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Erratum

We apologize for a mistake in the setting of the cover of this magazine.
The *application for URSI Correspondents* should have been printed on the back cover. For some mysterious reason the inside front cover was not printed.
Please find below the *Table of Contents*.
With our apologies for the inconvenience caused.
Sincerely yours,

Inge Heleu
Production Editor

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Editorial

Dear URSI Correspondent,

Welcome to the Summer issue of your Bulletin. As some of you already know, our collegue Ralph Kleinman died some weeks ago. This scientist has been very active in URSI, particularly in Commission B, and had participated in many General Assemblies of our Union. His personality is honored in the next pages.

Besides this sad news, this issue of our Bulletin contains a contribution by a group of collegues about magnetospheric radio soundings. This paper describes a future NASA mission for magnetopause-to-aurora exploration which launch is scheduled to be the first one of the next century and millenium as well. Its scientific objective is the understanding of the global dynamics of terrestrial magnetosphere and its response to changing solar-wind conditions.

In the administrative part of this issue you will find the 1997 budget summary of the Union as well as usual annoucements sections over conferences as well as a book reviewed by URSI correspondents.

Piotr Sobieski, Editor

URSI Homepage

As always, your suggestions to improve the URSI Homepage are welcome. Please contact the Webmaster at : inge.heleu@intec.rug.ac.be

The actual contents of the URSI Homepage (http://www.intec.rug.ac.be/ursi) is :

A brief overview of URSI with a current list of officers

A more detailed description of URSI

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URSI Representatives on other Scientific Organisations

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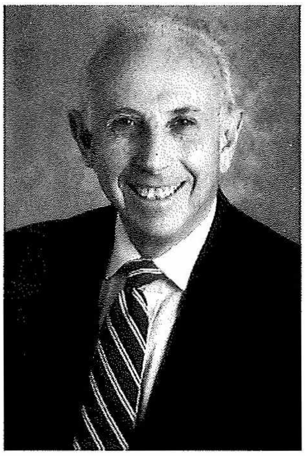
In Memoriam

Ralph E. Kleinman
1929 - 1998

The scientific community lost a dear friend and colleague when Ralph E. Kleinman died on February 23, 1998, in Newark, Delaware, after suffering a stroke. Ralph was UNIDEL Professor of Mathematical Sciences at the University of Delaware, and Director of the Center for the Mathematics of Waves, which he established in 1988.



Ralph Kleinman was born in 1929, and grew up in Lindenhurst and Forest Hills, New York. He received a BA in mathematics from New York University, in 1950, and an MA in mathematics from the University of Michigan, in 1951. He worked at Michigan's Radiation Laboratory for two years before serving in the US Army at Redstone Arsenal, in Alabama. He returned to the Radiation Lab in 1955. While there, he received a Fullbright fellowship to study at the Delft University of Technology, where he obtained a Doctor in de Technische Wetenschappen (equivalent to a US PhD) in 1961.

Until 1968, when he moved to Delaware, Ralph was a research mathematician at the Radiation Lab of the University of Michigan. In his early work, he concentrated on radiation and scattering, providing rigorous foundations for computational work being carried out at the lab. He was attracted to low-frequency scattering early in his career, and returned to the subject often. At the time of his death, he had just completed a volume on low-frequency scattering with George Dassios, of the University of Patras.

Ralph was known for his work on integral equations, applied to problems in scattering and wave propagation, in which he addressed theoretical issues that are relevant to computation. Later, he branched out in several new directions, among them inverse problems and optimization problems associated with radiation and scattering. His many co-authors in these areas include Tom Angell, of the University of Delaware, and Gary Roach, of the University of Strathclyde.

In the mid-1980s, electrical engineers were beginning to use iterative methods in the solution of scattering problems. The basic method came in many different flavors. Among Ralph's accomplishments was to gather all these different methods within one mathematical framework, and to explain their convergence properties. Most notable among his contributions to inverse-scattering problems was his work with Peter van den Berg of the Delft University of Technology, in which they proposed a reconstruction procedure called the modified-gradient technique. This method is computationally very efficient, and has been tested on electromagnetic scattering data collected by the Air Force Rome Laboratory in Ipswich, Massachusetts. Indeed, one of Ralph's remarkable achievements in this field-along with Robert McGahan, of the Rome Laboratory at Hanscom-was to organize several competing groups in inverse scattering, convincing them to apply their methods to real data and report their findings.

Most recently, he collaborated with George Hsiao of the University of Delaware on a procedure for using the result of a computation to estimate the error in the solution of an integral equation arising in a scattering problem. An approach of this type is particularly valuable because of the confidence it can give the user in the output of a calculation. Perhaps what made Ralph's contributions to scattering and wave propagation unique was his ability to recognize the real problems facing the engineers who solve these problems in the real world, and to provide useful answers to them through the application of mathematical analysis. It was for such insight and ability that he was named a Fellow of IEEE in 1994.

Over the years, Ralph collaborated with many colleagues in the US and Europe. He was an ideal person to work with: easy-going, energetic, full of ideas, and willing to do the hard work that came with the joint project. Many of these collaborations blossomed into lifelong friendships. In the classroom, Ralph was an inspiring and enthusiastic teacher. He was adviser to nine PhD students in his career, and served on dissertation committees of numerous others in the US and Europe. One of his achievements at Delaware was his role in establishing the American Association of University Professors (AAUP) as the bargaining unit representing the faculty at the university. He was active in the faculty government at Delaware, serving as president of both the Faculty Senate and the College of Arts and Science Senate. He also served as president of the Delaware chapter of AAUP.

Ralph was responsible for organizing several conferences and workshops. In 1993, he was the organizer of the SIAM-INRIA Conference on Mathematical and Numerical Aspects of Wave Propagation, held in Newark, Delaware.

An inspiring teacher, a respected colleague, and a wonderful friend, Ralph will be missed by all who knew him.

[Editor's note: The above was originally prepared by Prof. Fadil Santosa for the SIAM News and was slightly edited by Dr. W. Ross Stone]

URSI Accounts 1997

As usual we present in this June issue of *the Radio Science Bulletin*, the audited accounts of URSI.

Overall URSI is in a sound financial shape. Over the last triennium the operating expenses exceeded slightly the operating income, but this was more than compensated by the return generated by our assets. Maintaining this delicate balance for the next triennium in the face of slowly rising costs will be a challenge.

Finally, it should be noted that the item "Loss on exchange" does not reflect an actual loss due to currency exchange, but a change in value of part of the assets when expressed in dollars. Since most of the income and expenses of URSI are in the same currency, namely Belgian francs, the URSI finances are not much influenced by currency exchange rate variations. Expressing the accounts in dollars, as required by ICSU, makes it somewhat more difficult to distinguish between exchange rate variations and real changes in income and expenditure.

P. Lagasse, Secretary General
P.J.B. Clarricoats, Treasurer

BALANCE SHEET : 31 DECEMBER 1997

	US$	
ASSETS		
Dollars		
Merrill Lynch WCMA	5,717.25	
Generale Bank	15,024.96	
Smith Barney Shearson	643.93	
		21,386.14
Belgian francs		
Banque Degroof	6,375.93	
Generale Bank	143,973.47	
		150,349.40
Investments		
Demeter Sicav shares	22,794.75	
Rorento Units	111,084.59	
Aqua Sicav	64,103.22	
Merrill-Lynch Short Term (1320 units)	12,115.28	
Smith Barney Utilities Fund	81,764.00	
Reinvestment S.B. Utilities	29,380.79	
Smith Barney Grade Bond	49,300.00	
Reinvestment S.B. Grade Bond	19,250.23	
	389,792.86	
355 Rorento units on behalf of van der Pol Fund	12,950.41	
		402,743.27
Other		
Petty cash		1,162.68
Total Assets		**575,641.49**
Less creditors		
IUCAF	4,487.71	
ISES	6,087.09	
		-10,574.80
Balthasar van der Pol Medal Fund (1)		-12,950.41
NET TOTAL OF URSI ASSETS		**552,116.29**

The net URSI Assets are represented by :

Closure of Secretariat :		
Provision for Closure of Secretariat		45,000.00
Scientific Activities Fund :		
Scientific Activities in 1998	80,000.00	
Publications in 1998	60,000.00	
Young Scientists in 1998	10,000.00	
Administration Fund in 1998	80,000.00	
I.C.S.U. Dues in 1998	10,000.00	
		240,000.00
XXIV General Assembly Fund :		
During 1998 :		40,000.00
Total allocated URSI Assets		**325,000.00**
Unallocated Reserve Fund		227,116.29
		552,116.29

Statement of Income and Expenditure for the year ended 31 December 1997

I. INCOME	US$	
Grant from ICSU Fund and Special Contributions	9,000.00	
Allocation from UNESCO Subvention to ICSU	10,000.00	
UNESCO Contracts	0.00	
Contributions from National Members	146,153.88	
Contributions from Other Members	0.00	
Special Contributions	1,170.35	
Contracts	0.00	
Sales of Publications, Royalties	13.55	
Sales of scientific materials	0.00	
Bank Interest	1,212.22	
Gain on Exchange	0.00	
Other Income	94,973.21	
Total Income:		**262,523.21**

II. EXPENDITURE		
a1) Scientific Activities		50,437.35
General Assembly 1996	6,832.46	
Scientific meetings: Symposia/Colloquia	36,022.85	
Working Groups/Training Courses	0.00	
Representation at scientific meetings	1,582.04	
Data Gather/Processing	0.00	
Research Projects	0.00	
Grants to Individuals/Organizations	6,000.00	
Other	0.00	
Less covered by UNESCO Contracts	0.00	
a2) Routine Meetings		13,145.76
Bureau/Executive committee	13,145.76	
Other	0.00	
a3) Publications		31,893.71

b) Other Activities		14,102.00
Contribution to ICSU	8,102.00	
Contribution to other ICSU bodies	6,000.00	
Activities covered by UNESCO Contracts	0.00	
c) Administrative Expenses		71,361.58
Salaries, Related Charges	47,459.38	
General Office Expenses	4,126.67	
Office Equipment	1,915.20	
Audit Fees	1,803.52	
Bank Charges	2,288.25	
Loss on Exchange	13,768.56	
Total Expenditure :		**180,940.40**
Excess of Income over Expenditure		**81,582.81**
Accumulated Balance at 1 January 1997		470,533.48
Accumulated Balance at 31 December 1997		**552,116.29**

Rates of exchange :

1 January 1997	$1 = 32.00 BEF
31 December 1997:	$1 = 36.90 BEF

Observation :
The account indicated with (1) is represented by :

355 Rorento Shares : market value on 31 December 1997 (Acquisition value : US$ 12,950.41)	21,305.80

Market value of investments on December 31, 1997 ($1 = 36.90 BF) :

- DEMETER SICAV :	43,379.35	
- RORENTO UNITS (2) :	390,106.12	
- AQUA-SICAV :	71,236.29	
- M-L SHORT TERM :	10,145.00	
- SMITH BARNEY UTIL. :	121,090.22	
- SMITH BARNEY GRADE :	72,450.78	
		708,407.76

(2) including the 355 Rorento of v.d. Pol Fund

APPENDIX : Detail of Income and Expenditure

I. INCOME		US$
Special Contributions		
Commonwealth Science Council	1,170.35	
Support YS Programme URSI General Assembly Lille		
		1,170.35
Other Income		
Revenue Lille General Assembly	71,430.54	
Interest on Smith Barney Utilities Fund	8,528.89	
Interest on Smith Barney Grade Bond	4,855.03	
Sale of ML Short Term	10,062.00	
Reimbursement bank charges	96.75	
		94,973.21
II. EXPENDITURE		
General Assembly 1996		
Organization	68.56	
Scientific activities - officials	1,846.80	
Scientific activities - others	500.22	
Printing Proceedings	2,905.88	
Correspondents Cards (Printing + Mailing)	1,511.00	
		6,832.46
Symposia/Colloquia/Working Groups :		
Commission A	6,480.00	
Commission B	0.00	
Commission C	4,000.00	
Commission D	0.00	
Commission E	4,000.00	
Commission F	7,586.18	
Commission G	3,756.67	
Commission H	4,200.00	
Commission J	0.00	
Commission K	6,000.00	
Other	0.00	
		36,022.85
Grants to Individuals/Organizations		
ICTP-ITU-URSI	6,000.00	
		6,000.00
Contribution to other ICSU bodies		
FAGS (96 + 97)	4,000.00	
IUCAF (97)	2,000.00	
		6,000.00
Publications :		
Printing "The Radio Science Bulletin"	15,540.27	
Mailing "The Radio Science Bulletin"	14,702.30	
Transfer of income ('96) on publications on behalf of Radio Science Press	107.75	
Electronic publications & WWW	1,520.49	
Printing New Correspondents Cards	22.90	
		31,893.71

Magnetospheric Radio Sounding on the IMAGE Mission

Robert F. Benson et al.

Abstract

Radio sounding can be used to obtain accurate remote, as well as *in situ*, electron number density (N_e) measurements in magnetized space plasmas. It is based on the reflection of radio waves at the location where the refractive index goes to zero. The N_e structure of the terrestrial ionosphere has been routinely investigated by both ground-based and satellite-borne sounders. The terrestrial magnetosphere, on the other hand, has never been subject to routine radio-sounding investigations.

Recently, NASA selected Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) as the first Medium-class-Explorer (MIDEX) mission. IMAGE is scheduled to be launched on January 1, 2000 and has the scientific objective of understanding the global dynamics of the terrestrial magnetosphere and its response to changing solar-wind conditions. The IMAGE payload includes a radio plasma imager (RPI) in addition to far ultraviolet (FUV), extreme ultraviolet (EUV) and neutral atom (NAI) imagers. The RPI will consist of a swept-frequency digital radio sounder covering the frequency range from 3 kHz to 3 MHz. It will be designed similar to modern state-of-the-art ground-based digital ionospheric sounders. It will employ on-board digital signal-processing techniques and will be capable of measuring echo amplitude, phase, time delay, Doppler spectrum, polarization and direction-of-arrival as a function of sounding frequency. Most RPI soundings will be taken near apogee at a geocentric distance of 8 R_E between 45 and 90∞ north geographic latitude. In this region, the spacecraft will be immersed in the N_e cavity extending from the plasmapause to the magnetopause. The RPI will often be able to simultaneously determine the N_e profiles leading up to these two boundaries. In addition, it will be able to produce echo maps showing magnetospheric N_e structures. The combination of such information with the FUV, EUV and NAI images, will provide unprecedented global descriptions of magnetospheric dynamic plasma processes.

1. Introduction

The ionosphere and magnetosphere are the ionized (plasma) regions of the terrestrial atmosphere. Since the ionosphere is strongly influenced by the terrestrial magnetic field, it can be considered as part of the magnetosphere. Yet these two regions have often been investigated separately, the ionosphere mainly from the point-of-view of radiowave communication and the magnetosphere because of its interaction with the solar wind. These regions can be defined in a number of different ways, one being in terms of the motions of free electrons. The ionosphere is the

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Greenbelt, Maryland 20771, U.S.A.
Fax: (301)-286-1771

region extending from about 60 to several thousand km where the motions of free electrons have a strong effect on medium-and high-frequency radiowave propagation. The magnetosphere is the region at higher altitudes (extending out to the boundary with the solar wind) where the terrestrial magnetic field dominates electron motions.

Both regions were experimentally confirmed using remote probing with radio waves prior to the advent of the space age in 1957. The ionospheric experiments were based on reflections of man-made radio waves [*Appleton and Barnett*, 1925; *Breit and Tuve*, 1926]. The magnetospheric experiments were based on the detection of naturally-produced (from lightning flashes) low-frequency waves (whistlers) that were guided from one hemisphere to the other along the direction of the Earth's magnetic field [*Storey*, 1953]. The lower portion of the ionosphere has since been routinely investigated from the ground using ionospheric radio sounders (ionosondes) based on the pulsed sounding technique of *Breit and Tuve* [1926]. The shielding effect of the ionosphere has prevented the conduct of similar routine ground-based sounding of the magnetosphere.

There have been compelling scientific and practical motivations for investigating the ionosphere and magnetosphere. The overall scientific objective has been to understand the underlying physics of these dynamic plasma regions of the terrestrial environment. An early practical motivation (long before the advent of communications satellites) was the optimization of long-distance radio communications. Another major one was to understand and possibly mitigate damaging effects due to magnetospheric substorms and magnetic storms which are characterized by enhanced currents in high and low-latitude plasma domains, respectively. These effects play havoc with communications systems, high-latitude power-line grids and pipelines, and the operations of man-made satellites and other high-technology systems. It has been argued that the original practical motivation for ionospheric research, i.e., long-distance radio communication, evaporated with the advent of communications satellites. This argument was not well accepted in areas (such as defense) where redundancy is of prime importance. Ironically, rather than eliminating the need for ionospheric research, advanced technology has emphasized its importance since the performance of state-of-the-art systems (e.g., the Global-Positioning-System satellites) are often limited by ionospheric dynamics. In the case of space-weather or solar-storm related effects, satellite operations are sometimes interrupted or even terminated. Such environmental effects may have contributed to the interruptions of television services dependent on the Canadian geostationary satellite Anik E-1 in January, 1994 and to the January, 1997 failure of the Telstar 401 satellite. From the scientific point-of-view, an improved understanding of the complex physics of the ionosphere and magnetosphere is not limited to the terrestrial system since an extrapolation of this knowledge will lead to a better understanding of the plasma environments of other planets.

2. Brief Review of Ionospheric Radio Sounding

The type of ionospheric radio sounding under discussion here is based on the reflection of short-duration radio pulses. This reflection occurs in a region where the transmitted radiowave frequency equals the local wave cutoff frequency for electron waves. The wave cutoff frequency depends on the propagation mode. To illustrate, consider a linearly-polarized wave transmitted from the ground, and propagating with the wave vector **k** perpendicular to the direction of the terrestrial magnetic field **B**. In certain frequency ranges, it is broken into two modes in the presence of **B**. One of these has the wave electric field parallel to **B** and the wave propagates with linear polarization exactly the same as in the case of no background **B**. It is thus called the ordinary (O) mode. Since it can also exist outside of the plasma, it is also called a free-space mode. The other mode has the wave electric field perpendicular to **B** with a small component parallel to **k**. This elliptically-polarized wave is called the extraordinary wave which, in a plasma such as the ionosphere, has two branches. In ionospheric terminology they have been designated as the X mode (which, like the O mode, can exist in free-space) and the Z mode (which only exists within a plasma).

The O mode wave cutoff is equal to the ambient electron plasma frequency f_N (also commonly designated as f_p) which is related to the electron number density N_e and is given by

$$f_N @ 9 (N_e)^{1/2} \qquad (1)$$

when fN is expressed in Hz and N_e in m^{-3} (or kHz and cm^{-3}, respectively). The X mode wave cutoff is designated as f_X, which is dependent on |**B**|, and is related to f_N as follows:

$$f_X = (f_H/2) \{1 + (1 + 4 f_N^2/f_H^2)^{1/2}\} \qquad (2)$$

where f_H is the electron gyrofrequency given by

$$f_H = 0.028 |\mathbf{B}| \qquad (3)$$

when f_H is expressed in kHz and |**B**| in nT. The Z mode wave cutoff is designated as f_Z and is related to f_X by the following expression:

$$f_Z = (f_H/2) \{-1 + (1 + 4 f_N^2/f_H^2)^{1/2}\} = f_X - f_H \qquad (4)$$

In the case of **k** parallel to **B**, there are two free-space modes which are circularly polarized, one with the wave electric field vector rotating in the right-hand sense (the R mode) and one rotating in the left-hand sense (the L mode). The wave cutoffs for the R and L modes are the same as for the X and Z modes given in (2) and (4), respectively.

In the more typical case of propagation oblique to **B**, there is a smooth transition between the free-space modes of parallel (R & L) and perpendicular (X & O) propagation.

Thus the two free-space modes are often designated as the R-X and L-O modes (see, e.g., *Goertz and Strangeway* [1995]). In ionospheric terminology, these modes are often referred to as X and O even when the propagation direction is very nearly parallel to **B** (see, e.g., *Budden* [1985]).

Ionospheric sounding using ground-based ionosondes has been carried out for seven decades. A review of the evolution of the instrumentation over this period (which included the transformation from analog to digital instruments) is given in *Hunsucker* [1991]. Since this sounding is based on total reflection, only those signals reflected between the sounder and the location of the peak f_N can be returned during vertical-sounding experiments. This restriction limits the altitude range of vertical sounding. Thus ionospheric sounders have been classified as either ground-based or topside sounders. Ground-based sounders investigate the ionosphere up to the altitude of peak N_e (typically 300 km), whereas topside sounders investigate the region from the altitude of the spacecraft down to the altitude of the peak.

Topside ionospheric sounding has been performed by satellite-borne sounders for three and a half decades [*Jackson et al.*, 1980; *Jackson*, 1986]. The highly successful Alouette/ISIS program yielded more than 50 satellite-years of topside sounding operation and nearly 1,000 scientific publications based on analog sounders (recording echo amplitude and delay time as a function of frequency) designed by *Franklin and Maclean* [1969]. An effort is currently underway to convert selected Alouette/ISIS topside-sounder data from an analog to a digital format [*Benson*, 1996, see also http://nssdc.gsfc.nasa.gov/space/isis/isis-status.html]. Additional ionospheric topside sounders have been flown as described by *Pulinets* [1989]. Recently, a bistatic rocket experiment produced topside N_e profiles during active auroral conditions in addition to unique observations concerning wave propagation parallel to **B** and wave-particle interactions [*James*, 1996].

Figure 1 illustrates how the echoes received by ionospheric sounders are related to the vertical N_e distribution in an assumed horizontally-stratified ionosphere. It is composed of four separate figures combined to illustrate how a complete ionospheric vertical N_e profile is produced from topside and ground-based ionosonde data. The data were simultaneously collected during a pass of the Alouette 1 satellite over Wallops Island, Virginia. The sounder data are presented in the form of echo time delay as a function of the sounder frequency. The time delay t is often expressed in terms of

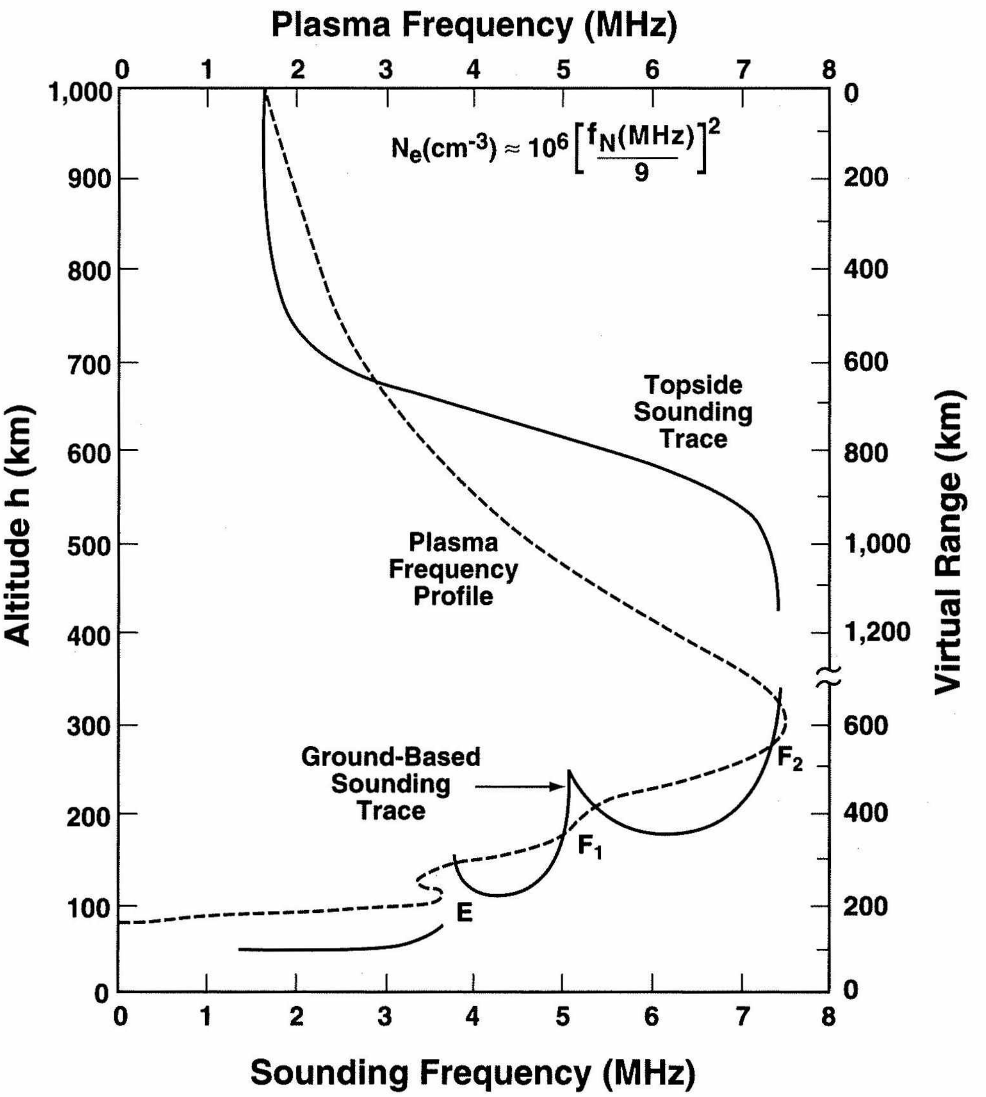

Figure 1. Vertical N_e profiles (dashed line) calculated from topside (Alouette 1) and ground-based (Wallops Island, Virginia) ionosonde O-mode traces (solid curves) presented in the form of virtual range (right scale). The vertical true height (left scale) N_e distribution is expressed in terms of plasma frequency units (top scale) in order to compare with the O-mode ionogram traces which are based on the bottom scale. In order to keep the topside and ground-based sounding traces from overlapping, they are plotted using a scale (right) compressed by 1/2 of the altitude scale (left). The data correspond to 1651 UT, 10 June 1968. Adapted from Jackson et al. *[1980].*

a virtual (or apparent) range given by ct/2, i.e., assuming that the propagation is at the free space speed of light c. The solid lines represent the O-mode traces as they appeared on the data records (called ionograms) from both the ground-based Wallops Island ionosonde and the Alouette 1 topside sounder (1,000 km altitude). One of the four figures used to make this composite consisted of the solid curves at the bottom which were obtained from the Wallops Island ionogram which displayed the virtual range (lower right axis) as a function of sounder frequency (bottom axis). These traces were produced by reflections from the ionospheric E and F regions. The second of the four figures used in the Figure 1 composite consisted of the solid curve starting at the top. It was obtained from the Alouette 1 ionogram which displayed the virtual range (top right axis) as a function of sounder frequency (bottom axis). The third and fourth figures used in this composite have been blended into one dashed line trace. It represents the vertical N_e distribution with true altitude (left scale) calculated from the ionosonde data. In order to aid in the comparison of the N_e profile with the ionogram traces, N_e has been converted to f_N (top scale) using (1). The portion of this profile below about 300 km altitude (with the E, F_1, and F_2 regions labeled) was derived from the Wallops Island ionosonde reflection labeled "Ground-Based Sounding Trace"; the portion above 300 km was derived from the Alouette 1 reflection trace labeled "Topside Sounding Trace". It is instructive to compare the ionogram traces (solid lines) with the corresponding portions of the vertical f_N profile (dashed line). (Note: in the ionosphere the wave energy travels with a speed less than c, thus the apparent range on the right scale is greater than the true range, converted to altitude, on the left scale; the right and left vertical scales have been adjusted for optimum comparison of the ionogram traces with the f_N profile.) The smooth topside (above 300 km) f_N profile produces a smooth ionogram trace with steep gradients near the wave cutoff (between 1 and 2 MHz) at the satellite altitude (1,000 km) and near the f_N peak (between 7 and 8 MHz). The structured E and F regions (dashed line below 300 km), however, produce major signatures on the corresponding (ground-based) ionogram trace. The local minimum at the E layer (called the E valley) produces a clear break in the ionogram trace. The minor inflection at the F_1 layer, produces a dramatic cusp in the ionogram trace. These signatures have become easy to recognize by ionospheric scientists and they provide instant insight of the reflecting medium. A similar situation is expected in the case of magnetospheric radio sounding using RPI on IMAGE.

3. Brief Review of Magnetospheric Remote Sensing Radio Techniques

Ground-based magnetospheric radio experiments date back to the work of *Storey* [1953] on highly dispersed very low frequency signals called whistlers that originate in lightning flashes. Whistlers observed at ground stations have been found to propagate along discrete geomagnetic field-aligned paths. These paths, or ducts, are formed by N_e irregularities in the direction perpendicular to **B** that are maintained all along the magnetic-field line from one hemisphere to the other. The frequency versus time, or dispersion, properties of a whistler can be used to determine both the ducting magnetic field line as well as N_e in the region of the path most distant from the Earth. Energy from a single lightning flash is regularly observed to travel along multiple paths, allowing the simultaneous probing of field lines corresponding to different latitudes. Much of the methodology for such passive magnetospheric probing with whistlers was developed during the IGY (the 18-month International Geophysical Year extending from June, 1957 through 1958) and immediately thereafter in the early 1960's. A variety of satellite techniques for interpreting dynamic whistler-mode spectra received in space were developed in the mid-to-late 1960's. From these and later studies, valuable information has been obtained in many areas including equatorial N_e profiles, global structure of the plasmasphere, ionosphere - magnetosphere plasma interchange, large scale plasma motions, whistler-mode propagation within ducts, and propagation in the nonducted mode and in the presence of multiple ion species. The investigations clearly revealed the important role whistlers play in wave-particle interactions - including the scattering of energetic electrons into the atmospheric loss cone.

In addition, there were many passive experiments involving ground and satellite based reception of magnetospheric VLF emissions due to hot plasma effects originating either spontaneously or by triggering. Others provided the first observations of resonant interactions between whistler-mode signals from Navy transmitters and energetic magnetospheric electrons.

References to this early magnetospheric radio research may be found in the classic book by *Helliwell* [1965] and in many review articles including those by *Smith and Brice* [1964], *Kimura* [1967] and *Carpenter* [1968]. Present day perspectives on various aspects of this research and on its later diagnostic applications may be found in *Sazhin et al.* [1992], *Sonwalkar* [1995], *Hayakawa* [1995], and *Lemaire and Gringauz* [1997].

One of the most favorable locations on Earth for passive whistler observations has been found to be near the 75° west meridian in Antarctica. This location was also found to be favored for the injection of controlled VLF waves into the magnetosphere. Active experiments, conducted from Siple Station over a period of 15 years, provided a wealth of information on the problem of wave-particle energy and momentum exchange in the magnetosphere, including a threshold for exponential growth of coherent waves, saturation, and triggering of new frequencies, (see, e.g., *Helliwell* [1988]). Information on the group delay and Doppler shift of signals from powerful VLF communication and navigation transmitters has been used to investigate several topics, including whistler-mode duct structure, plasma bulk motions, and temporal density variations of the magnetospheric thermal plasma (see, e.g., *Thomson* [1981] and *Clilverd et al.* [1992]).

Exploratory magnetospheric sounding of plasma wave structures using high-power radar facilities has also been performed. *Gurevich et al.* [1992] reported receiving echoes from an altitude of about 4,000 km in the polar magnetosphere using the Sura HF heating facility operating at a frequency of 9.31 MHz with an effective radiating power of about 30 MW. They attributed the echoes to backscatter from ion acoustic turbulence in the field-aligned current region in this altitude region. Related experiments were performed earlier using ionospheric incoherent scatter facilities [*Foster et al.*, 1988; *Rietveld et al.*, 1991]. At times, these experiments recorded enhancements of the incoherent scatter spectrum so intense that they were attributed to contamination from hard targets such as satellites. Convincing arguments were made that the signal enhancements could be explained by the presence of ion acoustic waves. While these techniques do not promise to yield magnetospheric N_e values, they could yield valuable information on magnetospheric dynamics and plasma instability processes.

There have been a number of *in situ* active and passive magnetospheric radio experiments that have been used to obtain N_e. These have included a bistatic propagation experiment that measured the integrated N_e between the ISEE 1 and 2 satellites [*Harvey et al.*, 1979], a series of relaxation sounders, that measured the ambient N_e from the frequencies of plasma resonances and wave cutoffs (see eqs. 1-4) of sounder-stimulated emissions on ISEE 1, GEOS 1 and 2, and EXOS B and D [*Etcheto et al.*, 1983; *Oya and Ono*, 1987; *Oya et al.*, 1990], plasma wave receivers on Hawkeye, DE 1, and GEOTAIL that have been used to deduce ambient magnetospheric N_e values from naturally-produced emissions [*Calvert*, 1981a; *Persoon*, 1988] and map magnetospheric boundaries [*Matsumoto*, 1995], and thermal noise measurements to measure N_e and the electron temperature T_e [*Meyer-Vernet and Perche*, 1989]. The thermal noise technique is well adapted to measurements of N_e and T_e in the outer plasmasphere, the plasmapause and the cusp.

A radio sounder that will be capable of measuring both the ambient and remote N_e throughout the magnetosphere is now being prepared for flight. The next two sections describe the mission, the measurement capabilities of the sounder, and the feasibility of magnetospheric sounding.

4. The IMAGE Mission

IMAGE (Imager for Magnetopause-to-Aurora Global Exploration) has been selected to be NASA's first Medium-class-Explorer (MIDEX) mission. It has the scientific objective of providing an understanding of the global dynamics of the terrestrial magnetosphere in response to changing solar wind conditions. The mission was designed to answer the following questions: (1) What are the dominant mechanisms for injecting plasma into the magnetosphere on substorm and magnetic-storm time scales? (2) What is the directly driven response of the magnetosphere to solar wind changes? and (3) How and where are magnetospheric plasmas energized, transported, and subsequently lost during storms and substorms? Many of the processes related to these questions have time scales of the order of minutes to hours yet our present understanding of the magnetosphere is based on accumulated measurements taken over time scales of months to decades. The IMAGE instruments are designed to provide global images, on the time scale of minutes, of plasma processes at work throughout the magnetosphere from the plasmapause (the outer boundary of the high-density inner magnetosphere called the plasmasphere) to the magnetopause (the outer magnetospheric boundary). In high-latitude regions the images will include the polar cusp (the dayside region where solar-wind plasma readily enters and ionospheric plasma exits) and will extend down to the altitudes of brilliant auroral displays (ª 100 km). While the radio sounder on IMAGE will not provide global images in the same sense as the other imagers on the satellite, it will for the first time provide dynamic information (time scale of minutes) on the locations and shapes of important boundaries such as the magnetopause and plasmapause during the same time interval that global images are being collected by the other instruments. This capability, combined with the accumulated knowledge gained from magnetospheric modeling based on many decades of observations, promises to provide unprecedented insight into the plasma processes involved in the three questions listed above. For example, by measuring N_e profiles in the polar cusp on one-minute time scales, it will be possible to determine whether solar-wind plasma entry is a steady-state or an impulsive process. Also, the effects of substorms on the loss of plasmaspheric ionization can be determined by monitoring the plasmapause N_e gradient.

IMAGE is scheduled to be launched into a highly elliptical polar orbit with an apogee geocentric distance of 8 R_E (the mean Earth radius, R_E, is 6,371 km) on January 1, 2000. IMAGE will make use of four imaging techniques: neutral atom imaging (NAI), extreme ultraviolet imaging (EUV), far ultraviolet imaging (FUV), and radio plasma imaging (RPI) during a two year mission. A brief description of the IMAGE mission can be found in *Green et al.* [1996] and the IMAGE Home Page at http://image.gsfc.nasa.gov.

Neutral atom imaging relies on the detection of neutral particles from the Earth's auroral zones, polar cusp and ring current. The neutral atoms are formed by charge exchange between magnetospheric ions and low-energy neutrals in these regions. The neutrals travel in straight lines from their place of origin to the point of their detection. They will be detected by a complement of 3 NAI instruments on the IMAGE satellite, producing images of the charge-exchange regions on a time scale of the order of minutes. This complement is composed of low energy (10 - 300 eV), medium energy (1 - 30 keV), and high energy (10 - 500 keV) neutral atom imagers (LENA, MENA and HENA, respectively).

The EUV (30.4 nm) imager will obtain images of the entire plasmaspheric distribution of He^+ in single exposures with angular resolutions of 0.6∞ and temporal resolutions of ten minutes and greater. The FUV imager will consist of three different detectors: (1) a set of three geocorona photometers (FUV/GEO), to determine the distribution of hydrogen atoms in the Earth's extended neutral atmosphere (the geocorona) by observing Lyman-alpha emissions (121.6 nm), (2) a spectrographic imager (FUV/SI) for separately measuring Doppler-shifted Lyman-alpha emissions (121.8 nm) (resulting from aurora emitted by charge-exchanged precipitating protons) and auroral-oxygen emissions at

135.6 nm, and (3) a wideband imaging camera (FUV/WIC) to image the aurora over the broad (140 - 190 nm) Lyman-Birge-Hopfield bands of N_2 for maximum day and night spatial resolution.

The RPI will consist of a swept-frequency digital radio sounder covering the frequency range from 3 kHz to 3 MHz (100 km to 100 m free-space wave length range) in order to measure the magnetospheric N_e from 0.1 to 10^5 cm^{-3}. The lowest frequencies will be used mainly for local soundings and thermal-noise measurements to determine ambient N_e values. Long-distance sounding to the magnetopause will generally involve f ≥ about 30 kHz, i.e., to targets with $N_e \geq$ about 10 cm^{-3}. It is called an imager rather than a sounder because in addition to measuring echo signal strength and delay time as a function of sounding frequency, as in traditional ionospheric topside sounders (but with greater sensitivity than these earlier sounders), it will be capable of measuring the echo direction-of-arrival and Doppler spectrum. Thus the RPI will be able to produce maps of the echoing structures. Most of the RPI soundings will be taken near the 8 R_E apogee radial distance between 45 and 90∞ north geographic latitude. In this region, the spacecraft will be immersed in a magnetospheric N_e cavity extending from the plasmapause to the magnetopause as illustrated in Figure 2. Ionospheric sounding of the ionospheric N_e peak shown in the bottom of the figure was briefly discussed in Section 1. It was discussed from the point-of-view of ground-based sounding (to investigate the region below the peak N_e in Figure 1), and topside sounding from satellites (to investigate the region from the peak N_e up to the satellite altitude of 1,000 km in Figure 1 which is well below the plasmapause in Figure 2). Because of the unique location of IMAGE in the magnetospheric N_e cavity, it will simultaneously perform magnetospheric sounding upward to the magnetopause and downward to the plasmapause. This type of sounding has been discussed in a number of publications [*Reiff et al.*, 1994a; *Reiff et al.*, 1994b; *Calvert et al.*, 1995; *Fung and Green*, 1996; *Green et al.*, 1996; *Reiff et al.*, 1996; *Green et al.*, 1998] and will be described in more detail in the next section.

5. Magnetospheric Radio Sounding from IMAGE

The RPI on IMAGE will have capabilities similar to modern state-of-the-art ground-based digital ionospheric sounders [*Reinisch*, 1996]. It will be capable of measuring the following information associated with the received echo resulting from a transmitted pulse: frequency, time delay, amplitude, phase, Doppler spectrum, polarization and direction-of-arrival. (Only the first three were measured by the Alouette and ISIS analog topside sounders.) RPI will use two mutually orthogonal 500-m tip-to-tip dipoles in the IMAGE spin plane for transmission. These antennas will also be used for reception as will a third 20 m tip-to-tip length dipole along the spin axis. The IMAGE spacecraft will rotate in the cartwheel mode, i.e., with its spin axis normal to the orbit plane, with a spin rate of 0.5 rpm. This spin rate will be achieved with full deployment of the thin (0.4 mm) BeCu 28 gauge 7-strand non-insulated wire spin-plane antennas in a time period on the order of one month after launch by alternately deploying the antenna wires and spinning up the spacecraft using magnetic torquing near perigee (1,000 km altitude). It will be possible to transmit all the energy either in the R-X or L-O polarization relative to the satellite spin vector in order to reduce the antenna-pattern nulls in the spin plane. On-board digital signal-processing techniques (coherent pulse compression and Doppler integration) will be used to increase the signal-to-noise ratio. The RPI sounder data will be used to produce N_e profiles and echo maps of N_e structures. Such techniques are currently in use by a global network of ground-based digital ionospheric sounders [*Reinisch et al.*, 1995; *Scali et al.*, 1995]. The ionospheric sky maps are produced by these ground-based sounders by first separating the echoes from various moving N_e irregularities by their different Doppler shifts and then using an array of spaced antennas to determine directions of arrival. The concept used by RPI on IMAGE will be similar but the Doppler shifts will be due to the relative velocity between the moving plasma reflecting surface and the moving spacecraft, and the directions of arrival will be determined from the amplitude and phase measurements of the signals received on the three orthogonal antennas.

The RPI will be able to determine the distances to the magnetopause, plasmapause and other magnetospheric N_e structures, such as the polar cusp. It will also determine the corresponding N_e values at these boundaries. In addition, it will be able to simultaneously determine the N_e profiles leading up to some of them. Since N_e increases inward from the plasmapause, echoes at higher frequencies will arrive from deep within the plasmasphere. These echoes will enable N_e profiles to be deduced on time scales of minutes, much shorter than the typical time scales involved in magnetospheric dynamics. They will be obtained in the directions of increasing N_e gradients and, at times, it will be possible to simultaneously deduce N_e profiles in different directions.

Simulated magnetospheric echoes received by RPI are presented in Figure 3 as solid lines. The simulation assumes that IMAGE is located at a radial distance of 6 R_E along a radial line from the center of the Earth at 25∞ magnetic latitude. It is based on a three-dimensional magnetospheric N_e model. The dashed line shows the variation of f_N along a radius that passes through the IMAGE satellite. This figure is analogous to Figure 1 for the ionospheric case. As in Figure 1, the N_e profile is expressed in terms of f_N (top scale) so as to directly compare with the echo traces. There are three important differences, however, between these figures. First, in the ionospheric case of Figure 1 the profile was derived from existing ionospheric data, whereas in the magnetospheric situation of Figure 3 the comparable data do not exist and the RPI radio-reflection traces were simulated based on 3-D ray-tracing.

The second difference between Figures 1 and 3 is that the observed reflection traces for the ionosphere in Figure 1 correspond to two different sounders whereas the simulated magnetospheric reflection traces in Figure 3 correspond to a single sounder. In the ionospheric case in Figure 1 an N_e peak is under investigation and two sounders are required,

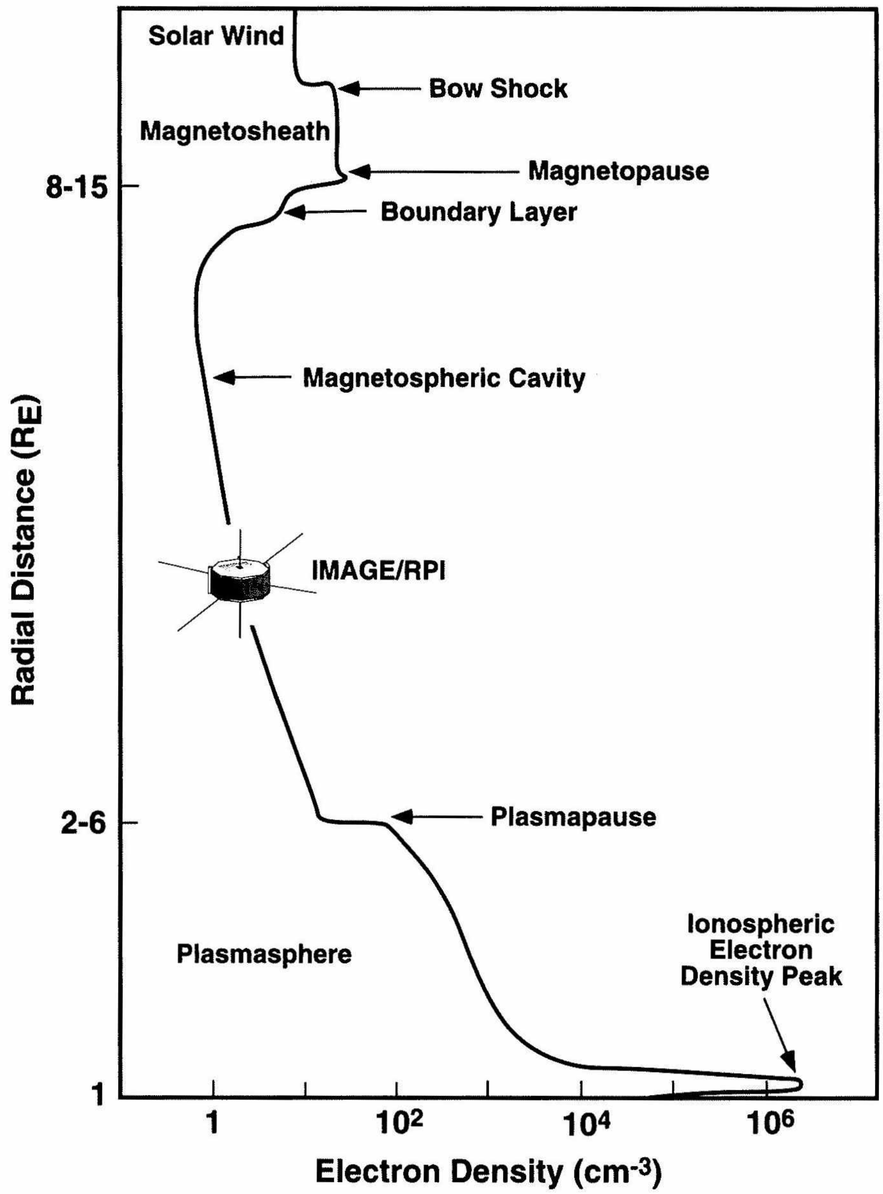

Figure 2. Schematic illustration of the IMAGE spacecraft in the magnetospheric N_e cavity extending from the plasmapause to the magnetopause. The RPI on IMAGE will be able to simultaneously perform radio sounding upward toward the magnetopause and downward toward the plasmapause.

one above and one below the N_e peak altitude. In the magnetospheric case in Figure 3 an N_e valley is under investigation and only one sounder (in the valley) is required. The magnetospheric reflection trace in Figure 3 from the direction of the plasmapause (labeled "Toward Earth") is analogous to the ionospheric topside trace in Figure 1. The traces are inverted relative to one another because the virtual range increases downward in the case of the topside-sounder presentation of Figure 1 and upward in the case of the "Toward Earth" simulated RPI echo trace in Figure 3. They both extend from the wave cutoff condition at the satellite (zero virtual range) to the frequency corresponding to the maximum f_N. The simulated RPI magnetospheric trace in Figure 3 from the direction toward the magnetopause is analogous to the ionospheric ground-based sounding F region trace in Figure 1. The magnetospheric trace in this case starts at a large apparent range (rather than zero) because the transmitted wave going toward the magnetopause initially propagates into a region of decreasing N_e. It has to travel some distance before it encounters an N_e value capable of causing total reflection. The delay time then decreases with increasing frequency for a short frequency interval (even though the wave is penetrating deeper into the medium) because the wave propagation speed increases as the frequency increases.

The third difference between these figures becomes apparent when comparing the virtual range scales on the right side with the distance scales on the left side in each case. Aside from the change in direction on the right-hand side (as described above), there is a major difference in the magnitude of the scales. In the ionospheric situation of Figure 1, the virtual range (right) and true distance (left) scales differ by a factor of two and the virtual distance to a particular feature on the reflection trace is usually considerably greater than the true distance to the corresponding feature on the ionospheric f_N profile. In the magnetospheric situation of Figure 3, these scales are the same and the virtual distance to a particular feature on the reflection trace is often comparable to the true distance to the corresponding feature on the magnetospheric f_N profile. These differences are attributed to the differences in the relative geometry between the directions of the profile and the echoes in each case. In the ionospheric situation (Figure 1), where the ionosphere is assumed to be horizontally stratified, the echoes are vertical and are aligned along the vertical f_N profile. In the magnetospheric situation (Figure 3), the radial direction of the f_N profile (which crosses the IMAGE satellite position) does not generally coincide with the normals to the f_N contours. Thus the directions of the echoes, which coincide with these normals at the reflecting location, will be different than the direction corresponding to the f_N profile in Figure 3. In addition, the long distances with conditions of low N_e in the magnetospheric case (where the operating frequency will often be much greater than f_N) decrease the difference between virtual and true range.

In Figure 3 the sounder reflection traces were simulated using the ray-tracing modeling code of Green _[1988]_, which includes refraction effects, based on the 3-D N_e model. When RPI flies on IMAGE, N_e profiles will be deduced from the reflection traces using inversion techniques [*Jackson*, 1969; *Huang and Reinisch*, 1982]_ as was done in the case of the ionospheric soundings of Figure 1. As IMAGE travels along its orbit it will be possible to construct N_e contours in the orbital plane as was done in the topside ionosphere using the Alouette and ISIS satellites _[*Warren*, 1969]_ even during intense auroral kilometric radiation [*Benson and Akasofu*, 1984]. RPI will also provide information on distortions of the geomagnetic field from the reception of ducted echoes propagating along magnetic field-aligned paths of N_e irregularities _[*Calvert*, 1981b]. In addition to these remote measurements, the RPI on IMAGE will provide accurate *in situ* N_e measurements, down to the instrumental lower frequency limit of 3 kHz (corresponding to N_e of 0.1 cm^{-3}), from sounder-stimulated plasma resonances _[*Benson*, 1977]_ and thermal noise measurements [*Meyer-Vernet and Perche*, 1989]. The latter technique also provides the electron temperature.

One of the greatest contributions of RPI to the IMAGE mission will be the capability to produce echo maps of N_e structures in the vicinity of important boundaries such as the magnetopause, polar cusp and plasmapause on time scales of minutes. As pointed out earlier, similar maps are routinely produced by modern ground-based sounders. A sequence of N_e echo maps will be produced over intervals on the order of hours, in the apogee portion of the IMAGE orbit (period about 13 h). They will provide unprecedented information on magnetopause dynamics while other IMAGE instruments obtain global images of the inner magnetosphere. In addition, the plasmaspheric N_e profiles obtained from the RPI during these long time intervals will provide a degree of "ground truth" information for these global images. These profiles will be used to follow the dynamic erosion and later filling of magnetic flux tubes. Plasmaspheric erosion is believed to be driven by the penetration of a strengthened convection electric field and interaction with newly injected ring current populations following substorm onset. Flux tube filling involves a complex interplay between ionospheric outflow and heating at high altitudes. The RPI real-time monitoring of the absolute electron densities in the outer plasmasphere, together with the EUV and ENA images, will provide a global insight into the nature of these processes for the first time.

Calvert et al. _[1995]_ considered the feasibility of performing such measurements with a radio sounder in the magnetosphere. This study included the effects of curved targets as seen by a sounder located between the plasmapause and the magnetopause. In this situation there is a decreased echo power return from the convex plasmapause (defocusing) and an increased echo power return from the concave magnetopause (focusing). The decreased power return at the plasmapause due to defocusing is not much of a problem for RPI on IMAGE because the plasmapause marks a region of increasing N_e with increasing distance from the spacecraft and thus frequencies where the RPI antennas operate at their greatest efficiency will be used.

The magnetopause is a challenging radio sounding target because the low electron density there (see Figure 1) requires sounding frequencies which will be well below 100 kHz most of the time. In this frequency range the transmitted power is proportional to f^4 and even the long 500-m dipoles are very inefficient radiators at such low frequencies (they become shorter than 1/2 the vacuum wavelength at frequencies below 300 kHz). The RPI radiated power at 30 kHz will be about 50 mW (corresponding to a rms voltage at the root of the antennas of 3 kV from the 10 W transmitter). As a point of comparison, the highly successful ISIS 1 and 2 ionospheric topside-sounders would radiate 50 mW at about 280 kHz (based on Equation (20) of *Calvert et al.* _[1995]_ using 1 kV (from a 400 W transmitter) and a 73.2 m tip-to-tip, 13 mm diameter, stem dipole). (Note: the ISIS satellites each used two antenna lengths to cover the frequency range from 100 kHz to 20 MHz.) Of course the ISIS ionospheric sounding distances were considerably less than the magnetospheric sounding distances to be overcome by the RPI and the ISIS long-distance sounding was mainly performed at higher frequencies corresponding to greater antenna efficiency.

Nevertheless, there are several additional factors (in addition to the above-mentioned longer antennas and higher antenna voltage) that greatly enhance the capability of RPI (for long-distance sounding to the magnetopause) relative to ISIS (for ionospheric sounding). Namely, RPI will benefit from (1) several dB of echo signal gain from magnetopause focusing, (2) a 22 dB gain from a smaller receiver bandwidth (300 Hz compared with 50 kHz on ISIS) so the received echo power competes with less noise power, (3) a 3 dB gain from using two transmitters that drive the two spin-plane dipoles ± 90∞ out of phase in order to transmit waves with R-X or L-O polarization (ISIS used one transmitter, and one receiver, into one of two dipoles depending on the transmission frequency); on reception, the simultaneous use of orthogonal antennas will eliminate polarization fading of the received signals and will enable wave polarization discrimination of these signals in order to aid in the interpretation of the echoes, (4) a set of three mutually orthogonal antennas for direction finding (ISIS did not have a spin-axis antenna), (5) double tuning at the receiver inputs to reduce the risk of saturation by out-of-band signals, and transmit antenna tuning to aid in obtaining the 3 kV antenna voltage (ISIS did not use antenna tuning),

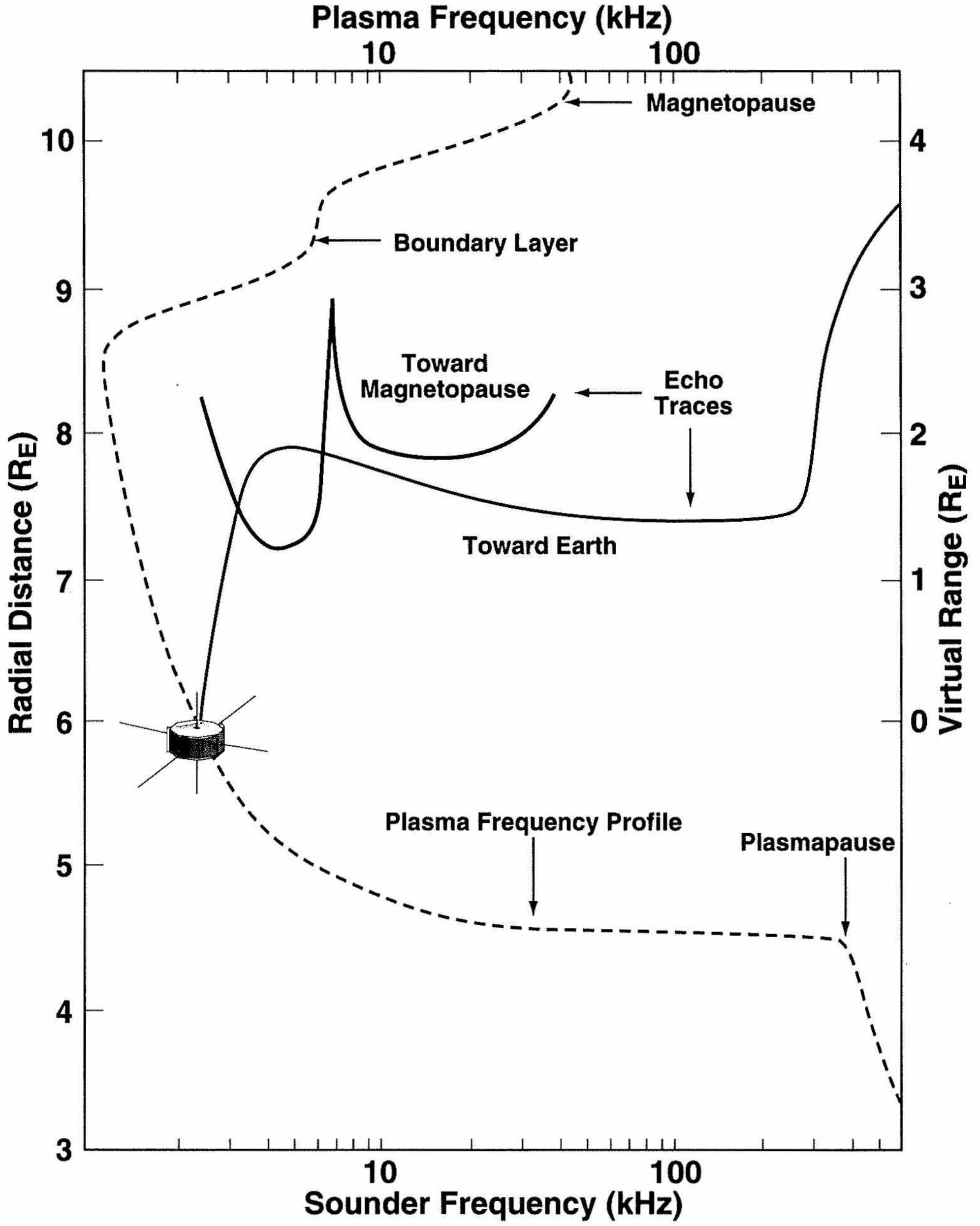

Figure 3. Similar to Figure 1 except in this magnetospheric case the O-mode echo traces are simulated using ray tracing, including refraction effects, based on a sounder located at a radial distance of 6 R_E at 25∞ magnetic latitude in a 3-D N_e model.

(6) coherent pulse compression and (7) Doppler integration. The gain from the last two depend on the wave form being used, it was 21 dB in the example discussed by *Calvert et al.* [1995]. They are well-proven digital signal processing techniques used by a large number of ground-based ionospheric sounders. They could not be employed by the ISIS topside sounders because the detected receiver video output signal was used rather than the entire waveform. Coherent pulse compression, which correlates the transmitted and received pulses, allows long low-power pulses to be transmitted without sacrificing echo-range resolution. Doppler integration is based on transmitting M pulses (e.g., M = 8 or 16) at the same frequency and calculating separate Fourier transforms from the sequence of M time samples taken at the same echo delay after each pulse (and repeating the process for each echo-delay increment). It is routinely used to map the motions of ionospheric N_e irregularities in the dynamic high-latitude regions even in the presence of severe spread F (a condition where N_e irregularities distributed throughout the ionospheric F region produce many echoes that result in the spreading of the F-layer reflection trace over a broad area on the ionogram trace) [*Reinisch et al.*, 1995]. It is expected that the magnetosphere will also contain large-scale regions of N_e irregularities that will be detected in a similar way by the RPI.

Calvert et al. [1995] concluded that a sounder of the type planned for RPI on IMAGE could make N_e measurements of magnetospheric structures with 10% accuracy, a range resolution of 500 km and an angular resolution of 4∞ at magnetopause target distances of 4 R_E on a time scale of about three minutes. This claim has generated some debate in the scientific community [*Greenwald*, 1997a; *Calvert et al.*, 1997; *Greenwald*, 1997b]. It is worthwhile to note when considering such discussions, that *Calvert et al.* [1995] considered a model magnetopause centered at a radial distance of 10 R_E with a sounder at a radial distance of 6 R_E, whereas the apogee of the IMAGE orbit will be at 8 R_E. Thus, the sounding distance to a 10 R_E magnetopause for RPI will be 1/2 the magnetopause/sounder distance used in the feasibility study of *Calvert et al.* [1995] corresponding to a four-fold increase in echo power (6 dB) over what was considered in that study. In addition, *Calvert et al.* [1995] discussed only one specific waveform as an example to illustrate how pulse compression and spectral integration enhance magnetospheric radio imaging. The RPI instrument to fly on IMAGE will use different transmission waveforms that will be selectively used to satisfy different measurement objectives.

Since these waveforms are considerably different from those that have been previously used in topside ionospheric sounding, e.g., in the Alouette/ISIS program, a brief description of them will be given here. The RPI will predominantly use three different waveforms: (1) complementary phase coded pulse sequences, (2) staggered pulse sequences and (3) frequency-modulated (or "chirp") pulses. Each of these transmission waveforms has advantages and disadvantages. Under certain circumstances two or even all three waveforms will be used to observe and resolve details of the structure and dynamics of the reflecting plasma.

The first waveform will be used with pulse repetition rates PRR between 0.5 to 4.0 pulses per second. The former rate corresponds to an inter-pulse period of 2 s and, assuming pulses of length 16 x 3.2 = 51.2 ms (where 3.2 ms is the "chip" length of the phase code), will allow virtual ranges (ct/2) to be measured from distances ranging from slightly more than 1 R_E to almost 46 R_E (a maximum delay time of 2 - 15 x 0.0032 s is used since the last 15 phase-code samples before the next sounder pulse do not contain the complete pulse phase code). The maximum range in the case of the 4 pps rate is reduced to slightly less than 5 R_E. In either case, the target range resolution is defined by the compressed pulse width of 3.2 ms corresponding to 480 km or less than 0.1 R_E. While the latter case with the higher PRR is limited to shorter ranges, it is capable of measuring larger Doppler frequencies f_D and hence higher radial velocities v_r given by

$$v_r = l f_D/2 \qquad (5)$$

where l is the free-space wavelength [*Flock*, 1979]. The maximum unambiguous f_D is limited by the Nyquist sampling criterion to one half the data sampling rate DSR, i.e., $f_D < DSR/2$. When using complementary phase coded pulse sequences, the data sampling rate becomes DSR = PRR/2 because the pulse-compressed data from two transmitted pulses are summed (in order to reduce signal leakage into other range bins). Thus, the maximum unambiguous f_D becomes f_D = PRR/4 and the maximum v_r that can be measured is lPRR/8. For an operating frequency of 30 kHz, expected to be used for magnetopause sounding, the maximum radial velocities are 0.3 and 5 km/s for PRR = 0.5 and 4.0 pps, respectively. Since quadrature samples (sometimes called sine and cosine samples) of the intermediate frequency are made, the sign of the Doppler shift (and hence of v_r) will also be determined. Thus the first waveform will be limited to probing plasma structures moving relative to the satellite with speeds of less than 5 km/s when sounding at 30 kHz. During sections of the orbit where the spacecraft moves essentially parallel to the magnetopause N_e contours, good results will be obtained if the boundaries are not moving too quickly toward or away from the satellite. These boundary relative-motion constraints become even more severe (by an order-of-magnitude) near the plasmapause where the higher N_e values will require sounding frequencies around 300 kHz.

These limitations in the Doppler measurements will be overcome by using the second waveform. The staggered pulse sequence used in this case consists of unevenly spaced 3.2 ms pulses. The transmission-pulse time slots are m x 3.2 ms with m values varying from 1 to 768. In order to leave sufficient space for the reception of echoes, not all m values are used. On each sounding frequency a total of about 300 pulses will be transmitted and special correlation techniques will be used to determine the spectra at each of up to 128 ranges. The staggered-pulse-sequence waveform is designed to provide a maximum unambiguous f_D = 150 Hz (corresponding to the maximum data sampling rate of 1/0.0032). From equation (5), it is seen that this capability leads to the detection of a maximum relative v_r of 750 km/s at 30 kHz. Such capabilities should allow radio imaging of the magnetopause even during the presence of wave-like magnetopause structures with amplitudes of thousands of kilometers and radial motions as large as 150 km/sec as reported by *Safrankova et al.* [1997] based on data from the Russian satellite - Czech subsatellite pair INTERBALL 1/MAGION 4. In the case of plasmapause sounding at 300 kHz, radial motions up to about 75 km/s could be detected which is far in excess of anything likely to be sustained for more than a few minutes at most.

Although waveform (2) has great capabilities in highly dynamic conditions, it also has some limitations. Some of the received echoes may be lost because they arrive during the transmission of one of the later pulses. This situation leads to range and Doppler leakage that cannot be totally resolved by the software. Such problems, occurring during conditions of high Doppler shift, will be resolved by employing the third waveform based on chirp pulses. These pulses will have a linear frequency modulation and the target range is obtained from the beat frequency of the received and transmitted signals. In the case of the RPI, the range accuracy will be 300 km for the chirp waveform. The ability to detect an echo from a transmitted chirp signal is not affected by high Doppler shifts. Such shifts, however, introduce target range errors since the Doppler shift will be added to the beat frequency. For the RPI chirp waveform, a Doppler shift of 5 Hz will result in a range error of 300 km. Range and Doppler ambiguity can be resolved when RPI successively transmits two or three of the available waveforms at each frequency.

It must be kept in mind that the first waveform is not restricted to pulse lengths of 16 x 3.2 = 51.2 ms, and that pulses with 1 x, 2 x, 4 x and 8 x 3.2 ms may be used under highly dynamic condition, i.e., when the conditions of the reflecting medium are changing on a time scale shorter than the probing pulse time duration.

Eliminating range and Doppler ambiguities by using the above procedures will be at the cost of temporal and/or spatial resolution. Thus it is planned that such muti-mode operations will be periodically scheduled among normal single-mode operations in a manner so as to maximize resolution while minimizing ambiguity. These capabilities will make the RPI to fly on IMAGE even more capable than the magnetospheric sounder discussed by *Calvert et al.* [1995].

6. Summary

A wealth of magnetospheric N_e information (as well as information on magnetospheric wave-particle energy and momentum exchange) has been obtained from more than four decades of ground-based experiments involving whistler-mode waves. These remote radio observations have been complemented by *in situ* measurements involving numerous satellites. Though the resulting accumulated knowledge is substantial, and has provided an important base for understanding the general problem of the interaction of planetary magnetospheres with a stellar wind, many major questions remain concerning the complex physics of the global response of the terrestrial magnetosphere to the dynamic nature of the solar wind.

Radio plasma Imaging with RPI during the IMAGE mission will apply state-of-the-art digital sounding techniques, in routine use in ground-based ionospheric sounding, to the investigation of the magnetosphere. The resulting high time-resolution measurements of distant N_e structures will provide critical information needed to resolve fundamental magnetospheric problems. Combining the RPI boundary locations, N_e profiles and echo maps of N_e structures with images from the other IMAGE remote sensing instruments will produce dynamic global descriptions of fundamental magnetospheric processes.

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Annual Report for 1997 from IUCAF

1. Introduction

IUCAF, the Inter-Union Commission on Frequency Allocations for Radio Astronomy and Space Science, was formed in 1960 by URSI, IAU and COSPAR. Its brief is to study the requirements of radio frequency allocations for radio astronomy, space science, and remote sensing in order to make these requirements known to the national and international bodies that allocate frequencies. IUCAF operates as a standing committee under the auspices of ICSU, the International Council of Scientific Unions and is strongly supported by IAU, URSI and COSPAR. ICSU works under the umbrella of the United Nations organization UNESCO.

2. Membership

At the end of 1997 the composition of IUCAF was:

URSI	W.A. Baan	U.S.A.(currently in The Netherlands)
	R.J. Cohen	United Kingdom
	A. van Eyken	Norway
	W. Keydel	Germany
	P. Poiares Baptista	The Netherlands
	K. Ruf	Germany
	J.B. Whiteoak	Australia
IAU	S. Ananthkrishnan	India
	A.R. Thompson	U.S.A.
	K. Kawaguchi	Japan
	B.A. Doubinsky	Russia
COSPAR	D. Breton	France
	A. Gasiewski	U.S.A.

Ex Officio Advisers:

Director ITU Radio Bureau	Robert Jones	Canada
Chairman ITU Radio Board	M. Miura	Japan

During the 1997 IAU General Assembly in Kyoto, Japan, replacement changes were made to the IAU representation on IUCAF: Dr. K. Kawaguchi from Nobeyama Observatory in Japan, Prof. Dr. S. Ananthkrishnan from the Tata Institute and the Giant Meter Radio Telescope (GMRT) in Pune, India. Thanks to R. Sinha (India) and M. Ishiguro (Japan) for their service to the spectrum management community.

IUCAF continues to maintain its network of Correspondents in 35 countries in order to interact with national authorities responsible for radio frequency management.

3. International scientific meetings

During the period of January to December 1997, IUCAF Members and Correspondents took part in the following meetings:

February

The Annual Meeting of CORF, the Committee on Radio Frequencies of the USA National Research Council, in Washington, DC.

March

Meeting of CRAF, the Committee on Radio Astronomy Frequencies of the European Science Foundation, in St. Petersburg, Russia.

May

The WRC-97 Conference Preparatory Meeting in Geneva [IUCAF 434].

June

Meeting of ITU-R Working Party 7D in Geneva [IUCAF 435].

July

The first meeting of ITU-R Task Group 1-5 on Unwanted Emissions in Geneva [IUCAF 436].

August

The IAU XXVth General Assembly in Kyoto, Japan [IUCAF 438].

September

The 17th Annual Meeting of the Space Frequency Coordination Group SFCG-17 in Houston, USA [IUCAF 437].

October

Second meeting of CRAF in Zurich, Switzerland.

October

The ITU-R Radiocommunication Assembly 1997, Geneva [see IUCAF 439, 441].

October/November

The ITU-R World Radiocommunication Conference 1997 [IUCAF 440, 441 and 441A].

4. Description of relevant issues

4.1 IAU General Assembly

Just as the URSI GA in August 1996, so also the General Assembly of the International Astronomy Union (IAU) has turned into one long working session for IUCAF. Two general meetings were well attended. Several well attended special sessions of the GA were totally dedicated to spectrum issues. In addition, a special meeting on spectrum management for Observatory Directors was organized to brief the directors on the trends in spectrum management and to unify the RAS efforts in this area. An extensive report on the various meetings has been reproduced on the IUCAF Website (Doc 438).

A major issue discussed during the IUCAF meetings and the Directors' meeting related to the coordination proceedings in progress with Motorola's IRIDIUM (see Doc 438). IUCAF has been leading in the this coordination efforts, and IUCAF has repeated expressed willingness to coordinate with IRIDIUM on behalf of the radio astronomy community. At the writing of this report no real progress has been made in reaching any satisfactory coordination agreement. During the IAU GA the "Kyoto Declaration" was drafted under the leadership of Prof. Roy Booth (Sweden), which was signed by 36 observatory directors. The Declaration draws attention to the increasing problems experienced by radio astronomers and proposes to resolve this problem through vigilance, education of other spectrum users and in-house research. Strong support has been expressed by the directors for the activities of IUCAF, CRAF and CORF.

Another issue discussed extensively at the GA was the use of the mm wave frequencies above 60 GHz, which are becoming of interest for commercial use. Up till the present time, the passive users have been mostly alone in using these bands. Concern was expressed about the 95 GHz Cloud Radar proposed by fellow scientists from the remote sensing community. An amicable solution has since been found on this issue (see section 4.4.1 below). The "IUCAF mm Wave Working Group" on the use of frequencies above 70 GHz is working intensely on this issue (see item 4.6 below).

4.2 Joint URSI-IUCAF Efforts - Commsphere Conferences

During the ICSU XXVth General Assembly in Washington D.C. in 1996, URSI and IUCAF presented the text for Resolution 1 on "The Need for Radio Frequency Spectrum for Radio Science". The final statement of this resolution "Urgently requests the Executive Board to persuade governments and the International Telecommunication Union, through the appropriate bodies, to maintain adequate protection of those spectral windows that are vital to research of the above types". URSI, under the leadership of Vice-President J. Shapira and with support from IUCAF, is taking further action on this issue on behalf of ICSU. A letter is being prepared to be sent to all National Academies of Science explaining the needs of the passive scientific spectrum users and suggesting specific actions to be taken at the national level.

IUCAF continues to supports the organizational efforts for the Commsphere Conferences, and particularly Commsphere Africa (July 1998, Dakar), and Commsphere 99 (January 1999, Toulouse). These conferences are aimed at facilitating "an open discussion on spectrum use and spectrum applications". Participants of the conferences have professional backgrounds and interests that vary from governmental spectrum management, commercial operations, industrial design environments, and passive/scientific spectrum use, to the building and providing communication infra-structure of developing countries. IUCAF members actively participate in these conferences as they provide the correct forum for open discussions on spectrum matters.

4.3 ITU-R Radiocommunication Sector

4.3.1 ITU-R Task Group 1-5 on Unwanted Emissions

The standards proposed in the final version of Recommendation ITU-R SM.329 by the Task Group 1-3 on "Spurious Emissions" were rather lenient and did not reflect state-of-the-art engineering practices. This Recommendation ITU-R SM.329 has been reviewed at WRC-97 and incorporated into Appendix S3 of the Radio Regulations, such that these new "spurious emission standards" will apply to all systems installed after January 2003 and to all transmitters after January 2013. The community will need to wait six years before these new (and greatly inadequate) "Category A" limits (from the USA and Canada regulations) will be first enforced. Already the CEPT countries have put in place their own standards, which are typically 20-30 dB more stringent than the TG 1-3 standards. Furthermore, the recommended (lenient) standards for the Space Services, are only "design goals" until re-considered and possibly redefined at WRC-99.

At WRC-97 the Recommendation 66 was also modified to allow the new Task Group 1-5 to do its work on "Unwanted Emissions", which includes unsolved issues on spurious emissions as well as out-of-band emissions. IUCAF members are playing an leading role in the ongoing work of Task Group 1-5 on behalf of the passive user community. Several IUCAF papers have been contributed to these proceedings describing issues of spurious and out-of-band emissions in passive bands and the particularly serious threats of downlinks of the space services.

4.3.2 ITU-R Working Party 7D and 7C

Working Party 7D meets twice a year and deals with ongoing radio astronomy spectrum studies within the ITU-R. The radio astronomers working in WP7D maintain the liaison with other Study Groups such as those of the Space Services in SG 4 and 8. WP7D provides a forum to put forth new ideas and standards on protection for the radio astronomy service. Current issues within WP7D are a) the "10 percent issue", relating to the amount of time that can be lost to man-made interference, b) the use of Monte Carlo methods for the determination of coordination distances between mobile spectrum users and radio astronomy observatories, and c) the mmwave radio spectrum above 71 GHz. Similarly WP7C works on behalf of the remote sensing community.

4.3.3 The Radiocommunication Assembly and World Radiocommunication Conferences

The bi-annual ITU World Radiocommunication Conference ("WRC-97") was held in Geneva from October 27 to November 21, 1997. Spectrum allocation issues for the Radio Astronomy ("RAS") were not on the Agenda for this Conference, only issues of peripheral interest. However, the allocation of spectrum for the Earth Exploration Satellite ("EES") service was an important part of the Agenda, because the EES had not been allocated any spectrum since 1979. The EES was partially successful in its efforts regarding relevant issues, while the RAS was more so. Participation from both the radio astronomy and Earth exploration communities was strong during the Conference and there was effective coordination between both groups. The remote sensing people were all part of national delegations, while half of the RAS representatives were part of the IUCAF delegation. With a total of 15 delegates at WRC-97, the RAS had a mid-size delegation. The ITU

Radiocommunication Assembly ("RA") dealing with the work of the ITU Study Groups was held in the week preceding WRC-97.

IUCAF submitted one input document to the RA (IUCAF 439) related to the use of Monte Carlo methods in the determination of coordination zones around radio observatories. The input Document for WRC-97 (IUCAF 440) was a position document describing the IUCAF positions on all WRC-97 Agenda Items relating to the RAS. This document was well received and was used within IUCAF and among administrations to help determine the course of action in these issues.

The following global trends characterized the WRC-97 conference:

1. The Conference showed a continued pressure from operators and certain administrations to consolidate more spectrum allocations for satellite applications.
2. Serious coordination efforts still need to be made to allow implementation of many planned (mostly non-GSO) satellite systems and to allow a peaceful coexistence of new systems and existing systems. It appears that sharing in certain bands between different satellite systems and various terrestrial applications will be very difficult if not impossible.
3. The demand for high frequency spectrum has risen dramatically with the possibility of terrestrial and satellite-based high-density data systems. Specific new assignments have been made for such applications up to frequencies of 66 GHz. In particular, "high density fixed" applications have been given provisional band space for providing such services as "Internet to the home and the car". An aerostat balloon system is being designed to serve about 200 cities worldwide in this manner from heights of 20 km or more. Although many of these systems might still be far into the future, passive spectrum users are warned that the (currently interference-free) mmwave spectral regions may soon have active applications.
4. Other services, such as those of terrestrial fixed and aeronautical radio navigation, are seriously worried about "harmful interference", a fact they strongly expressed at the Conference. It is becoming clear that the RAS and EES are not anymore the sole sufferers from unwanted emissions and so there may be some new allies of the passive spectrum users.

4.4 Current Spectrum Management Issues

4.4.1 95 GHz Cloud Radar

In the past radio astronomy community has expressed reservations about the space borne Cloud Radar at 95 GHz proposed by fellow scientists from the remote sensing community. WRC-97 adopted a narrow (100 MHz) allocation in the 94 - 94.1 GHz band for active remote sensing. A new footnote RR 5.562 restricts this band for cloud radars only. These radars will be turned off over mmwave RAS observatories.

4.4.2 Mobile Satellite Services

The negotiations between IUCAF and the GLONASS administration (Russia) resulted in a plan to "clean up" the 1612 MHZ RAS band from GLONASS emissions by the year 2006. Progress is being made and the band is already considerably cleaner than before. Currently IUCAF is again intensely working on preventing interference in this band from Mobile Satellite Service operations from systems such as Motorola's IRIDIUM with 66 satellites. An inadequate design of the satellites causes them to produce out-of-band emissions in the RAS band during higher traffic loading, which will destroy observations at a number of radio observatories. No progress has yet been made in the stand-off situation with Iridium but the discussions with MSS operators are ongoing. IUCAF members are also part of the discussions in CEPT SE28, and ITU-R TG 1-5 on general satellite issues.

In various discussions and publications, IUCAF has expressed its strong concerns about the interference potential from downlinks of the space services. These are the single most imminent threat for the terrestrial passive spectrum users. The emission standards for satellite transmission systems are not very restrictive, because economic factors play a dominant role in their design. In particular, as the operating frequencies get higher, it is becoming more difficult to build effective filters. IUCAF Documents 442 and the IUCAF contribution to Joint Discussion 5 on Interference at the IAU (Doc 444) clearly state the problems and some of the solutions.

4.5 Remote Sensing Issues

The EES community was not completely successful in all its objectives for WRC-97. About 18 allocations for the Earth Exploration Satellite service have been made in bands from 400 MHz to 94 GHz. Some of these allocations were upgrades from secondary to Primary and some are new worldwide Primary allocations. Many have restrictive "non-interference to existing services" footnotes. Before WRC-97 extensive studies had been done to realign the allocations in the 50.2 - 71 GHZ bands to accommodate the needs of the EES (passive) and SR (passive) and other active services (like Inter-Satellite Service) in the high-opacity oxygen absorption bands. The proposals for the allocation plan have been adopted by WRC-97. The allocations for EESS (passive) above 71 GHz have been deferred to WRC-99 (see next section).

4.6 Passive Spectrum Use at Frequencies above 71 GHz

A new resolution from WRC-97 calls for studies of EESS (passive) and RAS frequency bands above 71 GHz (WRC-99 Agenda 1.16). The two communities are working together intensely in order to align their requirements for spectrum use at higher frequencies at WRC-97. The frequency range above 30 GHz has drawn strong interest for commercial applications. On the other hand, the passive spectrum users and particularly the radio astronomers have essentially had all the spectrum in the various atmospheric windows up to frequencies of 1000 GHz available for observations of the thousands of lines from many molecules. This picture will change rapidly as new techniques become available.

The IUCAF "mmWave Working Group" is playing an important role in the preparations for WRC-99 and for the preparation of a coordinated request for passive spectrum allocations at high frequencies. This group has characterized the radio astronomy use of the mmwave spectrum over the last 20 years and has attempted to prioritize various observing bands. Indeed WRC-99 is likely to be the last conference where corrections may be made to existing allocations in order to accommodate passive services. IUCAF and the mmWG is submitting studies to ITU-R Working Party 7D regarding the sharing conditions of critical bands between radio astronomy and other terrestrial services. In particular, the remote locations of radio observatories allow sharing of mmwave spectrum with Mobile and Fixed services by creating quiet zones or coordination zones.

5. Publications and reports

All reports are available on the IUCAF Home Page at http://www.nfra.nl/iucaf/ Most reports have been distributed to the complete IUCAF electronic mailing list. Any person requiring additional information on spectrum management relating to the passive use spectrum may contact the IUCAF Secretariat.

IUCAF 432 - URSI Commsphere 97, Lausanne, February 1997

IUCAF 433 - Annual Report 1996 of IUCAF

IUCAF 434 - Conference Preparatory Meeting CPM97 for WRC-97, Geneva, May 1997

Various inputs to ITU-R Working Party 7D

IUCAF 436 - ITU-R Task Group 1-5, Geneva, July 1997

IUCAF 437 - Space Frequency Coordination Group SFCG-17, Houston, 1997

IUCAF 438 - IAU General Assembly 1997, Kyoto, August 1997

IUCAF 439 - Input Radiocommunication Assembly (RA97/PLEN/54-E), Oct 97

IUCAF 440 - Input ITU-R WRC-97, (WRC-97 144-E) Geneva Oct/Nov 1997

IUCAF 441 - WRC-97 RAS and EES Results, Geneva, Oct/Nov 1997

IUCAF 441A - WRC-97 Results, Condensed Version, Geneva, Oct/Nov 1997

IUCAF 442 - IUCAF Position on Radio Interference, November 1997

6. Organizational matters

Finances: Generous support from URSI, IAU, and COSPAR has enabled IUCAF to make travel grants to its Members and Correspondents to ensure adequate participation at important conferences. During 1997 IUCAF was able therefore to participate actively in meetings of the Radiocommunication Sector, at the meetings of ITU-R Task Group 1-5, the ITU-R World Radiocommunication Conference 1997 all in Geneva, the IAU General Assembly in Kyoto, Japan, and SFCG-17 of the Space Frequency Coordination Group in Houston, USA.

It is increasingly important that IUCAF representatives attend key spectrum meetings. Already the IUCAF members are often outnumbered by representatives advocating commercial use of the spectrum. The radio astronomers working on spectrum issues are mostly volunteers. Within the radio astronomy community there is one such spectrum manager at the National Science Foundations in the USA and recently a second person started work at Dwingeloo, The Netherlands, as Spectrum Manager for the European Science Foundation. On the other hand, the remote sensing community has a number of professional spectrum managers. Since the coordination problems are becoming more global, IUCAF has an important role to play in preserving the cleanliness of the bands allocated for passive and active scientific use. Such global efforts require an increased travel budget and the continued support of URSI, IAU, and COSPAR is essential. In addition, IUCAF Members and Correspondents have obtained substantial financial support for travel from their home institutions.

Secretariat: IUCAF has no formal Secretariat. During 1997 the business of the IUCAF Secretariat was conducted from Arecibo Observatory, Puerto Rico, USA and was generously supported by the NAIC, the National Astronomy and Ionosphere Center, which provided partial travel support, secretarial support and access to all means of electronic communication. NAIC is operated by Cornell University under a cooperative agreement with the National Science Foundation of the United States of America. Beginning 1998, the IUCAF Secretariat has changed coordinates to the Westerbork Observatory, Netherlands Foundation for Radio Astronomy (NFRA-ASTRON) in Dwingeloo, The Netherlands.

7. General publications

A number of publications appeared during 1997 that relate to spectrum issues for the passive services. A rather complete list of publicly available articles is maintained at the IUCAF WWWeb site (www.nfra.nl/iucaf/).

In addition, various articles and Letters to the Editor in Nature, Sky and Telescope, Physics Today, and some national newspapers mentioned the IRIDIUM issue, the WRC-97 results, and the general plight of the passive services to keep their passive spectrum clean.

Various papers of a more technical nature have been submitted by IUCAF Members and associates to ITU-R committees and conferences, the European Science Foundation, the USA Federal Communication Commission, and the European CEPT.

The contributions to Joint Discussion 5 from the IAU GA will be published as a book and edited by Prof. S. Isobe (Japan). This review will provide a broad discussion of "astronomical pollution issues" and will be useful as a general information document.

8. Conclusion

At this time of rapid growth in the telecommunication industry, the position of the passive spectrum users is also strengthened. There is increasing recognition that the protection levels for passive spectrum use are a necessity for survival. The passive spectrum user community has not changed its "need for protection message" for many years, although many experiments are done at power flux density levels of one or several orders of magnitude below the protection levels published in the ITU literature. A growing number of administrations has become cognizant of he needs of the passive services and is committed to provide for and protect them.

The protection levels for harmful interference are often difficult to meet by active spectrum users. Some companies and operators take pride in cooperating with the passive users. Others hope the problem will go away and try to steam-roll applications through the system that are less efficient in their use of the spectrum. Of course, spectrum efficiency has different meanings for different spectrum users, depending on the financial consequences.

Certain members and friends of IUCAF are participating in efforts to bring the radio spectrum pollution issue to the highest governmental offices. The OECD Mega-Science Forum on Radio Astronomy has addressed these issues and intends to bring them to the attention of government officials and leaders of the telecommunication industry. IUCAF wholeheartedly supports this effort and hopes that this will lead to increased recognition of the global issues facing the scientific community.

The issues for the passive user community are clear. For the radio astronomers, the satellite downlinks comprise the most imminent threat that necessitates constant supervision. In this regard, the work of Task Group 1-5 is indispensable for setting standards for unwanted emissions in the future. TG 1-5 is indeed looking at practical rules for protecting the passive user operations. The allocations in the spectrum above 71 GHz will be high on the list of priorities for the communities because of the deadlines put by the WRC-99 conference. Within the telecommunication race, the role of IUCAF is becomes more globally inclusive each day.

W.A. Baan, Chairman
Dwingeloo, The Netherlands

CONFERENCE REPORTS

Radio Africa '97

Nairobi, Kenya, 4 - 8 August 1997

The Second Regional Workshop on Radiocommunication in Africa (Radio Africa '97) was held at the Kenya College of Communication & Technology (KCCT) in Nairobi, Kenya from 4th to 8th August, 1997.

The workshop which was described by the participants as "most successful" was attended by 126 participants coming from eighteen (18) countries of the world (U.S.A, United Kingdom, France, Belgium, Switzerland, Israel, India, Egypt, Nigeria, Ghana, Senegal, Cameroon, Botswana, Liberia, Ethiopia, Tanzania, Uganda and Kenya).

The workshop was officially opened by the Kenya Minister for Transport and Communications, Hon. Wilson Ndolo Ayah, M.P, EGH, in a colourful occasion which attended by a number of high ranking personalities both from the Government, public and private sector.

His Excellency, the Italian Ambassador to Kenya, Dr. Di Leo attended the opening in his official capacity.

Other International Scientific Organizations that were represented were :

- URSI represented by Dr. J. Shapira (Israel)
- ICTP : Prof. G.O. Ajayi (Nigeria)
- ITU/BDT : Prof. R. Struzak (Switzerland)
- INTELSAT : Dr. F. Daniba (U.S.A)
- INMARSAT : Dr. T. Ogunderu (U.K)
- IARU (Region 1) : Mr. H. Wellens (Belgium)

Also present at the opening ceremony were the Managing Directors and Directors of various local and international organizations with business interests in Radio Communications Industry.

In his introductory speech during the opening ceremony, the Organizing Secretary of the Workshop, Dr. D.O. Oming'o gave a brief historical background of RadioAfrica workshop series and outlined the broad objectives of the RadioAfrica '97 workshop, namely:-

i. To highlight advances in Radio communication for the development of the Africa continent.
ii. To foster collaboration among African scientists working in the area of Radio communication
iii. To identify need and formulate regional joint research projects cutting across national boundaries for the solution of Radio comunication problems in Africa.
iv. To assess and build on the progress so far achieved since the 1995 RadioAfrica workshop held in Nigeria.

He concluded by thanking all the co-sponsors of the workshops, and the Kenya Government for accepting to host the activity and according safe passage to all the participants.

The occasion was also addressed by the Managing Director of Kenya Posts and Telecommunications Corporation, Mr. Jan Mutai. In his address, Mr. Mutai reiterated: " ..... this forum gives African and international researchers, engineers and technologists an opportunity to discuss the latest developments and research findings in Radio Science/technology with a view to identifying problem areas and finding solutions.

The key note address was given by the Minister for Transport and Communications (in Kenya). Hon. Wilson Ndolo Ayah. In his address, the Minister outlined the Kenya Government's policy on liberalization and privatization of the Telecommunications Industry. The policy document, he said, outlines reform measures to be undertaken in the Telecommunications sector in order to stimulate growth and development. He also emphasized the need for efficient frequency spectrum utilization and management, and challenged the workshop participants to explore ways and means of enhancing use o appropriate technology and cost effective Radio systems on the African continent.

During the workshop a total of 55 papers were presented (18 invited and 37 contributed). The technical presentations and discussions centred around the following broad areas:

i. Antennas and Propagation
ii. Satellite Communication
iii. Mobile/Cellular systems
iv. Frequency Management and utilization
v. Optical Fibre Communication: which, through not a radio-based system, is a rapidly developing new technology complementary to wide band digital radio communication systems.

Participants

The participants were drawn from Telecommunication Service providers (public and private), universities and Research institutions, Government Departments and Service consumers, mainly from within the African continent.

Invited speakers (papers) were drawn world-wide from a few identified researchers and specialists in their respective fields.

A total of 126 participants (including 14 invited speakers) attended the workshop, three (3) of whom were young scientists sponsored by the organizing committee namely:-

i. George Ishiekwene, Faculty of Science, University of Liberia, Liberia;
ii. Yinka Babalola, University of Science of Technology of Akure, P.O. Box 159, Ikere-Ekiti, Nigeria;
iii. S.O. Olieka, Department of Engineering, Kenya College of Communications Technology, Box 30305 Nairobi, Kenya.

Organisers

Members of the Local Organizing Committee comprised of representatives from various public (academic and research) institutions in Kenya.

The composition was as follows:-

1. Alfred V. Otieno (patron), University of Nairobi
2. F. Mwasi (Chairman), Directorate of Civil Aviation
3. D.O. Oming'o (Organizing Secretary), Kenya College of Communication Technology
4. J.K. Muli, Kenya College of Communication Technology
5. G.M. Kibiru, Meteorological Services Department
6. S. Wesechere, Directorate of Civil Aviation
7. G.S. Odhiambo, University of Nairobi
8. M. A. Okanya, Jomo Kenyatta University of Technology
9. J.T. Ituli, Ministry of Research
10. M.O. Okoth, Technical Training and Technology
11. A.C. Koech (Mrs), Kenya Posts and Telecommunications Corporation

Sponsors and co-Sponsors

The workshop was sponsored by a number of International and National Organizations:-

i The International Centre for Theoretical Physics (ICTP) - Trieste, Italy.
ii The International Union of Radio Science (URSI) - Gent, Belgium
iii The International Amateur Radio Union (Region 1)
iv The World Meteorological Organization
v The British Council (Nairobi, Kenya)
vi The Kenya Posts and Telecommunications Corporation
vii The Kenya College of Communications Technology
viii Kenya Airways
ix Air Gabon
x Kenya Meteorological Department
xi Kenya Directorate of Civil Aviation

Scientific visits and social activities

Scientific visits were arranged with the Departments of Electrical and Electronic Engineering of the University of Nairobi and the Kenya College of Communications Technology for guided tours within their departments.

Both TV and Radio interviews/recording on topical issues related to the Workshop theme (i.e Development of Radio Communication in Africa) were also arranged and conducted by the Kenya Broadcasting Corporation. A few workshop participants were nominated to participate in the two programmes

The social activities included:-

i) A guided group tour of the Nairobi National Park and Animal Orphanage.
ii) Cocktails through the courtesy of:-
   - The Local Organizing Committee on Monday 4th August '97
   - International Amateur Radio Union - Region 1 - on Wednesday 6th August '97
   - The Kenya College of Communications Technology on Friday 8th August '97

Invited speakers and titles of papers

1. Prof. Peter A. Bradley (Rutherford Appleton Laboratory, United Kingdom):
   i) A.M. Sound Broadcasting
   ii) H.F. Antennas and Raders
2. Prof. R. Struzak (TTU/BDT - Geneva, Switzerland):
   - Spectrum Management and utilization
3. Prof. Pierre Degauque (University of Science & Technology, Lille, France):
   - Electromagnetic compatibility
4. Prof. D.S. Dawound (University of Botswana, Gabarone, Botswana):
   - Mobile Communication
5. Prof. G.O. Ajayi (Obafemi Awolowo University, Ile-Ife, Nigeria):
   - Tropospheric Radiowave propagation
6. Prof. I.E. Owolabi (University of Ilorin, Ilorin, Nigeria)
   - Ionospheric Radiowave Propagation
7. Dr. Felix Daniba (INTELSAT, Washington, DC, USA):
   - Developments and Future Trends in Satellite Communication
8. Dr. T. Ogunderu (INMARSAT, United Kingdom):
   - Development and Future Trends in Maritime Communication
9. Dr. Joseph Shapira (Vice-President, URSI, Haifa, Israel):
   i) Personal Satellite Communication Systems
   ii) Cellular Communications and beyond
10. Prof. M.V. Pitke (Tata Institute of Fundamental/ Research, Bombay, India):
    - Development and Future Trends in wireless Communications
11. Prof. T. Raji (Akintola University of Science & Technology , Ogbomoso, Nigeria):
    - T.V and sound Broadcasting
12. Prof. R.J. Akello (University of Nairobi, Nairobi, Kenya):
    - Electromagnetic Radiation Effects on Human Beings and Environment
13. Prof. A.V. Otieno (University of Nairobi, Nairobi, Kenya):
    - Optical Fibre Communication
14. J.H.N. Van de Groenendaal (I.A.R.U, Region 1, South Africa) :
    - Amateur Radio in Research Development

Scientific Results/Resolutions

The workshop provided a healthy forum for discussions and interactions among scientists both from within the African continent and beyond.

During the workshop "COMMSPHERE - AFRICA" born and the nucleus for International committee on Commsphere - Africa was constituted comprising of representatives from each African country represented at the workshop. Broad objectives of Commsphere - Africa were formulated viz:

i. To eliminate barriers and foster co-operation between African Scientists and PTT Administrations in the broad areas of communications.
ii. To enhance interaction and eliminate the language barrier between Fracophone and Anglophone African countries in telecommunication collaboration.

Dakar, Senegal was proposed to be the host for Commsphere - Africa 1998 and that Dr. Gaston Zongo, the observatory Director, for development work on Telecommunications for all PTT administrations in Francophone Africa be contacted on the issue.

It was further proposed that Commsphere - Africa be held in the first half of 1998 and that Prof Gabriel Ajayi (Nigeria) will co-ordinate the activity in consultation with Dr. Joseph Shapira - Vice President of URSI (Israel)

At the end of the workshop a number of resolutions were passed, some of which were to be presented to various Government Administrations in Africa and International Scientific Organizations for consideration and action.

These resolutions were:-

1. That manpower training in the area of radio communications should be intensified in all African countries.
2. That a great deal of emphasis should be placed on determining the type of technologies suitable for rural access systems in Africa.
3. That great effort should be made to initiate design and development of small-scale and medium-scale communication industries in Africa.
4. That effort should be made towards the establishment of measurements, instrumentation and standards facilities on the continent.
5. That in view of the level of high technology imported for use in nationally sensitive areas, there is the need to pay attention to the security aspects.
6. That there is the need to take maximum advantage of Information Technology techniques, such as the E-Mail & Internet, in improving information dissemination among African scientist, schools and colleges and the populace in general.
7. That there is the need to establish a Radio Africa secretariat for proper coordination of activities and information dissemination e.g. through newsletters, bulletins and journals. The secretariat should preferably be rotational.
8. That a regional radio-communication centre for manpower training research and development be established in Africa, preferably in Nigeria, so that the African region could benefit from the reservoir of human and materials resources existing in radio communication in Nigeria. The centre should be supported strongly by the organisation of African Unity, ITU, ICTP and other international organisations. The ICTP is called upon to initiate the project.
9. That African countries must take effective participation in ITU activities particularly those pertaining to frequency and satellite-orbit management.
10. That the ICTP and other international organisations should strengthen the laser and fibre optics centres situated in Ghana and Sudan for manpower training in the African Region. These centres are very important because of the increasing role of laser and fibre optics in telecommunications and other areas of human endeavour.
11. That Radio Africa '99 regional workshop be held in Botswana. International support for the workshop will be most welcome.

NB: The book on proceedings may be obtained from the Organizing Secretary :

Dickson Ochola Oming'o
The Organising Secretary, RadioAfrica '97
P.O. Box 30305, NAIROBI, KENYA
Tel. 254 2 891201 ext. 2614, Fax 254 2 891949

SAR/MST8

Bangalore, India, 15-20 December 1997

The School on Atmospheric Radar in Tirupati, India (10-13 December 1997) and The Eighth International Workshop on Technical and Scientific Aspects of MST Radar in Bangalore, India (15-20 December 1997)

Since the beginning of the MST (mesosphere-stratosphere-troposphere) radar era in the middle 1970's several workshops have been held, and these have become standardized in the International Workshops on Technical and Scientific Aspects of MST Radar. After such workshops had been held in USA, Europe and the Far East, it was decided to hold the 8th workshop in India. This Eighth International Workshop on Technical and Scientific Aspects of MST Radar was preceded by the School on Atmospheric Radar, which was held in Tirupati at the Sri Venkateswara University (SVU) and the Indian National MST Radar Facility (NMRF) in Gadanki. The School on Atmospheric Radar (SAR) took place 10-13 December 1997, and the Eighth International Workshop on Technical and Scientific Aspects of MST Radar (mst8) took place on 15-20 December 1997 in the Hotel Ashok in Bangalore. Both activities were sponsored by SCOSTEP, URSI, the Department of Space (DOS) and the Department of Science and Technology (DST) of the Government of India, the Council of Scientific and Industrial Research (CSIR) of India, the Sri Venkatesvara University (SVU) in Tirupati, and the Indian Space Research Organization (ISRO).

The SAR was prepared by a steering committee, constituted by Dr. A.P. Mitra, Prof. P.B. Rao and Dr. J. R%ottger, with the latter as international coordinator. The local organization was under Prof. D.N. Rao and Dr. A.R. Jain. The international coordinator arranged the lecture contributions by experts from the international MST radar community. These lectures dealt with radar scattering from refractive index irregularities in a turbulent flow (lecturer: Dr. R. J. Doviak), radar scattering from meteors, hydrometeors, lightning and dusty/icy plasma (Dr. J.Y.N. Cho), principle radar system requirements and hardware (Dr. I. M. Reid), data analysis and validation (Dr. M. Yamamoto), MST radar interferometry (Dr. J. R%ottger), gravity waves and turbulence (Dr. W.K. Hocking), wind profiling and combination with other instruments, rockets and balloons (Dr. M. Petitdidier), and the operational use of atmospheric radars in tropical meteorology (Dr. M. Yamanaka). Further lectures were given by the NMRF and SVU staff on the science, operation and experiment performance at the NMRF. Intensive group discussions and hands-on training was performed after the lectures. Some 70 participants joint these lectures and training sessions, whereof 15 were from outside India. Each participant received a set of lecture notes, which had been compiled in two volumes. The SAR had been opened in a formal ceremony at the Sri Venkateswara University, where Prof. R.R. Daniel presented the inaugural address. A dinner was hosted by the NMRF and the school finished with a panel discussion with the lecturers, which was chaired by the international coordinator Dr. J. R%ottger. Generally, the scope and performance of the school was regarded very successful and it was considered that such schools should be repeated in future.

Following this school the lecturers and participants traveled to Bangalore to participate at the Eighth International Workshop on Technical and Scientific Aspects of MST Radar (mst8), where they were joint by workshop participants from all over the world. A total of 130 scientists and engineers took part in mst8, where 52 were from outside India, and from 17 countries. The program and organization of mst8 had been prepared by an international steering group consisting of Prof. S. Fukao, Prof. M.F. Larsen, Prof. C.H. Liu, Dr. A.P. Mitra and Dr. J. Röttger, with the latter as chairman. The local organization was under the direction of Prof. P.B. Rao of NMRF and Dr. S.C. Chakravarty and S. Chandrasekharan of ISRO. These were supported by a national organizing committee (chair Dr. A.P. Mitra), a local organizing committee (chair Prof. P.B. Rao) and technical, administrative and financial subcommittees. The mst8 was opened in a formal inauguration with speeches of Prof. P.B. Rao, Dr. J. R%ottger, Dr. A.P. Mitra and Prof. R. Narasimba of the National Institute of Advanced Studies in Bangalore, who gave the inaugural address. A message from the president of SCOSTEP, Prof. C.H. Liu, was read at the workshop inauguration.

The workshop contributions had been grouped into four main topics, which were overseen and prepared by main session organizers under the coordination of the chairman of the international steering group. These main sessions dealt with the topics: (1) Scattering processes (main session organizer: Dr. K.S. Gage), (2) Atmospheric dynamics (Dr. W.K. Hocking), (3) Meteorology (Dr. J. van Baelen, Dr. G. Nastrom) and (4) New developments and facilities (Prof. S. Fukao. Prof. S. Avery). These topics were subdivided into the sessions (1) MST scattering and reflection, ionospheric scattering and techniques for measuring scattering and reflection; (2) Lower atmospheric turbulence, lower atmospheric winds and waves, and mesosphere and lower thermosphere phenomena; (3) Meteorological applications with the Indian MST radar, operational use of wind profiler networks, diverse aspects of meteorological studies with ST radars, and middle atmosphere meteorology; (4) Highlights of coordinated observations, new technical developments, and new achievements at facilities and observations. A total of 162 papers were presented at the workshop, whereof 124 were given orally and 38 displayed as posters. Lively discussions highlighted the workshop presentations. Working group meetings took place in the evenings.

The chairman of ISRO, Dr. K. Kasturirangan, had invited the workshop participants for a pool-side dinner during which young representatives from each continent gave short speeches. Another evening was governed by an stirring cultural event at Rudhraksha Farm House in the rural outskirts of Bangalore, during which a variety of exquisite Indian dances, performed by professional actors, gave an outstanding impression to the participants.

A final plenary session, presided by the chairman of the international steering group of mst8, took place during which sessions were summarized, recommendations on scientific, operational and educational activities were adopted, the workshop format was discussed and activities between workshops considered. Five standing working groups were reconfirmed or created. These are: (1) System calibrations and definitions (chaired by: Dr. J. Röttger), (2) Analysis and data validation (Dr. M. Yamomoto and Dr. D. Holdsworth), (3) Accuracy and requirements for meteorological applications (Dr. G. Nastrom), (4) International collaborations (Prof. P.B. Rao), (5) Studies of transient phenomena such as meteors, lightning, etc. (Prof. B. Lokanadhan).

The plenum accepted an invitation by the French delegation to hold the next workshop mst9 in March 2000 in Toulouse. The workshop was closed by warm words of thanks by Dr. T. van Zandt, who expressed on behalf of the participants the deep appreciation to the local and international organizers for the excellent accomplishments and completion of the workshop.

Abstracts of the presented oral and poster papers were included in a book of abstracts published by the Indian Space Research Organization ISRO. The final publication of extended abstracts in the workshop proceedings will be in a Handbook for STEP, published by SCOSTEP.

The contributions to and the performance of this workshop mst8 as well as the school SAR proved again the profound development of the technical, scientific, operational and educational directions of the MST radar community.

The School on Atmospheric Radar and the 8th International Workshop on Technical and Scientific Aspects of MST Radar is a main activity of the URSI Joint Working Group GF.1 on the Middle Atmosphere.

Jürgen Röttger

CPEM'98

Washington, DC, U.S.A., 6 - 10 July 1998

The upcoming Conference on Precision Electromagnetic Measurements, CPEM98, will be hosted by the National Institute of Standards and Technology in Gaithersburg, Maryland, and will be held from Monday, July 6 through Friday, July 10, 1998 at the Renaissance Washington D.C. Hotel, 999 9th Street N.W., Washington DC 20001, U.S.A. Click here for a map to the conference.

This biennial conference has proven its outstanding reputation over more than three decades as an international forum for precision electromagnetic measurements. The objective of CPEM98 is to exchange information on topics such as:

Topics

Antennas & dielectrics
Automated measurement systems
DC/LF measurements & standards
Fundamental constants
International compatibility of measurements
Microwave/mmwave measurements (RF and EMC)
Nanotechnology (Cyroelectronics)
Optical wavelength metrology
Power & energy
Quantum standards
Realizations of units
Time & frequency

Participants are encouraged to stay at the conference hotel which is conveniently located near the Smithsonian Museums and gardens on the Mall, the U.S. Capitol, National Monuments, and Chinatown.

The 4th of July celebration of Independence Day falls on the Saturday preceding the conference, and a fabulous fireworks display and concert will take place on the Mall. The hotel is extending the conference rates to cover that weekend (July 3-5, 1998). An opening reception for the conference will be held Sunday evening, July 5, and another reception will be held in the exhibitors area on Monday evening, July 6. The conference banquet will be on Wednesday evening, July 8.

Tours of the NIST laboratories in Gaithersburg, MD will be available on Friday, July 10, 1998, following the final session of the conference. An extensive Companion Program will be available for accompanying persons, including trips to many tourist attractions around the Washington, D.C. area.

Contact

Katherine H. Magruder
Conference Secretary
NIST, Bldg. 220, Room B162
Gaithersburg, MD 20899, U.S.A.
Tel: (+1 301) 975-2402, Fax: (+1 301) 926-3972
email: katherine.magruder@nist.gov

1998 Asia-Pacific Microwave Conference

- Beyond Wireless Multimedia Society -
Yokohama, Japan, 8-11 December 1998

The 1998 Asia-Pacific Microwave Conference (APMC'98) will be held at the Convention Center in Pacifico Yokohama, Yokohama, Japan, on December 8-11, 1998. This conference is organized and sponsored by the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan, and is cooperatively sponsored by IEEE MTT-S, URSI and IEEE MTT-S Tokyo Chapter.

Topics

1. Solid State Devices and Circuits
2. FET, HEMT, HBT and Other Devices
3. Low-Noise Devices and Techniques
4. High-Power Devices and Techniques
5. Signal Generation, Frequency Conversion and Control Circuits
6. Monolithic Integrated Circuits
7. Passive Devices and Circuits
8. Packaging Techniques
9. Guided Waves
10. Filters and Resonators
11. Ferrite and Surface Wave Components
12. Microwave and Millimeter Wave Systems
13. Communication Systems (Satellite, Mobile/Personal and Terrestrial)
14. Remote Sensing
15. Microwave Medical/Biological Applications

16. EMC/EMI
17. Active Phased Array Antenna Systems
18. Scattering and Propagation
19. Electromagnetic Field Theory
20. Computer Aided Design
21. Microwave Antennas
22. Microwave Photonics
23. Microwave Superconductivity
24. Submillimeter Wave Techniques
25. Measurement Techniques
26. Others

Deadlines

Paper Submission Deadline: June 1, 1998
Notification of Acceptance: August 1, 1998
Camera-Ready Manuscript Deadline: October 1, 1998

Workshops and short courses

The workshops and the short courses will be held on December 11, 1998. The topics and the lecturers are listed below.

Workshops

1. Microwave/Millimeter Wave Short-Range Communication Systems Technology
2. Wireless Handy Terminals: How Small Can They Be?
3. Superconducting Microwave Applications to Mobile Communications
4. New Technologies for Exploiting the Spectrum beyond the Millimeter Wave Region
5. Medical and Biological Applications of Microwaves
6. Advanced Design of Microwave/Millimeter Wave MMICs
7. HBT Technology for Next Generation Wireless and Fiber Optic Systems
8. Leading-Edge Silicon Devices and Their Applications to Microwave/Millimeter Wave Circuits
9. New Propagation Phenomena in Millimeter Wave Planar Circuits/Lines and Their Applications
10. Recent Progress in EM Analysis Software

Short courses

1. Prof. Tatsuo Itoh, UCLA, "Active Antennas - Integration of Microwave Circuits with Antennas -"
2. Prof. Dieter Jaeger, Gerhard-Mercator-University, "Microwave Photonics"

The details of each workshop and short course will be announced in the Advance Program.

Japan Microwave Prize

During the APMC'98, the Japan Microwave Prize will be awarded to the authors of the papers selected from those accepted for presentation at the APMC'98 by the Japan Microwave Prize Committee, as outstanding contributions to the microwave field.

Contact

Prof. Yoshio Kobayashi
Chairperson, Steering Committee
c/o REALIZE INC.
4-1-4 Hongo, Bunkyo-ku
Tokyo 113-0033, Japan
Phone: +81-3-3815-8590
Fax: +81-3-3815-8529
E-mail: rlz@ppp.bekkoame.or.jp

WWW

http://www.ieice.or.jp/iinkai/apmc/index.html

COMMSPHERE '99

Toulouse, France, 25-28 January 1999

In the March issue of the Radio Science Bulletin *we published the announcement for Commsphere'99 in the two official languages of our Union.*

Commsphere is an International Symposium on the Future of the Telecommunications and the Electromagnetic Environment.

The following WEB site :

http://www.cnes.fr/actualites/commsphere

provides updated information on the Conference collects intended participations and requests for the second announcement (preliminary programme, registration form...) to be circulated by October 9, 1998.

June 1998

Day on Diffraction '98
St. Petersburg, Russia, 2-4 June 1998
Contact : Dr. Valery E. Grikurov, Dept. Math. & Comp. Phys., Inst. on Physics, St.Petersburg University, Uljanovskaia 1, Petrodvoretz, Russia, Fax : +7 812-428 7240 and +7 812-298 4436, E-mail: grikurov@mph.niif.spb.su, http://snoopy.phys.spbu.ru/~grikurov/dd98/dd98.html

MMET'98 - International Conference on Mathematical Methods in Electromagnetic Theory
Kharkov, Ukraine, 2-5 June 1998
Contact : MMET'98, c/o Dept. Computational Electromagnetics, IRE NAS, Ulitsa Proskury 12, Kharkov 310085, Ukraine, Tel: +380 572-448595, -377380, Fax: +380 572-441105, -377380, -365968, E-mail: veliev@dut.kharkov.ua or alex@emt.kharkov.ua, http://www.intec.rug.ac.be/ursi/mmet98.html

Bianisotropics'98
Braunschweig, Germany, 3-6 June 1998
Contact : Prof. Dr.-Ing. A.F. Jacob (Organizer), Institut für Hochfrequenztechnik, Technische Universität Braunschweig, D-38092 Braunschweig, Germany, Tel: +49 531-391 2469 , Fax: +49 531-391 5841 , E-mail: chiral98@tu-bs.de, http://www.tu-bs.de/bian98/

International Conference on Telecommunications
Chalkidiki, Greece, 22-25 June 1998
Contact : Dr. I. Gragopoulos, Aristotle University of Thessaloniki, Greece, E-mail : itse@egnatia.ee.auth.gr, http://www.athena.auth.gr/ICT98.html

EMC Wroclaw'98 - 14th International Wroclaw Symposium on Electromagnetic Compatibility
Wroclaw, Poland, 23 - 26 June 1998
URSI Working Group E1 will organise a Workshop on "Mathematical Methods in Frequency Planning" during this conference.
Contact : EMC Symposium, Box 2141, 51-645 Wroclaw 12, Poland, Fax : +48 71-728878, e-mail: emc@il.wroc.pl, http://www.emc98.wroc.pl/

July 1998

CPEM98 - Conferences on Precision Electromagnetic Measurements
Washington, DC, U.S.A., 6-10 July 1998
Contact : Katherine H. Magruder, Conference Secretary, NIST, Bldg. 220, Room B162, Gaithersburg, MD 20899-0001, USA, Tel. : +1 301-975 4223; Fax : +1 301-926 3972; e-mail : katherine.magruder@nist.gov, http://www.eeel.nist.gov/cpem98/

IGARSS'98 - 1998 IEEE International Geoscience and Remote Sensing Symposium
Seattle, Washington, U.S.A., 6-10 July 1998
Contact : Tammy I. Stein, IEEE Geoscience and Remote Sensing Society, 2610 Lakeway Drive, Seabrook TX 77586, U.S.A., Fax +1 281-291 9224, Email tstein@phoenix.net, http://engine.ieee.org/society/grs/igarss.html

32nd COSPAR Scientific Assembly
Nagoya, Japan, 12-19 July 1998
Contact : COSPAR Secretariat, 51, Bd de Montmorency, F-75016 Paris, France, Tel. +33 1-4525 0679, Fax +33 1-4050 9827, E-mail : COSPAR@paris7.jussieu.fr, http://www.mpae.gwdg.de/COSPAR/COSPAR.html

PIERS'98
Nantes, France, 13-17 July 1998
Contact : PIERS 1998, 5, rue de Valmy, F-44041 Nantes Cedex 01, France, Fax : +33 2-51-88-20-20

August 1998

Vth International Suzdal Symposium on Modification of the Ionosphere by Powerful Radio Waves
Moscow, Russia, 26-29 August 1998
Contact : Prof. V.V. Migulin, Vth International Suzdal Symposium, Russian URSI Committee, Russian Academy of Sciences, Mokhovaja St. 11, 103907 Moscow, Russia, Fax +7-095 334-0124

September 1998

EMC Roma'98
Rome, Italy, 14-18 September 1998
Contact : Symposium Secretariat EMC'98 Roma, AEI-Ufficio Centrale, Attn. Daniela Fioramonti, Piazzale R. Morandi 2, I-20121 Milano, Italy, Tel. : +39 2-77790205/218, Fax : +39 2-798817, E-mail: conferencesaei@aei.it, http://www.aei.it/emc98roma.html

Physics and Engineering of Millimeter and Submillimeter Waves
Kharkov, Ukraine, 15-17 September 1998
Contact : Dr. A.A. Kostenko, Institute of Radiophysics and Electronics, National Academy of Science of Ukraine, 12 Acad. Proskura St., Kharkov 310085, Ukraine, Tel. & Fax +380 572-44 1105, E-mail : symposium@ire.kharkov.ua, http://www.intec.rug.ac.be/ursi/SMW98.html

Spanish National Symposium URSI'98
Pamplona, Spain, 16-18 September 1998
Contact : Secretaría del Symposium URSI'98, UPNA, Dpto de Ing. Eléctrica y Electrónica, Campus de Arrosadía, s/n, 31006 Pamplona,Spain, E-mail: congreso.ursi@upna.es

URSI Commission F Triennial Open Symposium Wave Propagation and Remote Sensing
Aveiro, Portugal, 22-25 September 1998
Contact : Dr. Armando C.D. Rocha, Instituto de Telecunicaçoes, Universidade de Aveiro, 3810 Aveiro, Portugal, Tel. +351 34-370324, Fax +351 34-381128, E-mail : arocha@av.it.pt, http://www.av.it.pt/ursi/

ISSSE'98 - 1998 International Symposium on Signals, Systems and Electronics
Pisa, Italy, 29 September - 2 October 1998
Contact : Organizing Secretariat, ISSSE'98, University of Pisa, Dept. Information Engineering, Via Diotisalvi 2, I-56126 PISA, Italy, Tel. : +39 50-879740/879768, Fax : +39 50-879812, e-mail: incor@sirius.pisa.it, http://www.iet.unipi.it/ISSSE98

November 1998

IEEE-APS conference on Antennas and Propagation for Wireless Communications
Waltham, MA, USA, 2-4 November 1998
Contact : Prof. Tuli Herscovici, APWC98, 52 Agnes Drive, Framingham, MA 01701, USA, Tel. : +1 508-788 5152 , Fax : +1 508-788 6226, E-mail : tuli@tiac.com, http://www.tiac.net/users/tuli/apwc98/welcome.html

JINA 98 - Tenth International Symposium on Antennas
Nice, France, 17-19 November 1998
Contact : Secretariat JINA 98, France Telecom/CNET, Fort de la Tête de Chien, F-06320 La Turbie, France, Fax: +33 4-9210 6519, E-mail: jina.cnet@wanadoo.fr, http://wwwelec.unice.fr/JINA-98/

December 1998

Asia-Pacific Microwave Conference
Yokohama, Japan, 8-11 December 1998
Contact : Prof. Yoshio Kobayashi, Faculty of Engineering, Saitama University, Urawa, Saitama 338, Japan, Fax +81 48-857 2529, E-mail : yoshio@reso.ees.saitama-u.ac.jp

1999

January 1999

Commsphere'99
Toulouse, France, 25-28 January 1999
Contact : Dr. Pierre Baüer, CESBIO, 18, avenue Edouard Belin, F-31401 Toulouse Cédex 4, France, Tel : +33 5-6155 8525, Fax : +33 5-6155 8500, e-mail : pierre.bauer@cesbio.cnes.fr, http://www.cnes.fr/actualites/commsphere

February 1999

EMC Zurich '99 - 13th International Zurich Symposium and Technical Exhibition on Electromagnetic Compatibility
Zurich, Switzerland, 16-18 February 1999
Contact : Dr. Gabriël Meyer, Communication Technology Laboratory, Sternwartstraße 7, CH-8092 Zurich, Switzerland, Tel. +41 1-632 2790, Fax +41 1-632 1209, E-mail : gmeyer@nari.ee.ethz.ch, http://www.nari.ee.ethz.ch/emc/emc.html

August 1999

XXVIth URSI General Assembly
Toronto, Canada, 13-21 August 1999
Contact : URSI GA '99 Secretariat, National Research Council Canada, Ottawa, Ontario K1A 0R6, Canada, Tel. +1 613-993 7271, Fax +1 613-993 7250, E-mail : ursi99@nrc.ca, http://www.nrc.ca/confserv/ursi99/welcome.html

URSI cannot be held responsible for any errors contained in this list of meetings.

The Guidelines and Rules for URSI Sponsorship of Meetings can be found on the URSI Homepage at its new location :
http://www.intec.rug.ac.be/ursi/Rules.html
or obtained from the URSI Secretariat (for coordinates, please see the inside of the front cover).

News from the URSI Community

NEWS FROM URSI MEMBER COMMITTEES

EGYPT

The Sixteenth National Radio Science Conference (NRSC'99) will be held at the Ain Shams University in Cairo, Egypt from February 23 to February 25, 1999.

The Egyptian Member Committee holds a National Radio Science Conference yearly, covering the ten URSI commissions.

The conference is cosponsored by : the Academy of Scientific Research and Technology (ASRT), b-TtMinistry of International Cooperation (MIC), cte IEEE Egyptian section,and the IEEE-EDS society. The financial support is from both the ASRT and MIC. The conference has a special poster session for students and young scientists.Also the conference grants 10 free student memberships to the IEEE and EDS society for students with accepted papers. Although the conference is national , papers from abroad are accepted.

Topics of interest

The technical programme will consist of invited and submitted papers covered by the URSI Commissions A to K. Abstracts should be sent to Prof. Ibrahim A. Salem.

Deadline

Deadline for submission of manuscript : Oct.10, 1998
Notification of acceptance and author kits : Nov. 14, 1998

Contact

Prof.Ibrahim A. Salem
Academy of Scientific Research and Technology
Department of Scientific & International Unions
101 Kasr El-Eini St, Cairo, Egypt
Fax : (202)-594-1270
E-mail: isalem@brainy1.ie-eg.com

GERMANY

The German Member Committee will organise its annual "Kleinheubacher Tagung" from 28th September to 2nd October 1998 in Schloß Kleinheubach. Main).
The topics cover the ten URSI commissions

Contact

PD Dr.-Ing. L. Klinkenbusch
Lehrstuhl für Theoretische Elektrotechnik
Ruhr-Universität Bochum
Gebäude IC-FO 05/562
Universitätsstr. 150
44801 Bochum
Tel: 0234-700-6338
Fax: 0234-7094-479
E-mail: klinke@theoret.ruhr-uni-bochum.de

Deadline

Deadline for abstracts : 15th May 1998
Notification of acceptance : end of June 1998

Language

The official language will be German.

Schwerpunktthemen :

ST1 Numerische Feldberechnung - Verfahren, Anwendungen, Validierung
ST2 Digitale Fernsehübertragung -Kabel, Satellit, Terrestrisch
ST3 Space Weather

Abstracts

Unlike recent years, the abstracts need to be sent to :
Copernicus Gesellschaft e.V.
Max-Planck-Str. 13
37191 Katlenburg-Lindau
Germany
Tel: +49-5556-91099
Fax: +49-5556-4709
E-mail: URSI@COPERNICUS.ORG

Dr. V.U. Reddy, President of the Member Committee in India, asked us to publish the following information.

I) National Conference on Communications'98

The National Conference on Communications (NCC'98), the fourth in the series organized by the Joint Telematics Group of the Indian Institute of Science, Bangalore, and the Indian Institutes of Technology at Chennai, Delhi, Kanpur, Kharagpur and Mumbai, was held during 29-31 Jan 1998 at the Indian Institute of Science, Bangalore, India. The conference focussed on the recent research and development activities of scientists in the Indian academic institutions and industry in the broad area of communications.

The conference began with four half-day tutorials on Multicarrier Modulation for High-speed Communication, Advances in LAN switching, Network Management and Fiber in the access loop: Approaches and Options. The tutorials were followed by the technical sessions which comprised of plenary lectures, presentations of contributory research articles and papers on development of products, in the areas of modulation theory, coding, networking, signal and data compression, and signal and image processing.

There were two special invited lectures, one by Prof. Govind Swarup, FRS, Emeritus Professor, National Centre for Radio Astrophysics, Pune, and another by Prof. P.V. Indiresan, President, Indian National Academy of Engineering. The title of Prof. Swarup's lecture was Can India become a world power through tele-networking and extensive software export—a challenge to educational institutes and industry and that of Prof. Indiresan was How can India become technologically competitive? There was a panel discussion on Public data networks— directions and scope.

II) ATM-Workshop'98

A 2-day workshop on "Selected Topics in ATM Networking" was held on February 13 and 14, 1998, at the Indian Institute of Science, Bangalore, India. The program consisted of the following six tutorials.

Overview of ATM

Evolution of networks towards ATM, ATM networking concepts, ATM standards overview, ATM internetworking ATM based QoS support to IP networks

ATM Switching

Cell switching technologies, tradeoffs between buffering strategies, comparison of architectures

Connection Admission Control

Source traffic parameters, shaping and policing, quality of service constraints, equivalent bandwidth of a source

The ATM Private Network—Network Interface (PNNI)

Routing in ATM PNNI, topology and metric aggregation, addressing

The Available Bit Rate (ABR) Service

The ABR service concept, RM cells and source behaviour, switch algorithms, max-min fair bandwidth sharing, distributed and adaptive algorithms, TCP over ABR

Integration of ATM into the IP World

Issues in handling datagrams in a connection-oriented environment, holding time policies, routing, addressing, QoS for connections, NHRP and MARS, issues in RSVP over ATM

Prof. Kumar N. Sivarajan, Electrical Communication Engineering, Indian Institute of Science, India, was the Coordinator.

III) National Conference on Communications'99

The National Conference on Communications (NCC'99), the fifth in the series, organized annually by the Joint Telematics Group of the Indian Institute of Science, Bangalore, and the Indian Institutes of Technology at Chennai, Delhi, Kanpur, Kharagpur and Mumbai, is scheduled for 30—31 January 1999. The NCC'99 is being organized by the Indian Institute of Technology, Kharagpur. The conference will comprise of pre-conference tutorials, technical sessions and presentations of the state of the art products in the broad area of communications.

Topics

Baseband and RF communication Source, channel and cipher coding Signal/Image processing and optical signal processing Mobile/Wireless/Cellular communication, local loops Satellite/Optical/Multimedia/ATM broadband networks Emerging telecommunication technologies

Contact

Prof. S.L. Maskara
Electronics & Electrical Communication Engineering
Department, IIT
Kharagpur-721302, India
E-mail : NCC99@hijli.iitkgp.ernet.in

IRELAND / UNITED KINGDOM

A joint two-day symposium involving the Ireland and UK Radio Science Committees is scheduled to take place in Dublin on 3-4 December 1998.

It is envisaged that the presentations at the symposium will include topics from the Commissions in which both countries have a significant interest.

Contact

Professor M.C. Sexton, MRIA
Conference Director
Royal Irish Academy
19 Dawson Street, Dublin 2, Ireland
Tel. +353 1-676 2570, Fax +353 1-676 2346

SPAIN

The XIII Spanish National Symposium URSI'98 will be held in Pamplona at the Universidad Publica de Navarra during the days 16-18 of September.

The URSI Commissions B, C, D and K are involved.

Topics

EM Electromagnetism CM Components and Microwaves Circuits RP Radiation and Propagation RA Radar MS Mobil and Satellite Communications DF Photonic Components and Devices ST Telecommunication Systems VI Speech and Image Processing PS Signal Processing NS New Telecommunication Services TE Telematics ED Education EA Ambiental Effects AB Biomedical Applications

Contact

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31006 Pamplona, (SPAIN)
e-mail: congreso.ursi@upna.es

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http://www.iee.upna.es/congresos/ursi.htm

Deadlines

Reception of the documents: 30 April 1998
Communication of acceptation: 31 May 1998

BOOKS FROM URSI CORRESPONDENTS

Electromagnetics Waves

by Carlo G. Someda
University of Padua, Italy

published by Chapman and Hall 1998
Paperback, 614 pp., 234 x 156 mm, UKP 37.50
ISBN 0.412.57870.0

This book provides a comprehensive and modern treatment of electromagnetic waves. The extensive coverage begins with Maxwell's equations and ranges to current applications including communications, radar and photonics. The book takes a modern approach and, unlike many texts, gives a unified view of electromagnetic waves and their applications in the telecommunications industry.

Electromagnetic Waves is an updated and enriched version of an already highly successful text that the author has published in Italian. Professor Michael C. Sexton (URSI Correspondent, Royal Irish Academy Council) and Dr. Richard J. Black (Associate, Stanford University) co-operated with him in the preparation of this English version. It includes numerous examples and problems which will aid the reader in his or her understanding.

Serving the needs of both advanced students of physics and telecommunications engineering, *Electromagnetic* Waves is also the essential comprehensive textbook for people interested in any level of the field. Furthermore, it relates theory to practical application and shows the relevance of the material using contemporary examples of engineering practice, concentrating on principles rather than extensive mathematical proofs.

For further information, please contact: Mr. David Ross, Commissioning Editor (Electronic and Electrical Engineering), Chapman and Hall, 2-6 Boundary Row, London SE1 8HN, United Kingdom, Tel: +44 171 410 6934, Fax: +44 1 71 865 0014, E-mail: david.ross@ chall.co.uk.

Les fondements de la mesure du temps

Comment les fréquences atomiques règlent le monde
de Claude AUDOIN et Bernard GUINOT

Culture scientifique 1997, 320 pages
245 F (prix public TTC au 1 décembre 1997)
Masson Editeur
ISBN 2 225 83236 6

La mesure du temps fondée sur des propriétés atomiques est née en 1955, avec le premier étalon de fréquence à jet de césium. Depuis, les horloges atomiques ne cessent de progresser et sont au cœur de nombreuses activités, telles que les comparaisons de temps, l'unification mondiale de l'heure ou la recherche en astronomie, géodésie, géophysique, télécommunications, etc.

Cet ouvrage fournira des réponses détaillées au lecteur intéressé par la mesure du temps appliquée aux divers domaines cités.

Les auteurs

Claude Audoin est directeur de recherche au CNRS, laboratoire de l'horloge atomique à Orsay.
Bernard Guinot est astronome à l'Observatoire de Paris, ancien directeur du Bureau international de l'heure.
Une des originalités de cet ouvrage tient à l'association de ses auteurs, un physicien et un astronome, donnant une vision complète du thème traité.

Contenu

Présentation de l'ouvrage
Les principes de la mesure du temps
Mesure du temps et modèles théoriques
L'evolution de la mesure du temps
Le temps des horloges
Les étalons atomiques de fréquence
La mesure atomique du temps
Temps astronomiques
Quelques applications de la mesure ultra-précise de la fréquence du temps

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Book Review

Advances in Complex Electromagnetic Materials

by A. Priou, A. Sihvola, S. Tretyakov and A. Vinogradov
published by Kluwer Academic Publishers, Dordrecht, 1997
ISBN 0—7923—4503—7
Hardcover, 396 pages, USD 199

Proceedings of the NATO Advanced Workshop on Electromagnetics of Chiral, Bi—isotropic, and Bi—anisotropic Media (Chiral'96).

Contents : Introduction. General. Fundamental issues of bi—anisotropic electromagnetics. Continuum modelling of complex media. Scattering and diffraction from bi—anisotropic structures. Electromagnetic modelling of complex particles. Experiments, measurements, applications.

Workshops and conferences specifically concerned with the electromagnetics of chiral, bi—isotropic and bianisotropic media were initiated in 1993. Since their inception they have become a fixture on the list of annual meetings for researchers actively interested in the electromagnetics of complex media. These meetings have provided a stimulating setting for the exchange of research results, the development of new directions of theoretical and experimental research and the fostering of new research collaborations. Equally importantly, they have provided a platform for vital mutual interaction between scientists from the so—called West and those from the Former Soviet Union countries. Chiral'96 (which has meanwhile been succeeded by Bianisotropics'97 and '98) was held aboard a river boat travelling from St.~Petersburg to Moscow. Its collected proceedings have now been published in the NATO Advanced Science Institutes Series.

Advances in Complex Electromagnetic Materials contains a total of 31 papers grouped into 6 subject areas with a quite extensive coverage of topics. The one omission is perhaps a lack of reports of nonlinear research — the topic of just one paper (on weakly nonlinear composites) and briefly being touched upon here and there. But then, conference proceedings can only provide what has actually been presented at the conference, which leaves the editors little choice in the matter.

Not surprisingly (when considering the conference venue), the book is dominated by papers authored and coauthored by researchers from the FSU countries; about 2/3s of all manuscripts originate there. In that sense the volume gives access to research by many individuals which was perhaps until now unavailable to non—FSU scientists.

The section General sets off the book with two very interesting papers — one dealing with historical, the other with more scientific issues — outlining Fedorov's covariant methods; techniques that had a vast impact on complex media research in the Soviet Union. The literature review closing this section is of little value, however. The choice of unrefereed one—page conference abstracts or summaries for half of the references collected is most peculiar in the opinion of this reviewer; especially, when (due to the efforts of Udo Unrau and colleagues) a vast collection of more than 1600 references about complex media electromagnetics research has been available via an electronic database since 1994 with regular updates of all archival literature.

The section on Fundamental issues of bi—anisotropic electromagnetics provides papers dealing with reflection and transmission problems for various types of bianisotropic media such as magnetic anisotropic chiral media, gyrotropic crystals and Omega structures plus a manuscript on pulse distortion in a chiral medium, the latter being the only contribution in the book dealing with time—domain electromagnetics (as opposed to the frequency—domain).

Continuum modelling of complex media presents papers on non—local response of composites; certain effective medium theories for bi—isotropic mixtures, as well as bianisotropic superlattices; weakly nonlinear chiral composites; optically induced rotation in chiral media and the Faraday effect and magnetogyration in superlattices.

With a total of 8 contributions, Scattering and diffraction from bi—anisotropic structures is the largest section. Topics which are investigated deal with 3—D chiral objects; frequency selective surfaces; wedge coated with bi—isotropic layer; the relation of chiral properties to acoustic wave polarization in semiconductors; chirowaveguides; surfaces waves in Faraday chiral media; and chiroplasmas.

Electromagnetic modelling of complex particles continues the theme of composites by providing a review of chiral media research with resonant particles and further papers on polarizabilities of conductive bianisotropic particles, composites of chiral scatterers and planar chiral structures.

The final section on Experiments, measurements, applications contains contributions about measurements on chiral liquid crystals; chiral waveguide measurements, and manufacture of microwave chiral materials. Furthermore, the response of chiral and chiral—ferrite media is studied experimentally and the concept of magnetostatically controlled bianisotropic media is investigated.

The book has been produced in an attractive layout with formats reasonably uniform throughout the contributions. An avoidable omission concerns the lack of abstracts in a fair number of papers, however. The problem of different notational conventions — always difficult to coordinate in a collection of manuscripts from various sources — has been overcome very satisfactorily through a detailed note in the Introduction as well as through the insertion of explanations into the manuscripts where necessary.

Advances in Complex Electromagnetic Materials is a useful book for the active researcher in complex media electromagnetics. Most importantly, it provides an in—depth look at past and present research in this field in the FSU countries and it is predominantly that aspect which makes this collection of papers from Chiral'96 valuable. Unfortunately one needs to fear that the expensive price of USD 199 will be detrimental to a wide—spread availability of this volume.

W.S. Weiglhofer
University of Glasgow

SPECIAL OFFER TO URSI CORRESPONDENTS

AIMS AND SCOPE

The Journal of Atmospheric and Solar-Terrestrial Physics is an international journal concerned with the interdisciplinary science of the Earth's atmospheric and space environment. Papers are published on the results of experiments and their interpretations, and on theoretical or modelling studies. Papers dealing with remote sensing carried out from the ground or with *in situ* studies made from rockets or from satellites orbiting the Earth are particularly suitable. Plans for future research, often carried out as an international programme, are also discussed. Besides original research papers, discussion papers and short reports, the journal includes commissioned review papers on topical subjects and special issues arising from chosen scientific symposia or workshops. The journal covers the physical processes operating in the troposphere, stratosphere, mesosphere, thermosphere, ionosphere, magneto-sphere and heliosphere. Phenomena occurring in other "spheres" and supporting laboratory measurements are also considered. The journal deals especially with the coupling between the different regions. Regarding the upper atmosphere, the subjects of aeronomy, geomagnetism, auroral phenomena, radio wave propagation and plasma instabilities are examples within the broad field of solar-terrestrial physics which emphasise the energy exchange between the solar wind, the magnetospheric and ionospheric plasmas, and the neutral gas. In the middle and lower atmosphere, the topics covered include dynamics, radiation and chemistry, atmospheric electricity and electrodynamic effects, including lightning and its effects, and anthropogenic changes. Helpful, novel schematic diagrams are encouraged as is the use of colour.

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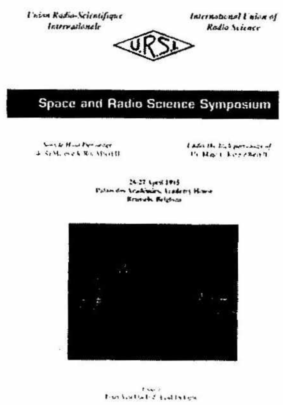
URSI Publications

Proceedings of the "Space and Radio Science Symposium"

Editors: Peter Van Daele and Paul Delogne

ISBN 90-9008628-5



This "Space and Radio Science Symposium" was held on 26-27 April 1995, at the occasion of the 75th Anniversary of our Union.

Copies of these Proceedings are available at the URSI Secretariat for 500 Belgian francs per copy (for countries outside Europe we charge an extra 140 Belgian francs per copy for mailing costs).

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Modern Radio Science 1996

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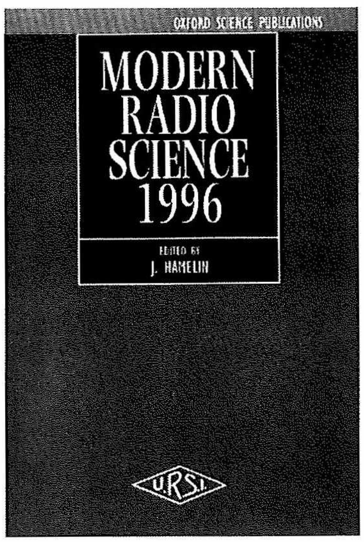

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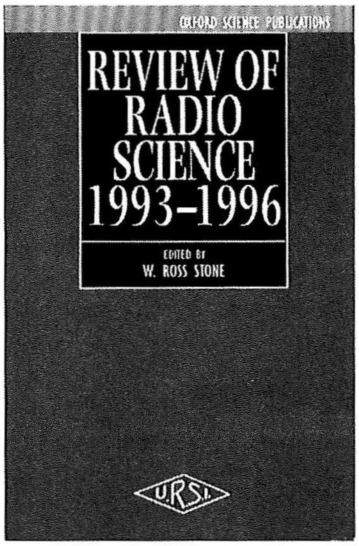

Handbook on Radiopropagation Related to Satellite Communications in Tropical and Subtropical Countries

Editor: G.O. Ajayi
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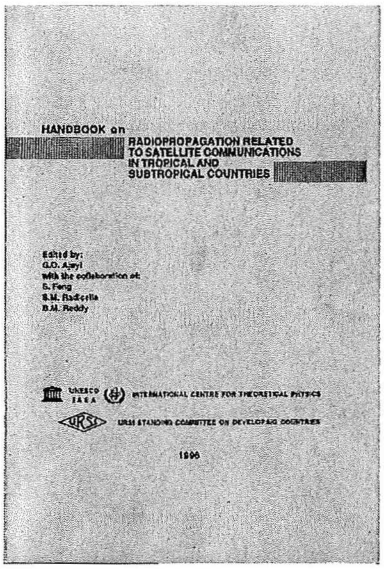

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