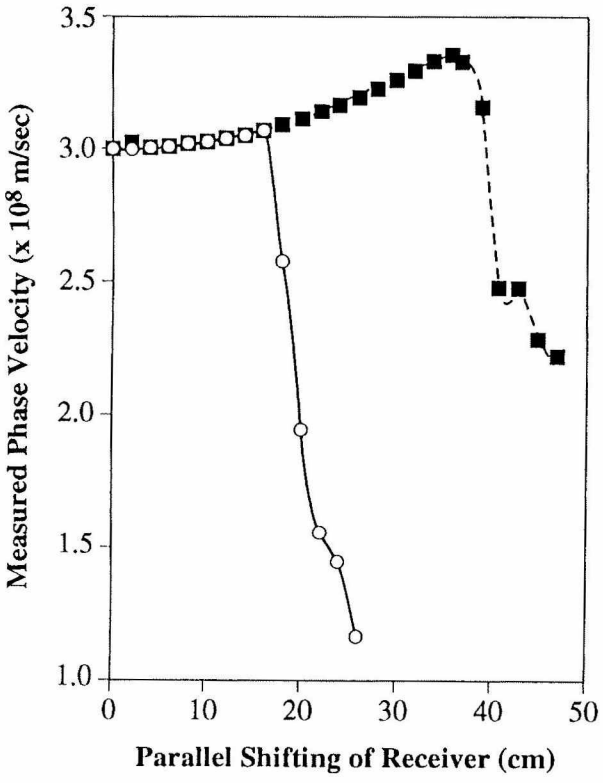


*Figure 2. The resulting velocity of microwave pulses ("phase velocity"), calculated from the transit time measured in the setup of Figure 1. Circles indicate parallel receiver-horn orientation. Crossed squares indicate receiver-horn orientation toward the transmitter (after Giakos and Ishii, [22]).*

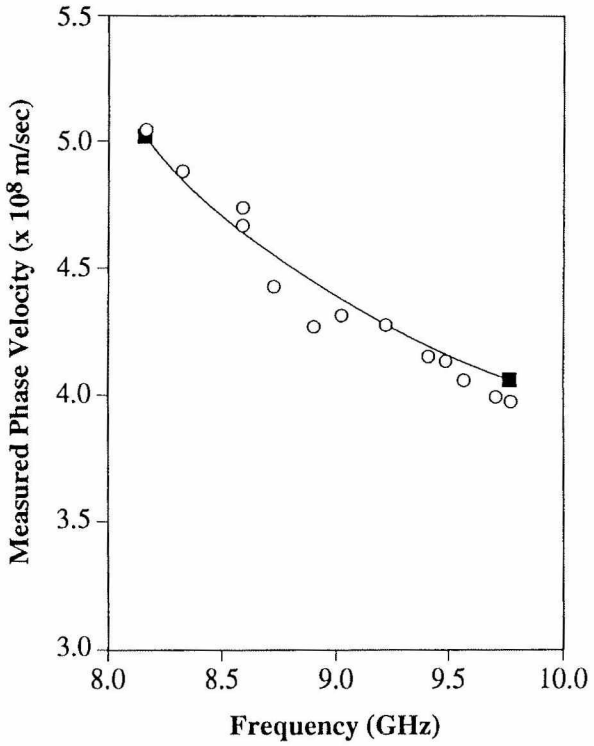


*Figure 3. The velocity of microwave pulses ("phase velocity") measured from the transit time through a waveguide. The solid line indicates theoretical values, and the black dots are measured values (from Giakos and Ishii, [23]).*

Since that time, the most-serious public challenge to their

work has been published in *Microwave and Guided Wave Letters* [32]. In this paper, Wansheng Su, Ioannis M. Besieris, and Sedki M. Riad, at Virginia Polytechnic Institute, show very clear photos of trailing edges of pulses propagating in X-band waveguide. From their data, they conclude unequivocally that "...a pulsed microwave signal cannot travel faster than light." In April of 1993. I phoned Dr. Giakos, whose PhD dissertation, "Detection of Non-TEM Waves in Open Space," was supervised by Ishii. Giakos is currently a research associate at the University of Tennessee, but is still pursuing the topic of faster-than-light propagation as time permits. When I asked him about his reaction to the VPI paper, Dr. Giakos pointed out several differences between the VPI experiment and the Marquette University work. For example, Ishii and Giakos always observe the leading edge of the pulse, while the VPI paper described the behaviour of the trailing edge. Had such opposing results had shaken his faith in his own position? Dr. Giakos replied that "A year ago, I was 99% sure, and now I am 100% sure" that he and Dr. Ishii are right. He stands by the conclusions of their publications so far, although recently he has de-emphasised the concept of phase velocity in their work, since it has led to confusion.

## 4. Conclusions

What have Ishii and Giakos discovered? It is hard to say. As I remarked in the beginning, there are only two possibilities: Either they have found something truly remarkable, or they are mistaken.

Some voices have been raised in objection to the publication of Ishii's ideas at all. They feel it damages the reputation of journals to publish material that is in obvious violation of accepted physical laws. I will confess to some initial feelings along these lines myself, but as I investigated the two historical episodes, my attitude changed. The scientific method demands a fair hearing for all experimenters who carry out work in good faith. Whatever else one may say about Giakos and Ishii, they appear to be investigators of integrity.

It is surprising that no outsider with sufficiently impressive credentials has made the trip to Milwaukee to see first-hand what is really taking place in Ishii's laboratory. Until this is done, we can likely look forward to the continuing saga of microwaves faster than light.

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# Energy Release in the Magnetosphere

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Generation of radio emission in natural plasmas is a common mechanism by which a plasma rids itself of excess free energy. This process is realised in many places ranging from laboratory through ionospheric and magnetospheric plasmas to star coronae and other astrophysical objects. The radiation is clearly nonthermal and hence highly time variable and narrow band, which makes it more difficult to identify in remote astrophysical objects than in the natural plasmas surrounding the earth, the nearby strongly magnetised planets, and the Sun. In each of the latter cases, the source of the radiation is close enough to yield significant radio fluxes at the Earth. For this reason, nonthermal emission processes have historically been identified first on the Sun, in the terrestrial aurora as AKR (auroral kilometric radiation)[1], and near the Earth's bow shock. Interplanetary emissions from interplanetary shocks and from travelling electron beams, known as type III bursts, are another common example.

The advantage of releasing energy by radio emission rather than via "normal" instabilities is that the radio emission transports energy away at a very high speed and over large distances, provided that the plasma is not opaque with respect to radio waves. The speed is close to light velocity. Energy can in this way be released without the necessity to convert it into other forms of energy or redistribute it in the plasma by more complicated means. The most straightforward process is direct amplification of one of the free space magnetoionic free space modes in the plasma (the x- or o-mode). This mechanism, which can be interpreted as negative reabsorption of wave energy by the plasma, is known as the cyclotron maser. It appears to be the most likely explanation for certain nonthermal solar radio emissions as well as AKR and other planetary radio radiation. However, there is a large number of other processes which also lead to nonthermal radiation from a plasma: weak turbulence processes, strong turbulence radiation from cavitons, etc.

Because of the above-mentioned advantages of radio emission one would expect that almost every plasma containing free energy in one or the other way would prefer to excite radio waves over all other energy redistribution processes. Surprisingly nature lets us know that this is by no means the case. Even the strongest nonthermal radio emitters identified in natural plasmas — such as the solar corona, auroral plasmas, and shock waves — radiate away only a fraction of the available energy, while the bulk of the energy is fed into other dynamical processes taking place in the plasma such as streaming, heating, or turbulence.

The transformation of the free energy into radio waves seems difficult. The reason is that in plasmas most of the energy is not stored in single particle motions or plasma waves but in bulk motions and bulk momenta of the plasma as well as in magnetic fields. Hence, the plasma usually chooses to redistribute the energy internally prior to electing a radiation mechanism to spit out energy into free space. These energy redistribution mechanisms are more violent, while the transformation into radio waves is a gentler process.

In order to quantify this conclusion, consider the magnetosphere of the earth. It represents an obstacle in the solar wind of cross-sectional area $3 \times 10^{16}$ m$^2$. The quiet solar wind power flowing through this area is about $8 \times 10^{12}$ W of which magnetospheric processes dissipate only about 2-3%. The latter value is not very precise but is based on an average 50 kV potential drop across the magnetosphere and average current density of 4 MA flowing in the magnetosphere[2]. During disturbed times the energy input is a factor of 10-50 higher but the percentage of energy dissipation is nearly constant. Measurements of auroral kilometric radiation fluxes encompass a wide range. Very weak events range from 1–10 kW total power assuming isotropic emission, while the strongest events have been claimed to radiate a total power of $10^9$ W. The usual radiated power is more frequently around 0.1 GW, but higher values have recently been considered based on ISEE 3[3]. In any case the radio emission is only a fraction of the energy dissipation by other processes, basically auroral and tail processes in magnetospheric example.

What are these alternative processes? Essentially three mechanisms have been proposed since the advent of magnetospheric physics, but it has not been determined which one is the dominant process. It seems to be generally agreed upon that the diffusive dissipation of energy in the magnetosphere does not play an important role. The relevant competing mechanisms are tail reconnection and parallel electric field Joule heating or acceleration at lower altitudes in the magnetosphere. The former may be a directly driven process if tail flux is added by solar wind momentum transfer to the magnetosphere (by dayside reconnection at the magnetopause, for example), or it may be an explosive internal instability which when a threshold is exceeded discharges the excess amount of energy stored in the tail current sheet or stretched magnetic tail field lines at a distant point in the magnetosphere where a magnetic X-point is formed. In both cases the current sheet is shortened, energy dissipated into Joule heating, particle acceleration along and transverse to the magnetic field, generation of electrostatic

potentials, and low frequency electromagnetic waves (Alfvén waves, slow mode waves, and in rare cases also fast waves). The main release, however, is probably ejection of plasma from the magnetosphere along the tail in the anti-sunward direction in the form of "plasmoids." This ejection rids the magnetosphere of large amounts of excess energy in the form of excess plasma, and only a fraction of the energy is left in the magnetosphere which is transported inward into the inner magnetosphere.

This latter fraction is probably then subjected to the second energy dissipation mechanism which is based on the generation of parallel electric fields either through the action of the mirror force along the field lines in a system which conserves the current strength, or though double layer or electrostatic shock formation. The latter structures have been observed frequently in connection with the aurora. If asymmetric they contain real potential drops which may accelerate particles. If symmetric, the energy dissipation occurs by more complicated paths: wave excitation and generation of turbulence in the interior of the structures, with particles turbulently accelerated during their transit time across the structure. Observations show that turbulent structures are related to electrostatic shocks[4]. The shocks appear in regions where field aligned electron fluxes coincide with lower-hybrid (VLF) turbulence while ion cyclotron waves are generated farther outside of the structures. Double layers on the other hand are more laminar and have been shown to contain in most cases only very weak potential drops. In the magnetosphere one has not measured so-called strong double layers yet. The weak double layers in the average have zero potential drop [5], but some of them have drops of the order of a few Volts. Hence, they can give rise to strong energy dissipation only if they are very numerous along the auroral field line, which in turn implies that they are physically small structures. The potential lines will then close only below the many double layers, and the particles must pick up small mounts of potential in each of them.

Such weak double layers will barely contribute to generation of radio radiation. Such radiation can however be expected to be excited in the turbulent electrostatic shocks[6], where interaction between lower hybrid waves, upper hybrid waves and the fast auroral electrons takes place and the small scale structure of the shock region contributes to the structuring of the radio emission source.

This discussion seeks to close the picture between the major energy release mechanisms and the generation of radiation and to explain why the energy is not directly converted into radiation. Though radiation would be a very efficient mechanism, the plasma chooses a more violent way to rid itself of excess energy, a way by which it can ejects large material blobs from the magnetosphere. This large-scale process is initiated by the reconnection of magnetic field lines via an instability which has not yet been satisfactorily simulated but which possibly is some kind of tearing mode. After the excess plasma is ejected, the remainder of the energy is transported by currents in low frequency waves and by ion and electron beams down to the lower magnetosphere, where parallel fields are turbulently generated in electrostatic shocks and weak double layers. Radiation is produced as a by-product by either turbulent excitation or by direct maser emission[7], while the remaining part manifests itself in other auroral phenomena as auroral dynamics and the various auroral scales. Future theoretical as well experimental studies will have to be performed to decide which of the mechanisms and under which conditions is the dominant one.


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# Oliver Lodge - The Forgotten Man Of Radio?

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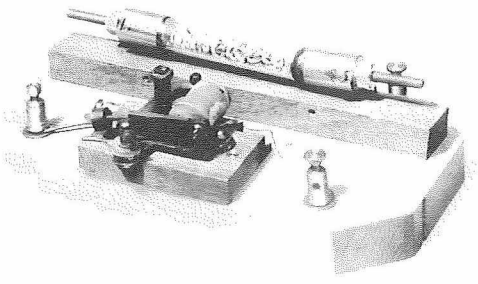
The distinction of transmitting the first radio message must go to Oliver Lodge, Professor of Experimental Physics at University College, Liverpool. He first did this publicly at a meeting of the British Association in Oxford on 14 August 1894. This was some six years after Hertz's famous experiment in Karlsruhe in which he verified Maxwell's mathematical prediction that the waves which he detected were the same as light except at a much lower frequency. Hertz provided the first proof of that theory but saw no practical application in what he'd done. That feat in itself was to be of enormous significance and he stands supreme in the annals of physics for that reason. When Lodge performed his demonstration he too made no claims for the eventual usefulness of his technique but it is the first recorded occasion on which intelligence was transmitted through space without wires. For a practical application of radio the world had to wait for the arrival in England of Marconi in 1896. It is important to place in context the contributions of each of these pioneers of the science and engineering of radio and to accord to each the recognition that is rightfully their due.

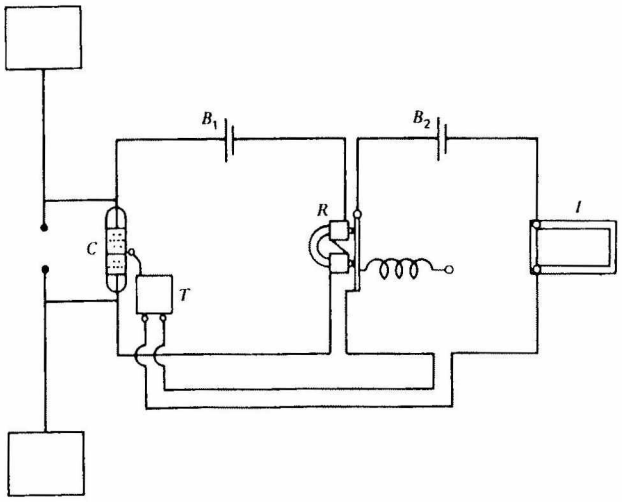
At that demonstration in Oxford, which was at a joint meeting of physicists and physiologists on the subject of vision, Lodge transmitted Morse code letters from his induction coil and spark gap transmitter in the Clarendon Laboratory to a receiver some 60 metres away in the Oxford Museum. He described it as "a very infantile form of radio telegraphy", a statement reflecting his modesty but an undoubtedly significant one because it established what he had actually done when the induction coil was actuated by a Morse key operated by his assistant E E Robinson. The receiver consisted of a coherer, a Lodge invention, which was connected to either a Morse recorder which printed onto tape or a Kelvin marine galvanometer, the deflected light spot of which made viewing by the audience easier. In that audience were Silvanus P Thompson and J A Fleming, both notable scientists in their own right and therefore well able to appreciate what they had just seen.



*Oliver Lodge's coherer and trembler, ca 1894 (photo from the British National Museum of Science and Industry).*

*Sir Oliver Lodge*

Why then, given this seemingly undeniable demonstration of signalling without wires, has the name of Lodge been largely forgotten when the pioneers of radio are discussed? Why are Hertz and Marconi alone remembered while Lodge, who performed a demonstration "which excited great interest", in a university of renown and in front of a large audience which consisted of many illustrious men of science, has almost been ignored? There are many possible reasons. One may be that Lodge was a polymath in the sense that his scientific work covered a wide area, not just electrical phenomena, with his on-going quest for experimental evidence to confirm the existence of the ether probably persisting longest in the public memory. Another may be that, like many scientists for whom discovery and not commercial exploitation is the important goal, Lodge made no attempt in 1894 to protect his findings by patent. He did so three years later but by then Marconi had already established himself. With his commercial acumen and the patronage of no less a figure in English electrical engineering circles than William Preece, the former engineer-in-chief of the Post office, Marconi was developing a radio system which would present Lodge with formidable competition.



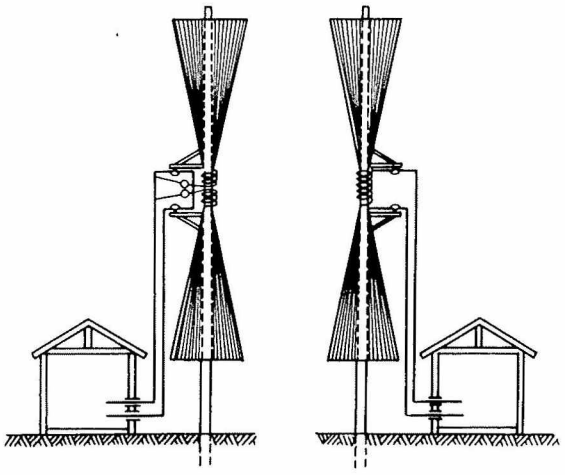

*Lodge's receiving system used in oxford in 1894. B1, B2 — batteries; C — coherer; T — trembler; R — relay; I — inker. Both C and t appear in the photo on the previous page.*

A further possible reason for his lack of recognition is that Lodge was not just an experimentalist, he was also a renowned lecturer, much loved by his students and the lay scientific community who attended his many presentations at the Liverpool Physical Society. His time therefore was not devoted to research. He also became a well-known populariser of "wireless" as the scientific adviser to the magazine "Popular Wireless" and then, in 1923, consultative editor for "Harmsworth's Wireless Encyclopaedia". Whereas these roles will have contributed greatly to the enlightenment of the public in all aspects of this new, exciting subject, some of his scientific contemporaries and particularly his critics will have viewed this as a retrograde step which decreased his credibility in their eyes. He has therefore come to be regarded by many as a populariser of science rather than as one who challenged its frontiers.

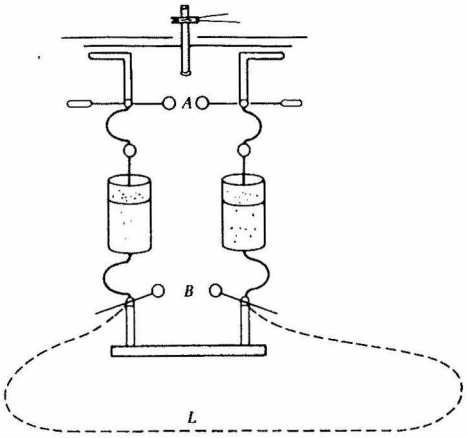
But there is yet another reason which may be more significant than all the others. Lodge had long had an interest in psychic phenomena and, after 1910, he played an increasingly prominent part in research into the paranormal and had published widely in this area. Undoubtedly this foray into a subject which continues to be viewed with the utmost scepticism by most scientists subsequently did his reputation considerable harm and generally tarnished his image. That a previously highly respected member of the inner-circle of science should now espouse such a dubious cause was reason enough for many to discredit him and thereby to diminish his contributions to the development of radio. Whatever the reasons Sir Oliver Lodge has not, of late, received the recognition due to him for his work which laid many of the foundations of modern radio communications and broadcasting.

To examine Lodge's work and to appreciate its significance viz a viz that of Hertz and Marconi we need to consider his role in the seemingly unrelated controversy which raged, most acrimoniously at times, about the performance of the lightning conductor. The Post Office had, by 1880, installed hundreds of thousands of lightning conductors throughout England to protect their investment in telegraph lines and equipment. They were not always successful. At the meeting of the British Association in Bath during September 1888, Lodge took issue with Preece's view that an effective lightning conductor had just to be of adequate height relative to the structure it had to protect and must offer the lowest resistance to the flow of current. This was achieved by the use of appropriate material and by ensuring that the conductor was "properly" grounded. Preece rejected the very idea of inductive reactance let alone its role in reducing the effectiveness of a lightning conductor. Lodge stressed that the minimization of this inductive component was crucial to the successful performance of the lightning conductor. In this he was supported by the theoretical work of Oliver Heaviside which was based on Maxwell's equations and together they constituted a considerable thorn in the side of Preece. This very public clash between two men of considerable reputation was ultimately to cost Lodge dearly in 1896 when Preece threw his full support (and that of the Post Office) behind Marconi when he well knew of the work that Lodge had done in this field. Preece's enthusiastic support, caused G F Fitzgerald, the Irish physicist and brilliantly intuitive speculator on Maxwell's theory and regular correspondent with Hertz, Lodge and Heaviside, to comment in a letter to the latter that Marconi "had done no more than Lodge and others... in observing Hertzian waves at a distance". Even Marconi himself claimed to have just an improved form of coherer as his own invention.

Lodge had performed a number of experiments in February 1888 using his Leyden jars to investigate how the lightning conductor functioned. In the process of doing this he discovered, one might say by serendipity, a mechanism which provided real evidence of the electromagnetic waves predicted by Maxwell. He called this the "recoil kick"



*Lodge's transmitting and receiving antennas ca 1897.*




*Lodge's apparatus for the "alternate path" experiment ca 1888.*

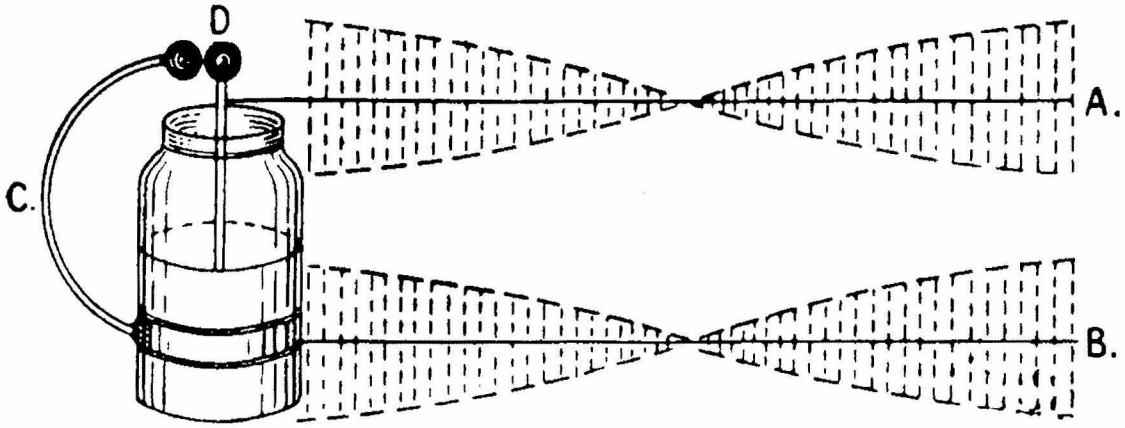
experiment. Essentially his charged Leyden jar discharged into two parallel circuits: one containing a conventional spark-gap of highly polished copper spheres, the other,the "alternative path", was provided by a single wire, with a resistance of just 0.025 ohms, looped around the laboratory. As he expected a flash occurred across the spark gap; a result which would have amazed Preece since that gap was "shorted out" by the wire! The impulsive nature of the discharge and the inductance of the wire were the cause. Of even more significance though was the fact that the intensity of the spark across the gap was actually greater than that at the output of the electrostatic generator used to charge the Leyden jar. Investigation of this phenomenon by Lodge and his assistants showed that it was due to the existence of standing waves along the wire with their characteristics nodes and antinodes. By decreasing the capacity of the Leyden jar and by varying the length of the wire from about 30m, which indicated resonance at 5MHz, to only a few centimetres he was able to cause the intensity of the spark to increase or decrease. In a darkened room the antinodes could be clearly seen as a visible glow or brush discharge of varying intensity along the wire. Lodge had discovered electrical resonance. He measured the wavelength of these standing waves and related it to the "capacity of the jar" and the inductance of the circuit. He recorded in his notebook the fact that he had succeeded in generating, detecting and measuring electromagnetic waves which, he said "disturb the surrounding medium and send out radiations, of the precise nature of light". There is considerable significance in his statement that the waves disturb the surrounding medium because it indicates that he recognized that they were not in the wires but were in the space between them: what he called the ether.

Lodge demonstrated these effects at scientific meetings during March and May 1888 and published an account of them in the Journal of the Society of Arts in June of that year. His definitive article "On the Theory of Lightning Conductors" was submitted to The London, Edinburgh and Dublin Philosophical Magazine on 7 July 1888 and was published in Vol.26 of August 1888.

When Hertz commenced his experimental work he was influenced not by Maxwell's equations, which postulated a finite velocity of propagation, but by Helmholz's (and Newton's) action-at-distance which implied an infinite value. The task which he set himself was to determine if the propagation of electromagnetic energy was a wave-like phenomenon possessing a finite velocity. He did this by way of a brilliant experiment in interferometry where he measured the wavelengths of the standing waves by using various radiators and receptors of different sizes and a reflecting metal sheet in his 12m long laboratory. Hertz thus accepted Maxwell's theory of electromagnetic waves in February 1888 and by March had calculated their velocity of propagation (erroneously, as it transpired). He published his results in Wiedemann's Annalen in July 1888, the month in which Lodge's paper on lightning conductors — which emphasized his verification of Maxwell's theory — was submitted to the Philosophical Magazine.

*Of particular importance... is the ruling of the United States Supreme Court as late as 1943 that the only valid patent of the three held by the Marconi company in this area (RF resonance or tuning) was that acquired from Oliver Lodge in 1911.*

Lodge and Hertz were working on the same problem at the same time. They had in fact met in 1881 when Lodge visited Karlsruhe in the hope of meeting Helmholtz, which he did, albeit only briefly. In the absence of the great man, it was his demonstrator Hertz who showed him around the laboratories. At the end of July 1888 Lodge read Hertz's paper and resolved to re-establish contact with him. They subsequently corresponded regularly until Hertz's untimely death in 1894. At the meeting of the British Association in Bath that September Lodge was in the audience to hear Fitzgerald, in his role as President of its Mathematical and Physical Sciences Section, call "the world's attention to Hertz's discoveries" while also mentioning Lodge's work in passing.. The following day Lodge himself spoke and readily acknowledged "the superiority of Hertz's method ... as evidence of... waves" compared with his own. What is most important though is to recognize that whereas Hertz had produced electromagnetic waves which radiated freely into space,




*Lodge's "syntonic" Leyden jar experiment. Lodge likened these standing waves from his "recoil kick" experiment to water in a bath "surging to and fro when it is tilted". He showed that the period of the waves was related to the inductance L and the capacity S (as he called it) of the system by* $T = 2\pi\sqrt{(LS)}$.

Lodge had used the wires in his "recoil kick" experiment as a transmission line or waveguide which confined the energy to the region between the conductors. Both techniques made use of the interference between an incident and a reflected signal as a means of proving the existence of a wave-like phenomenon. Heaviside, for one, had no doubt that both methods were equally conclusive in confirming Maxwell's theory. He even went further and said that Lodge's method might even be more so because its theory "can be more closely followed".

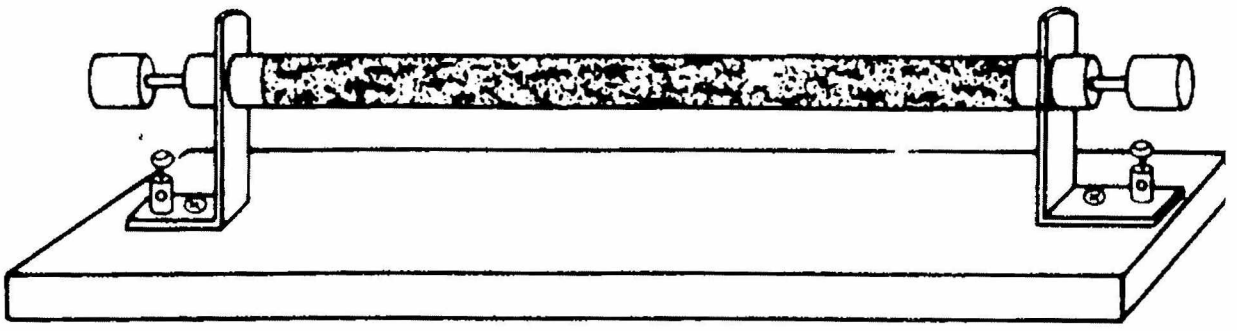
There was another feature of Lodge's "recoil kick" experiment which was subsequently to play a very significant part in Marconi's work and was to be the centre-piece of a legal confrontation between the two. As noted previously, Lodge recognized that the sensitivity of the spark to the length of the wires was an indication of resonance but he felt that this word was "too suggestive of some acoustic reverberation phenomenon" and so he called the effect "syntony", this being "the synchronizing of the vibration period of two things" and he used it in all his subsequent work when describing resonance.

When Marconi developed his commercial apparatus he designed it such that it could be "tuned" and so respond selectively to signals of different frequencies but his patent, filed in 1896 and the first radio patent ever issued, in 1897, contained no reference to either "tuning" or "syntony". In 1897, before the Marconi patent was in the public domain, Lodge filed four patents which related specifically to his radio telegraphy system. Two dealt with improvements to his coherers while the others were described as "Improvements to Syntonized Telegraphy" and they must now be seen as crucial contributions to the science of radio engineering, being the first to describe the method of achieving selective communications by radio. In other words a method was described of tuning both the transmitter and the receiver to a selected frequency by the use of a "syntonizing self-inductance coil" in conjunction with the capacitance provided by the antennas or "definite radiators", as Lodge called them. This led ultimately to the formation in 1901 of a syndicate with his colleague Alexander Muirhead in order to further develop and exploit this idea commercially.

Because of these Lodge patents Marconi was legally prevented from using "syntony" or resonance in his radio system, notwithstanding his famous "four sevens" patent of 1900 which has been described as his "master tuning patent". He was forced to acquire the patent rights, for an undisclosed sum, from the Lodge-Muirhead syndicate in 1911 in order to be able to enforce his own patent claims against a number of other challengers in succeeding years. Of particular importance, when the priority of Lodge's work is discussed, is the ruling of the United States Supreme Court as late as 1943 that the only valid patent of the three held by the Marconi company in this area was that acquired from Oliver Lodge in 1911. It is well to be reminded that this land-mark legal decision, though long since forgotten in the scientific literature and certainly in the popular view of things, gave priority to Lodge for a crucial element of radio communications.

Before drawing this review of some of Lodge's work to a close it is important to discuss very briefly some of his other contributions to radio science. His antenna system or "definite radiator" has already been mentioned in passing. It is worth considering in somewhat more detail though because the form that he chose is still in common use today as the biconical antenna.

Lodge used that configuration because he saw it as providing the distributed capacitance which he wanted rather than the lumped variety in the form of either conducting spheres or



*Drawing of the Lodge coherer of 1894 (see also the photograph on the cover of this issue). It was Lodge who gave this early (possibly the earliest radio detector) its name, though the technique was well known of using iron filings in a glass tube as a "detector" when they cohered or stuck together when subjected to an emf across the terminals.*

plates at the ends of the wire, as used originally by Hertz. His syntonic transmitter and receiver were tuned to resonance by using either series or shunt inductance connected to the antennas' terminals.

By definition therefore, his systems were narrow-band thus providing the selectivity which he identified as being necessary to obtain communication privacy with a radio system. By contrast today, the biconical antenna is generally used because of its inherently wide bandwidth which is a fundamental feature of its angular dependence. An apparently natural consequence of using inductors in his antenna circuits, but one which required considerable insight when it was first done by Lodge, was the use of transformer-coupling. This technique is now standard practice for purposes of impedance matching and for the control of the bandwidth of such coupled circuits and was first described by Lodge in his 1897 patent.

There are three other gems within the panoply of Lodge's peripatetic work which must be noted because of the significance of each in subsequent years. The first and arguably the most prescient was his attempt in 1894 to detect radio emissions from extra-terrestrial sources, most notably the sun. The experiment failed because his coherer detector of centrimetric waves was not sufficiently sensitive. This is recognized though as the first attempted experiment in radio astronomy and preceded the first successful one by some 37 years. Whereas he failed in his primary task to receive noise from the sun he certainly received interference from the electrically-powered tram system in the Liverpool area! This, coupled with the fact that he occasionally picked up "communication from ordinary telephone lines" overhearing such oddities as "people ordering potatoes for dinner" was to become the forerunner of electromagnetic compatibility (EMC) much later within the next century and electronic eaves-dropping (ECM), first practised in precisely that way in the first World War. Finally, Lodge, being aware of the degrading effect that electrical noise had on the performance of his communication systems, and knowing that such noise was associated with resistance, suggested that conductors might be immersed in liquid hydrogen or helium "for at these temperatures the resistance of metals almost disappears". Might this not be the first predicted use of, at least, cryogenics and ultimately the science of superconductivity?

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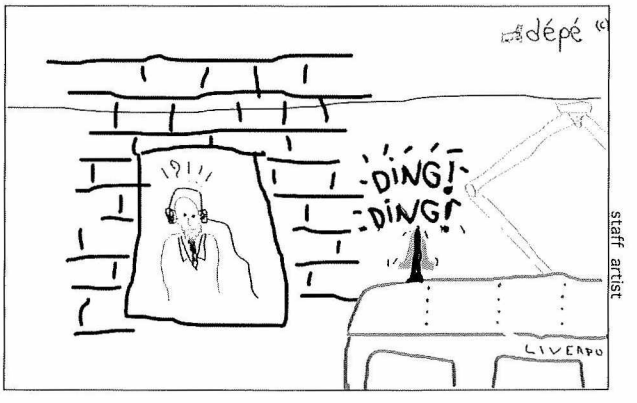


*"By Jove! It's a sort of strange ringing noise..."*

# Progress in Electrodynamics of Complex Materials

**Ari Sihvola**

*Helsinki University of Technology*

Among the dynamic areas of electromagnetics and microwave research, the problems of wave-material interaction have received special and intensive attention. Addiction to this fascinating field has infected scientists and engineers mostly in Europe, the United States, and Russia. But today we already face the fact that the epidemic has spread globally, and reaches countries like China, Israel, and South Africa.

Material effects in electromagnetics are indeed important. Very unfortunate is therefore the elementary approach of the electrical engineering or physics textbooks which has too deeply imbued us with the simplistic idea of homogeneous, isotropic, lossless dielectric and magnetic materials. This is a dull picture. And it is unfair because complex materials are neither rare in nature nor impossible to synthesize. The application potential of new, "exotic" media in radio science and engineering is enormous, and many of the ideas still undiscovered.

What are these complex materials? As examples of different classes we might mention chiral, nonreciprocal, gyrotropic, anisotropic, bianisotropic, and nonlinear media. Each type of these displays a special electromagnetic or magnetoelectric effect beyond the normal isotropic polarizabilities.

It seems that the new wave of research on complex materials started with emphasis on chirality. Chiral media are characterized by intrinsic handedness which means that chiral objects are different from their own mirror images. With increasing theoretical understanding of the behavior of chiral media and growing amount of experimental data, the research has now shifted towards more general media, nonreciprocal and bianisotropic materials.

*Fig. 1. Professor L. Shemetkov, Rector of Gomel State University, opening the* Bianisotropics'93 *seminar.*

*Fig. 2. Co-chairmen of the seminar at the dinner table. (Academician F I Fedorov and Prof A N Serdyukov).*

This evolution has generated a need for seminars devoted to complex materials. *Bi-isotropics'93* was held in Finland in February 1993. The continuation workshop, *Bianisotropics'93* was organized in the University of Gomel, in the southeastern part of the republic of Belarus in 12—14 October 1993. This three-day seminar attracted around 30 scientists and engineers from Belorussia, Russia, Finland, France, and England.

The talks and discussions in *Bianisotropics'93* ranged from theoretical analyses of complex media electromagnetics, through modeling of helix scattering, to applications in microwave and millimeter wave engineering. As examples of the presentations given in Gomel, two papers from the Proceedings of the seminar are published in the following.

"On the wave normal equation for bianisotropic media" is the title of the paper by Academician F I Fedorov from Minsk. In a compact form, he presents plane-wave electromagnetic description in a very general medium, allowing all the constitutive parameters to be tensors. Using covariant notation, he discusses different restricting conditions for reciprocal and uniaxial materials. Fedorov's paper is, in my opinion, particularly informative to Western scientists for its vector and dyadic notation that has been used in the Former Soviet Union. Although strange at first sight, the notation is useful. It may even be worth learning for future needs

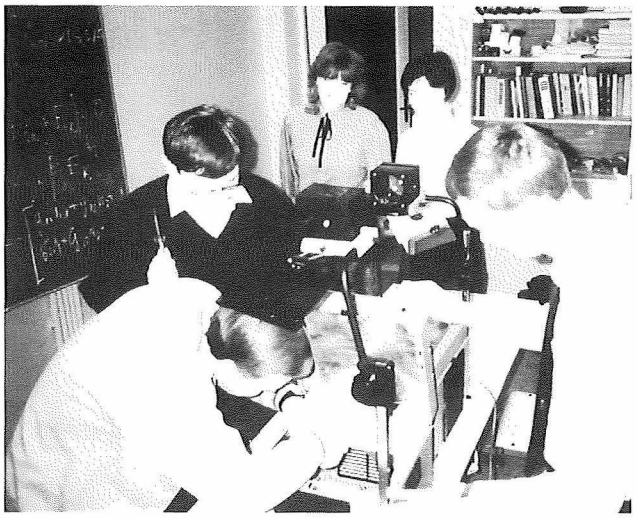

*Fig. 3. The overhead projector is a valuable piece of equipment in Gomel, and also a sensitive device. Radioscientists, fortunately, are often trained as electrical engineers.*

because of the increasing scientific relations across the iron curtain we once had.

Frédéric Guérin contributes the other paper, *Experimental aspects of microwave chirality research*, which is more experimentally oriented. The paper responds to the need of characterizing real chiral materials, and discusses the problem of determining the material parameters of chiral media using electromagnetic measurements. Results are shown for artificial chiral samples manufactured by Thomson CSF Laboratories in France.

The Proceedings of the *Bianisotropics'93* Workshop have been published by the Electromagnetics Laboratory of Helsinki University of Technology. For a copy, please contact Ari Sihvola. The next workshop on novel mirowave materials (Chiral'94) will be held in Périgueux, France, in 18—20 May 1994. See the Call for Papers elsewhere in this issue of Radioscientist Bulletin.

# Experimental Aspects of Microwave Chirality Research

**F Guérin[1,2], M Labeyrie[1], and P Y Guillon[2]**

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**ABSTRACT**

In this paper, the focus is on experimental microwave chirality research. After briefly discussing wave propagation in a chiral medium, as well as basic equations relative to reflection and transmission through a chiral slab, and reflection from a metal-backed chiral layer, current artificial chiral materials active at microwave frequencies are mentioned. In particular, we describe the processing of chiral composites with ferroelectric ceramic inclusions. Then, the free-space measurement bench used for characterizing the samples is presented, along with the method for computing the constitutive parameters. Results on the chirality parameter and the reflectivity are given. We also introduce some work done on numerical modeling with finite-element computations.

## 1. WAVE PROPAGATION, REFLECTION AND TRANSMISSION

The description of chiral, or reciprocal bi-isotropic media, requires a third complex scalar constitutive parameter in addition to the permittivity and the permeability. One way of writing the constitutive equations, known as the Drude-Born-Fedorov formalism, is as follows [1]

$$\mathbf{D} = \varepsilon_D \mathbf{E} + \varepsilon_D \beta \nabla \times \mathbf{E}$$
$$\mathbf{B} = \mu_D \mathbf{H} + \mu_D \beta \nabla \times \mathbf{H} \qquad (1)$$

Here $\beta$ accounts for the chirality of the medium and carries the unit of length. Analysis of wave propagation in a chiral medium [2] shows that there are 2 canonical left-and right-circularly (LCP and RCP) polarized waves, which respective wavenumbers $k_-$ and $k_+$ are

$$k_- = \frac{k}{1 - k\beta} \quad \text{and} \quad k_+ = \frac{k}{1 + k\beta} \qquad (2)$$

The intrinsic wave impedance of such a medium is given by $\eta = (\mu_D/\varepsilon_D)^{1/2}$.

Using the impedance and the two LCP and RCP wavenumbers, reflection and transmission through a chiral slab of thickness d can be easily quantified. Writing

$$\Gamma = \frac{\eta - \eta_0}{\eta + \eta_0} \quad \Phi = e^{i(k_- - k_+)d} \quad \text{and} \quad \Psi = e^{2ik_+ d} \qquad (3)$$

where $\eta_0$ is the impedance of free-space, the normal incidence reflection coefficient for a linearly polarised plane wave can be written as

$$S_{11} = \frac{\Gamma(1 - \Phi\Psi)}{1 - \Gamma^2 \Phi\Psi} \qquad (4)$$

while the normal incidence transmission coefficient (corresponding to the copolarised part of the transmitted field) is

$$S_{21} = \frac{(1+\Phi)\Psi^{1/2}(1-\Gamma^2)}{2(1-\Gamma^2\Phi\Psi)} \qquad (5)$$

Because the two complex LCP and RCP wavenumbers are different, both circular birefringence and dichroism occur in transmission. The transmitted wave is therefore generally elliptically polarised with an ellipticity tanφ, the major axis of the polarisation ellipse being tilted with respect to the incident wave polarisation direction by and angle α. The rotation angle and the ellipticity are given by

$$\alpha = \frac{\mathrm{Re}(k_- - k_+)d}{2}$$

$$\text{and } \tan\varphi = \mathrm{th}\left(\frac{\mathrm{Im}(k_- - k_+)d}{2}\right) \qquad (6)$$

These two parameters display a resonant behaviour at discrete frequencies related to the microstructure of the medium (the rotation angle vanishes and changes sign, while the ellipticity reaches an extremum value), which can also be observed for the real and the imaginary parts of the chirality parameter. It is worth noting that for a chiral layer illuminated at normal incidence, polarisation rotation and circular dichroism occurs in transmission only, not in reflection. The normal incidence reflection coefficient $S_{11mb}$ of the same metal-backed chiral layer can also be computed and is expressed as

$$S_{11mb} = \frac{(\Gamma+\Phi\Psi)}{1-\Gamma\Phi\Psi} = \frac{\dfrac{\eta-\eta_0}{\eta+\eta_0} - e^{2ik_{eq}d}}{1-\dfrac{\eta-\eta_0}{\eta+\eta_0}e^{2ik_{eq}d}} \qquad (7)$$

$$\text{where } k_{eq} = \frac{k_- + k_+}{2} = \frac{\omega\sqrt{\varepsilon_D\mu_D}}{1-(\omega\sqrt{\varepsilon_D\mu_D})^2}$$

All these expressions strictly apply to homogeneous or effectively homogeneous chiral media. For composites which inclusions are not necessarily small with respect to the wavelength in the matrix, they still allow a simple description of the interaction between the wave and the composite chiral medium, and yield reasonably good results [3], at least as far as transmission properties such as the rotation angle and the chirality parameter are concerned.

## 2. ARTIFICIAL MICROWAVE CHIRAL MATERIALS

Lindmann was a pioneer in fabricating and measuring chiral composites optically active in the GHz range [4]. Recently, extensive experimental studies were carried out in the USA on composites with metallic helices [5]. Some activity is now developing in Europe. The recent interest in artificial chiral materials is justified by the fact that these media could be used for improving the properties of absorbent coating or various microwave devices because of their particular electromagnetic characteristics. In order to fully benefit from the degrees of freedom brought by the nature of the inclusion material, it seemed interesting to us to explore the possibilities offered by ceramics. We therefore decided to work with ceramic inclusions.

A high dielectric constant material, barium strontium titanate (BST), was chosen as the inclusion material [3]. Ceramic helices are produced by coating carbon fibres of a few microns in diameter with a ceramic slurry, and winding the subsequent fibres on a graphite rod. After a suitable heating cycle, carbon- and organics-free sintered ceramic helices are obtained. The helices are then randomly dispersed into an epoxy matrix, which losses can be adjusted by the addition of carbon powder.

## 3. MEASUREMENT TECHNIQUE AND MATERIAL PROPERTIES COMPUTATION METHOD

The stage following the composites processing is the evaluation of their microwave properties. A free-space measurement setup existing at IRCOM is used for that purpose. It consists mainly of 2 spot-focused horn lens antennas linked via transitions and coaxial cables to an HP 8510 network analyser. A view of the bench is presented in figure 1. A description of its general features and calibration has already been given elsewhere [5,6], so that we should focus only on material properties measurement.

Three independent complex quantities must be obtained in order to be able to fully characterise a chiral sample. In our case, the technique used is basically a reflection-transmission one (therefore thickness resonances may perturb the results). The normal incidence reflection coefficient, along with the normal incidence transmission coefficients for the copolarised and crosspolarised parts of the transmitted field are measured. The computational scheme is as follows (see [3] for details). Using (5) along with the corresponding equation for the crosspolarised part of the transmitted field, the rotation angle and the ellipticity can be directly obtained. Then, using (4), the wave impedance is computed. The next stage is the computation of k- and k+ , where an ambiguity relative to the determination of the real parts of the 2 wavenumbers has to be solved. Finally, from the values of η, $k_-$ and $k_+$, those of $\varepsilon_D$, $\mu_D$, and β are easily deduced.

## 4. SOME EXPERIMENTAL RESULTS

Figure 2 represents the measured chirality parameter of one

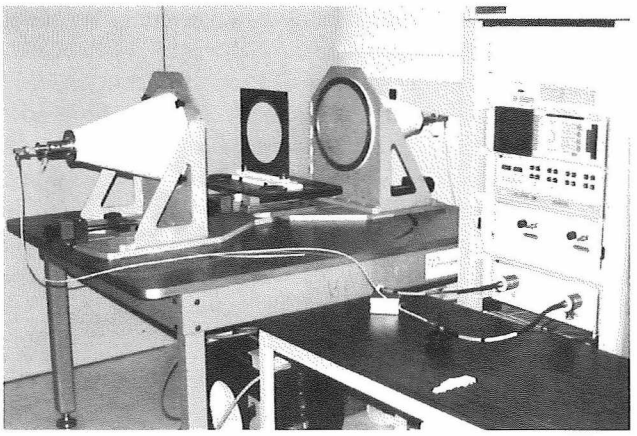

*Fig. 1. IRCOM free-space microwave bench. Recent upgrades make testing from 6 to 110 GHz possible. A furnace with transparent windows can be used for working up to 800° C.*

of our samples in the 8-36 GHz range. The central part of the main (and seemingly the only) resonance, not represented in the figure, is around 6 GHz. Therefore, what can be seen in figure 2 is the trailing edge of this resonance. At 10 GHz, the magnitude of $\beta$ is about 0.28 mm: this yields values of $|k\beta|$ and $|k\beta|^2$ respectively equal to 0.14 and 0.02, which show that the degree of chirality is fairly low, even though the rotation angle of the composite is about 40° at the same frequency.

On the same sample, $\varepsilon_D$ and $\mu_D$ were measured and the 3 constitutive parameters were used for computing the normal incidence reflection coefficient using equation (7). $S_{11mb}$ was also measured. The comparison between computed and experimentally determined values is shown in figure 3.

The fairly good agreement between the 2 curves shows that in this particular case, although the size of the helices is comparable to the wavelength in the matrix and to the thickness of the sample, and even though some additional efforts are needed to improve the accuracy with which $\varepsilon_D$ and $\mu_D$ are determined, the measured values of the constitutive parameters may be used for predicting reflectivity values. Further experimental work is underway to quantify scattering effects in such materials and to understand the influence of chiral resonances on their reflectivity.

## 5. NUMERICAL MODELLING

One of the challenges of chirality research is to establish a link between the microscopic properties of the material (i.e. the properties of the inclusions) and the macroscopic properties of a composite. We have developed a numerical technique, based on the computation of the field scattered by an helix, aimed at calculating the properties of a chiral homogeneous medium. This technique involves a finite-element computer code, Antenna Design, developed at Thomson-CSF Radars and Countermeasures Division. Preliminary results on the radar cross section of ceramic helices have been presented recently [7]. More detailed results on metallic and dielectric inclusions, as well as experimental validation of the modelling results will be reported soon.

## CONCLUSION

In this paper, we tried to give a brief overview of microwave chirality research at Thomson-CSF and IRCOM. Ceramic helices are fabricated by a coating-winding technique, which allows a wide range of materials to be shaped in the form of a small size spring, and dispersed in a host medium to produce chiral composites. Using a free-space bench, normal incidence measurements are carried out on the materials and their effective properties, including chirality, are computed by an analytical method. Because of the heterogeneous

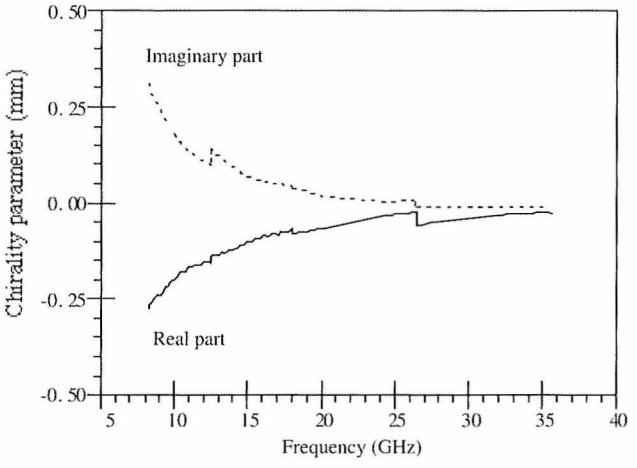


*Fig. 2: Chirality parameter of a composite with 3.4 % (in volume) BST helices (diameter = pitch = 3 mm, 3 turns, left-handed) in an epoxy-carbon matrix. Thickness 9.1 mm.*

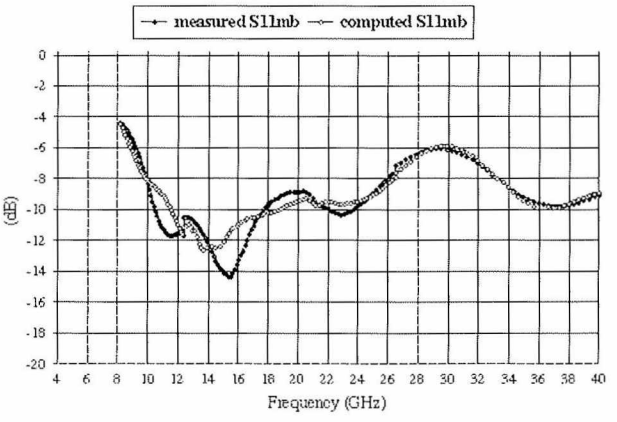


*Fig. 3: Measured and computed normal incidence reflectivities of a composite with 3.4% (in volume) BST helices (diameter = pitch = 3 mm, 3 turns, left-handed) in an epoxy-carbon matrix. Thickness 9.1 mm.*

character of microwave chiral composites, it appears that new measurements and numerical models are necessary to better quantify propagation and loss phenomena in these materials. Ongoing work is currently devoted to computer simulation of electromagnetic scattering by an helix and effective properties computation.

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# On the wave normal equation for bianisotropic media


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For plane time-harmonic electromagnetic waves $\mathbf{E}e^{i\varphi}$, $\mathbf{H}e^{i\varphi}$, $\varphi = \omega(\mathbf{mx}/c - t)$ the Maxwell equations have the form [1,3]

$$\mathbf{D} = -\overset{\times}{\mathbf{m}}\mathbf{H} = -[\mathbf{m},\mathbf{H}] \qquad \mathbf{B} = \overset{\times}{\mathbf{m}}\mathbf{E} = [\mathbf{m},\mathbf{E}] \qquad (1)$$

Here $\mathbf{m} = n\mathbf{n}$ is the refraction vector [1,2], $n$ is the refraction index, $\mathbf{n}$ is the wave normal ($\mathbf{n}^2 = 1$), $\overset{\times}{\mathbf{m}}$ stands for the antisymmetric tensor dual to the vector $\mathbf{m}$, and $[\mathbf{m},\mathbf{H}]$ denotes the vector product.

*[The scalar product between vectors is denoted without any multiplication sign, by* **ab**. *The Gaussian system of physical units is used in the paper. For bianisotropic media with the constitutive equations]*

$$\mathbf{D} = \varepsilon\mathbf{E} + \alpha\mathbf{H} \qquad \mathbf{B} = \mu\mathbf{H} + \beta\mathbf{E} \qquad (2)$$

it follows from (1) that

$$\varepsilon\mathbf{E} + (\alpha + \overset{\times}{\mathbf{m}})\mathbf{H} = 0 \qquad \mu\mathbf{H} + (\beta - \overset{\times}{\mathbf{m}})\mathbf{E} = 0 \qquad (3)$$

Eliminating the magnetic field vector $\mathbf{H}$ we have the wave normal equation

$$\left|\varepsilon - (\alpha + \overset{\times}{\mathbf{m}})\mu^{-1}(\beta - \overset{\times}{\mathbf{m}})\right| = 0 \qquad (4)$$

For arbitrary tensors $\varepsilon$, $\mu$, $\alpha$, and $\beta$, the evaluation of the determinant (4) results in a rather complicated expression. However, we can simplify the analysis by eliminating the tensor $\mu$ (or $\varepsilon$) with the help of the linear transformation [4,5] of all the vectors:

$$\mathbf{E} = \overline{\mu}_1\mathbf{E}' \qquad \mathbf{H} = \overline{\mu}_1\mathbf{H}' \qquad \mathbf{m} = \overline{\mu}_1\mathbf{m}' \qquad (5)$$

and the tensors

$$\varepsilon = \mu_1\varepsilon'\mu_1 \qquad \mu = \mu_1\mu'\mu_1 \qquad \alpha = \mu_1\alpha'\mu_1$$
$$\beta = \mu_1\beta'\mu_1 \qquad \overset{\times}{\mathbf{m}} = \mu_1\overset{\times}{\mathbf{m}}'\mu_1 \qquad (6)$$

Here $\mu_1^2 = \mu$, and $\overline{\mu}_1 = |\mu_1|\mu_1^{-1}$ is the tensor adjoint to the tensor $\mu_1$. If $\mu$ is a symmetric and positive definite tensor then $\mu_1$ always exists and it has the same properties. After such replacement we obtain from (3):

$$\varepsilon'\mathbf{E}' + (\alpha' + \overset{\times}{\mathbf{m}}')\mathbf{H}' = 0 \qquad \mathbf{H}' + (\beta' - \overset{\times}{\mathbf{m}}')\mathbf{E}' = 0 \qquad (7)$$

Note that always

$$(\mu_1 \mathbf{m}')^{\times} = \mu_1 \overset{\times}{\mathbf{m}}' \mu_1 \qquad (8)$$

since $\tilde{\mu}_1 = \mu_1$ (see [5]).

*[ $\tilde{\alpha}$ denotes the transpose of a matrix.]*

Also, $\mu' = \mu_1^{-1}\mu\mu_1^{-1} = 1$

If $\mu = 1$ we have from (4)

$$\Delta = \left| \varepsilon - (\alpha + \overset{\times}{\mathbf{m}})(\beta - \overset{\times}{\mathbf{m}}) \right| = \left| \gamma + \kappa + \overset{\times}{\mathbf{m}}^{\,2} \right| = 0 \qquad (9)$$

where

$$\gamma = \varepsilon - \alpha\beta \qquad \kappa = \alpha\overset{\times}{\mathbf{m}} - \overset{\times}{\mathbf{m}}\beta \qquad (10)$$

With the help of the covariant methods expounded in [1,3,5] we obtain

$$\Delta = \Delta_0 + \Delta_1 + \Delta_2 + \Delta_3 + \Delta_4 \qquad (11)$$

where each term $\Delta_k$ is a polynomial of $\mathbf{m}$ of the power $k$:

$$\Delta_0 = |\gamma| \qquad \Delta_1 = (\bar{\gamma}\kappa)_t \qquad \Delta_2 = \left( \bar{\gamma}\, \overset{\times}{\mathbf{m}}^{\,2} = \gamma\bar{\kappa} \right)_t$$

$$\Delta_3 = |\kappa| + \left( \left( \overline{\gamma + \kappa} - \bar{\gamma} - \bar{\kappa} \right) \overset{\times}{\mathbf{m}}^{\,2} \right)_t$$

$$\Delta_4 = \left( \bar{\kappa}\ \overset{\times}{\mathbf{m}}^{\,2} + \gamma\ \overline{\overset{\times}{\mathbf{m}}^{\,2}} \right)_t \qquad (12)$$

Here the index $_t$ denotes the trace of a tensor. From (10) and (8) we obtain, using the same methods [1,3,5]:

*[Here and in the following the unity matrix is omitted, so that $\gamma - \gamma_t$ means the matrix $\gamma$ minus its trace multiplied by the unity matrix. Unlike in the Western tradition, here* **a.b** *denotes the dyadic product between vectors. In the expression for $\Delta_4$ we have in fact the product of two scalars.]*

$$\Delta_0 = |\varepsilon| - (\bar{\varepsilon}\alpha\beta)_t + (\varepsilon\bar{\beta}\alpha)_t - |\alpha\beta|$$

$$\Delta_1 = \left( (\bar{\gamma}\alpha - \beta\bar{\gamma})\overset{\times}{\mathbf{m}} \right)_t \qquad \Delta_2 = A + B\mathbf{m}^2 + \mathbf{m}\rho\mathbf{m}$$

$$A = \left( \alpha\overset{\times}{\mathbf{m}} \right)_t \left( \beta(\gamma - \gamma_t)\overset{\times}{\mathbf{m}} \right)_t + \left( \beta\overset{\times}{\mathbf{m}} \right)_t \left( \gamma\alpha\overset{\times}{\mathbf{m}} \right)_t$$

$$B = \left( \alpha\beta(\gamma - \gamma_t) \right)_t - \bar{\gamma}_t \qquad (13)$$

$$\rho = \bar{\gamma} + \bar{\alpha}\gamma + \gamma\bar{\beta} - \beta(\gamma - \gamma_t)\alpha - \tilde{\gamma}^{-1}\left( \beta\alpha\tilde{\bar{\gamma}} - (\beta\alpha\tilde{\bar{\gamma}})_t \right)$$

$$\Delta_3 = \mathbf{m}\gamma\mathbf{m} \left( (\beta - \alpha)\overset{\times}{\mathbf{m}} \right)_t + [\mathbf{m}, \gamma\mathbf{m}]\ (\tilde{\alpha} + \beta)\ \mathbf{m} - [\mathbf{m}, \tilde{\alpha}\mathbf{m}]\ (\tilde{\alpha} + \beta - \beta_t)\ \beta\mathbf{m}$$

$$\Delta_4 = \mathbf{m}^2\mathbf{m}\varepsilon\mathbf{m} - \mathbf{m}\alpha\mathbf{m}.\mathbf{m}\beta\mathbf{m}$$

If $\alpha = \beta = 0$, the equations (11), (13) simplify to

$$\mathbf{m}^2\mathbf{m}\varepsilon\mathbf{m} + \left( \bar{\varepsilon}\ \overset{\times}{\mathbf{m}}^{\,2} \right)_t + |\varepsilon| = 0 \qquad (14)$$

which coincides with the covariant wave normal equation obtained in [1,3]. With the help of the transformation inverse to that in (5), (6) ( $\mathbf{m} \to \bar{\mu}_1^{-1}\mathbf{m}$, $\varepsilon \to \mu_1^{-1}\varepsilon\mu_1^{-1}$ ) we obtain from here the corresponding equation for magneto-anisotropic media $\mathbf{m}\varepsilon\mathbf{m}.\mathbf{m}\mu\mathbf{m} + \mathbf{m}\mu\left(\bar{\varepsilon}\mu - (\bar{\varepsilon}\mu)_t\right)\mathbf{m} + |\varepsilon\mu| = 0$, first deduced in[1,7] (see also [3,5]).

In the case $\Delta_1 \neq 0$, $\Delta_3 \neq 0$ the medium is nonreciprocal. If $\beta = -\tilde{\alpha}$ we have from (13) $\Delta_1 = \Delta_3 = 0$, ie this condition connecting $\alpha$ and $\beta$ is *sufficient* for reciprocity in the general case [8]. Under this condition, $\gamma = \varepsilon + \alpha\tilde{\alpha} = \tilde{\gamma}$ and we have from (13) that

$$\Delta_0 = |\varepsilon| + (\bar{\varepsilon}\alpha\tilde{\alpha})_t + (\varepsilon\ \overline{\tilde{\alpha}\alpha}\ )_t + |\alpha|^2$$

$$A = (\alpha\overset{\times}{\mathbf{m}})_t \left( (2\gamma - \gamma_t)\alpha\overset{\times}{\mathbf{m}} \right)_t$$

$$B = \left( \overline{\alpha\tilde{\alpha}} \right)_t - \bar{\varepsilon}_t - 2\left( (\varepsilon - \varepsilon_t)\alpha\tilde{\alpha} \right)_t$$

$$A = (\alpha\overset{\times}{\mathbf{m}})_t \left( (2\gamma - \gamma_t)\alpha\overset{\times}{\mathbf{m}} \right)_t$$

$$\rho = \bar{\gamma} + \bar{\alpha}\gamma + \gamma\tilde{\bar{\alpha}} = \alpha(\gamma - \gamma_t)\alpha + \gamma^{-1}\left( \tilde{\alpha}\alpha\bar{\gamma}(\tilde{\alpha}\alpha\bar{\gamma})_t \right) = \tilde{\rho}$$

$$\rho = \bar{\gamma} + \bar{\alpha}\gamma + \gamma\tilde{\bar{\alpha}} = \alpha(\gamma - \gamma_t)\alpha + \gamma^{-1}\left( \tilde{\alpha}\alpha\bar{\gamma}(\tilde{\alpha}\alpha\bar{\gamma})_t \right) = \tilde{\rho}$$

$$\Delta_4 = \mathbf{m}^2\mathbf{m}\varepsilon\mathbf{m} + (\mathbf{m}\alpha\mathbf{m})^2 \qquad (15)$$

However, the condition $\beta = -\tilde{\alpha}$ is *not necessary* as we can see from an example of uniaxial bianisotropic medium. For such media $\varepsilon = \varepsilon_0 + \varepsilon_1 \mathbf{e}.\mathbf{e}$ and

$$\alpha = a_0 + a_1 \mathbf{e}.\mathbf{e} + a_2 \overset{\times}{\mathbf{e}} \qquad \beta = b_0 + b_1 \mathbf{e}.\mathbf{e} + b_2 \overset{\times}{\mathbf{e}} \quad (16)$$

where $\mathbf{e}$ is the unit vector $\left(\mathbf{e}^2 = 1\right)$ along the symmetry axis. The multitude of tensors of the shape (16) forms a commutative algebra. Its elements are given by three numbers: $\alpha = (a_0, a_1, a_2)$. The law of multiplication is

$$\begin{aligned} &\alpha\beta = \\ &(a_0, a_1, a_2)(b_0, b_1, b_2) = \\ &(a_0 b_0 - a_2 b_2, a_0 b_1 + a_1 b_0 + a_1 b_1 + a_2 b_2, a_0 b_2 + a_2 b_0) \\ &\qquad = \beta\alpha \end{aligned} \quad (17)$$

We have $|\alpha| = (a_0 + a_1)(a_0^2 + a_2^2)$, $\overline{\alpha} = \left(a_0(a_0 + a_1), a_2^2 - a_0 a_1, -a_2(a_0 + a_1)\right)$, and

$$\begin{aligned} &\alpha^{-1} = \\ &(a_0, a_1, a_2)^{-1} = \\ &\frac{1}{a_0^2 + a_2^2}\left(a_0, \frac{a_2^2 - a_0 a_1}{a_0 + a_1}, -a_2\right) \end{aligned} \quad (18)$$

These relations allow us to evaluate all the expressions in (13). Denoting $\gamma = (g_0, g_1, g_2)$, $\overline{\gamma} = (g_0', g_1', g_2')$, $(\tilde{\alpha} + \beta - \beta_t)\beta = (c_0, c_1, c_2)$ we obtain

$$\Delta_1 = 2 D_0 \mathbf{em} \qquad \Delta_3 = \mathbf{em}\left(D_1 \mathbf{m}^2 + D_2 (\mathbf{em})^2\right) \quad (19)$$

$$\begin{aligned} D_0 &= g_0'(b_2 - a_2) + g_2'(b_0 - a_0) \\ D_1 &= 2 g_0 (b_2 - a_2) + K \\ K &= g_1(a_2 - b_2) + g_2(a_1 + b_1) - a_1 c_2 - a_2 c_1 \end{aligned} \quad (20)$$

It is easy to see that for uniaxial media the expressions (13) contain the wave normal vector $\mathbf{n}$ only in the form $\mathbf{en} = \cos\theta$, therefore the refraction index $n$ depends only on the angle $\theta$ between the propagation direction and the symmetry axis. For any direction of $\mathbf{n}$ orthagonal to the axis $\mathbf{e}(\mathbf{en} = 0)$ the reciprocity condition holds (see (19)). When $\alpha$ and $\beta$ are independent and $\alpha = \tilde{\alpha}$, $\beta = \tilde{\beta}$ $(a_2 = b_2 = 0)$ all the coefficients with the index 2 are equal to zero and also $D_0 = D_1 = D_2 = \Delta_1 = \Delta_3 = 0$. So the condition $\beta = -\tilde{\alpha}$ is not necessary for reciprocity. All these conclusions are true also when $\mu = \mu_0 + \mu_0' \mathbf{e}.\mathbf{e}$, ie for any uniaxial medium.

General conditions for reciprocity of uniaxial media read $D_0 = D_1 = D_2 = 0$. Since we have 8 coefficients in $\varepsilon$, $\alpha$, $\beta$ (or 10 if $\mu \neq 1$) then evidently these three conditions can be satisfied by a wide spectrum of parameters. In particular, from $D_1 = D_2 = 0$ we have $(g_0 + g_1)(b_2 - a_2) = 0$. Therefore, in addition to the conditions $\beta = -\tilde{\alpha}$ or $\alpha = \tilde{\alpha}$, $\beta = \tilde{\beta}$, which concern only the tensors $\alpha$ and $\beta$, there also exist reciprocity conditions related to the equation $g_0 + g_1 = 0$. These affect $\varepsilon_0$ and $\varepsilon_1$.

Evidently we can analyse any other special cases based on the general relations (11)-(20).

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# IAGA/URSI JWG on VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere

A J Smith

This newsletter contains reports of the working group's activities at the recent general assemblies of our parent bodies — URSI and IAGA — held, respectively, in Kyoto and Buenos Aires. There is also some advance notice of future meetings, and news from members of our community in different countries around the world. This issue features in particular reports on VLF observations in Finland and in India. I would like to thank those who have contributed to this newsletter and I hope you find it of some interest. Contributions for the next issue are welcome.

## XXIVth URSI General Assembly, Kyoto: 25 August – 2 September 1993

It was a pleasure for me to meet many of you in Kyoto and enjoy in the pleasant milieu of the ancient city of Kyoto some friendly and valuable discussions about our common interests in VLF/ELF phenomena and their use in studying the ionosphere and magnetosphere. The scientific programme of the assembly included several interesting and stimulating sessions of relevance to the scope of the VERSIM working group. We cannot fully report all these here, but mention a few, including the session on *Whistlers and Particle Precipitation* convened by H J Strangeways and U S Inan.

## Whistlers and Particle Precipitation

This well-attended session was held on 1 September 1993; about a dozen papers (including associated posters) were presented on a variety of topics based on ground-based and satellite observations and theoretical modelling work. The session was mainly devoted to the Trimpi effect and related topics. Highlights of some of the papers are summarized below:

**M J Rycroft** (Cranfield) Gave an invited review on the subject (published in *Reviews of Radio Science* 1990-92) and began by noting that the American longitude is a preferred one. He discussed recent work by Inan on VLF heating of the ionosphere by lightning, supported by Taranenko et al., and Burke et al.'s Dynamics Explorer observations at L = 2.5 of a large upward flux of electrons. There were two pulses: (a) direct acceleration due to **E**; (b) due to gyroresonance. Other topics reviewed were Kelley *et al.*'s observations made above intense thunderstorms, AOEs (anomalous optical events), the "early Trimpi" controversy (i.e.\ is this due to upward current ( Armstrong), transient electric fields ( Burke), or heating ( Inan)?).

**R L Dowden** (University of Otago) characterised the Trimpi problem according to whether the scale size of the precipitation region was large compared to the geometric mean of the path length and wavelength (the geometrical optics approximation, i.e.\ regions not small or with fine structure); or small (the scattering case). He presented results for NWC to Dunedin (4 closely-spaced receiving stations) and Wellington. Amplitude and phase perturbations can have a different appearance even at neighbouring stations; this can be interpreted in terms of the increasing phase of the scattered phasor as you go from receiver to receiver on the chain. Sometimes simultaneous events were seen at Wellington; interpretation: the precipitation was on the great circle path to Wellington. Also discussed was "the case of the missing Trimpi", in which neither amplitude nor phase perturbation was recorded at one of the points on the network, whilst neighbouring stations (16 km away) did see an effect. A new type of event was described — RORDs (rapid onset rapid decay), consisting of a "spike" plus a Trimpi. The spike is of unknown origin; it is not broadband, but NWC signals are scattered. It adds to the Trimpi event to give the observed appearance. Summary: 1. Paths a few km apart give different Trimpis sometimes. 2. Simultaneous observations of Trimpis occur on paths 600 km apart; however this does not imply 600 km wide structure. 3. Lateral distribution of precipitation is usually not gaussian. 4. RORD LIEs appear simple in structure.

**U S Inan** (Stanford University) discussed a number of topics: the global importance of the Trimpi effect; onset and recovery signatures and their interpretation; and spread-spectrum remote sensing. Also treated were lightning-induced heating: new observations and kinetic modelling; and modification of the lower ionosphere by a transmitter. On the first topic, work by Burgess has focussed on conjugate precipitation, strongly correlated with whistlers (locations ascertained by DF). The speculation that every whistler precipitates somewhere, and a calculation from world whistler rates, leads to an inferred energetic electron lifetime in the magnetosphere of about $5 \times 10^4$ day (cf. plasmaspheric hiss $10^3$–$10^4$ day), so ducted whistlers may be as important as plasmaspheric hiss for particle loss from the radiation belts. On the second topic, recovery signatures tell us about D-region ionisation profiles. Different curvatures on different paths tell us about details of the spectrum of the precipitation. On the subject of signatures of LEP versus heating; only lightning on great circle paths is associated with heating events. LEP from lightning can be seen further away from the GCP. Confirmation of VLF heating has been found in Newfoundland (Gander) observations of NSS, when NAA switches off for maintenance. A similar effect was seen by

NSS on NAA received at Huntsville. The spread-spectrum analysis technique involves a full digital demodulation of MSK, and non-linear processing.

**A J Smith** (British Antarctic Survey) described Trimpi observations made on MSK transmissions observed at Halley and Faraday stations, Antarctica.

**D Nunn** (University of Southampton) described his model which is based on Wait's, but generalised from the unimodal case. The region of interest is described by a perturbation of the susceptibility tensor. The Born approximation is assumed, i.e. E'=0 or D'=0. The interpolation and scattering equations used were described. MODEFINDR is used to model the propagation. For modal scattering, the off-diagonal elements of the scattering matrix are significant (and profile-dependent). Modelling of the size and shape of a patch was illustrated. Paths considered were Omega-Australia to Dunedin (complex intermodal situation), NWC to Dunedin, and NPM to Palmer/Faraday. The model needs different profiles from those of Wolf and Inan, in order to reproduce Inan's results (at high altitude: lower energy particles). Future upgrades to the model: relax the Born approximation; a better version of MODEFINDR; use the whole tensor; apply to the heating problem; apply to slant LIEs (lightning-induced ionisation enhancements).

**H J Strangeways** (University of Leeds) considered the size and shape of LIEs using a 3-dimensional duct model with more than one duct. Wave energy is focussed near the equatorial plane. Ondoh had found duct widths 10–20 km (at 90 km altitude these map to about 9 km). 3-D ray tracing shows that a whistler is confined to a small region at the equatorial plane (see modelling by Laird). There is an amplitude threshold effect. Fine duct structure (reported by the E\"otv\"os group) implies a distribution of duct widths. Thus a LIE is unlikely to be a single gaussian structure; possibly a bigger structure in longitude than latitude.

**Y N Taranenko** *et al.*'s (Stanford University) paper was presented by Professor Inan and concerned optical emissions. Lightning ( Krider and Guo, 1983) gives rise to typical fields 10 $Vm^{-1}$ at 100 km altitude (decay time 100 μs). Lightning events near a perturbed patch (Boeck et al., 1992) were considered. Lightning can lead to enhanced airglow in the D-region (Shuttle observations); there is an association with electrons up to 10 eV in energy. This work solved Maxwell's and Boltzmann's equations in the time domain. There was a 20% density enhancement due to the first flash, and more flashes before recovery. This increases reflection of all modes (resulting in an always positive amplitude Trimpi).

**C and O Ferencsz** (Eötvös University) presented four poster papers, giving a new non-monochromatic full-wave whistler model, involving a rigorous solution of Maxwell's equations. Various solutions, e.g. homogeneous, nonhomogeneous, etc., were described. Separation of the effects of sources and propagation (losses) is possible. Data from Halley station, Antarctica, and the Intercosmos-5 satellite were compared with theory. Artificial splittings are produced at amplitude minima.

**K Tang** (CIE, Peking) described observations of whistlers and VLF emissions at Great Wall station, Antarctica, from 1984 onwards. VLF observations were made at the second Chinese station Zhongsan (near Davis) in 1988, but no whistlers were seen. What was described as a "harmonic whistler" was presented, though discussion from the floor suggested that such an effect could be due to cross-modulation in the equipment.

## Forty Years of Whistlers

This stimulating and informative tutorial lecture was given by **R A Helliwell** and is published in Modern Radio Science 1993 (edited by H Matsumoto). It covered a wide range of related topics beginning with a historical review of the subject, including early work on whistlers by Barkhausen, Eckersley, and Storey. For historical interest, he showed a comparison of some of Storey's original whistler data recorded in Cambridge in 1951, and published in 1953, with recordings made in Cambridge (at British Antarctic Survey) in 1993, illustrating the enormous increase in VLF/ELF manmade radio noise in urban areas in the intervening 42 years. Other topics on natural phenomena included MR (magnetospherically reflected) whistlers, proton heating, and Draganov et al.'s recent theory that whistlers can evolve into hiss, and that this can account for much of the observed plasmaspheric hiss.

Turning to whistler waves artificially stimulated by the Siple VLF transmitter, he discussed the concept of integration length and the second order resonance near the equatorial plane responsible for the so-called CWI (coherent wave instability). Fallers or risers are generated depending on which side of the equator the interaction region is located. The input signal amplitude in the equatorial plane is critical. He described the whistler simulation experiment: the peak amplitude is often the same as the saturation level. Other topics included: the predicted escape of whistler-mode signals on open field lines into the tail (which could possibly be observed at moon orbit); the threshold effect (path selective); suppression of the second frequency in 2-frequency experiments when they are close; sidebands; the strong effect of weak PLHR (power line harmonic radiation) and its relationship with natural MLR (magnetospheric line-structured radiation); the simulation of (pseudo) noise by the Siple transmitter and the development of "chorus" from "hiss"; frequency ramps and their effect based on the interaction length where $f'=f_H$ and $df'/dt = df_H/dt$ ($f'$ is the Doppler-shifted wave frequency). The interaction will tend to join any pair of wavelets if you choose the right point on the field line.

## Terrestrial Electromagnetic Environment

This session contained several papers of interest to the VERSIM community.

**A C Fraser-Smith** discussed the 1/f power law for radio noise, with the notable exception of the minimum near the Earth-ionosphere waveguide cutoff. He noted that background levels due to manmade noise are rising all the time, so it is becoming increasingly difficult to make measurements of natural ELF/VLF electromagnetic noise, except in remote areas like Antarctica. Man's pollution of the electromagnetic environment is illustrated by the fact that fields near typical electrical appliances at 50 Hz are of order $10^7$ times higher than the natural level.

**V A. Rafalsky** (Ukraine) described his work on atmospherics, from observations in Ukraine and on a ship in the Atlantic Ocean. The location of lightning and transverse resonances in the ionosphere (excited by spherics) were discussed. Cutoff frequencies increase with the order of the mode. Recording of $E_Z$ and two H components of the wave allows the range and direction of the source to be inferred. A model of terminator crossing is included in the analysis. The inferred lightning distribution shows source regions in Africa and South America.

**M Hayakawa** (University of Electro-com\-munications) also dealt with the location of lightning, by means of dispersion analysis and direction-finding. His technique allowed $h$, $D$ and $t_0$ to be inferred from tweek dispersion. The signal is mixed with a "pseudo-spheric". The accuracy of the technique is $h < 700$ m; $d < 40$ km. Three stations are required to fix the location. The 'Field Analysis Method' was used for DF at one station, in the South China campaign. Near the cutoff frequency for the waveguide, the incidence angle $i \rightarrow 0$. Left-handed polarisation of whistlers is observed near to cutoff; there is some disagreement between theory and experiment.

**A J Smith** (British Antarctic Survey) described the new VELOX (VLF/ELF logger experiment) instrument recently deployed at Halley, station Antarctica (L=4.3), and discussed some initial results from the system.

**O Molchanov** (Institute of Earth Physics, Moscow) and M. Parrot (LPCE/CNRS, France) began with a review of PLHR (power line harmonic radiation) observed on spacecraft (see Kimura et al., 1987). Emissions stimulated by PLHR show geographical control and weekly effects (the Sunday effect has been reported). LHE (line harmonic emissions) are observed in the range 3–5 kHz. MLR has $f$=30–500 Hz; $df/dt$ = 0.3–4 Hz $s^{-1}$. Any theory needs to explain: (1) The amplitude and doppler shift of PLHR; (2) triggering and wave-particle interactions (coherent instability in the equatorial plane); (3) triggering in the upper ionosphere; (4) demodulation near the satellite. Lefeuvre and Bullough showed evidence of geographical control, though there were sceptics — e.g. Lyons, Tsurutani, and Thorne. According to Parrot et al. (1991), power consumption is still increasing, so PLHR effects should be also. It is important to estimate the "power flux" compared to auroral effects. Aureol-3 findings were reported. There was an effect in electrostatic turbulence (72 Hz electric field component only), the magnitude of which (on average) decreased slowly from a peak on Monday to a minimum on Saturday (by a factor of about 2) with a slight increase on Sunday and a big increase to the Monday peak. The observations provide evidence for the ionospheric origin of PLHR-related emissions.

## VERSIM

A meeting of the working group was held at Kyoto on 31 August 1993. 14 members were present, with A J Smith in the chair. After receiving the chairman's report on past activities, the meeting agreed to recommend the continuing existence of the working group, since fulfilled a need, serving as a forum for the VERSIM community. The meeting recommended that U.S. Inan should continue as URSI co-chairman for the next three years. The VERSIM Newsletter was endorsed as a useful medium of communication, especially during the intervals between scientific assemblies. It was noted that the sessions of interest to VERSIM, proposed for the 1996 URSI Assembly (see list below), were likely to be 'pared down' to 2 or 3, because of pressure of time. The remainder of the meeting was occupied by reports given by various members present.

**A R W Hughes** (South Africa) reported that the new station at Sanae, Antarctica, was to be occupied in 1995. The VLF/DF programme continues, with an OMSKI receiver deployed at Sanae at the beginning of 1993. TV recordings of aurorae in the Antarctic are made together with correlated VLF, recorded simultaneously. They are purchasing "Omni-PAL" receivers from Otago University (R L Dowden); at present the software for this instrument is still being written. A system will be operated in Natal on a 150 km baseline (3 stations).

**Gy Tarcsai** (Hungary) spoke of work on the digital matched filtering of whistlers, and a new rigorous solution of Maxwell's equations for whistler studies. The techniques have been applied to Aureol-3 data, Halley whistlers, Palmer whistlers, Roberval frequency ramps, and data from the SAS experiment on the ACTIVE satellite (260 M-Bytes of data), looking for nonlinear effects. A new SAS-2 instrument (5-component) is being developed for flight on the CESAR (Central European Satellite for Atmospheric Research) satellite. Trimpi recordings have been made for 2-3 weeks in Hungary. 20–30 good Trimpi events were seen on NAA and NSS; these will be analysed in collaboration with workers at Otago and British Antarctic Survey. A Trimpi receiving system will be operated together with German, French, and Hungarian scientists. He pointed out that the region is

conjugate to South Africa (e.g. Sarajevo is conjugate to Durban!). Work is in progress on the automatic detection and analysis of whistlers; a powerful technique has been developed and will be used on the CESAR satellite.

**J Manninen** (Finland) described VLF recordings made in northern Finland since 1989, some in connection with overpasses of the AKTIVNY satellite. Recordings are made only during campaigns, which were connected with EISCAT, etc. The sites used are very quiet and are located in the *L*-range 5–6. 15 hours of data have been collected on VHS videotape, including many VLF phenomena of interest. Collaboration is proceeding with the Polar Geophysical Institute (Apatity, Russia). There will be a campaign in November 1993, involving M. Rietveld (EISCAT). (For further information, see later in this newsletter.)

**M J Rycroft** (UK) described a developing array of VLF receivers around Europe. Outside the plasmapause, chorus-induced precipitation may be visible by this network. He noted in particular, that the NAA–Cambridge and NSS–Cambridge paths overlap, which may reduce the degrees of freedom in interpreting the data in terms of the effect of precipitation into the lower ionosphere.

**F Lefeuvre** (France) mentioned work done using the Aureol-3 data which is held at Orleans. Future activities include participation in the INTERBALL mission (which is due to be launched in mid-1994). Theoretical studies include nonlinear effects due to VLF transmitters, and the use of neural networks to identify spherics, whistlers, etc. in the data.

**U S Inan** (USA) described the Palmer-Rothera-King George Island experiment to be conducted in 1994. VLF observations across the continental United States continue, and a special VLF heating experiment is in progress at Gander (Newfoundland) to look at heating of the lower ionosphere by the NAA transmitter, using NSS as the probe wave. VLF observations have started in Alaska to diagnose the D-region modified by the HIPAS HF Heating facility. The Automatic Geophysical Observatory program is moving along. Three new AGOs are to be deployed during austral summer 1993–94.

**A J Smith** (UK) reported on activities of the British Antarctic Survey. The first full year of data was now available from the new VELOX (filter-bank type) VLF/ELF receiver at Halley. Initial results were being reported in a paper at one of the sessions at Kyoto. Broad-band and narrow-band recordings at Rothera were to be initiated in 1994 at part of an international US-UK-Brazil collaboration. The BAS AGO programme is now proceeding well, with the first deployment of an ELF/VLF receiver on one of the AGOs scheduled for the 1994–95 Antarctic summer season (for further information, see later in this newsletter).

## 7th IAGA Scientific Assembly, Buenos Aires: 8–20 August 1993

A meeting of VERSIM was held at Buenos Aires, on 14 August 1993; in the absence of both VERSIM co-chairmen, it was chaired by L.R.~Piazza. Those present exchanged news and views, and endorsed the continuation of the working group and the proposal for a VERSIM session at the 1995 IUGG (see below).

## Forthcoming meetings

### IUGG, Boulder, 1995

IAGA will be meeting during the 21st General Assembly of IUGG to be held in Boulder, Colorado, USA. For general information, contact: IUGG XXI General Assembly, c/o American Geophysical Union, 2000 Florida Avenue NW, Washington DC 20009, USA.

A VERSIM half-day session on *Whistler Mode Waves and Particle Precipitation* (conveners A.J. Smith and U.S. Inan) has been scheduled for inclusion in the scientific programme.

In this session the focus will be on the precipitation into the ionosphere of energetic electrons by whistler mode waves, both natural and artificial. Papers on the observations of whistler-mode waves and associated wave-induced precipitation effects, as well as on theoretical and computer-based modelling of the interactions and the associated ionospheric effects, are invited.

The abstract deadline will be: **1 February 1995.** More details will be published in a forthcoming {\it IAGA News.

### URSI, Lille, 1996

The next URSI General Assembly will be held in Lille, France, in 1996. Some of the proposed sessions for this Assembly, of relevance to VERSIM, are:

*Nonlinear wave theories and observations in space*

*Lightning and its interaction with the ionosphere*

*Whistler-mode waves at high latitudes*

*Electromagnetic coupling between the ground, the ionosphere, and the upper atmosphere*

*Transient effects in the ionosphere*

### IAGA, Uppsala, 1997

The 8th Scientific Assembly of IAGA will be held in Uppsala, Sweden. The proposed dates are 3–15 August 1997.

## News from the VERSIM Community

### Finland

From **Jyrki Manninen**, Department of Physics, University of Ouluand, and Tauno Turunen, Geophysical Observatory, Sodankylä

We have measured VLF waves in different parts of northern Finland since 1989. All measurements have been related to some specific project. During 1989 and 1990 we tried to receive VLF signals from the Russian 'Aktivny' satellite but without success. In December 1990 we coordinated VLF and EISCAT (incoherent scatter radar) measurements for the first time. Now we are preparing two papers related to impulsive precipitation events and dayside high-latitude magnetic impulse events.

In 1991 we included auroral TV observations and ULF measurements in our experiment. Accurate timing can be a problem when comparing different kinds of geophysical data from different data sets. For that reason, we now record all data on the same video tape. The ULF waveform is recorded on the audio track using FM subcarriers, whilst the TV signal is recorded to the video track together with multiplexed time information.

In February 1991 we recorded more than 1000 whistlers within 6 hours. In that case the L-shells of the whistler ducts were changing with magnetic disturbance. That was natural, but sometimes there were even one-to-one correlations between changes of L-shell of the whistlers and the magnetic X-component.

In October 1991 very intense VLF waves were recorded after a strong magnetic storm (Kp exceeded 8). In the afternoon sector, numerous radio broadcasts, coming mostly from Russia, were detected by our equipment. We observed also some very strong PLHR events which we believe were related to a.c. currents flowing in the Swedish railway system at 16 $^2/_3$ Hz.

In 1992 and 1993 our measurements were mostly related to EISCAT/auroral campaigns. Many auroral substorms were recorded simultaneously with hiss and morning chorus. In any case, there are two very interesting phenomena: (i) radio broadcasts observed directly in VLF range, and (ii) whistler-triggered chorus which seems to be related to magnetic Pc-1waves (like the events reported by Smith *et al.*, 1985).

A recent campaign was related to an ionospheric heating experiment and EISCAT measurements. The data analysis is not yet complete but we have found that the radio broadcast we observe seems to be around 6 MHz. Of course the most natural explanations are related to equipment limitations, but we carried out a test in which the heater used 6 MHz modulated with sinusoidal VLF wave and we did not receive anything in the VLF range (the distance of the transmitter was 95 km from the VLF receivers). This proves that the explanation lies elsewhere than in the equipment. We also found some cases when a 1375 Hz sinusoidal heating signal produces harmonics, see a recent paper by Barr and Stubbe *Geophys. Res. Lett., 20* (1993) on harmonics from Tromsø heating facility.

The VLF instrumentation used in 1989–1992 (spring) contains two orthogonal magnetic loops which have an effective area of 126 m^2 and theoretical sensitivity of 6.7 x$10^{-17}$ $Wm^{-2}$ $Hz^{-1}$. Since 1992 (autumn) we have used new antennas which have an effective area of 1000 $m^2$, so their sensitivity is about 100 times better. The antenna is square (10 m x 10 m) with 10 turns. Since 1991 we have also had a two-component ULF magnetometer (magnetic coil with 4000 turns and very high quality amplifiers). It can see even weak Pc-1 pulsations. Since 1992 we have used a wide-angle and wide-wavelength diode-photometer (45° acceptance angle and 450–1200 nm wavelength). All wavelengths are integrated, so it cannot be used to distinguish different auroral emissions, but it can readily detect aurorae almost anywhere in the sky. We record the signal both in DC (total intensity) and in AC (just variation or pulsation) modes. All data are recorded by a HiFi video tape recorder which has two audio channels with 90 dB dynamic range and 20 Hz – 20 kHz frequency range, and one video track where we record the auroral TV image with multiplexed time information. The VLF frequency band we record at present is from 0.2 kHz up to 9.2 kHz.

We have started cooperation with PGI, Apatity, Russia (E Titova) and some contacts also exist with Hungary (Gy Tarcsai). We would welcome any other cooperation which would make use of our high-quality VLF data recorded in the auroral zone.

### UK

From **A J Smith** and **M A Clilverd**, British Antarctic Survey, Cambridge

At Halley, Antarctica, we are continuing to make broad-band VLF goniometer recordings on a continuous, synoptic 1-in-5, or synoptic 1-in-15 basis. The analogue magnetic tape recorders were replaced by DAT (digital audio tape) recorders at the beginning of 1994. In addition we have continued to operate our VELOX VLF/ELF logger instrument (see VERSIM Newsletter No. 5 for a description). A condensed summary of the data is sent promptly and regularly to NASA as key parameters for the GGS (Global Geospace Science) mission, which are available centrally.

OMSK receivers, designed to study Lightning-induced Electron Precipitation through the study of Trimpi events, are planned to operate throughout 1994 at Halley and Faraday stations, Antarctica. Each receiver can record simultane-

ously the amplitude and phase of two Omega signals and two MSK signals. At Rothera (68° S, 68° W; L=2.8) a short-term VLF experiment in collaboration with the USA (Palmer station) and Brazil (King George Island) will proceed during the winter of 1994, to study lightning-induced electron precipitation into the ionosphere. The Rothera equipment will consist of a Trimpi detector (OMSK receiver), and broadband (0–10 kHz) VLF recordings made synoptically every 1 minute in 5. At Faraday, the VLF Doppler experiment receiving whistler-mode signals from VLF transmitters continues in operation; the receiver software has recently been upgraded to extend the observable range of group delays, and further improvements are in the pipeline. Faraday will close as a British manned observatory in March 1996; some experiments (not including VLF observations) may be continued using automated systems. The VLF Doppler experiment is likely to be moved to Halley in the first instance.

Two BAS AGOs (Automatic Geophysical Observatories) have been operating in Antarctica since the 1991/92 season, at Halley (for testing) and at site 'A77' (77.5° S, 23.4° W). These each carry a three-axis magnetometer and a riometer. Both AGOs operated well through the 1993 winter. A third AGO is in the process of deployment on the Recovery Glacier at around 80.8° S, 20.4° W. It is planned to deploy the first AGO VLF/ELF instrument at this site during the 1994/95 summer season.

## Czech Republic

From **F Jirícek and P Tríska**, Geophysical Institute of the Czech Academy of Sciences

During the past two years, VLF/ELF waves observations and data processing have continued in the frame of the ACTIVE (Intercosmos 24 and MAGION 2) and APEX (Intercosmos 25 and MAGION 3) projects. The satellite VLF-broadband analogue data have been processed together with some plasma parameters (electron temperature, density and ion composition) with the aim of studying some LHR associated phenomena, e.g.the origin of LHR-whistlers, the occurrence and origin of some types of emissions, and plasmapause signatures in the outer ionosphere during disturbed periods. Special attention has been paid recently to the outer ionosphere phenomena associated with earthquakes. Two MAGION-type satellites are being prepared now as a Czech contribution to the INTERBALL project (1994–1996), each of them carrying a three-axis magnetometer, VLF/ELF instruments and plasma monitoring experiments.

## India

From **Birbal Singh**, R.B.S. College, Bichpuri, Agra-283105

Whistler studies in India were started in 1963 under the guidance of late Professor B.A.P. Tantry of Banaras Hindu University and continued until 1973. During this period, extensive ground based observations were carried out at two high altitude research stations: Gulmarg (geomagnetic latitude 24∞N) and Nainital (geomagnetic latitude 19∞N) and the bulk of whistler data collected. Analysis of the data indicated that: (i) the activity increased in the months of March and April; (ii) the majority of the whistlers occurred in the hours around midnight; and (iii) the activity increased sharply during periods of magnetic disturbance. A detailed ray-tracing study, with realistic low-latitude ionospheric models, indicated that the duct propagation of low latitude whistlers is unlikely.

During the period 1974–1988, whistler studies were conducted mostly at Agra station (geomagnetic latitude 17°N) and occasionally at Varanasi station (geomagnetic latitude 15°N). However, even during this prolonged period of study, some major problems like *whether ducts are formed in the low latitude ionosphere or not; if yes, then under what mechanism?, what is the duct lifetime?*, etc., could not be solved. On the other hand, evidence was found in support of the nonducted prolongitudinal mode of propagation for low-latitude whistlers and also the influence of ionospheric irregularities like spread-F and sharp density gradients on their propagation characteristics.

## Whistler studies under AICPITS

Recently, in 1989, the Indian Department of Science and Technology sponsored a coordinated study of ionospheric irregularities over India under its All India Coordinated Programme of Ionosphere Thermosphere Studies (AICPITS). Under this programme, fourteen stations were established all over the country to monitor ionospheric irregularities by recording amplitude scintillations of VHF signals at 244.16 MHz from the FLEETSAT satellite. Four of these stations, namely Srinagar, Agra, Varanasi, and Bhopal, supported an additional experiment of whistler observations, side by side with that of the VHF scintillation observations. While the main object of the whistler observations was to solve the long enduring problems by simultaneous observations at multiple stations, the other object was to examine whether ionospheric irregularities like spread-F could influence the whistler propagation at low latitudes. If so, then both whistlers and scintillation should occur simultaneously. The results of three years of study along these lines have shown that: (i) the whistler occurrence at low latitude stations is very rare and sporadic; (ii) some new results such as higher harmonics of tweeks, daytime whistlers and daytime chorus emissions have been obtained for the first time; and (iii) on no occasions were whistlers and scintillations observed simultaneously.

Since the results found during this campaign period are not very conclusive, it has been decided to continue the studies

for another period of four years with improved observation techniques augmented with a direction-finder at the higher latitude station of Jammu (geomagnetic latitude 24\degN). The observations are to be computerised, and efforts are to be made to carry out real-time analysis of the data.

## Japan

A conjugate campaign of VLF direction-finding observations was carried out in Iceland and at Syowa station, Antarctica, in September–October 1993. This project was to investigate the conjugacy of ELF/VLF waves between Iceland and Syowa, in order to study solar wind energy injection into the magnetosphere. For example: Are similar waves seen simultaneously at conjugate locations? Do they move the same way (both polewards or both equatorwards) at the same time? Are any scintillations similar (this will depend on the propagation through the conjugate ionospheres)?. Measurements are made at Syowa and two spaced stations in Iceland. VLF WDF (Wave Distribution Function analysis) and goniometry are done at each site, as well as auroral observations, etc. The campaign was scheduled in September/October when there is sufficient darkness to observe aurorae at both conjugate locations. The project is a collaboration between Chiba University and NIPR (National Institute of Polar Research).

Also at Chiba, **S. Shimakurais** planning to set up a Trimpi experiment using the path \mbox{\Omega-Japanto Chiba, on 10.2 kHz. In addition, a digital real-time receiving and analysis system will be installed on the Chiba campus. Measurement of two wave components (in winter only, as there is too much atmospheric noise in the summer) will give the arrival direction as well as range (i.e.\ the source location can be inferred) of lightning, and thus allow studies to be made of lightning propagation and source location distribution.

## South Africa

From **A R W Hughes** Space Physics Research Institute, University of Natal, Durban.

During an expedition to Marion Island from 19 April to 15 May 1993, it is planned to run the following instruments: (i) VLF goniometer, (ii) an Omnipal or OMSKI VLF receiver, (iii) a magnetometer, and (iv) a UV flux monitor. Simultaneously VLF observations close to the conjugate point may be made by Eigil Ungstrupand Reiner Friedel. One of the aims of the campaign is to study hiss enhancements occurring with a periodicity of \sim40 s, which may be related to substorms.

## Synoptic VLF Observations

This note is to remind VERSIM experimenters of the working group's recommendations regarding the timing of broadband synoptic VLF recordings, in order to facilitate detailed comparisons of data from different observing sites. For 1-minute-in-5 synoptic sampling, the minutes recorded should whenever possible be 00–01, 05-06, ... 55–56 past the hour; for 1-minute-in-15 sampling, the minutes recorded should be 05–06, 20–21, 35–36 and 50–51.

## The role of the VERSIM Working Group

The working group serves as a forum for workers studying the behaviour of the magnetosphere and ionosphere by means of ELF and VLF radio waves, both naturally and artificially generated. Originally the emphasis was on probing of the magnetosphere by whistlers, but recently the scope has become somewhat broader. The group aims to promote research in this field by facilitating the exchange of ideas, information and experience between active research workers and other interested scientists. This is done through regular meetings at IAGA and URSI Assemblies, and via the circulation of a newsletter. The group has also been active in sponsoring scientific symposia at IAGA and URSI Assemblies, in areas relevant to its field of interest, and in coordinating observational campaigns. There are currently 95 scientists from 22 different countries (Australia, Austria, Belgium, Brazil, China, Czech Republic, Denmark, Finland, France, Germany, Hungary, India, Japan, New Zealand, Norway, Russia, South Africa, Sweden, Ukraine, UK, USA, and Yugoslavia) on the VERSIM mailing list.

Please send any information of interest to other members of the working group, for publication in the next newsletter, to the editor, A J Smith, at the address given below; electronic mail preferred, otherwise mail or fax.

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# INSPIRE and the Solar Eclipse of May 10, 1994

**William W L Taylor**

On May 10, 1994, an annular solar eclipse will sweep across the North Pacific, North America, the North Atlantic and parts of Europe and Africa. Most of the US will experience at least a 50% coverage of the sun, with a maximum coverage of about 88%. Most people will not notice the resulting decrease in solar illumination or any other effect of the eclipse. If they happen to see the pinhole camera effect of the eclipsed sunlight shining through gaps in tree foliage, however, they will see not bright disks of light on the ground, but bright disks with bites taken out by the moon. In the US, hundreds of high school classes, participating in the INSPIRE project will be making observations of audio frequency radio waves, hoping to see a difference in the waves they observe. They will certainly be observing sferics, the audio frequency pulses of radio waves from lightning which propagate in the earth ionosphere waveguide. Sferics set the natural noise level in the atmosphere. Emissions from power lines, 50 or 60 Hz and their harmonics, contribute to the noise. The students will also observe US and Russian radio navigation stations, OMEGA and ALPHA at frequencies between 10 and 15 kHz.

Since the Earth's lower ionosphere is primarily created by solar UV, and since radio waves in the audio frequency region propagate in the earth-ionosphere waveguide, it is natural to expect that the eclipse will have an effect on radio propagation. The changes may be observable with INSPIRE receivers that the classes have built. For example, the minimum frequency of sferics may slightly decrease during the eclipse, as the lower parts of the ionosphere disappear, forming a larger gap between the ionosphere and the earth, thus allowing a slightly larger wavelength to propagate.

The receivers were made available by The INSPIRE Project, Inc., a non profit educational and scientific corporation, organised to bring the excitement of observing natural and manmade radio waves in the audio region to high school students. Underlying this objective is the conviction that science and technology are the underpinnings of our modern society, and that only with an understanding of science and technology can people make correct decisions in their lives, public, professional, and private. Stimulating students to learn and understand science and technology is key to them fulfilling their potential in the best interests of our society.

Most of the observing classes will be using audio frequency or VLF receivers that were built by previous high school physics classes at the same schools they now attend. Projects were organised by INSPIRE over the last five years to make VLF receiver kits available for observations of a USSR satellite, ACTIVE, and a Shuttle/Spacelab investigation,

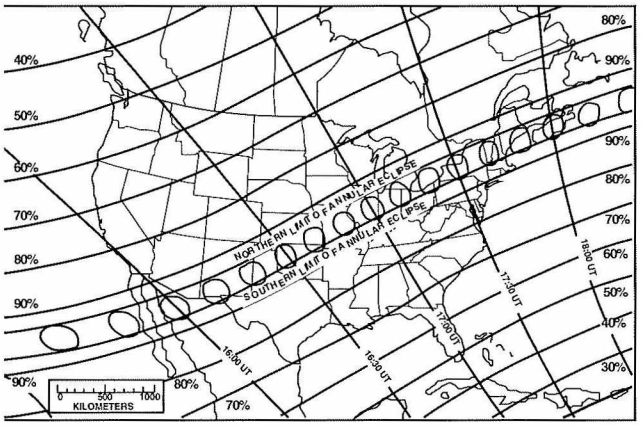


*Fig. 1. The path of the annular solar eclipse over North America on May 10, 1994. The percentages/maximum on the Fig. are the overlap of lunar and solar diameters. From Espanak and Anderson [1993].*

SEPAC. The classes purchased the kits, built the receivers, made observations and analysed the data.

Kits and completed electric field receivers may also be offered for sale for about $60 to students, classes, teachers, amateur scientists and others to allow them to participate. Those who already have HSGS (magnetic field) or INSPIRE (electric field) receivers will be able to use them, of course. Publicity for INSPIRE radio wave observations during the eclipse has begun [*Mideke*,1993a,b and *Taylor*,1993d], and will continue. Figure 1 shows the path of the eclipse in North America [*Espenak* and *Anderson*, 1993]. Everywhere in the contiguous 48 states will experience at least a 48 percent coverage of the solar disk as measured by the overlap of lunar and solar diameters.

## ACTIVE

In 1988, the Space Research Institute of Moscow requested that NASA participate in its upcoming ACTIVE (which is not an acronym) project. ACTIVE was a pair of satellites launched in 1989 with a 10.5 kHz transmitter onboard one to study wave particle interactions and the propagation of VLF waves. NASA responded by authorising a group of US. scientists to make ground observations and theoretical calculations relevant to ACTIVE.

To support ACTIVE science in the US, a volunteer organisation dubbed HSGS (High School Ground Station) was quickly established by W. Taylor; W. Pine, a high school

physics teacher; and two amateur scientists, M. Mideke and J. Ericson. The objective of HSGS was to recruit high schools to help gather data on 10.5 kHz electromagnetic (radio) waves which might be observed on the ground. A large number of ground receiving sites were needed, both to enhance the probability of receiving the radio waves from ACTIVE, and to determine the propagation paths to the ground.

HSGS had several objectives. The first was to ascertain whether high school classes could successfully complete a project that included mechanical and electronic construction and a rigorous data-gathering procedure. The second was to see if high school physics teachers could integrate the instructional material into their curriculum. NASA provided moral support and TRW provided financial support to defray the cost of the packages. The packages included an electronic kit, an audio tape of expected phenomena, and 161 pages of instructional material. The packages were developed and distributed to interested high schools in California, Ohio, Maryland, Virginia, and the District of Columbia.

A Workshop was held at Chaffey High School in Ontario, California in December 1990, to acquaint high school teachers and students with ACTIVE and HSGS. Fifty-four students and teachers from 17 high schools attended. While designed for schools in southern California, one teacher attended from Washington, DC.!

Many of the schools that received kits successfully operated them, recording the data on cassette tapes for analysis. The transmitting antenna on the ACTIVE satellite apparently failed to deploy properly, however, resulting in a decrease in signal strength of about 30 dB. Even though no waves were observed on the ground, the teachers reported a very high level of enthusiasm in their students. The teachers integrated the HSGS instructional material into their units on waves, electronics, radio, and the atmosphere. The student and teacher enthusiasm proved to HSGS that continuing such a program would be very useful in stimulating interest in science in general and space physics in particular among high school students. This volunteer organisation evolved into INSPIRE.

## INSPIRE/SEPAC

Following ACTIVE and the proof of the concept through HSGS, INSPIRE was formally organised. The objective of INSPIRE was to increase high school participation by a factor of ten and to more or less permanently establish a set of high school physics classes (through their teachers) around the country to make observations of radio waves in the audio region. SEPAC (Space Experiments using Particle Accelerators), a payload on the ATLAS 1 Spacelab mission, flown in March/April 1992, provided the initial enthusiasm for INSPIRE classes. SEPAC consisted of an electron accelerator and support instrumentation and performed many experiments in the ionosphere, including producing an artificial aurora and investigating the electromagnetic waves produced by a pulsed electron beam (a virtual antenna).

The ATLAS 1 payload did not include a subsatellite to receive the waves from the SEPAC virtual antenna, so the logical alternative was to establish a set of ground receiving stations to receive the radio waves. INSPIRE provided that service to the SEPAC investigator team, and at the same time, allowed high school students the opportunity to take data that would be used in a published basic research project.

To publicise INSPIRE, the project sent invitation letters to "The Physics Teacher" at the 10,000 largest high schools in the US (of about 20,000 total). In addition, articles publicising INSPIRE were published in various journals [*Anonymous*, 1991a, b, c, d; *Ericson*, 1991a, b; *Mideke*, 1991; *Pine* and *Taylor*, 1991; *Reneau*, 1991; *Anonymous*, 1992a, b, c; *Taylor et. al*, 1992; and *White*, 1992]. More than 1,000 schools responded with orders for the package. The package included an electronic kit for a VLF receiver, 250 pages of background and instructional material, an audio tape of expected phenomena and a promise to analyse any tapes that were sent to INSPIRE after the mission. Only the first 1,000 orders could be filled due to the limited resources available to INSPIRE. Figure 2 shows the geographical distribution of the participating classes.

A Workshop for INSPIRE/SEPAC was held at the Academy for Science and Foreign Languages, a public magnet middle school in Huntsville, Alabama, in March 1992. Aimed at middle and high schools in Madison County, Alabama, 40 teachers and others from northern Alabama attended. It was sponsored by the University of Alabama at Huntsville.

An elaborate information distribution network was established to inform the participants of the experiment schedule, including hourly announcements on WWV (the U.S. time and frequency shortwave radio station), announcements on four electronic bulletin boards, and a toll-free telephone

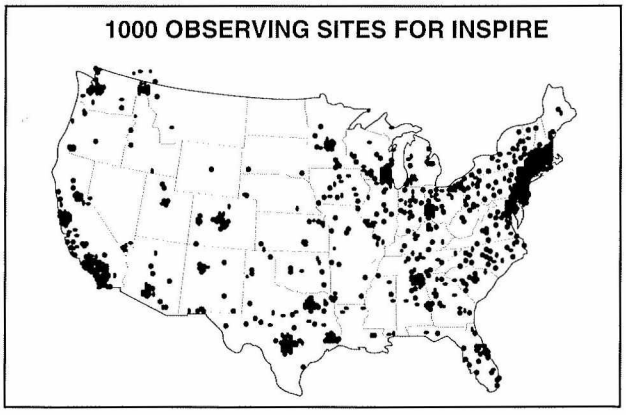


*Fig. 2. Locations of the 1000 high schools that participated in INSPIRE/SEPAC.*

number with a recorded announcement that was changed as new information became available. ATLAS 1 was to fly for about a week and the operations plan called for ten virtual antenna experiments over the U.S.

The electron accelerator failed, however, during its second virtual antenna operation, over the north eastern U.S. Many schools in that area observed during that operation and many high schools all over the U.S. participated in the subsequent backup listening experiment to study the changes in sferic (lightning impulse) propagation at sunrise. Approximately 300 cassette tapes were sent to INSPIRE for analysis. Each of the participant classes who sent tapes received in return at least one spectrogram of the data they had collected, a personal letter from M. Mideke, who performed all the analysis, describing what they had observed, and a Certificate of Appreciation for participating. As with ACTIVE, the teachers and students were wildly enthusiastic about INSPIRE. The project gave them a means of relating the physics they learned in class to a real, practical experiment, and one that was being done cooperatively with NASA, using the Space Shuttle. Some classes also performed computer analysis of the signals they received.

The two highest quality INSPIRE observations from the north eastern U.S. experiment are being carefully analysed. While the initial results showed that waves from the SEPAC virtual antenna might have been observed on the ground, Figure 3, more detailed analysis has failed to substantiate the early, promising results. Nevertheless, INSPIRE/SEPAC data will continue to be analysed. The results were reported at the Kyoto URSI General Assembly in August 1993 [*Taylor, et al.*, 1993a] and will be presented at the Fall American Geophysical Union meeting [*Taylor*, 1993b]. A publication is also in preparation [*Taylor*, 1993c].

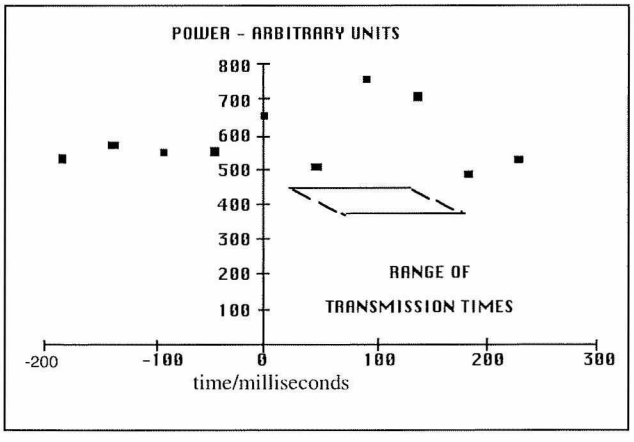


*Fig. 3. The average power received on the ground during the 140 transmissions during Functional Objective (experiment) 7-2.*

## INSPIRE/TSS-1R

NASA has tentatively approved the reflight of TSS-1 (Tethered Satellite System)-1 for the Fall of 1995. The TSS-1R payload includes an electron accelerator which, at low ionosphere densities, such as typical nighttime densities, will modulate the current in the 20 km long tether wire. If modulated at audio frequencies, the tether would act as an antenna and might be a radio wave source in the ionosphere that would be detected on the ground. INSPIRE will volunteer observers' support to the Principal Investigators to make ground observations. Two factors would maximise INSPIRE usefulness for the science, an orbital inclination of about 50! so that the orbit covers the 48 contiguous US, and appropriate operations over the US.

## OTHER INSPIRE ACTIVITIES

INSPIRE project will continue, rallying around opportunities for observations of special events, but with a base of activity to make US-wide observations of natural and manmade phenomena. The INSPIRE Journal will be an important part of these activities. It is published biannually and has a small subscription fee. It describes INSPIRE activities and INSPIRE results. Another activity is a continuing coordinated observation campaign, in which participants across the U.S. make simultaneous observations to study the propagation of radio signals in the audio range. Examples are manmade signals such as the OMEGA and ALPHA radio navigation stations, and natural radio emissions such as sferics and whistlers (magnetospherically frequency dispersed impulses from lightning).

In addition, more high school physics classes will be recruited to participate in INSPIRE, to learn about space and NASA through the study of the ionosphere, lightning, electronics, mechanical and electrical construction techniques, data gathering procedures, and data analysis. Spring and fall observing campaigns will be organised to observe natural and manmade phenomena.

INSPIRE is dedicated to providing opportunities to all interested students, and giving specific encouragement to those who are generally less interested in or less able to participate in scientific or technical fields. Special efforts will be made to encourage participation by disadvantaged schools as well.

INSPIRE plans to hold several Workshops each year in the US. The Workshops will be primarily organised by local teachers and volunteers and will be designed to offer an introduction to INSPIRE, its projects, kit building (sometimes the students and teachers do not have the expertise to build the kits without help), site location and data gathering procedures. A Workshop will typically be held on a Saturday, with INSPIRE participants (teachers and students) attending.

A Workshop agenda might include short talks by a national INSPIRE organiser, introducing INSPIRE, describing previous projects and describing new projects (such as Eclipse-94); a talk by the local organiser; a talk about building kits; and a talk by a representative of the local power company. After these talks, the Workshop would break up into small groups to discuss particular aspects of INSPIRE, to locate electromagnetically quiet sites, to build kits, to learn more about the phenomena that can be observed with INSPIRE receivers, and to learn about data analysis.

INSPIRE has been limited so far to the US. But this has only been because of the limitations of time by the organisers. Anyone anywhere could become involved with INSPIRE, which welcomes additional volunteers. Participation could range from helping a class, organising Workshops, providing state, local, or national organisational skills or starting INSPIRE activities in another country. To see how you could participate in INSPIRE or learn more about INSPIRE activities, send a self-addressed business sized envelope with two stamps if you are from inside the US, or an equivalent, self-addressed postage return paid envelope if you are from outside the US, to:

**Bill Pine, INSPIRE**
1348 N. Quince Upland
CA 91786
USA

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# The IPS-71 Advanced Digital Ionosonde

**Terry D Kelly**

*KEL Aerospace Pty Ltd , 231 High Street, Ashburton, Victoria, 3147, Australia*

The IPS-71 digital ionosonde from KEL Aerospace has a new Doppler interleaving feature which allows fast measurement of multi-frequency (and multi-height) Doppler in the ionosphere. It gives high performance levels in the key areas of phase coherence, low internal noise and high IMD (2nd and 3rd Order Intermodulation Distortion) performance which is essential in areas such as Europe which suffer from very high levels of HF interference. In co-operation with Australian Defence Research scientists and university researchers, KEL has developed a user friendly software interface which is highly intuitive and which allows the user to quickly and easily perform all necessary functions with this Ionosonde, generally without even reading the Operating Manual.

**Features of the IPS-71 include:**

- Conventional Ionograms (with accurate complex amplitude)
- Doppler Ionograms (to study ionospheric dynamics, TID's etc)
- Phase Sounding (for precision group height & structure)
- Surveillance Sounding (an important diagnostic tool)
- Remote Control
- SMARTIST-III Auto-Scaling
- Data Printing & Editing Software

**Optional features include:**

- Angle & Direction of Arrival (Software & Antenna System) including: Skymapping, Tilt and Doppler Drift.

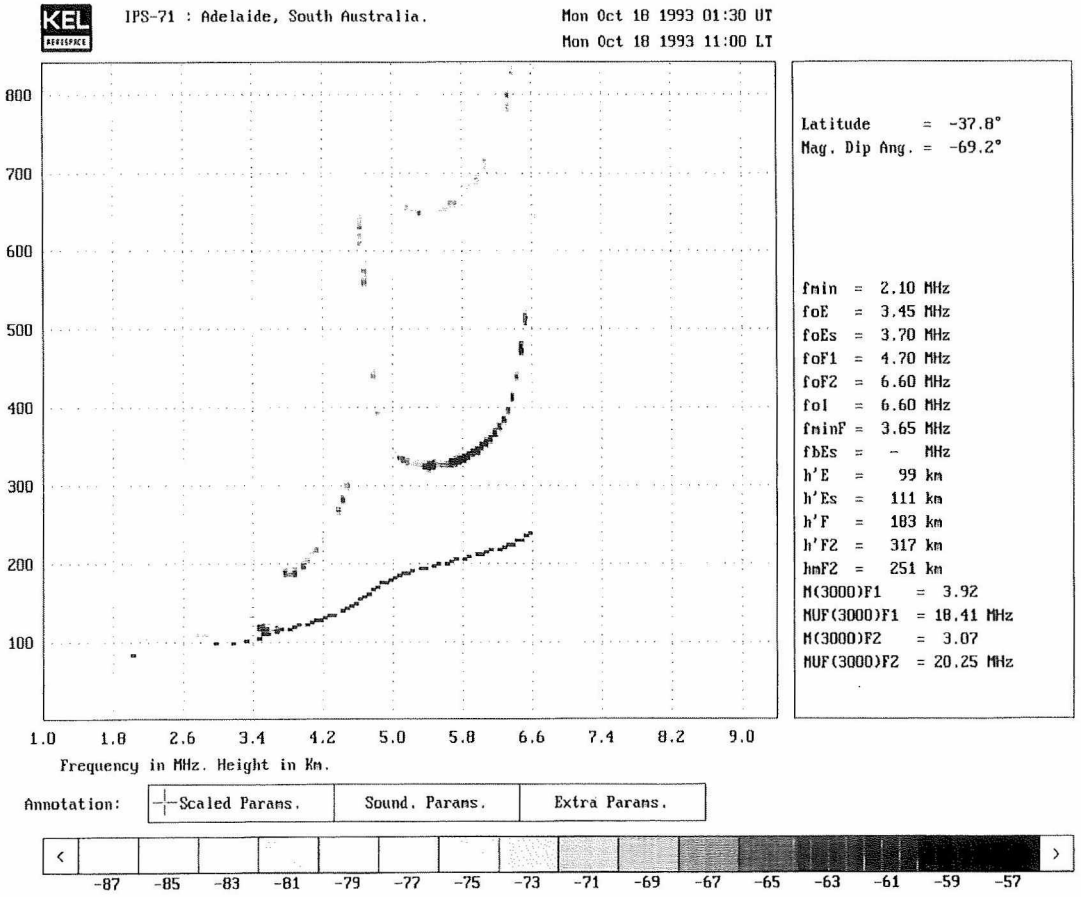



Fig. 1. Conventional ionogram with O/X separation, taken in approximately 20 seconds. Autoscaled results are at the right of the ionogram. [Amplitudes are displayed in colour on the author's originals of these and following figures — Ed].

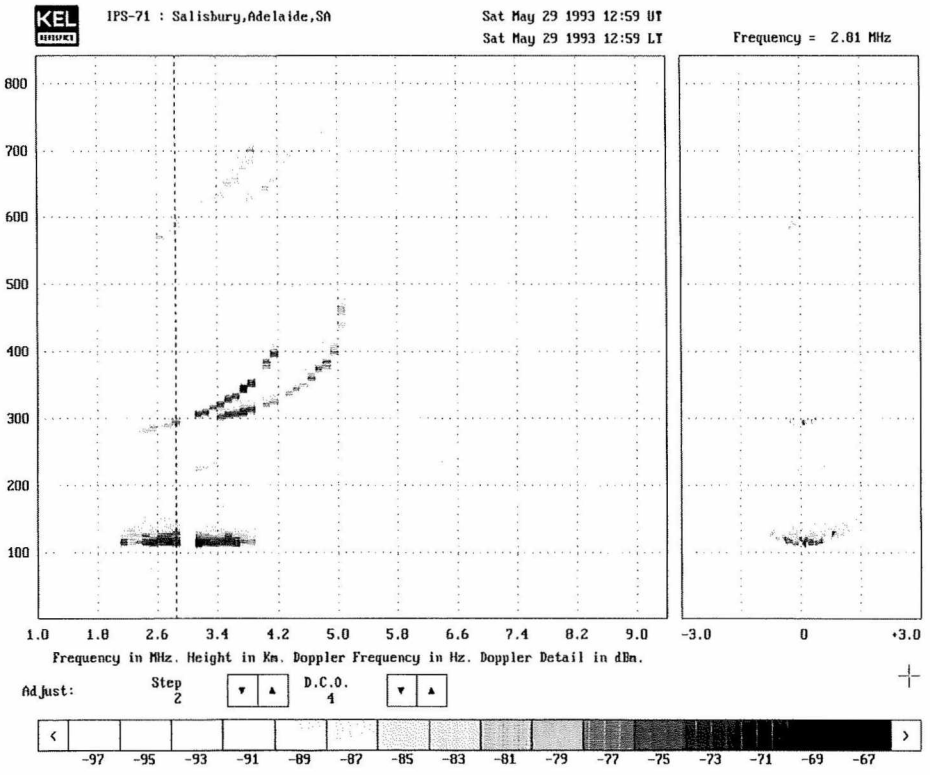



*Fig. 2. Doppler Ionogram & Display*

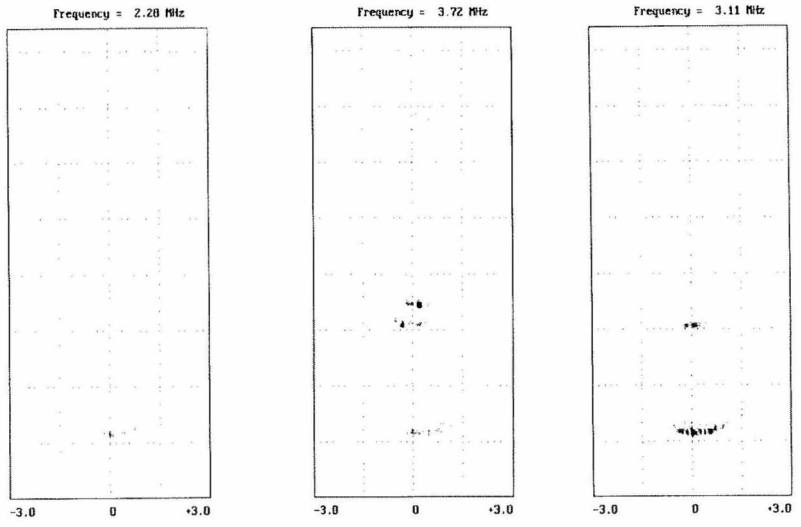



*Fig. 3. Three more Doppler Windows*

- SMARTPOL-III Auto True Height Software
- Oblique Sounding (Software, Antennae & GPS Synchronisation)
- Remote Control Station Software

In its most basic configuration the IPS-71 produces amplitude, Doppler, phase and surveillance data, yet its price is similar to that of the earlier IPS42/DBD43 Digital Ionosonde Systems which only measured virtual height and frequency.

The IPS-71 may be connected to a simple, pre-existing double delta antenna (exactly as used by the IPS-42), or it may be connected to a triple-delta to obtain O/X separation of echoes, or thirdly, to a small array of four crossed-loop receiving antennae to obtain angle and Direction of Arrival (DoA) information using phase interferometry.

The IPS-71 is controlled by, and stores all data in, the PC DOS environment. Data files are compressed to provide economical data storage and to enable low cost data trans-

mission over long distances for near real-time data acquisition. Remote communications are achieved also in the PC environment, using Remote Control software operating on a PC, with standard modems.

Ionograms are displayed with SVGA resolution using the VESA standard which offers high speed and high resolution for colour displays of amplitude, Doppler, phase and other parameters. Colour printing is possible, using economical HP Colour DeskJet plain paper printers. Black & White printing is possible using HP DeskJet or LaserJet printers.

Acquisition of conventional, Doppler and phase ionograms may be pre-programmed, using the IPS-71 'Timer' which will schedule soundings at required times and intervals. Autoscaling may be performed in real time. The IPS-71 may be configured with special purpose software which would allow one group of remote callers to have access only to autoscaled results whilst a second group of authorised callers may have access to the actual ionogram data and a third group could have complete remote control of the IPS-71.

Certain HF frequencies may be banned, according to the regulatory requirements of each country. A typical list of banned frequencies is supplied as part of the software with each IPS-71 and is readily accessible by the user, in a standard text file. The user may add, delete or modify the list of banned frequencies as required. It should be noted however that the 2 kW pulse power of the IPS-71 is utilised for less than 0.5% of the time. Furthermore the IPS-71 linear transmitter has a specially shaped pulse which is designed to minimise interference. These characteristics of the IPS-71 all contribute toward a high level of environmental compatibility in the radio spectrum.

Figure 1 shows a convectional ionogram. Figure 2 comprises an 'Amplitude Ionogram' and a 'Doppler Window'. The Doppler window may be displayed for any channel on which the sounding occurred. In this case the first frequency channel was 2.81MHz. Figure 3 shows three more windows. In these examples the Doppler Shift Axis extends from zero Doppler shift to ± 3.0 Hz. The actual frequency at which the Doppler shift is being measured is indicated at the top of each Doppler Window. Amplitudes are displayed as coloured pixels, which are positioned according to the range and the Doppler Shift for each data point. A histogram display also is available, showing the amplitude versus Doppler Shift for each range bin on any selected frequency.

## Surveillance Sounding:

This is a means of locally or remotely monitoring the HF environment and of confirming the correct operation of the receiver, frequency synthesiser and signal processing parts of the IPS-71. By monitoring the accurate amplitudes of local ground wave interference and by regularly monitoring the amplitudes of sky wave interference it is possible to build an understanding of the local HF environment. An example is shown in Figure 4.

## PADIS (Portable Advanced Digital Ionosonde System)

The IPS-71 may be regarded as a portable since it is housed completely in a small functional cabinet and is built to modern commercial standards, with ruggedised features including triple lightning protection on the transmitter and receiver, extra high quality connectors, heat-sensing air cooling system and tough construction.

With more than 80 of the earlier model of IPS-42, 4A and 4B Ionosondes working in 25 countries around the world KEL is planning to deliver approximately 100 of these new sounders worldwide during the next few years. Availability typically is 3-4 months, depending on the level of orders at any one time.

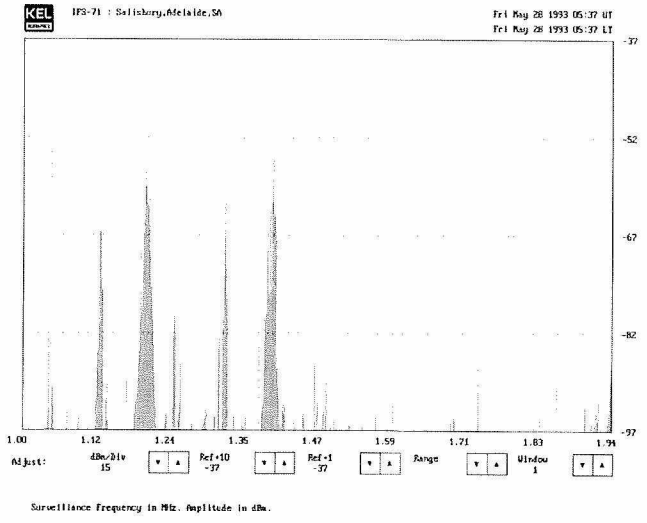
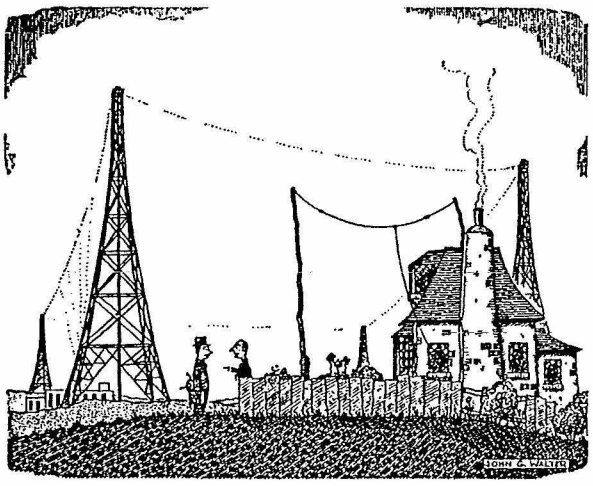



*Fig. 4. Passive reception spectrum*

# Electromagnetic Compatibility

**edited by Pierre Degauque and Joel Hamelin† , Oxford University Press, ISBN 0-19-8 56375-2, hard-back, 652 pages, Price US$95.00, 1993.** [This book is a verbatim translation of the French language paperback, *Compatibilité Électromagnetique*, published by Dunod, Paris, ISBN 2-04-018807-X, 1990.]

This material, now available in English or French, fills a real need. Unlike various earlier publications in handbook format, this compilation is a masterful presentation of all facets of the subject. The editors Professor Degauque and Dr Hamelin have enlisted eight of their compatriots to share in the preparation of the eleven chapters. The English translation was executed by Henry Whyte in an impeccable manner with the assistance of the two editors. However, it appears that the translated version has not been updated beyond what appears in the original French edition submitted in 1988. *[Ed — the* Punch *cartoon I have inserted on the right indicates that EMC has been problematic for a long time!]*



"THE SET WORKS ALL RIGHT, BUT I CAN'T QUITE SEEM TO CUT OUT THE LOCAL STATION."

*From* Punch *ca. 1930.*

In Chapter 1, Degauque and Hamelin pose the question: "La Compatibilité électromagnetique : Science ou Regle de savoir-vivre?" (Is EMC a science or a code of behaviour?) No direct answer is given but the editors go on to say that their objective is to achieve compatibility between the operation of a sensitive system and its electromagnetic environment. The three main categories of the book are : (1) To describe the interfering source and to determine interfering fields it may radiate, (2) To consider all the possible modes of coupling between the disturbing source and the disturbed system in both a qualitative and quantitative manner, and (3) To design simulations and tests which may lead eventually to the implementation of protective procedures.

In Chapter 2, Hamelin describes the sources of natural noise with emphasis on lightning phenomenology. He and his colleagues have made many original contributions to the subject. However, the reader might desire to consult a companion book "Lightning Electromagnetics" edited by R L Gardner where the electromagnetic propagation effects are discussed in more detail particularly from the analytical standpoint. It was published also in 1990, by Hemisphere; Taylor and Francis, New York.

In Chapter 3, A Azoulay gives us a very nice concise review of electromagnetic "man-made" (person-made) noise which may predominate over that from natural sources particularly in urban areas and at frequencies above a few kilohertz. This is a subject of numerous study groups in the CCIR over the past several decades and URSI Commission E has played a major role here. One observation, in a modern context, is that field strength at 1 metre in front of a computer terminal can range from 20 to 50 dB (μV/m) over the frequency range from 20 to 200 MHz. Many other examples are given by the author of this chapter.

In Chapter 4, M Gaurrand covers electromagnetic pulses of nuclear origin and gives a interesting history of such phenomena and reviews the relevant physics. In one example he shows curves of the electric field pulse as a function of time for a 100 kt explosion computed for a homogeneous atmosphere.

In Chapter 5, J Piponnier expounds on the management of the frequency spectrum and related regulation. Here, as the author points out, there are major problems of incompatibility when different communication systems must share the available spectrum and still provide guaranteed space for essential services such as air and sea navigation.

In Chapter 6, B Demoulin presents a very readable and certainly useful outline of the characterisation of screened cables. This is one of the core subjects in electromagnetic compatibility and many papers on such topics appear in the IEEE Trans. on EMC. The author here, like most engineers, who need to design things, use transmission-line equivalences based on circuit concepts. The surface transfer impedance of the cable shield here plays a major role and the author presents some key measuring techniques for this and related parameters. Very briefly he calls attention to field theory methods for treating braided sheaths such as published by the reviewer and his colleague D A Hill and also by Professor Paul Delogne (former Adjoint Secretary General of URSI). The reader may also wish to consult the latter's excellent book "Leaky feeders and Sub-surface Communication Systems", IEE EM Series, 1982.

† *[Pierre Degauque is currently the chairman of the French National Committee of URSI and Joel Hamelin is the past chairman of international Commission E of URSI]*

In Chapter 7, Degauque gives a fairly exhaustive account of the theory and practice of cable coupling with the earth or ground plane. A key problem here is to determine the propagation constant of the cable or overhead conductor as a function of the geometrical parameters and the electrical properties of the adjacent imperfectly conducting half-space. As he points out many of the earlier approaches have a limited validity. The reviewer's interpretation is that the effective series impedance and shunt admittance, of the equivalent transmission line, are spatially dispersive in the sense that these parameters are functions of the sought-for propagation constants. A recent book by Samir Mahmoud "Electromagnetic Waveguides" IEE EM Wave series, 1991, covers the field theory of some of these problems with reference to cables in sub-surface tunnels.

In Chapter 8, F Molinet gives a more-or-less self contained account of the interaction, of wire antennas and related structures, with an incident plane wave. In chapter 9, Y Le Gullou, covers the penetration of electromagnetic waves into three-dimensional open and closed structures of various shapes. Many of the numerical techniques are discussed in detail. In Chapter 10, B Besnault describes general measurement procedures in a very thorough fashion with many practical hints. In Chapter 11, M Blanchet provides what appears to be a very complete description of simulation schemes particularly with regard to nuclear-source generated fields.

There is no doubt this collection of tightly edited chapters, written by these very competent French scientists and engineers, is the most authoritative documentation on the subject in a compact form readily accessible to the radio science community. The sale price, while high, is not unreasonable. Both French and English editions are printed in a uniform style with numerous high-quality illustrations. Also the extensive references, while none later than 1988, do cover the world literature with a possibly forgivable emphasis on French journals and conference proceedings.

**James R Wait**
2210 East Waverly
Tucson, AZ 85719-3848, USA

## Modern Radio Science 1993

**edited by Hiroshi Matsumoto, Oxford University Press, ISBN 0-19-856379-7, hardback, Price US$37.50. 1993, 249 pages.**

This book contains written versions of two general lectures and ten tutorial lectures presented at the general assembly of URSI held in Kyoto, Japan in August 1993. The topics covered are: The future of high definition television and digital broadcasting; Radar exploration of Venus; New communication technologies; Modern antenna design concepts; Mobile and personal communications; Radio spectrum management; Synthetic aperture radar and ocean imaging; Global ionospheric modelling; History of radiowave whistlers; The charm of radio astronomy and "why is the sky dark?"; and, finally, Non-thermal interaction of electromagnetic waves with cells in human body tissues. Taken as a whole these lectures, given by highly regarded individuals, demonstrate the vitality of electromagnetic wave science and the interactions with related disciplines such as electrical engineering, geophysics, space science, telecommunications and medicine. It certainly is a worthwhile purchase if you (like this writer) were not able to attend the Kyoto General Assembly.

**James R Wait**

## Singular Electromagnetic Fields and Sources

by J Van Bladel, Oxford University Press, ISBN 0-19-856200-4, hardback, Price US$75.00. 1991, 237 pages.

The author of this book is the former Secretary General of URSI. It is the first book-length treatment of the subject which deals principally with the physical behaviour of electromagnetic fields in the vicinity of sharp edges and discontinuities in structures. The "infinities", which arise in the mathematical world, are classified and explained in a comprehensive and understandable fashion. In spite of the seemingly academic focus of the book, the results are vitally important in the modern computer emphasis on solving realistic electromagnetic problems where we need to incorporate the "edge behaviour" at the outset of the formulation. The author has summarised his own published papers and those of other noted electromagneticians in a masterful fashion. I will cherish my copy of this gem.

**James R Wait**

## Electromagnetic Waves

**by David H Staelin, Ann W Morgenthaler, and Jin Au Kong. Prentice Hall, Englewood Cliffs, NH 07632, 562 pages, ISBN 0-13-225871-4, Price US$63 (approx).**

This book is similar to other basic electromagnetic books which concentrate on dynamics such as; Microwave Engineering by Pozar, Llioa's microwave engineering book, and a small dose of antennas of Thiele and Stutzman flavour. Included is the usual development of Maxwell's equations and their solutions.

With over 170+ graphs, the reader will certainly "see" what

**continued on next page, second column**

# Methods for Electromagnetic Field Analysis

**by Ismo V Lindell, Clarendon Press, Oxford, 1992, ISBN 0-19-856239-X. XII + 290 pages, 24 figures, hardcover, £40.**

During the last decades the media, in which electromagnetic fields were studied, became more and more complicated. A (dyadic) permittivity $\varepsilon$ and a (dyadic) permeability $\mu$ are not sufficient for the constitutive relations of e.g. Tellegen media and chiral media. There the electric and magnetic flux densities are related to both the electric and magnetic field intensities. Therefore in addition to $\varepsilon$ and $\mu$ two more quantities $\xi$ and $\zeta$ must be introduced. For the most general cases all four quantities $\varepsilon, \mu, \xi, \zeta$ are dyadics. Such media are called bianisotropic, whereas media with four scalar constitutive quantities are named bi-isotropic.

Since dyadics play an important role in almost all calculations of this book, chapter 2 is devoted to establish lots of expressions for and relations between dyadics, many of them are new. The most important results are collected as dyadic identities in the appendix. The author uses Gibbs' notation including double scalar and double vectorial products, supplemented with some carefully chosen abbreviations for the adjoint of a dyadic and the sum of its principal minors.

Time-harmonic fields are most important for media not varying in time. With the common factor $\exp j\omega t$ the field vectors are complex and represent polarization ellipses. Their properties are thoroughly discussed in chapter 1.

In chapter 3 equations for the field vectors, including boundary conditions, are established in many different forms for bianisotropic media and their most important less general specializations. Vectorial and scalar potentials are introduced in different forms.

Chapter 4 deals extensively with active transformations of the field vectors and constitutive dyadics. Very interesting generalizations of duality transformations and proper orthogonal transformations are presented, e.g. affine and reflection transformations.

To represent the electric and magnetic field vectors with the electric and equivalent magnetic current sources, four Green dyadics are needed, two of them are curls of the other two. In chapter 5 the Helmholtz equations for the latter two are derived for anisotropic media and also equations for the corresponding scalar Green functions. Discussions of special cases and of singularities follow and also a section of plane waves in bianisotropic media.

After the introduction of complex source points in the foregoing chapter the concept of equivalent sources is minutely treated in chapter 6. These are different sources which give rise to the same field within a certain spatial region.

The method of images, used in electrostatics to replace a conducting surface near a charge source by an image source located at its mirror image position, is generalized in chapter 7 to time dependent electromagnetic problems for plane stratified media. After the general formulation of the exact image theory is given, it is applied to surface problems, to the Sommerfeld half-space problem, and to microstrip geometry.

This concisely written book contains much more information than one would expect from its size. This is mainly due to the consequent use of coordinate-free vector and dyadic notation. There are no detailed proofs of mathematical results, Therefore a profound reader has to use pencil and paper to grasp the full content of a deduction. The invariance of the scalar triple product under cyclic permutation of the three vectors and the expansion of the triple cross product are the main foundation stones for the proofs of the dyadic identities.

The book is a very valuable tool for anybody investigating electromagnetic fields in complicated media.

**Kurt Suchy**
Institut für Theoretische Physik II
Heinrich-Heine-Universität Düsseldorf
Universitätsstr. 1
Geb.25.32
D - 40225 Düsseldorf, Germany

**continued from previous page**

is going on with the electromagnetic fields. There are 200+ problems in the book with the traditional problems of; transmission line analysis, waveguides, waves at planar boundaries, resonators, and antennas. This offering was written with the senior level student in mind and gives him plenty of opportunity to practice.

Some interesting point are; the final chapter on acoustics, the anisotropic media section (3.2), the section on waves in a plasma (3.3), and the perturbation of a resonator (8.7).

The drawback to the current edition is that there are no references. But for the professor considering textbooks for his class in electrodynamics, this edition is more than adequate.

**Glen Evans**
16458 Bolsa Chica, #162
Huntington Beach, CA 92649
USA

# ANNOUNCEMENT OF OPPORTUNITY

# EISCAT and the International Scientific Community

**Jürgen Röttger**

The EISCAT Scientific Association performs investigations of the ionosphere and its coupling with the magnetosphere, the aurora, the upper and middle atmosphere by using the incoherent scatter radar technique. EISCAT, located in northern Scandinavia close to 70°N and at 66° invariant latitude, is also used as coherent scatter radar, for studying instabilities in the ionosphere, as well for investigating the structure and dynamics of the middle and lower atmosphere and as a diagnostic instrument in ionospheric modification experiments with the Heating facility.

The investments and operational costs are shared between the EISCAT Associate countries Finland (SA), France (CNRS), Germany (MPG), Norway (Norges forskningsraxd), Sweden (NFR) and United Kingdom (SERC).

The EISCAT UHF radar operates in the 931 MHz band with a peak transmitter power of 1.5 MW and 32 m, fully steerable dish antennas. The transmitter and one receiver are in Tromsø, Norway. Receiving sites are also located near Kiruna, Sweden, and in Sodankylä, Finland, allowing continuous tristatic measurements to be made. The monostatic EISCAT VHF radar in Tromsø operates in the 224 MHz band with a peak transmitter power of 2 x 1.5 MW and a 120 m x 40 m parabolic cylinder antenna, which can be steered mechanically in the meridional plane from vertical to 60x north of zenith; limited east-west steering is also possible using phasing cables. The EISCAT Heating facility is located close to the radar facility in Tromsø. It consists of 12 transmitters of 100 kW CW power, which can be modulated, and three antenna arrays covering the frequency ranges 3.85 MHz to 8 MHz.

A new third-generation radar is now being constructed on Svalbard, almost 1000 km north of Tromsø. This EISCAT Svalbard Radar (ESR) will operate in the 500 MHz band, initially with 500 kW peak power, 25 % duty cycle and a 32 m fully steerable dish antenna. The ESR should be operational during first tests for internal use in the beginning of 1996.

The operations of EISCAT are distributed about equally between Common Programmes (CP) and Special Programmes (SP) and accumulate to more than 1500 hours per year. At present seven welldefined Common Programmes are run regularly, particularly covering the Incoherent Scatter Coordinated Observation Days (World Days) in the International Geophysical Calendar. The corresponding analyzed Common Programme data (electron density, electron temperature, ion temperature and ion velocity) are available through the NCAR CEDAR Data Base in Boulder, CO, USA.

A large number of Special Programmes are defined individually by scientists from the EISCAT Associates countries. These experiments are frequently performed in collaboration of scientists from these countries as well as with scientists from all over the world.

## Announcement of Opportunity for use of EISCAT

In order to allow wider access to the EISCAT systems in Tromsø, Kiruna and Sodankylä, a limited amount of experiment time can now be made available to a greater international scientific community for individual Special Programme experiments.

The proposals for such experiments should be preceded by a letter of intent to be submitted to the Director of EISCAT (address given below). It should be demonstrated in the letter of intent that the envisaged experiment would yield results, which are competitive or novel to the state of the art. Solid reasons should be given why the EISCAT system is needed for such an experiment. The letter of intent will undergo a certain reviewing procedure to allow an initial assessment on the unique merit of the experiment. An evaluation will also be done whether such experiments could be technically performed with the EISCAT systems. It will further be considered whether the proposed experiment could be included in a collaboration with groups or individuals within the EISCAT Associate countries, in cases where similar kinds of experiments are being done or planned already.

Detailed information on the EISCAT systems and the guidelines for experiments should be acquired from EISCAT in writing before submitting a formal letter of intent for EISCAT experiments.

After successful assessment of the letter of intent an official response will be issued by EISCAT, stating also the priority given to the experiment. A detailed proposal should then be submitted following as closely as possible the instructions provided in the answer by EISCAT. After final reviewing, experiment operation time will be allocated according to the EISCAT rules. The conventional rule for Special Programme experiments will apply, that EISCAT will provide the allocated experiment time free of charge, but EISCAT does not contribute to travel and all other related expenses.

More general information on EISCAT's systems, operations, rules, scientific results, and publications can be obtained from:

The Director, EISCAT Scientific Association
P.O. Box 812
S-981 28 Kiruna, Sweden

# ELECTRONIC URSI NEWS

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pril 11, 1994

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Areas of interest (*Please fill appropriate circles*)

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- ○ B Fields and Waves
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- ○ D Electronics and Photonics
- ○ E Electromagnetic Noise & Interference
- ○ F Wave Propagation & Remote Sensing.
- ○ G Ionospheric Radio and Propagation
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U.R.S.I.

There are two forms below. The left one is for radio scientists and engineers who wish to become URSI Correspondents who thereby receive the *Radioscientist & Bulletin* and enjoy several other benefits of Correspondentship (substantial discounts on URSI-sponsored journals and on future URSI conferences held jointly with other bodies with membership discounts). If you were a registered participant at the Kyoto General Assembly (August-September, 1993), or if you are an URSI official (eg, if your name and address was in the list recently published in the URSI *Information Bulletin*), you are already a Correspondent and so do NOT need to fill in either form, and may well have received your "membership" card by now. But if you are in doubt — and particularly if you receive no "membership" card by next month — please fill in the form and pay (US$40 for the 3-year period, 1994-1996) by credit card. Your status will be checked and you will not be debited if you are entitled to free Correspondentship. Payment other than by *VISA* or *MasterCard* can only be accepted by URSI HQ by prior arrangement. If paying the fee presents serious difficulties, fill in the form and accompany it with a letter stating your case for not paying the fee. The second form (right) is for institutions and libraries, and for subscription agencies. Only annual (Jan - Dec calendar year only) subscription is available (US$25 pa). Individuals, even if currently inactive in radioscience, should apply for Correspondentship (using the form on the left) which is financially more attractive. We suggest you photocopy the form you need at maximum enlargement for easy filling-in. The completed form may be airmailed or faxed but must be signed to validate the credit card number: applications received by email cannot be used for fee payment.

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This is my ☐ home ☐ business address.

Phone _____ ext._____ Fax _____

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Areas of interest (*Please fill appropriate circles*)

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- ○ B Fields and Waves
- ○ C Signals and Systems
- ○ D Electronics and Photonics
- ○ E Electromagnetic Noise & Interference
- ○ F Wave Propagation & Remote Sensir
- ○ G Ionospheric Radio and Propagation
- ○ H Waves in Plasmas
- ○ J Radio Astronomy
- ○ K Electromagnetics in Biology & Med

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