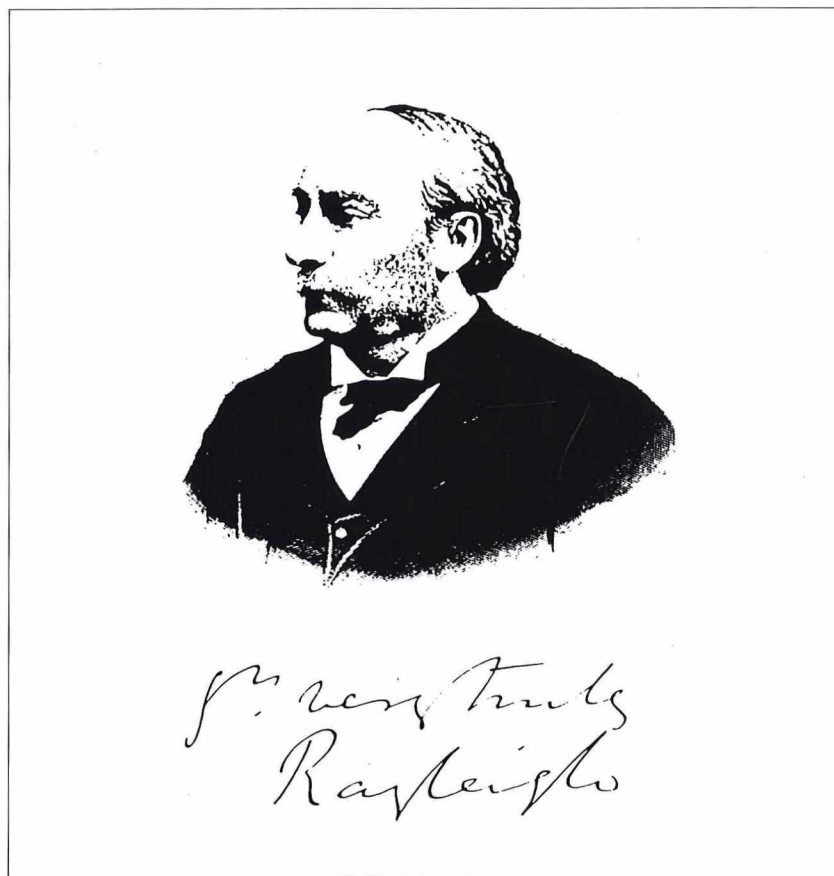


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Front Cover : Lord Rayleigh (John William Strutt) was the second (after Maxwell) Cavendish Professor of Physics at Cambridge University until his resignation in 1884. A list of his papers is reprinted in this issue, on pp. 14 - 15.

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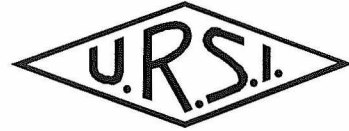
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Editorial



Dear URSI Correspondent,

It is hard to imagine how insipid life would be in the absence of rhythms. Winter darkness is just a pause, some eagerness period aimed at creating an absolute need for soft greens to replace sumptuous autumn colours. Nights are highly needed peaceful transitions toward new enthusiasms. Musical rhythms are a sustained invitation to the next dancing step.

The URSI rhythms are triennial, with General Assemblies as transitions from fruitful periods to renewed ambitions. The General Assembly in Lille was quite successful, with more than 1,200 participants. Thanks to those, Pierre Degauque and his team, who undertook the huge task of organising this essential transition period in the life of our Union.



Our Bulletin lives according to this rhythm. The present issue is relatively meagre, as it marks a transition period similar to winter and night. Besides two items which maintain and strengthen our background substrate with historical notes on G.F. FitzGerald and a reminder of scientific papers by Lord Rayleigh, it is budding with the list of those scientists who were elected to guide our Union during the next triennium.

The General Assembly offered an opportunity for improving the Bulletin as a very basic link between all URSI scientists. Many steps were defined toward this objective. More on this in the next issue.

Paul Delogne
Editor

URSI Officers 1996-1999



Following the elections at the XXVth General Assembly in Lille, France, the Officers of the Board and the Scientific Commissions for the 1996-1999 triennium are as given below.

The URSI Board of Officers :

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UTC Time Step



On n'introduira pas de seconde intercalaire à la fin de décembre 1996.

La différence entre UTC et le Temps Atomique International TAI est : de 1996 juillet 1, 0h UTC, jusqu'à nouvel avis : UTC-TAI = -30 s

Des secondes intercalaires peuvent être introduites à la fin des mois de décembre ou de juin, selon l'évolution de UT1-TAI. Le Bulletin C est diffusé deux fois par an, soit pour annoncer un saut de seconde, soit pour confirmer qu'il n'y aura pas de saut de seconde à la prochaine date possible.

No positive leap second will be introduced at the end of December 1996.

The difference between UTC and the International Atomic Time TAI is : from 1996 July 1, 0h UTC, until further notice: UTC-TAI = -30 s

Leap seconds can be introduced in UTC at the end of the months of December or June, depending on the evolution of UT1-TAI. Bulletin C is mailed every six months, either to announce a time step in UTC or to confirm that there will be no time step at the next possible date.

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Erratum



In the June issue of the Radio Science Bulletin, a book of Professor V.A. Borovikov has been reviewed. We were informed of a misprint in the title of the book. The correct

and complete title is : Uniform Stationary Phase Method. Also the word Piercy in 'Piercy integral' is incorrectly spelled. The correct spelling is Pearcey.

In Memoriam



ADAM K. SMOLINSKI

1914-1996

On February 29, 1996 passed away at the age of 85 a distinguished Polish scientist and academic teacher Professor Dr. Adam Smolinski. His activity has been connected with the Electronics Department of the Warsaw University of Technology (Politechnika Warszawska). He was the teacher and tutor of many hundreds of students and doctorands. His scientific activity can be divided in four parts : Communications and electronic circuits, magnetics, microwaves and optoelectronics. In each of these fields he created a scientific school and educated promoted researchers and followers.

Professor Smolinski has been very well known in URSI circles. He served for several years as the President of the Polish National Committee. In 1972 he was the Chairman of the Organising Committee of the XVIIth

General Assembly of URSI in Warsaw Poland. In the years 1972-1978 he served as the vice-chairman and chairman of the Commission D. Next he has been elected to serve as vice-president of URSI in the years 1978-1984. He has been engaged in many other Committees. He was for example the chairman of the Standing Committee on Future General Assemblies. He was a full member of the Polish Academy of Sciences, a Life Member of IEEE and a member of other scientific organisations and bodies. Personally I have had the opportunity and Honour to cooperate with Professor Smolinski in the frame of the activity of the Polish National Committee of URSI for many years. We will remember him for a long time to come.

Professor Stefan Hahn

President of the Polish National Committee of URSI



George Francis FitzGerald 1851- 1901

1. Introduction

In October 1898 Guglielmo Marconi (1874–1937) penned the following simple and direct letter ^[1]

The recipient was George Francis FitzGerald, who was born in Monkstown, Co. Dublin on August 31, 1851, and

*Madeira House
South Cliff
Bournemouth
Hants
23^d October 1898*

Dear Prof Fitzgerald

The Secretary of the Institution of Electrical Engineers has informed me that he thinks it would be perhaps some advantage to me and to the Institution if I was to become a Member of the same.

It is however necessary that two members should sign the usual form proposing me for admission.

I would feel very much obliged if you would kindly inform me whether you have any objection in doing so and in case you have not I will forward you the form for your signature.

Lord Kelvin has kindly undertaken to propose me for the Membership.

I have been carrying out some very interesting experiments at a distance of 18 miles on rather different lines to those I was engaged on some time ago and I hope to be soon able to send you an account of the facts and results we have obtained.

I have promised to read a paper on the subject of signalling through space before the Institution of Electrical Engineers in January.

Kindly remember me to Dr. Trouton and to my Dublin friends.

Hoping to hear from you soon I am dear Sir

Yours very truly

G. Marconi

*Dr. Sean S. Swords and Prof. B.K.P. Scaife are with the
Department of Electronic and Electrical Engineering
Trinity College
Dublin 2, Republic Ireland*

who died some six months before his fiftieth birthday on 22 February 1901.

It is fair to say that, until recently, FitzGerald was remembered, if at all, only through his association with the FitzGerald-Lorentz contraction hypothesis and the concepts of the Special Theory of Relativity. This situation has been remedied somewhat by O'Hara's and Pricha's excellent work "*Hertz and the Maxwellians*",^[2] wherein are highlighted the relative roles of Oliver Lodge (1851 – 1940), Oliver Heaviside (1850 – 1905), William Thomson (Lord Kelvin) (1824 – 1907), and George Francis FitzGerald in supporting the ideas of James Clerk Maxwell (1831 – 79) and in the promotion of the discoveries of Heinrich Rudolph Hertz (1857 – 94).

One cannot of course discuss FitzGerald, his work and his life without reference to the work of others, particularly the other "Maxwellians", but therein lies a danger of not appreciating the essential individuality and indeed independence of the man. That he should, in a letter discussing cathode rays written to Heaviside on 14 July 1896,^[3] set down in a short postscript the merits and demerits of a novel design of a bicycle is a small pointer to his character. More indicative, perhaps, of his wide interests are the letters to him^[4] from Otto Lilienthal (1848 - 96), the German aviation pioneer, in 1895 and 1896, and his own attempts to fly in a Lilienthal designed hang-glider in 1895 at Trinity College, Dublin. This attraction to flying was no passing fancy. Again, FitzGerald's interest in flying is evident in a short note which he wrote in 1900 for the *Aeronautical Journal*^[5].

Shortly after FitzGerald's death in 1901, Oliver Lodge wrote in *The Electrician*:^[6] At the same age as Clerk Maxwell, FitzGerald has gone from us: there has been no equal blow to Physical Science between the two events, in this country, possibly not in the world: for the untimely death of Hertz himself was no greater blow."

This paper, while concentrating on FitzGerald's contribution to the study of electromagnetic radiation, will endeavour to show that Oliver Lodge's words were justified. Firstly, some key milestones in FitzGerald's life will be set down.

2. Biographical

His father, who at the time of FitzGerald's birth in 1851 was rector of the parish of Kill O' the Grange in Monkstown, a south Dublin suburb, became Bishop of Cork and afterwards of Killaloe. His mother was a sister of Dr. George Johnstone Stoney (1826 – 1911), the physicist who named the *electron*. He was educated at home, with his brothers and sisters, by a private tutor Miss M.A. Boole, a sister of the mathematician and logician George Boole (1815 – 64), who was professor in Queen's College, Cork (now University College, Cork). In 1867 at the age of sixteen he entered Trinity College, Dublin. He was elected a Scholar in 1870 and in his BA degree in 1871 he took the highest place in Mathematics and Experimental Science. He gained Fellowship in 1877, the announcement of the award being made as is customary on Trinity Monday, which fell on May 28 that year. At that

time Fellowship was achieved by examination after several years of study: indeed previously, in 1873, he had been unsuccessful having to be content instead with a £60 premium. In 1877 there were question papers^[7] in Pure Mathematics, Mathematical Physics, Physical Astronomy,

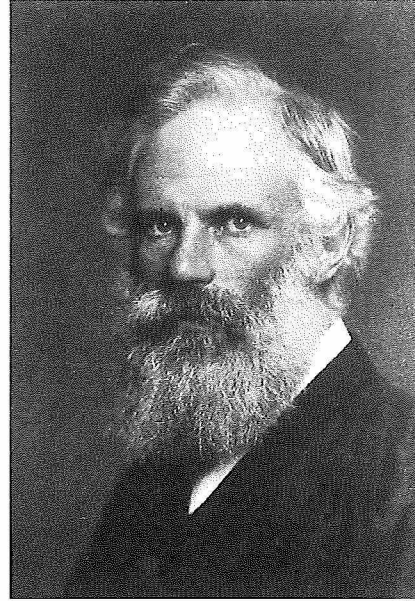


Figure 1 : George Francis FitzGerald

Molecular Mechanics, Tidal Hydrodynamics, Experimental Physics, and the Classics. On 11 February 1878 he was elected to membership of the Royal Irish Academy. In 1883 he was elected a Fellow of the Royal Society of London and in 1899 was awarded one of the Society's Royal Medals.^[8] Other bodies of which he was a member and in which he held office at one time or other were the Physical Society of London, the British Association, the Royal Dublin Society, and the Institution of Electrical Engineers. On December 21, 1885 he married Harriette Mary Jellett, daughter of John Hewitt Jellett (1817 – 88), Provost of the College. In 1886 he became Registrar of the School of Engineering and served in this office until his death: during his tenure he promoted and developed the teaching of electrical engineering in the College.

A visit to Dublin and to Trinity College today would probably not enlighten one on the world in which FitzGerald lived and worked. One needs to go back in time and a trustworthy guide is the botanist Robert Lloyd Praeger (1865 – 1953) who, reminiscing in 1941, wrote:^[9] The Dublin which I entered in 1893 was a pleasant and placid place, as vaguely concerned with the squibs and crackers of Ireland's representatives at Westminster as it was with the earnest money-worship of Belfast;... The interest of those years was heightened by the existence of a little coterie of scientific men who met daily in a modest bun-shop in Lincoln Place, kept by two young Cork women, the Misses Gardiner. I was much the junior member of the conclave both in years and learning, but in accordance with the freemasonry of science I was admitted as an equal. We

drank tea and devoured vast quantities of buttered toast, and discussion on almost every subject within the confines of the universe—and sometimes outside them—raged without ceasing. It was an exhilaration and a delight to me to have my limited stock increased daily by fresh facts and fancies bearing on so many branches of knowledge. Our leader and chairman honoris causa was George Francis Fitzgerald; and round him were grouped W. J. Sollas, A. C. Haddon, Grenville Cole, Thomas Preston, Frederick Trouton, R. J. Moss, and, by way of a lay assessor, T. J. McWeeny, head reporter on the staff of the “Freeman’s Journal”—a visitor from another planet, and a very useful one, who kept us from thinking that science was the only important thing in the world. John Joly would drop in occasionally, and Irishmen no longer resident here, like Sir William Ridgeway and Sir Joseph Larmor, would join us if they happened to be in Dublin. It was always a lively lunch table. The genial Fitzgerald, essentially a product of Dublin and Dublin University, was a big bearded man, and his resonant voice filled the little room, as he poured out wisdom and nonsense in a delightful medley—for he was a brilliant talker—often to the astonishment of customers at other tables. I once had an inspiring week with him on the Aran Islands—in 1895 it was—and learned to appreciate to the full his kindly outlook on life and great knowledge and humour.”

3. Electromagnetic radiation

Following his election to Fellowship in 1877 FitzGerald turned to a serious study of Maxwell’s theory of the electromagnetic field as propounded in his treatise published in 1873.^[10] FitzGerald was among the first to apply Maxwell’s theory to a particular problem. He chose that of the reflection and refraction of light at a plane interface between two dielectric media. This choice is easy to understand since FitzGerald’s predecessor as Erasmus Smith’s professor of natural and experimental philosophy, James MacCullagh (1809 – 47), had, some thirty years earlier, discussed this same problem on the basis of his theory of the luminiferous ether.^[11] MacCullagh followed Augustin Jean Fresnel (1788 – 1827) in assuming that the optical properties of matter were to be understood as the affects of matter on the elements of the ether. In 1823 Fresnel succeeded in providing a justification of the empirical equations discovered earlier by David Brewster (1781 – 1868) and now known as Fresnel’s sine and tangent laws. MacCullagh was able to deduce these laws from his theory. His theory had fallen out of favour because of the failure by anyone to construct a mechanical model which would be described by MacCullagh’s equations. Indeed he had



Figure 2 : G.F. FitzGerald testing his Lilienthal glider in College Park, 1895

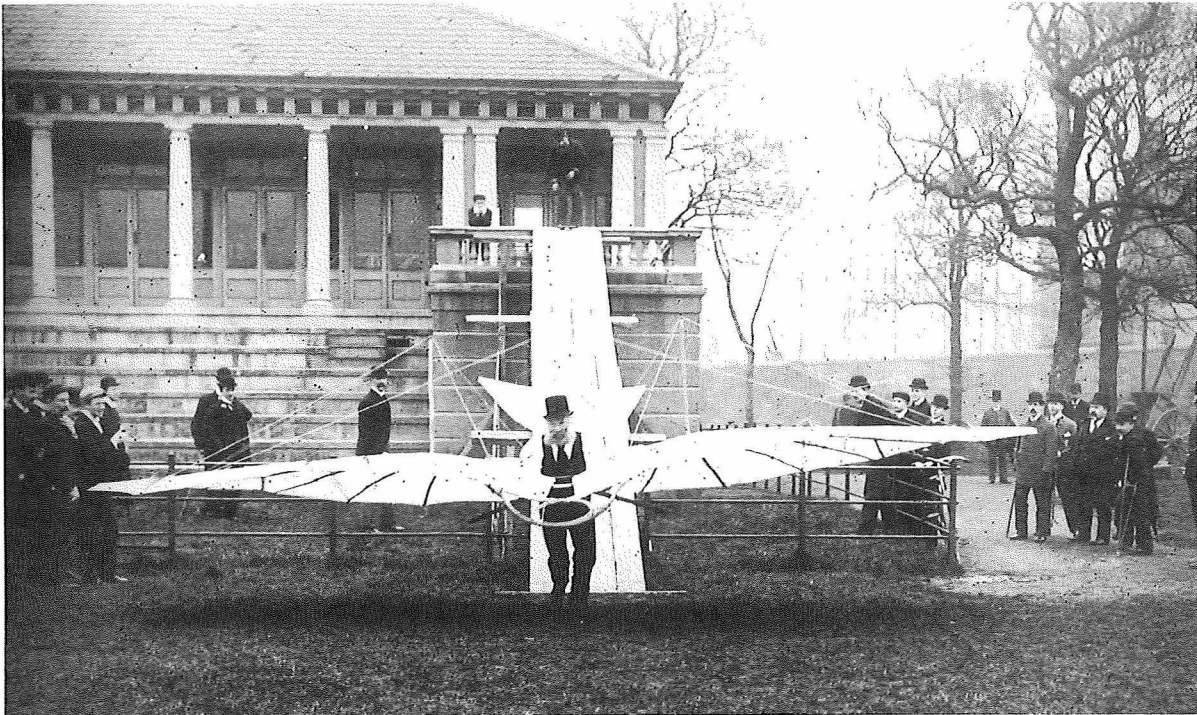


Figure 3 : G.F. FitzGerald using a ramp-assisted take-off for his Lilienthal glider, College Park, 1895

admitted his own failure to find such a model but emphasized that this did not invalidate his theory and expressed the opinion that “. . . the constitution of the ether, if it ever should be discovered, will be found to be quite different from anything that we are in the habit of conceiving, though at the same time very simple and very beautiful.”^[12]

FitzGerald pointed out that MacCullagh’s theory could be brought into harmony with Maxwell’s theory if the electric field intensity, \mathbf{E} , was identified with the curl of the ether displacement, \mathbf{x} , and the magnetizing force, \mathbf{H} , with the velocity, $d\mathbf{x}/dt$, of an element of the ether, that is

$$E = \text{curl}x, \text{ and } H = \frac{dx}{dt}$$

By adapting MacCullagh’s analysis FitzGerald was able to demonstrate that Fresnel’s laws were a consequence of Maxwell’s theory. This work was completed in 1878 and published in 1880.^[13]

At about the same time FitzGerald was giving serious consideration to the problem of how electromagnetic waves could be launched as is evident in the following quotation from Lodge:^[14] I used to discuss the possibility of producing these waves with my great friend, G.F. FitzGerald, whose acquaintance I made at the meeting of the British Association in Dublin in the year 1878; and he wrote some mathematical papers discussing the possibility of producing such waves experimentally. I myself also spoke at the British Association about them, in 1879, 1880 and again in 1882,

at the Royal Dublin Society. FitzGerald, as I say, mathematically examined what then seemed the abstruse question of electric wave production; and after some hesitation came to the conclusion that direct artificial generation of waves was really possible on Maxwell’s theory, in spite of certain recondite difficulties which at first led him to doubt it. (See “Scientific Writings” of FitzGerald, edited by Larmor, pp. 90-101). Indeed, one of his papers on the subject was originally entitled “On the Impossibility of Originating Wave Disturbances in the Ether by Means of Electric Forces”. The prefix “im” was subsequently dropped although his first, or 1879, paper concluded thus: ‘However these [displacement currents] may be produced, by any system of fixed or movable conductors charged in any way, and discharging themselves amongst one another, they will never be so distributed as to originate wave-disturbances propagated through space outside the system.’ In 1882, FitzGerald corrected this erroneous conclusion, and referred to some early attempts of mine at producing the waves. (“Scientific Writings”, p. 100). I shall state all this in order to emphasize the difficulty which in those early days surrounded the subject on its theoretical as well as on its practical side. In 1883, at the Southport meeting of the British Association, FitzGerald took a further step and surmised that one mode of attaining the desired result would be by utilizing the oscillatory discharge of a Leyden jar, if only we had the means of detecting such waves when they were generated.”

In 1882, following a study by Rayleigh (John William Strutt) (1842 – 1919) of the wave equation, FitzGerald^[15, 16, 17] realized that a possible solution of the wave equation

consisted of an outward propagating spherical wave of the form

$$\frac{\cos(\omega t - kr)}{r},$$

and, therefore, that rapidly alternating currents might give rise to electromagnetic radiation. He noted that one way of generating such currents would be to discharge capacitors through circuits of small resistance. By 1883 he was exploring ways of constructing circuits which would have a high resonant frequency and which would generate electromagnetic waves.^[18] At one point he considered the arrangement that Hertz was to use later, namely, that of two metal spheres joined by a thin conductor.

FitzGerald's notes contain the statement: "What would be the period of oscillation in a pair of spheres connected by a long wire? It comes to calculate the self-inductance for evidently the capacity would be practically that of either sphere. It is an entirely different state of affairs from a closed metallic circuit. I must consider the displacement current from one sphere to the other as having self-induction as this is part of the ordinary circuit otherwise the circuit would be open."

On the basis of the last comment he was led into a very involved calculation which he abandoned before completion. He then concentrated on the case of an alternating current in a circular coil and calculated the vector magnetic potential generated by it. He proceeded to calculate the energy around the loop and, after analysing how it changed with time, obtained the following expression for W , the power radiated (in SI units):

$$W = 160\pi^4 I_0^2 (\pi a^2 / \lambda)^2$$

in which the peak value of the current is denoted by I_0 , the radius of the loop by a and the wavelength by λ .

He announced this result to the meeting of the British Association in Southport in September 1883.^[19] Later in the year he published a more detailed account of this work.^[21] In his study of resonant circuits he seems to have decided that a frequency of 10 MHz was attainable,^[20] and he noted^[19, 21] that at this frequency the power radiated from a circular loop would be very small (about 50 μ W for an rms current of 1 A, and a loop radius of 1 cm). We now know, of course, that Hertz's electric dipole radiator was a far more effective device for launching electromagnetic waves than the magnetic dipole radiator studied by FitzGerald.

4. Repetition of Hertz's experiments

The uniqueness and importance of Hertz's achievement^[22] in carrying out and interpreting his Karlsruhe experiments (1886–88) cannot be questioned. Prior to this, several of his contemporaries such as David Edward Hughes (1831–1900), Silvanus Phillips Thompson (1851–1916), and Thomas Alva Edison (1847–1931) had observed what we now know to have been radiation phenomena. More

particularly, Oliver Lodge and FitzGerald had been purposefully and knowledgeably seeking after 'ether waves'.^[23] Hertz's work, however, had expertly demonstrated the existence and fundamental properties of radio waves and thus allowed the subsequent birth of radiotelegraphy in the 1890's. In the interim there was much analysis and consolidation of Hertz's results. In this regard the repetition of his experiments by the Swiss physicists Édouard Sarasin (1843–1917) and Lucien de la Rive (1834–1924) and their investigation of the currents in resonant-loop receivers are well known.^[24] However, the rôle of FitzGerald was likewise particularly significant in that, as previously alluded to, he called attention to Hertz's experiments at a meeting of the British Association in Bath, in 1888, and that soon after he set about repeating some of Hertz's experiments in collaboration with his assistant Frederick Thomas Trouton (1863–1922).

In October 1888, as reported by Trouton in *Nature* on February 21 1889,^[25] a replica of one of Hertz's early oscillators/transmitters was installed in a room of the Museum Building, a rather spacious structure which housed, and still houses, the Engineering School. The transmitter, or 'primary' as Hertz would have called it, consisted of two thin brass plates, supported by silk threads: each plate was about 40 cm square and carried a stiff wire some 30 cm long and furnished at the end with a brass knob. These knobs, which formed a spark-gap, were set about 3 cm apart. When the knobs were fed by an induction coil the transmitter operated at about 30 MHz (10 m wavelength). The 'secondary', or 'resonator', was, following Hertz, a circular loop of wire whose ends were fitted with small brass knobs. Trouton said that they formed the loop from 210 cm of no. 17 wire (1.4 mm diameter). The distance between the brass knobs could be adjusted by a screw arrangement and the complete resonator was mounted on a cross of wood for convenience in carrying about. As described by Trouton, there were two principal objectives in the experiments he and FitzGerald carried out. Firstly, when using the apparatus just described, it was possible to prove that action spread out from the transmitter at a finite velocity and that instantaneous action-at-a-distance was not occurring. Secondly, again imitating Hertz in their use of apparatus and employing parabolic-cylinder reflectors made of zinc (2 m high, 2 m wide, and 12.5 cm focal length) to obtain focussed beams of radiation of about 66 cm wavelength (455 MHz), they demonstrated that the electric disturbance was perpendicular to the plane containing the magnetic disturbance: this was achieved while obtaining reflections from a 3 ft (91 cm) thick stone wall. The two parabolic reflectors, one arranged for transmission and the other for reception, had each its own distinct type of dipole arrangement: the concentration of radiation then allowed definite angles of incidence with the wall to be set up so that analogues of optical experiments could be performed.

It is interesting, if one reverts to his 30 MHz experiment, to follow Trouton's reasoning in determining that a finite velocity of propagation pertained. He noted that it was possible to observe sparks in the receiver 6 to 7 m from the transmitter. When he brought a 3 m square sheet of zinc very close to the receiver (when in a sparking

position) the sparking increased in brightness. When the sheet was placed 2.5 m further back, the sparking ceased. However, when the sheet was placed at double this distance, some 5 m behind the receiver, the sparking was slightly greater than without the sheet. The first two observations alone could be explained by instantaneous, direct action-at-a-distance, by supposing the currents induced in the metallic sheet to oppose the direct action in the receiver everywhere and by also supposing that in the immediate neighbourhood of the sheet the direct action is overmastered by the magnitude of that from the sheet, while at 2.5 m away the two influences on the receiver just neutralize each other. However, the fact that the currents in the receiver are reinforced by the presence of the reflecting sheet at 5 m requires a constructive interference there of two actions, direct and reflected, propagating at a finite velocity.

The action of the loop resonator in detecting the presence and in displaying some of the properties of the radiation seems, perhaps, deceptively straightforward. The interference experiments to demonstrate the finite velocity of propagation and to measure the wavelength of transmission, as carried out by Hertz and repeated by FitzGerald and Trouton using a reflecting wall or a metal sheet, were not quite the same as one might carry out today, where a continuous-wave single-frequency source would be arranged to set up a standing wave pattern, whose peaks and troughs could readily be measured. As mentioned above, Sarasin and de la Rive investigated the behaviour of the loop resonator, as also did Vilhelm Bjerknes (1862 – 1951) who collaborated with Hertz in Bonn for nearly two years, working on resonance in oscillatory circuits. Bjerknes^[26] measured for a vibrator and for a resonator, such as those used by Hertz in his early experiments, the rate at which oscillations die away. He found that the rate of decay of the vibrator oscillations was very rapid (large logarithmic decrement) producing about 10 exponentially decaying useful oscillations. On the other hand, the rate of decay of the resonator oscillations was comparatively very slow (very small logarithmic decrement) producing some 1,000 complete oscillations before their amplitude fell to 1/10 of their original value. In effect, the transmitter, or vibrator, radiated an impulse which caused the resonator loop to oscillate at its own natural frequency. Hence the spacing between the maxima and minima obtained in the interference experiments depended primarily on the geometry or natural wavelength of the loop detector. The Hertzian transmitters were found to emit, as might be expected, not just a single frequency but a wide band of frequencies. This phenomenon of multiple resonance complicated the early observations and experimental work.

Before leaving these rather cursory observations on FitzGerald's experimental work, it is worth noting that, during the demonstration of the 30 MHz apparatus to the Dublin University Experimental Society in November 1888, sparking of the resonator was observed outside in College Park while the transmitter was indoors in a laboratory of the Museum Building. This has a certain similarity with Marconi and his early experiments at the Villa Grifone in 1894, when he removed his receiver from inside the Villa to ever increasing distances outside.

Maxwell's theory may be expressed in terms of an electric scalar potential, $\Phi(r, t)$, and a magnetic vector potential, $A(r, t)$. It was known that if the divergence of A was assumed to be zero, then changes in Φ were propagated instantly although the magnetic and electric vectors, $E(r, t)$ and $H(r, t)$, propagated with the speed of light, c_0 . This fact gave rise to considerable discussion as to the physical significance of the scalar and vector potentials. Heaviside^[27] held strongly to the view that it was the electric and magnetic vectors which were the basic entities and that to discuss the propagation of potentials was to enter into matters metaphysical.

At the meeting of the British Association in Leeds, in 1890, FitzGerald^[28] showed that if Φ and A were related by the equation

$$\text{div}A + \frac{1}{c_0} \frac{\partial \Phi}{\partial t} = 0$$

then Φ and A would each satisfy the wave equation and be propagated at the speed of light. This condition was also discovered independently by Lorentz, and bears his name.

5. Long-distance wireless telegraphy

Up to the time of his death in 1901, FitzGerald had not moved actively into the world of practical wireless telegraphy, but there can be no doubt that he was alert to what was taking place. At the conclusion of a letter to Heaviside^[29] dated 12 July 1900 and sent from Cooper's Hill, Surrey, he wrote "I have to go off now to help Minchin to put up some wireless telegraph poles" (George M. Minchin (1845 – 1914), a former colleague of FitzGerald, was Professor of Applied Mathematics at the Royal Indian Engineering College, Cooper's Hill, Surrey). Two years previously, in July 1898, FitzGerald accompanied Marconi on board the steamer 'Flying Huntress' when race results of the Kingstown (now Dún Laoghaire, about 10 km along the coast from Dublin) Regatta were sent to a station on shore by wireless.

In the commercially competitive atmosphere, involving precedence of invention and patents that understandably developed during the evolution of wireless communication in the late 1890s, one sees Lodge and Marconi as two of the principal actors: included also were many other well-known radio scientists such as William Henry Preece (1834 – 1913), John Ambrose Fleming (1849 – 1945), Adolf Karl Heinrich Slaby (1849 – 1913), and Nikola Tesla (1856 – 1943), and then to a lesser extent, perhaps, Trouton, Minchin, and FitzGerald. FitzGerald interacted with all the principal players. One of his main rôles in this regard seems to have been one of philosopher and friend endeavouring to assuage Lodge. The flavour of those years is well captured in the recent publication by Rowlands and Wilson.^[30]

Marconi's success with transatlantic signalling, firstly achieved on 12 December 1901 between Poldhu, Cornwall, and St. John's, Newfoundland, and later confirmed during

the voyage of the S. S. Philadelphia across the Atlantic from England some months later, resulted in speculation among radioscientists regarding the properties of an assumed conducting region of ions in the upper atmosphere.

The first indications of the existence of the ionosphere had arisen from theoretical considerations relating to diurnal variations in terrestrial magnetism. In this regard one can cite ^[31] Carl Friedrich Gauss (1772–1855) in 1838 but more particularly Balfour Stewart (1828–1887) in 1882 and Arthur Schuster (1851–1939) in 1889. Stewart and Schuster concluded that the upper atmospheric layers must conduct electricity much better than air near the ground. At a meeting of the British Association in Nottingham in September 1893, FitzGerald gave ^[32] an estimate of the period of oscillation of electrical disturbances around the earth, treating it as a conducting sphere surrounded by a concentric conducting layer: “The fact that the upper regions of the atmosphere conduct makes it possible that there is a period of vibration similar to those on a sphere surrounded by a concentric spherical shell.”

(The account of the meeting in *Nature* uses the phrase “If the Earth is surrounded by a conducting shell . . .”) He found that if the conducting layer were 6 miles (about 10 km) the period should be 0.3 s, while for a height of 60 miles the period should be 0.1 s. Also at this time, ^[33] and in relation to magnetic disturbances, he suggested the possibility of solar waves and of electrified particles emanating from the sun; what is now referred to as the solar wind.

In the context of transoceanic communication, he considered the possibility of diffraction around the earth and, writing to Heaviside on 7 May 1899, said ^[34]: “Have you worked at the propagation of waves round a sphere? A case of this is troubling speculators as to the possibility of telegraphing by electromagnetic free waves to America. It is evidently a case of diffraction and I think must be soluble. Perhaps the case of propagation round a cylinder would be easier and I think must have been done by Lord Rayleigh in some of his papers on wave motion past obstacles though he has probably only worked at the case of the obstacle small compared with the wave length.”

Later, on 20 May 1899, he wrote ^[35]: “I am afraid that wave propagation round a sphere is rather a complicated piece of mathematics but somehow it seems to me as if it should be workable.”

The manner in which this problem was later addressed, particularly by Hector Munro Macdonald (1865–1935), Rayleigh, and by Jules Henri Poincaré (1854–1912), is well summarized by Fleming. ^[36]

6. FitzGerald–Lorentz contraction

FitzGerald is, perhaps, best known for his hypothesis put forward to explain the failure, in 1887, of Michelson (1852–1931) and Morley (1838–1923) ^[37] to detect any tendency of the ether to be carried along by the earth. In discussion with Lodge ^[38] he suggested that their apparatus shrank in the direction of motion. In 1889 FitzGerald hypothesized ^[39] “that the length of material bodies changes, according as

they are moving through the ether or across, by an amount depending upon the square of the ratio of their velocities to that of light. We know that electric forces are affected by the motion of the electrified bodies relative to the ether, and it seems a not improbable supposition that the molecular forces are affected by the motion, and that the size of the body alters consequently.” Lodge drew public attention to FitzGerald’s idea in *Nature* on 16 June 1892, when he stated: “Prof. FitzGerald has suggested a way out of the difficulty by supposing the size of bodies to be a function of their velocity through the ether.” Five months later H. A. Lorentz ^[40] (1853–1928), independently, put forward the same hypothesis to explain ‘the negative result of Mr. Michelson’s experiment’.

This was not the only involvement of FitzGerald in the development of the Special Theory of Relativity. Shortly before his death FitzGerald suggested to Trouton ^[41] that he should attempt to determine whether a magnetic field was generated by the motion of an electric charge with respect to the ether. FitzGerald’s concept was that if such a magnetic field were generated its presence could be detected by observing the torque exerted on a freely suspended, electrically charged capacitor as it was carried through space by the motion of the earth. According to pre-relativistic ideas the torque would have been extremely small and proportional to the square of the ratio of the speed of the capacitor to the speed of light. The initial result of Trouton’s experiment was negative; this result was confirmed, in 1903, by the more elaborate and delicate experiment of Trouton and Noble ^[42] carried out at University College, London, after Trouton’s appointment there as Quain Professor of Physics in 1902. The Trouton–Noble experiment furnished additional evidence in support of the principle of the Special Theory of Relativity, namely, that absolute motion is undetectable.

7. FitzGerald and Education

If one were seeking to discover a dominant role in FitzGerald’s life, one might well argue that it was that of educationalist.

In 1892, in *Nature*, ^[43] he set down his idea of a University and stressed that “The business of Universities is to advance culture and knowledge and afford students an opportunity of learning how to do this”. In 1899 he was a key member of a small committee established by the Board of Trinity College to report on the teaching of electrical engineering in the Engineering School. The committee advised an increase in the electrical engineering teaching within the existing School of Civil Engineering and this course of action was successfully promoted by FitzGerald. ^[44]

Technical Education was inaugurated in Ireland in October 1887 with the opening in Dublin of the Kevin Street Technical School (now part of the Dublin Institute of Technology). FitzGerald played an important rôle in its foundation and was a member of the Board of Governors. He also served on the Board of Intermediate Education, while perhaps most important of all, outside of his university

duties, was his rôle in primary education. He was a member of the Board of National Education in Ireland. In this connection he became a member of the Belrose Commission, which was set up in July 1897 to "Inquire and report with a view to determining how far and in what form Manual and Practical Instruction should be included in the Educational System of the Primary Schools under the Board of National Education in Ireland".^[45] He assisted Dr. W. J. M. Starkie (1860–1920), President of Queen's College, Galway (now University College, Galway), in a special sub-committee of two, and their report published in July 1899 was deemed responsible for the changes which took place in National Education in Ireland in the early part of this century.

In a letter to Heaviside^[46] dated 20 May 1899 we glimpse a little of the heavy workload he was experiencing: "I have plenty to do between my ordinary lectures, Fellowship, and medical examinations, National School Board of Education, the Royal Veterinary College, committees on the Agriculture and Industries Bill now before Parliament, getting my family moved to the seaside, and preparing for an expedition with my wife to Cambridge for the Stokes' Jubilee and to London for the Royal Institution's centenary, besides London D.Sc. examinations theses and two interesting papers referred to me for report. In fact I am a bit addled between them all and have only time to write a letter to you like this because I leave other things to do one another out of a hopeless condition of mind of ever getting them done."

8. Conclusion

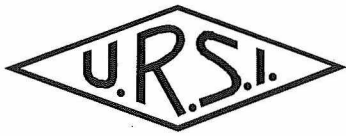
FitzGerald was a man of keen and creative intellect, possessing great zest for life and an engaging personality. He played his part in the development of science generally and, in particular, was a very keen and active member of the British Association for the Advancement of Science. His strength seems to have been the willingness and ability to embrace and to explore new ideas. His weakness seems to have been his inability to concentrate his activities; he was profligate with his talents as is clear from the very great range of his activities and commitments. The success of his work with Trouton suggests that FitzGerald's forte was in comprehending new concepts and conveying them to others. Despite Lodge's experimental skills and FitzGerald's grasp of theory, it was left to the genius of Hertz to confirm Maxwell's theory.

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Editorial comment on the Scientific Papers of Lord Rayleigh (John William Strutt)*

* This note is a reprint from the Editorial Comment published by Professor J.R. Wait in *Radio Science, Journal of Research NBS/USNC-URSI*, Vol. 69D, No. 9, September 1965, pp. 1307-1308. It still seems most fitting.

With the great outpouring of published papers on radio physics, it is worthwhile to return to the works of Lord Rayleigh (1842-1919) (picture on front cover). Many of the current ideas in electromagnetics, acoustics, and optics have germs in the original papers by Lord Rayleigh. It is a pity that many present-day authors prefer to refer to some available textbook or current journal article rather than giving the basic reference.

As a service to the readers and prospective authors of *Radio Science*, we list here the papers of Lord Rayleigh which appear to be closely related to the subject of the journal. No attempt is made to classify the papers according to subject. However it is believed that the following list includes those of special interest to researchers in electromagnetic wave propagation at all frequencies :

- On the light from the sky, its polarization and colour, *Phil. Mag.* XLI, 107-120, 274-279 (1871)
- On the scattering of light by small particles, *Phil. Mag.* XLI, 447-454 (1871)
- On double refraction, *Phil. Mag.*, XLI, 519-528 (1871)
- On the reflection of light from transparent matter, *Phil. Mag.* XLII, 81-97 (1871)
- Notes on Bessel's functions, *Phil. Mag.* XLIV, 328-344 (1872)
- On the reflection and refraction of light by intensely opaque matter, *Phil. Mag.* XLIII, 321-338 (1872)
- An experiment to illustrate the induction on itself of an electric current, *Nature* VI, 64 (1872)
- Some general Theorems relating to vibration, Section I. The natural periods of a conservative system, vibrating freely about a configuration of stable equilibrium, fulfill the stationary condition, Section II. The dissipation function, Section III., *Proc. London Math. Soc.* IV, 357-368 (1873)
- On a permanent deflection of the galvanometer-needle under the influence of a rapid series of equal and opposite induced currents, *Phil. Mag.* III, 43-46 (1877)
- On the relation between the functions of Laplace and Bessel, *Proc. London Math. Soc.* IX, 61-34 (1878)
- On reflection of vibrations at the confines of two media between which the transition is gradual, *Proc. London Math. Soc.* XI, 51-56 (1880)
- On the resolving-power of telescopes, *Phil. Mag.* X, 116-119 (1180)
- Note on the theory of the induction balance, *British Assoc. Report*, Swansea, 472-473 (1880)
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- On the infinitesimal bending of surfaces of revolution, *Proc. London Math. Soc.* XIII, 4-16 (1881)
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- On the invisibility of small objects in a bad light, *Proc. Cambridge Phil. Soc.* IV, 4 (1883)
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- On the measurement of electric currents, *Proc. Cambridge Phil. Soc.* V, 50-52 (1883)
- On the measurement of electrical resistance between two neighbouring points on a conductor, *Proc. Cambridge Phil. Soc.* V, 133-134 (1884)
- On the electro-chemical equivalent of silver, and on the absolute electromotive force of Clark cells (by Lord Rayleigh and Mrs. H. Sidgwick), *Phil. Trans. Roy. Soc. London* CLXXV, 441-460 (1884)
- On telephoning through a cable, *British Assoc. Report*, 632-633 (1884)
- On a galvanometer with twenty wires, *British Assoc. Report*, 633 (1884)
- Über die Methode der Dämpfung bei der Bestimmung des Ohms, *Ann. Physik Chem.*, Band XXIV, 214-215 (1885)
- On the self-induction and resistance of straight conductors, *Phil. Mag.* XXI, 381-394 (1886)
- On the intensity of light reflected from certain surfaces at nearly perpendicular incidence, *Proc. Roy. Soc. London* XLI, 275-294 (1886)
- On the existence of reflection when the relative index is unity, *British Assoc. Report*, 585-586 (1887)
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- On the theory of stellar scintillation, *Phil. Mag.* XXXVI, 129-142 (1893)
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- On the measurement of alternate currents by means of an obliquely situated galvanometer needle, with a method of determining the angle of lag, *Phil. Mag.* XLIII, 343-349 (1897)
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- On the propagation of electric waves along cylindrical conductors of any section, *Phil. Mag.* XLIV, 199-204 (1897)
- Note on the pressure of radiation, showing an apparent failure of the usual electromagnetic equations, *Phil. Mag.* XLV, 522-525 (1898)
- On the transmission of light through an atmosphere containing small particles in suspension, and on the origin of the blue in the sky, *Phil. Mag.* XLVII, 375-384 (1899)
- The theory of anomalous dispersion, *Phil. Mag.* XLVIII, 151-152 (1899)
- The mutual induction of coaxial helices, *British Assoc. Report*, 241-242 (1899)
- The law of partition of kinetic energy, *Phil. Mag.* XLIX, 98-118 (1900)
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James R. Wait, Editor



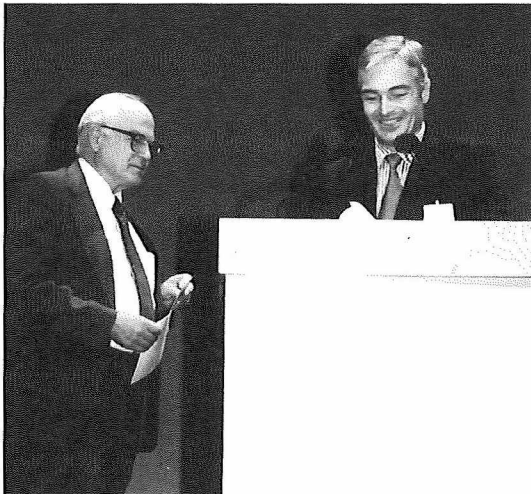
XXVth General Assembly

AWARDS CEREMONY

Presentation of the Balthasar van der Pol Gold Medal

Mr. Duncan Bathasar Kenneth James Milnes, grandson of Balthasar van der Pol, gave the following introductory speech :

I was deeply honoured and proud earlier this year when I received a letter from Professor Jull, who is Chairman of the U.R.S.I. awards panel, inviting me to present the Gold Medal initiated by my Grandmother in 1963 and dedicated to the memory of my Grandfather, Balthasar van der Pol. I am here as a representative of the family, in particular my mother, Irene, who was very disappointed not to be able to come due to my fathers ill health.



Mr. Duncan Bathasar Kenneth James Milnes presenting the Balthasar van der Pol Gold Medal for "Contributions to electromagnetics and the development of the method of moments" to Professor Roger Harrington.

I understand that it is traditional to present a short history of the person after whom the award is named so I have not only put together an outline of his distinguished career but also a few glimpses of the man himself from the family perspective.

My grandfather, who was born in Utrecht on 27th January 1889 and died in his home in Wassenaar, Holland, on 6th October 1959, was, during his lifetime, a man of many parts. He was a well known authority on pure and applied mathematics, a philosopher, a pioneer in natural

sciences, a musician and composer and a personality of international renown in telecommunications.

During the First World War, he was for some years assistant to Sir J.A. Fleming in London and Sir J.J. Thomson in Cambridge. In 1919, he was awarded the degree of Doctor of Physics from the University of Utrecht and, after a period as assistant to H.A. Lorentz in Haarlem, he was associated with the Philips Laboratories in Eindhoven, where he became Director of Research. In 1938, he received the title of Professor at the "Technische Hoogeschool" in Delft and in 1945 he was, in addition, appointed Rector of the temporary University of Eindhoven.

After his retirement in 1949, he devoted himself, above all, to international activities, having accepted his election as Director of the International Radio Consultative Committee (C.C.I.R.), during its fifth Plenary Assembly in Stockholm in 1948. The C.C.I.R. was, at that time, a permanent organ of the International Telecommunication Union (I.T.U.) and he dedicated himself to the service of this organisation, which was responsible, on a world-wide scale, for the preparation of scientific recommendations concerning communications of all types effected by the use of electromagnetic wave propagation.

From the purely scientific aspect, the predominating characteristic of his genius was a wide and comprehensive understanding of mathematical problems. For example, his extension of the theory of non linear oscillations in relaxation systems led to the construction of models which demonstrate the functions of the human heart under various conditions. It is well known that the basic non linear differential equation was called the "van der Pol Equation" and that his name is also closely linked with the development of the basic theory of frequency modulation. His development, assisted by K.F. Niessen, of the theories of J.R. Carson, concerning the modification of Oliver Heavisides operational calculus, led to a remarkable progress in the use of mathematical methods. My grandfather was impressed by the extraordinary work and character of Heaviside to such an extent that, on the occasion of his appointment as Professor of the Technische Hoogeschool in Delft, he took the introduction of this solitary but celebrated man as the theme of his professorial address.

He was also stimulated by Sommerfelds enunciation of the problems of electric wave propagation and he

undertook new studies, first assisted by K.F. Niessen, then in collaboration with H. Bremmer. These studies were so successful that they permitted the calculation of field strength at any distance over the surface of the earth. The construction of this theory led, by analogy, to the solution of the problem of the rainbow.

He was also a member of the Royal Netherlands Academy of Sciences, correspondent to the Academy of Sciences in Paris, Honorary Doctor of the Warsaw Polytechnic and Honorary Doctor of the University of Geneva. He received the Medal of Honour of the I.R.E., the Poulsen Medal of the Danish Academy of Technical Science and was, for many years, an active and honoured member and, ultimately of course, honorary President of the Union Radio Scientifique Internationale (U.R.S.I.).

In his letter of invitation, Professor Jull suggested that I might be in a different position to most of you here in the way in which I addressed Professor Doctor Balthasar van der Pol. It was a title in which he took a great deal of pleasure; it was, of course, "Opa".

From the time I was born to my Grandfather's death, we lived right next door to each other in Wassenaar and both lived in houses designed and built by my father. This privileged geographical position meant that I was able to destroy his concentration, totally, on many occasions. However, all I can recall is a slow and purposeful bowing of the head and a pair of warm blue eyes peering over the top of a large pair of glasses doing their utmost to be stern but, it has to be said, failing miserably.

Not only was his stature imposing (he was well over six foot tall) but his sense of humour was also immense. Any of you, who might have had the good fortune to have had a deal of warmth coupled with a well developed sense of fun.

When Opa heard either me or my sister nearby, he would often emerge from his desk with that same way of looking over his glasses but, on these occasions, his eyes would be filled with total confusion. He would be holding an envelope in one hand a stamp in the other. Then, this man, whose genius was recognised across many continents, would say "What do I do with these?" Some genius! Do you

know, it was years after his death that I realised finally just how many times my sister and I fell for that one.

My mother recalls how infuriating it could be to have such a talented father. All three of the children did their best to learn to play the piano. Unfortunately, my Grandfather had "perfect pitch" and could shout down from upstairs not only that the wrong note had been struck but precisely which note it should have been.

But teasing did not always go his way. As a joke, when my Aunt Dora was about ten, my Grandfather asked her if she knew if there were any dirty words in the dictionary. Indignant, Aunt Dora told him she would never look for such a thing. Miraculously, however, she was able to assure him that there was none.

Sadly, my grandfather died when I was still a little boy and, although proud of his achievements, I most remember and miss the man, my Opa; a hard act to follow in every way.

When I was invited to come here today, I asked if it would be possible to have some information about the winner of the award. I was impressed by how full his career has been and how much he had achieved. But, what caught my eye in particular was a paragraph from the letter of nomination written by Professor Susan Avery from the University of Colorado. It contained the following paragraph which I quote: "As an indication of Professor Harrington's influence on all of us in fields and waves, a distinguished scientist once told me the following anecdote. It seems that when he begins a new research problem, he clears his desk of all papers and books so that he can begin fresh and without clutter. Three days later, when he views his desk, it contains his work notes, two handbooks with his favourite integrals and special functions and his copy of Harrington's book "Time-Harmonic Electromagnetic Fields. This is not an unusual story. His admirers are legion and his distinguished reputation richly deserved." I feel sure you will all agree that this is a powerful testimonial.

It is, therefore, with the greatest of pleasure and respect that I present the Balthasar van der Pol Gold Medal for "Contributions to electromagnetics and the development of the method of moments" to Professor Roger Harrington.

Reply by Professor Roger Harrington

I am honored by your recognition of my work. It is very gratifying to be chosen from all the well-qualified workers in the field of radio science. I have worked in this field for many years and have enjoyed every moment of it.

I will use this opportunity to give a short history from my viewpoint of the origin and development of the method of moments for field computation. The basic idea of taking linear functional equation and representing it by a linear matrix equation is relatively old. Galerkin, a Russian mechanical engineer, developed his method around 1915, before it had a firm mathematical basis. Quantum mechanics, developed in the 1920's, used many of the ideas of linear spaces and their extension to Hilbert spaces. However,

before the advent of the high-speed computer, these methods were not popular because of the tedious computation required for their use. They were often thought of as a last resort numerical methods, to be used if everything else failed. In truth, however, they are no more numerical than other so-called analytical methods, at least if used properly. They merely emphasize a different aspect of mathematics, that of linear spaces and orthogonal projections.

In the mid 1960's several researchers started solving the electromagnetic field equations by numerical methods. Mei and Van Bladel used a subsectional and point-matching method to compute the scattering from rectangular cylinders. The accuracy obtained from these numerical solutions was

impressive, but, being brought up on variational solutions, I thought that even greater accuracy could be obtained by the latter method. I had been taught that "a parameter could be calculated correct to the second order if a function correct to the first order is used in a stationary formula." Hence, if I used a numerical solution for the current in a stationary formula for scattered field, I should get an order of magnitude higher accuracy for it than obtainable from a numerical solution. Or so I thought. I tried it for the simple case of scattering from a cylinder, and to my surprise I got exactly the same answer as obtained from the numerical solution.

Also during the early 1960's I was teaching a course on the use of linear spaces for applied mathematics, using Friedman's book. When it became available in the English translation, I also studied the Russian book by Kantorovich and Krylov. It became apparent to me that Galerkin's method was formally equivalent to the Rayleigh-Ritz variational method, and also to Rumsey's reaction concept. But the numerical method being used by researchers in electromagnetic theory was not really Galerkin's method. They used the apparently cruder methods, such as subsectional expansion and point matching. Were these also variational methods?

The answer was yes, at least in concept. There was no good reason why one had to choose expansion and testing functions the same, as was done in both Galerkin's method and in the Rayleigh-Ritz variational method. It was easier to prove mathematical theorems when they were the same, but it made solutions more difficult to calculate. One was really free to choose expansion and testing functions separately for computational convenience, and still claim that the solution was stationary in form. Next came the question as to what to call the general method. Certainly others had used it in the past, and I didn't want to introduce new jargon. After a search of the literature, I decided that the exposition most closely analogous to what I was using was that given by Kantorovich and Akilov. They called it the "method of moments," and hence that is the name I chose.

I and my coworker Dr. Joseph Mautz have been using this method for many years for many problems. Most of my graduate students have used the method in their Ph.D. dissertations. Many of my professional colleagues have used it in their work. Whole sessions on the method of moments have been scheduled for technical symposia. I am proud to have been instrumental in developing and popularizing this powerful method.

Presentation of the John Howard Dellinger Gold Medal

Professor David C. Chang, President of the US National Committee for URSI, gave a short introductory speech :

The Dellinger Award was established in 1964 in honour of the memory of former URSI Vice-President and Honorary President, John Howard Dellinger. Dr. Dellinger was an eminent U.S. radio scientist who devoted his career to science in public service as a leading figure in the U.S. National Bureau of Standards.

The Dellinger Medal is presented triennially to a scientist who has distinguished himself or herself in an area

of radio science within the purview of the Ten Commissions of URSI.

The 1996 recipient of the Dellinger Medal is Professor Tomohiro Oguchi, "For theoretical work on the polarization effects of non-spherical raindrops and the multiple scattering effects of hydrometeors."

On behalf of the United States National Committee for URSI, I take pleasure in presenting to you, Professor Oguchi, the Dellinger Gold Medal and this certificate proclaiming you the awardee. Congratulations!

Reply by Professor Tomohiro Oguchi

I am greatly honoured to receive the 11th John Howard Dellinger Gold Medal, and I want to thank the URSI Board of Officers for the recognition of my work which is in a little known branch of radio science.

Dr. Dellinger's prominent contributions to both the study of ionospheric propagation and the development of URSI were well known to me, because a very large number of people were concerned with ionospheric physics and ionospheric propagation when I joined the Radio Research Laboratory, Which is presently the Communications Research Laboratory, in 1956. Although my specific research field is the propagation of microwaves and millimeter waves in rain, and my contribution is limited

compared with Dr. Dellinger's many highly significant contributions, I feel very honoured in receiving the medal that bears his name since, in a broad sense, I am in the same research field of radiowave propagation.

During the course of my research, I have been influenced by and have benefited from valuable personal interactions with many scientists, including my supervisors and colleagues at the Communications Research Laboratory and those at the Commission F Meetings of the Japanese URSI Committee. I would like to extend my heartfelt gratitude to those people on this occasion. Unfortunately, they are too numerous to be named here. Nevertheless, if I were to be asked to mention the name of one person, that

would no doubt be Professor Sogo Okamura, who has continuously been involved in various matters of our Union, and was Vice President of the Union from 1981 to 1987. When I joined the Millimeter Wave Research Section of the Radio Research Laboratory as an inexperienced young staff member, he served concurrently as Chief of that section, in addition to his professorship at Tokyo University. He persuaded me to do research on the effects of rain on the propagation of millimeter waves. This has given me strong motivation and direction in my research until the present day. It gives me very great pleasure that Professor and Mrs. Okamura



Professor David C. Chang congratulates Professor T. Oguchi, Laureate of the 1996 Dellinger Award for "theoretical work on the polarization effects of non-spherical raindrops and the multiple scattering effects of hydrometeors".

have been able to attend this Award Ceremony in person.

My first experience of attending a URSI General Assembly was the Tokyo General Assembly in 1963. It was an exciting experience for a novice in the scientific community. From about 1973, I have had the opportunity of attending the General Assemblies and Commission F Open Symposia of the Union. Nothing is more important to me in the development of my research than free discussions which have allowed me to become acquainted with many excellent scientists from various countries. I wish to express my sincere gratitude to those scientists in accepting the Dellinger Gold Medal. Thank you very much.

Presentation of the Appleton Prize

The Appleton Prize was presented by Professor T.B. Jones, President of the URSI Committee in the United Kingdom (U.K. Panel for URSI). He made the following comments :

The Appleton Prize is awarded to a distinguished scientist in the field of Ionospheric Physics by the Council of the Royal Society on the recommendation of the Board of Officers of URSI. The Prize commemorates the life and work of Sir Edward Appleton who was a former President of URSI and who received the Nobel Prize for his work in Ionospheric Physics and Radio Propagation.

The present recipient, Professor Don Farley, is well known for his pioneering work on radar studies of the ionospheric and the underlying plasma physics necessary to interpret these observations. He was a student of Henry Booker, who was himself a student of Sir Edward Appleton. It was during a visit to Cambridge, where Sir Edward once held the chair, that Don Farley developed the correct plasma

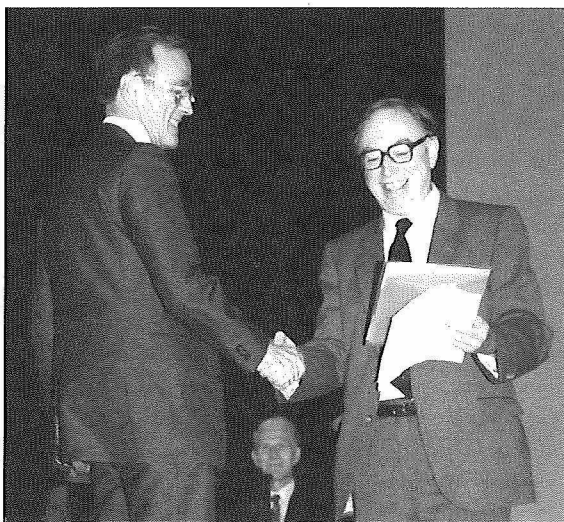
kinetic theory to account for the then newly discovered phenomena of Incoherent radar backscatter. It was through this pioneering work that the incoherent backscatter technique has now become the most powerful radio method

for studying the ionosphere and the magnetosphere.

Professor Farley has contributed in many areas of radio science, for example, his long association with the incoherent scatter facility at Jicamarca, Peru; his work at Cornell on plasma theory, including the well known Farley-Buneman instability; and the application of coherent radars for observing auroral and equatorial zone irregularities.

Professor Farley has made major contributions both to experimental and theoretical study of the ionosphere, thus continuing the tradition established by Sir Edward Appleton.

The citation for his award reads : For contributions to the development of the incoherent scatter radar technique and to radar studies of ionospheric plasma instabilities."



Professor T.B. Jones presenting the Appleton prize for "contributions to the development of the incoherent scatter radar technique and to radar studies of ionospheric instabilities" to Professor Don Farley.

I am enormously honoured and pleased to receive the Appleton Prize. I had the great good luck to be present when the incoherent scatter radar technique was first conceived. I was a graduate student at Cornell in 1958 and was one of the 10 - 15 people who heard Bill Gordon's first small colloquium on the subject. A few months later, Ken Bowles, an ex-Cornellian, made the first successful incoherent scatter observations in Illinois, and these indicated that the scatter was more complex than originally thought by Gordon; the ions somehow controlled the Doppler shifts even though the electrons did the actual scattering.

In 1959 I went off for a post-doctoral year at Cambridge University, at the Cavendish Laboratory, where I met Jack Ratcliffe, Tony Hewish, Martin Ryle, Ken Budden, Philip Clemmow, and Basil Briggs, among others. I also met John Dougherty, a very talented senior graduate student at the time, and he and I tried to learn some plasma physics and think about Bowles' results. We managed to work out a proper theory of the scattering process, as did several others at about the same time. It was exciting to be at the cutting edge of a new field when we were still in our twenties.

During the following year, spent in Sweden on another postdoc, I met Ken Bowles at a conference. He was building a huge incoherent scatter radar in Peru, and asked if I would like to join him. Why not, I thought! I was enjoying seeing the world, and I thought Peru sounded like an exotic place to go - which it was and is - and it would be fun to see this scattering first hand. So off I went with my wife Jennie and our two small children for what turned out to be six fascinating years at the Jicamarca Radio Observatory. Bowles taught me about the real world of experimental radar, especially that you can't always trust the data; there are always distortions that must be dealt with. Ken believed that there was no piece of equipment that he couldn't improve. He even drilled holes in our first computer a few days after it arrived and added some switches and diodes, after which it worked much better! My interests in the experimental side of incoherent scatter grew out of these years with Bowles. And he showed me the radar data that first suggested to me that the ionospheric plasma can be unstable and generate spontaneously growing waves.

All scientists know that we stand on the shoulders of those who have gone before us. Henry Booker, a wise and gracious man whom many of you knew, was my thesis advisor. Booker's advisor was Jack Ratcliffe at the Cavendish, who overlapped there with Sir Edward Appleton himself. And Appleton overlapped with J.J. Thomson, who first calculated the scattering cross section of an electron, a calculation that Bill Gordon actually repeated in his first musings about incoherent scatter. An interesting set of links, and in view of this prize, I find it pleasing, and only a slight stretch, to think of myself as a direct "descendant" of Appleton's - his great-grandstudent, you might say.

An aspect of science that is particularly satisfying to those of us in academia is watching our students develop. We are pleased when they do well, and so I am happy to see that one of my ex-students, John Sahr, is the Booker Fellow at this General Assembly, and two others, Dave Hysell and John Cho, are URSI Young Scientists. Elaine Chapin, another URSI Young Scientist, was a student of one of my students, Erhan Kudeki. That makes Elaine something like Appleton's (great)³-grandstudent! I am sure that many of our students teach us more than we teach them - especially about computers. I recently made the painful switch from a friendly Macintosh to a hostile Unix machine, with the help of much patient tutoring from several of my students and ex-students.

I would like to single out and particularly thank two of my colleagues, Wes Swartz and Ron Woodman, with whom I have worked for many years and who have contributed a great deal to incoherent scatter and other research at Jicamarca.

Finally, I would like to thank my wife Jennie, who has followed me around the globe during a total of 10 years overseas, at some cost to her own career, dealing with three new foreign languages and raising three children born in three separate countries. I am reminded of a story that she and I heard at an extremely elegant banquet in Sweden 11 years ago, but I won't burden you with that story here. Jennie tells it much better than I do anyway, and I am sure she will oblige anyone who is interested.

Thank you all for this honour: I have been to every General Assembly since 1960, and this is one I will not forget.

Presentation of the Issac Koga Gold Medal

Presentation of the Issac Koga Gold Medal by Dr. Yoji Furuhashi, President of the URSI Committee in Japan.

It is a great pleasure for me, as the President of the URSI Committee in Japan, to present the 1996 Issac Koga Gold Medal to Dr. Zoya Popovic, Professor of the University of Colorado in the United States of America.

I would like to start by describing briefly the rules for the Issac Koga Gold Medal, as well as the career of the late Professor Koga. The Medal is endowed to a young scientist under age 35 who has made outstanding contributions to

any of the branches of science covered by the ten Commissions of the URSI. It honors the memory of the late Professor Issac Koga, who was Vice President of the URSI from 1957 to 1963, President of the Union from 1963 to 1966, and Honorary President from 1981.

Professor Koga was born in Japan in 1899. He studied at the University of Tokyo, and became, first, Professor at the Tokyo Institute of Technology; later, Professor at the University of Tokyo; and finally, Dean of its Faculty of Engineering.



Professor Zoya Popovic accepting the Issac Koga Gold Medal for "contributions to the field of active microwave circuits, in particular, the original demonstration of the planar grid oscillator, as well as continuing efforts with quasi optical amplifiers and active antennas" from Dr. Yoji Furuhashi.

Professor Koga's researches covered a wide variety of topics in radio science. Particularly noteworthy among these was the invention, in 1932, of a piezo-electric crystal oscillator having an almost zero frequency-temperature coefficient. This is widely known as the Koga-cut crystal, and has been used in a variety of applications, in particular to international radio communications and broadcasting.

Professor Koga was a strict educator of young students and researchers, but at the same time a warm-hearted research leader. When he passed away in 1982, the URSI Committee in Japan proposed the establishment of this Gold Medal for young scientists in commemoration of Professor Koga as a great educator as well as a distinguished researcher. The first Koga Medal was awarded twelve years ago at the General Assembly in Florence, and this is the fifth award.

Let me now mention the distinguished scientific achievement of Prof. Zoya Popovic, for which she is receiving the 1996 Issac Koga Gold Medal today. The citation for the award mentions that she has made highly significant contributions to the field of active microwave circuits, in particular, the original demonstration of the planar grid oscillator, as well as continuing efforts with quasi-optical amplifiers and active antennas. Prof. Popovic, would you accept our hearty congratulations?

Reply by Professor Zoya Popovic

Thank you very much Mr. President for this big honour. I am aware that there are many people who deserve it more than I do, but gladly accept the luck.

I would like to thank all of my teachers. I only dare to hope that one of my students will some day thank me in front of this audience. In particular, I thank my PhD advisor and friend David Rutledge from Caltech for showing me what good research is. Dave also convinced me that you can get a lot done if you start at 5 in the morning.

Another of my teachers, Branko Popovic from the University of Belgrade, Serbia, who I took my first EM course from, also happens to be my father. Dad, thanks to you and Mom for teaching us that work is fun (as well as Maxwell's equations). My two younger sisters, Milica and Sofija (both grad students in electrical engineering at the University of Toronto and Northwestern), trained me well throughout our childhood with hard questions I was expected to know all the answers to.

The University of Colorado is a wonderful school with extremely competent people and I have made many good colleagues and friends - thanks go to Susan Avery, Ed Kuster, David Chang, KC Gupta, Lloyd Griffiths, Tim Brown, Alan Mickelson; Lucy Pao, Dana Anderson and many others.

My graduate students, of course, do all the work. They are busy now teaching my classes and maintaining the lab - in their absence I will admit that they are all excellent young people with bright professional futures ahead of them.

Finally, I thank my husband Srdjan Basta for his patience and my daughters Nina and Lena for helping me keep things in perspective.

Let me also thank our hosts: "Je suis très heureuse de pouvoir remercier (en Français) pour le prix que le jurie de l'URSI a trouvé bon de me décerner cette année. Ce prix, pour moi, sera à la fois un honneur et un encouragement dans mes futures recherches scientifiques. Merci encore une fois."



CONFERENCE REPORTS

SECOND INTERNATIONAL SCHOOL OF ATMOSPHERIC RADAR (ISAR 2) AND THE SEVENTH WORKSHOP ON TECHNICAL AND SCIENTIFIC ASPECTS OF MST RADAR (MST7)

Hilton Head Island, South Carolina, USA, 7 - 11 November 1995

The Seventh Workshop on Technical and Scientific Aspects of MST Radar (MST7) was held 7th-11th November 1995 at Hilton Head Island, South Carolina, USA. It was preceded by the Second International School of Atmospheric Radar (ISAR2) held on Sunday and Monday, 5th-6th November 1995, at Hilton Head. The co-conveners of MST7 and ISAR2 were C.H.Liu, J. Röttger, S. Fukao, and M.F.Larsen.

The ISAR2 was attended by eighty-one participants. A total of eight lectures were given at the ISAR2, covering theory, and experiments on hardware for atmospheric radar. Lecture notes were available to the participants. The lectures were:

- Signals from Scatterers in Turbulent Flow (R.J.Doviak)
- Atmospheric Radar Hardware (I.M.Reid)
- Radar Signal Processing (D.T.Farley)
- Introduction to Radar Techniques for Studies of the Ionosphere, Mesosphere, Stratosphere, and Troposphere (J.Röttger)
- UHF and VHF Techniques (T.Tsuda)
- Spaced Antenna and Interferometer Methods (E.Kudeki)
- MF, HF, and Meteor Studies of the Middle Atmosphere (W.K.Hocking)
- Radar Studies of Gravity Waves and Turbulence (R.A.Vincent)

Following this School, the Workshop MST7 took place from Tuesday to Saturday. One hundred and fifty-nine abstracts were submitted, indicating the broadened interest of the expanding MST radar community. The papers were presented orally in ten sessions with the topics given below (session conveners in brackets). In addition, there were two well-attended poster sessions. Posters showing summaries of existing and planned facilities were on display throughout the Workshop as well. The Workshop sessions were:

- Scattering Processes and Interpretation of MST Radar Echoes (S.Fukao)
- Gravity Wave and Turbulence Studies (W.K.Hocking)
- Combined MST Radar and Optical Measurements (L.Thomas)
- Combined MST/ST Radar and other Ground-based, In-situ or Space-borne Measurements (S.K.Avery)
- Comparison of Wind, Wave, and Turbulence

Measurements Obtained with Different Techniques (M.Yamamoto)

- Signal and Data Processing (T.Sato)
- Mesosphere Summer Echoes, Meteor Echoes, and Ionosphere Echoes (J.Y.N.Cho)
- Meteorological Applications (M.F.Larsen)
- Multiple Receiver/Interferometer Techniques (R.D.Palmer)

- New Hardware Developments and Systems (S.J.Franke)
A total of 124 oral and 29 poster papers were presented, and the total number of Workshop participants was 127. Extended abstracts of many of these papers will be printed in the Workshop Proceedings. Selected papers are scheduled to appear in a special issue of Radio Science.

A plenary session was held on the last day of the Workshop to summarize highlights of the sessions. It was noted that a Joint Working Group AFG1. The Middle Atmosphere, comprising URSI Commissions F and G, was established at the 1993 URSI General Assembly. The functions of this joint Working Group are to promote scientific activities concerned with atmospheric radars and other related techniques applying radio waves, coordinate organization of future MS Workshops and ISARs, collect and formulate recommendations to URSI Commissions F and G and advise them of related activities.

The activities of a task group to define accuracies required for specified investigations and wind profiler applications of MST radar were acknowledged and their continuation and extension found full support by the plenum.

Recommendations/resolutions to be presented as resolutions to URSI Commissions F and G and SCOSTEP were adopted as follows:

Resolutions on Equatorial Observations

Considering that the equatorial atmosphere is closely coupled with other parts of the earth's atmosphere and gives a significant influence to global weather and climate, and that a variety of observations have been extensively conducted there with very little coordination made among the observations, and

Recognizing that little effort has been realized in coordinating these observations despite the recommendations made by international bodies like URSI

and SCOSTEP, and

Noting that the MST community has the vast potential to contribute to the related research in these fields,

It is recommended that those international bodies should take all effective measures to realize these efforts to make truly international collaboration feasible in the equatorial atmosphere observations.

Considering the fact that high emphasis is presently developing to study the Polar ionosphere and upper atmosphere by incoherent scatter radar as well as supporting instrumentation and satellites,

It is resolved that MST and MF radars should be added to these upper atmosphere facilities for studying also the middle and lower atmosphere.

Recommendation on Training Courses and Schools

A recommendation was also adopted by the plenum to foster training courses and schools to be held by a small group of experts at radar sites on demand.

This Workshop MST7 and the School ISAR2 were sponsored by SCOSTEP, Clemson University, the National Science Foundation, and URSI. Thanks are expressed to the local organizers of ISAR2 and MST7, in particular Miguel and Patti Larsen from Clemson University for their tremendous and very productive work to make these activities at Hilton Head a great success.

Jürgen Röttger and Chao-han Liu

WAVE PROPAGATION AND REMOTE SENSING

Ahmedabad, India, 20 - 24 November 1995

The Seventh Triennial International Open Symposium of URSI Commission F was held in Ahmedabad, India, on 20-24 November 1995. The first of these symposia was held in la Baule (France) in 1979 and subsequent ones were in Lennoxville (Canada), Louvain-la-Neuve (Belgium), Durham, (New Hampshire, USA), La Londe-les-Maures (France) and Ravenscar (UK). The 76 people participating were from 17 countries, and the symposium maintained its tradition of a high standard of papers, informality and lively discussion. The symposium was hosted by Institution of Electronics and Telecommunication Engineers (IETE). Chairman of the General Organising Committee was Professor O.P.N. Calla. Chairman of enjoyable meeting, each of us taking away various new insights from this relaxed occasion.

Rather than have parallel sessions, the programme was divided into presentation papers and poster papers. In the conference proceedings volume, no distinction was made between the two authors of poster papers were invited to bring viewgraphs for use should gaps in the presentation session become available. In the event, 5 such gaps were filled, so that a total of 57 papers were presented and 12 posters were displayed, all to a good standard. Session titles

could only be illustrative of 8 topic areas: modelling, remote sensing, radiowave propagation (2 sessions), scattering, mobile radiowave propagation, climatic parameters and radar meteorology.

Having held Climpara'94 in Moscow undoubtedly increased the number of papers from Russia and the other New Independent States of the FSU. There were also a very large number of papers from India. It was a loss that about half the presentation papers from the FSU were not presented, largely with prior warning, but it did not seriously detract from a meeting at which many new people took an active part and many long-time participants were as fully involved as ever.

As well as buffet dinners and lunches, a midweek half-day visit was organised to an elaborate ancient well, to a modern large shrine complex and to an evening of village-style dinner and local dances. In the closing session, appreciation was expressed to having informality, short presentations (20 minutes including adequate discussion), close interaction in a small group, the poster session, the balance of remote sensing and wave propagation, and the local hospitality, atmosphere and food.

Martin P.M. Hall

INTERNATIONAL CONFERENCE ON ATMOSPHERIC ELECTRICITY

Osaka, Japan, 10 - 14 June 1996

The 10th International Conference on Atmospheric Electricity was held at Royal Hotel, Osaka (Japan) during the period of June 10-14, 1996. It seems to me that the conference was a great success, with the number of participants over 200 (one half: Japanese and another half: foreign scientists).

163 papers were presented in sixteen sessions; and those papers were roughly classified into three categories; (1) lightning, (2) atmospheric electric fields and ions and

(3) seismogenic phenomena. The first category included thunderstorm electrification (I), (II), (III), lightning discharges (I), (II), lightning detection and protection, lightning characteristics (I), (II), winter thunderstorms, triggered lightning, cloud-to-ionosphere coupling, and Schumann resonances and sferics. We will show some interesting outputs from these sessions. The first one is the lightning detection and protection. The recent development of electronics techniques including the personal computer

with the telecommunication provides us with fantastic remote sensing facilities. These are the magnetic direction finding (DF) system, the time of arrival (TOA) system and they presented scientifically interesting results based on this system. The idea of a combination of magnetic DF and TOA was also reported, and the concept for the new system was proposed. The VHF/UHF interferometer enabled us to see the charge distributions inside the thunder cloud as the location of electrical discharges. The second item is winter thunderstorms. Lightning activities during winter thunderstorms in Japan has been believed to show anomalous features. Twelve papers on this item were presented and we had hot discussions. One of the conclusions of this session is that the international cooperative research is necessary since we do not know the physical mechanism of winter thunderstorms sufficiently. The polarity of the lightning discharges is also an interesting subject, and the research on this subject is still going on. The last item is triggered lightning. The artificially triggered lightning experiments were conducted in US, France, China, Indonesia, Russia, and Japan. These experiments gave us the key for understanding the physical mechanism of discharge initiation. They provided us with the techniques of the protection schemes of electrical power lines including several apparatus against the lightning strike and its huge current. Moreover, the induced currents on the power line

due to the lightning strike can be examined theoretically and experimentally. Interesting papers were presented in the new field of cloud-to-ionosphere coupling. New features of red sprites, blue jets and elves attracted the attention of the audience, and the mechanism and the related consequences of VLF trimpis are also interesting. In relation to this field, several papers on ELF wave phenomena were presented such that ELF Q bursts were the consequence of red sprites, whose characteristics were extensively studied. Also, the background noise of Schumann resonance was studied as a possible indicator of global warning.

Another new subject was the atmospheric electromagnetic phenomena associated with earthquakes. Outstanding results on the seismo-electromagnetic phenomena in a wide frequency range (DC, ULF, ELF, VLF, and HF) were presented to suggest their possible use for the earthquake prediction. ULF signature was reported for the Guam earthquake occurred on August 8th, 1993, and then a comparison of seismogenic VLF emissions with the VLF sferics was extensively studied in order to distinguish between the two. Furthermore, anomalous behaviours in the subionospheric VLF (Omega) signals were found for the Kobe earthquake and they attracted a lot of attention.

Some Proceedings of this conference are still available and you can have a copy at a price of 5,000 Yen by contacting the following person.

Masashi Hayakawa

CLIMPARA'96

Oslo, Norway, 10 - 11 June 1996

Climpara'96 hosted by the Norwegian Telecommunications Administration and Telecom AS, was a special interest URSI Commission F Workshop held in Oslo on 10-11 June 1996. Its subject matter was 'Climatic parameters in radiowave propagation prediction'.

There were 39 participants from 19 countries, with a schedule of 8 personal reviews of contributions to the topic area and 20 papers on recent relevant activities. The proceedings contain 24 of these papers. There were sessions of structured discussions led by people with particular experience in the four main areas being considered: clear air, cloud, precipitation and mapping. There was lively discussion in these structured discussion sessions as well as after individual presentations.

Climpara'96 was immediately followed by parallel meetings of ITU-R Working Parties 3J and 3M which were giving some emphasis to the same general topic area. A clear distinction was made between the radio science of Climpara'96 and the radio engineering applications of the ITU-R WP meetings, but the mutual benefit of running the

meetings in serial were widely commented on. Many people found it possible to participate in both areas where normally they would participate in only one.

To some extent Climpara'96 built on the experience of Climpara'94, which was a special-interest URSI Commission F Open Symposium held in Moscow in June 1994. It included invited Keynote presentations, submitted research presentations, workshop sessions and a poster session (see URSI Radio Scientist and Bulletin, September 1994, pp 8-9). Climpara'96 also followed to some extent on the pattern of the URSI Commission F Special Open Symposium held in Rio de Janeiro in December 1990, on a similar theme (see URSI Bulletin June 1991, pp 23-26). That meeting was also followed immediately by concurrent meetings of these closely associated with these issues in two Working Parties of ITU-R. This arrangement enhanced the exchange of ideas and information on this topic between the two communities. There is already support for Climpara'98!

Martin P.M. Hall

CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS, CPEM'96

Braunschweig, Germany, 17 - 20 June 1996

The Conference on Precision Electromagnetic Measurements, CPEM'96, took place in the Civic Hall of Braunschweig, Germany, from 17 June to 20 June 1996. This Conference which is permanently sponsored by URSI has acquired an outstanding reputation over more than three decades as an international forum for precision electromagnetic measurements. It is held every two years, either in the USA (or Canada) or in a country outside North America. Besides the URSI, other permanent sponsors of the CPEM are the Bureau International des Poids et Mesures (BIPM), the IEEE Instrumentation and Measurement Society, the National Institute of Standards and Technology (NIST), USA, and the National Research Council (NRC) of Canada. The Commission A Chairman is a member of the CPEM Executive Committee. Traditionally, the Conference is organized mainly by members of the hosting national institute of metrology, but individual members of URSI are involved to a considerable extent. The CPEM was held in Braunschweig for the second time, after 1980, and again was organized by the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig. The Conference Chairman was Professor Volkmar Kose, Vice President of the PTB.

The number of attendants has considerably increased from about 470 at the CPEM'94 to about 600 scientists from 42 countries, who participated in the Conference this year. An increasing interest of companies and national calibration services in precision electromagnetic metrology was also observed. In 26 oral and 28 poster sessions, about 350 papers and posters were presented, among these 16 invited talks. One oral session was dedicated to post-deadline papers. The authors of the }best poster of the day} were honoured with a prize. In an extended Young Scientists Program, a financial contribution to the travel expenses was given to 23 young scientists from 13 different countries. Candidates to be included in this program were suggested by the members of the CPEM Honorary Committee, and the final selection was made by a commission of members of the CPEM Technical Program Committee. An additional financial contribution by various institutions allowed financial aid to be given to another 60 participants from developing countries and East European states.

The Conference opened with three plenary papers held by outstanding scientists who introduced three of the essential topics of CPEM'96: Nobel Laureate Klaus von Klitzing, Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany, gave an overview of new developments in the field of the Quantum Hall Effect (QHE). It was at CPEM 1980 in Braunschweig, that he gave his very first report on this effect before an international audience, for the discovery of which he was later awarded. In the two other lectures, Konstantin Likharev, State University of New York, Stony Brook, USA, reported on electronic devices in the nanometer range, the characteristics of which

are determined by single electrons, and Herbert Walther, Max-Planck-Institut Garching, Germany, reported on the quantum optics of single atoms. Following the Plenary Session, Richard Deslattes, Klaus von Klitzing, Volkmar Kose, Konstantin Likharev, and Barry Taylor were appointed Honorary Members of the Academy of Metrology of Russia by Professor Yuri Tarbeyev, Director of the Mendeleev Institute of Metrology (VNIIM), St. Petersburg.

Compared with the 1994 Conference, the number of submitted papers on frequency standards and electric quantum standards has considerably increased. Many of these sessions were dedicated to topics such as cesium beam and optical frequency standards and metrology, and time keeping and distribution, as well as to the different aspects of quantum metrology and fundamental constants. In the field of frequency standards, new fountain geometries and mechanisms of excitations are being developed and investigated, which will allow the uncertainty of Cs clocks to be reduced. On the other hand, novel optical frequency standards are developed on the basis of laser-cooled atoms and ions. As radiation sources for these standards, lasers are used which are based on new technologies such as laser diodes or solid-state lasers pumped by laser diodes and whose efficiency is considerably larger although their dimensions are small. It was reported that, for the first time, the frequency of the radiation of an optical Ca frequency standard could be successfully traced back to the frequency of the primary frequency standard (i.e. the Cs atomic clock) with coherent phase, thus reducing the uncertainty of the realization of the unit of length by a factor of 25.

Among the highlights in the field of electrical metrology were reports of the National Metrological Laboratory (NML) in Lindfield, Australia, and of the NIST, USA, on new determinations of the von Klitzing constant. T. Kinoshita, Cornell University, USA, presented a corrected value for the fine structure constant, which has been obtained, using quantum electrodynamics methods, from the experimentally determined anomalous magnetic moment of the electron. J. Martinis, NIST, Boulder, USA, reported on the development of an electron pump using the single electron tunneling effect (SET) and consisting of seven SET elements by which the charge of a capacitor is determined by counting the electrons with a relative uncertainty of 10^{-7} . In several sessions, a large number of papers covering DC and AC measurements, magnetic measurements, power, energy and high voltage measurements and SQUIDS were presented. Several groups reported on precision AC measurements of the QHE. About 20 papers dealt with AC-DC transfer. As a further step towards a more accurate value for the Avogadro constant, the molar mass of a silicon single crystal could be precisely determined by prompt (n, g)-spectrometry. The CPEM'96 included for the first time sessions on novel sensors and automated measurement methods and their

applications in precision metrology. In these sessions, too, all papers were well received, followed by extensive discussions which indicated the significance of the topics chosen.

In the field of RF measurements, 61 papers were presented in five oral and five poster sessions, which covered topics such as microwave and millimeter wave metrology, power and noise metrology, network analysis and antennas and EMC, including an invited talk by K. H. Gonschorek, Dresden Technical University, on modern computer tools for EMC analysis. There were two very informative reports on RF power standards in the Eastern European countries. Among the highlights were an invited paper on the development of RSFQ shift registers of 8 bit length for applications in RF noise metrology, which will operate at a clock frequency of about 70 GHz, and a paper describing a novel thin-film barretter in 3,5 mm coaxial technique serving as a broad-band RF power standard for frequencies up to 26,5 GHz with high efficient efficiency and low reflection. Two sessions on material measurements also aroused lively interest; these sessions also included

several papers on permittivity measurements at high temperatures.

Concurrently with the Conference, a very well-attended exhibition was held by more than 20 firms from the USA, the UK, Japan and Germany presenting precision measuring instruments.

Copies of the Digest of the CP EM'96 (IEEE Catalog Number 96CH35956) can be ordered from the IEEE Service Center, Conference Publications, Mrs. Pat Thompson, 445 Hoes Lane, P.O.Box 1331, Piscataway, NJ 08855-1331, USA. A selection of full Conference papers will be published in the April 1997 issue of the IEEE Transactions on Instrumentation and Measurement.

The next Conference (CP EM'98) will take place at the Renaissance Washington D.C. Hotel in Washington, D.C., USA, July 6 - 10, 1998. The Conference Chairman is Norman B. Belecki of NIST, Gaithersburg, the Conference Secretary is Katherine H. Magruder (Fax: 1(301)926-3972, E-mail: katherine.magruder@nist.gov, see also: <http://www.eeel.nist.gov/cpem98>).

Ulrich Stumper

13TH INTERNATIONAL WROCLAW SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

Wroclaw, Poland, 25 - 28 June 1996

The first Wroclaw Symposium on Electromagnetic Compatibility was held in 1972, when there was no regular conference on that topic in Europe. Since 1976 this biennial gathering has been successful in attracting world-class personalities and leading global organizations. Among others, Professor F.L. Stumpers, Honorary President of URSI, has directed without interruption the Program Committee over the twenty years of its existence. The symposium has enjoyed the sponsorship and cooperation of the most prestigious global organizations such as the International Union of Radio Science - URSI, the International Telecommunication Union - ITU, the International Electrotechnical Commission - IEC, the Institute of Electrical and Electronics Engineers - IEEE, to list only few of them.

The First International Wroclaw EMC Symposium was held in 1972. As it can be seen, year 1982 was peculiar: program, authors, papers and Proceedings were ready, but there were no participants. Because of the martial law status declared in Poland, the organizers decided not to gather participants. Over the years, the Wroclaw symposium earned recognition of the scientific and engineering world. In his review of URSI activities from 1922 until 1995, at the occasion of 75 anniversary of URSI, Dr. P. Bauer wrote in *The Radio Science Bulletin* (No. 277, June 1996, page 17):

Our Commission on Electromagnetic Noise and Interference deals, among others, with terrestrial and planetary noise of natural origin and man-made, the composite noise environment the effects of noise on system performance and the scientific basis of noise and inter-

reference control. Ever since 1975, the Commission participates actively in the planning and organisation of the very successful series of international symposia on Electromagnetic Compatibility, which are held alternatively in Wroclaw and in Zurich. According to our Honorary President, Professor Stumpers: EMC is really a multidimensional field of research and, in our highly technological civilisation, an indispensable one.

The history of the twenty four years during which the Wroclaw EMC symposium gathered every two years eminent scientists, engineers and administrators from around the world confirms that opinion. As in previous years the 1996 Symposium was organized by the Association of Polish Electrical Engineers, the Institute of Telecommunications, and the Wroclaw Technical University. It was co-sponsored by URSI and supported by other international organizations as well as by national associations of electrical and electronics engineers from 21 countries.

The Symposium Council was chaired by Prof. W. Majewski (Poland) with v-chairman Prof. A. Pilatowicz (Poland), and the Scientific Program Committee by Prof. F.L.H.M. Stumpers (The Netherlands) with v-chairman R.G. Struzak (Poland). The co-chairmen of the Symposium were Prof. D.J. Bem and Mr. J. Rutkowski, and the Organizing Committee was chaired by Mr. W. Moro.

There were 298 participants from 31 countries. The most numerous groups were from Poland (140), Russian Federation (29), Germany (18), Japan (15), Italy (10), Hungary (8), France (7), Switzerland (7). Some people

came from Canada, Egypt, Israel, Korea (Rep. of), Turkey.

Proceedings containing 161 papers accepted for presentation, delivered by 317 authors and co-authors from 32 countries were available to all the participants at the opening the Symposium.

On the day before the Symposium three events took place : URSI Commission E on EM Noise and Interference Open Meeting on EM noise and its impact on systems and equipment (chairman: Prof. V. Scuka, Sweden); COST 243 Electromagnetic Compatibility Workshop on EMC in Telecommunications (chairman: Prof. P. Corona, Italy); Tutorial EMC-Adequate-Design of Printed Circuit Boards (Simulation-Analysis-Measurements) given by Dr. W. John from Siemens Nixdorf Informationssysteme AG, Paderborn, Germany. On the day after the Symposium one event took place : COST 244 Biomedical Effects of EM Fields plenary meeting.

The Symposium was opened by its chairman, Prof. D.J. Bem. PTT V-minister, Dr. M. Rusin greeted the audience on behalf of Symposium Patron.

Three plenary sessions were held on the first three days of the symposium. The following papers were presented: EMC-Globalisation: The Role of Scientific Societies" by Dr. F. Mayer (France), representing IEEE-EMCS; EMC of Printed Circuit Boards and Microelectronic Engineering Techniques" by Dr. W. John (Germany); Key Issues in Spectrum Management" by Prof. R.G. Struzak (Poland); and Menace to Human Environment and Biological Effects of EM Radiation of Unspecified Frequency and Intensity Caused by Careless High Technology Implementations in the Near Future" by Prof. T. Yoshino (Japan).

Twenty five regular and nine poster sessions covered different fields of EMC.

The following invited sessions were organized:

- Terrestrial EM Noise, organized and chaired by Prof. M. Hayakawa (Japan);
- Lightning, EMP and LEMP - I and II, organized and chaired by Prof. M. Ianoz (Switzerland);
- EMC for PCB Design and Microelectronic Applications, organized and chaired by Dr. W. John (Germany),
- Electrobiolgy for Defeating Cancer and Other Diseases, co-organized by Prof. H. Kikuchi (Japan), and co-chaired by Prof. H. Kikuchi and Prof. S.F. Alfas (Denmark);
- EMC in Wireless Communication Systems, organized by Prof. W.C. Lee (USA), and chaired by Prof. K. Fujimoto (Japan),
- Signal Integrity, organized by Prof. I. Novak (Hungary), and chaired by Dr. F. Canavero (Italy),
- EMC Testing and Testing Requirements in View of the New European Standards Proposals, organized and chaired by Prof. A.S. Podgorski (Canada),
- Electromagnetic Compatibility in ISM Applications, organized and chaired by Prof. W.M. Van Loock (Belgium),
- EM Emissions Associated with Seismic Activity, organized and chaired by Prof. T. Yoshino (Japan);

The titles of the other sessions were:

- Antennas and Propagation, EMC Aspects (chaired by Dr. K.A. Hughes - ITU, Switzerland);
- Antennas and Propagation, EMC Aspects (poster session);
- Biological Effects of EM Radiation (poster session);
- Computational Electromagnetics - I and II (chaired by Prof. A. Karwowski, Poland);
- Education in EMC (chaired by Prof. J.A. Catrysse, Belgium);
- EMC in PCB (chaired by Prof. S. Nitta, Japan);
- EMC in Power Engineering (chaired by Prof. A. Pilatowicz, Poland);
- EMC in Wire Communication (chaired by Prof. G. Varju, Hungary);
- EMC Measurements and Instrumentation - I (chaired by Mr. M.C. Vrolijk, The Netherlands);
- EMC Measurements and Instrumentation - II (chaired by Dr. D. Hansen, Germany);
- EMC Measurements and Instrumentation (poster session);
- EMC Prediction, Analysis, Modelling (chaired by Prof. S.M. Radicella, Italy);
- EMC Prediction, Analysis, Modelling (poster session);
- EMI Sources and EMI Reduction Techniques (chaired by Prof. H. Trzaska, Poland);
- ESD, Lightning, EMP (chaired by Prof. V. Scuka, Sweden);
- ESD, Lightning, EMP (poster session);
- Grounding and Shielding (chaired by Dr. F.P. Dawalibi, Canada);
- Grounding and Shielding (poster session);
- Immunity (chaired by Prof. E. Habiger, Germany);
- Immunity (poster session);
- Natural and Man-Made EM Environment (poster session);
- Spectrum Management, Engineering, Sharing, Monitoring (chaired by Prof. R.G. Struzak, Poland);
- Spectrum Management (poster session).

The review of the content of papers offered is given in the overview presented by Prof. F.L. Stumpers.

Four workshops took place during the Symposium:

- Advantages of Using a Competent Body for CE-EURO-Certification, organized by EU Association of Component Bodies. Organizer and Moderator: Dr D. Hansen from EUROEMC SERVICE, Teltow, Germany,
- Surge Voltage Protection for Data and Telecom Systems, organized by Phoenix Contact, Blomberg, Germany. Speaker: R. Hausmann,
- Inter-operability of National Spectrum Management Systems, organized by European Radio communications Office, Copenhagen, Denmark. Speaker: T. Cesky,
- Protection and Certification of Aircraft Avionic Systems from Lightning Indirect Effects, organized by Lightning Technologies Inc., Pittsfield, USA. Speaker: R. Kolodziejczyk.

Young Scientists Program was organized with the financial support of URSI. Support was offered to two young scientists (from Belarus and Russia).

The technical exhibition was held during the Symposium with the participation of 10 companies (see App. 5). The exhibition was well attended.

The literature exhibition was organized in which exhibited were the publications of international organizations such as International Union of Radio Science - URSI, International Telecommunication Union - Radiocommunication Sector and Telecommunication Standardization Sector (ITU-R, ITU-T), European Telecommunication Standards Institute - ETSI, European Broadcasting Union - EBU, European Electrotechnical Standards Committee - CENELEC, and International Electrotechnical Committee - Special Committee on Radio Interference - CISPR and Technical Committee 77 Electromagnetic Compatibility. Besides some books on EMC, spectrum management and electromagnetics, yearly editions such as ITEM, and some specialized periodicals as e.g. Microwave News were shown.

The exhibition, a unique initiative on such symposia, was well received and well attended.

A computer network with dedicated server was available to all participants to enable software presentations and in depth discussions. The network was connected to Internet. Free of charge service was offered.

A Joint Meeting of the Symposium Council, the Scientific Program Committee, and the Organizing

Committee, together with Session Chairmen was held on the last day. The meeting was co-chaired by Prof. A. Pilatowicz v-chairman of the Symposium Council, and Prof. R.G. Struzak, v-chairman of the Scientific Program Committee. Prof. Stumpers, who did not come to the Symposium, wrote a letter to participants (see App. 6) and those present at the symposium should have limited topics. More scientific atmosphere of the Symposium in comparison with some other, more commercially oriented, events was praised.

It was also emphasized that mixing of theoretical and engineering topics is very fruitful and should be retained. The positive influence of the interaction between those involved in theory and those involved in the engineering practice cannot be overestimated.

Copies of the Symposium Proceedings (740 pages) are available from:

EMC Symposium
Box 2141
51-645 Wroclaw 12, Poland
fax: +4871 728878
e-mail: emc@ita.pwr.wroc.pl

The 14th Wroclaw Symposium on EMC is planned for June 23-26, 1998. Those interested may contact organizers under the address as above.

The Organising Committee

INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

Beijing, China, 21 - 23 May 1997

1. Call for Papers

We are delighted to announce that the 1997 International Symposium on Electromagnetic Compatibility will be held in Beijing, China (formerly announced in Shenzhen, China), on May 21-23, 1997. The Symposium will provide excellent opportunities for EMC researchers and engineers to present the latest research results and exchange views and experience. Prospective authors are invited to submit original, unpublished papers, on the current state of EMC technology. Technical areas include :

1. EMI Sources
2. Lightning Surge, EMP and ESD
3. EMI Coupling and Crosstalk
4. EM Wave Propagation and Fading in EMC Aspects
5. EM Environment
6. EMC Measurement
7. EM Sensor, Probe and Antenna
8. Shielding and Grounding /Technique and Material
9. EM Energy Absorber , Anechoic Material .
10. Filter, Transformer and Isolater
- 11 Immunity and Susceptibility/System, Device and Component
12. EMI Prediction, Analysis and Reduction Technique
13. Spectrum Management and Monitoring
14. Biological Effects
15. Seismo-electromagnetic Phenomena
16. EMC Education
17. EMC in Computer and PCBS
18. EMC in Power Engineering
19. EMC in Communication System
20. EMC in Automation System
21. EMC in Microelectronics
22. Stands, Regulations in EMC
23. Man-made Electromagnetic Noise
24. Other

2. Organisation

General Chairman: Gao Yougang, China

3. Language

English will be the official language at symposium.

4. Authors' schedule

Abstract and Summary mail by October 31, 1996. Notification of acceptance and author's kit mailed by December 15, 1996. Camera-ready manuscripts mailed by Feb. 28, 1997. On acceptance of a paper, all authors will be required to provide a camera-ready manuscript of no more than 4 pages. The Symposium Proceeding will be available at the symposium, which contains the full texts of all accepted papers in English.

5. Symposium registration

Registration fee covers admission to symposium, reception, refreshment and a copy of the proceedings.

IEEE Member(s)	Non-IEEE Member(s)	
US\$ 320	US\$ 360	Before Feb. 28, 1997
US\$ 355	US\$ 395	After Feb. 28, 1997

6. Conference schedule

May 20	Registration and Technical Visit
May 21-23	Technical Sessions
May 24	Tour to Great Wall and Ming Tombs
May 25	Post-Symposium Tours

7. Paper submission

Prospective authors should submit 4 copies of a 35-50 words abstract and a 500-750 words summary in English that explain clearly the contribution, its originality and the relevance to the EMC discipline. The title of the paper, author's name and address should appear on the summary. Please send the abstracts and Summary to :

EMC'97/Beijing
c/o Prof. Zhang, Linchang
EMC Research Section
Northern Jiaotong University
Beijing, 100044, China
e-mail: emclab@center.njtu.edu.cn

8. Hotel accommodations

All the participants and the accompanying persons will be accommodated in the Media Center, which is an attractive modern hotel.

Single occupancy: US\$40 person/day

Double occupancy (2 beds): US\$28 person/day

9. Visiting and exhibition

The Organizing Committee will arrange technical visits to universities or research institutes and guided local tour for accompanying persons which will be informed during the symposium. The International Technical Exhibition along with the symposium is being planned.

10. Contact

Ms. Fang Min
Secretariat, EMC'97
Chinese Institute of Electronics
PO Box 165, Beijing 100036, China
Fax: 86-10-68283458
Tel.: 86-10-68283463
e-mail: shaz@sun.ihep.ac.cn

FOURTH INTERNATIONAL SYMPOSIUM ON ANTENNAS AND EM THEORY

Xi'an, China, 19 - 22 August 1997

The goal of this international symposium is to provide a discussion forum for the researchers and practitioners who are engaged in the field of Antennas and EM Theory to present their new ideas and achievements in an academic and cordial atmosphere.

1. Organizer

Xi'an University and CIE Antenna Society.

2. Scope and main topics

1. electromagnetic theory
2. analytical & numerical method
3. ray & asymptotic technique
4. transient EM field
5. EM field in complex media
6. bioelectromagnetics
7. EM scattering
8. inverse scattering & EM imaging
9. antenna theory
10. antennas CCA & CAD
11. pattern synthesis
12. cavity & resonator
13. guided waves
14. wire antennas
15. slot antennas
16. microstrip antennas
17. reflector antennas & feeds
18. array antennas
19. phased arrays
20. satellite antennas
21. wideband communication antennas
22. modern measurement techniques
23. nonlinear electromagnetics
24. other topics on antennas & EM theory

3. Working language

English will be the official language at the symposium.

4. Symposium organizations

- Symposium Chairman : Mao Yukuan
- Vice Chairman : Liang Changhong
- Technical Program Committee : Wang Maoguang
- Organizing Committee : Liang Changhong

5. Registration Information

Attendees to the ISAE'97 will register at the Registration Desk at Tangcheng Hotel, Xi'an. The registration fee is U.S. \$250 per person. Three star hotel & meals will be provided for attendees for U.S. \$45 per day/per person.

6. Deadlines

Submission in camera-ready : Jan. 15, 1997

Notification of accepted paper : April 15, 1997

Notice that the submission of summaries is unnecessary. Please pay attention to the new deadlines.

For further information please contact :

ISAE'97

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URPS'97

URBAN RADIOWAVE PROPAGATION SYMPOSIUM

Tomsk, Russia, 2 - 4 September 1997

URPS'97 will be held in Tomsk, Russia on September 2-4, 1997. The Symposium is organised by the State Committee of Higher Education of Russian Federation, the Tomsk State Academy of Control Systems and Radioelectronics, and the Siberian Physical and Engineering Institution, in collaboration with URSI Commission F.

Principal themes of the symposium are to be:

- Radiowave propagation in urban areas,
- Security systems and location of urban objects using radiochannels,
- Radiolinks for urban telecommunications,

- Radiolinks for urban computer networks,
- Urban radioholography.

Papers on other related topics are also invited.

Interested authors are requested to submit a one-page abstract before 15 January 1997. The abstract should start with the title, authors' names, full address, telephone number, fax and e-mail. Please be sure to include e-mail address, telephone number and mail address of the corresponding author. In case of multiple authors, please indicate which authors wish to participate. The authors are requested to state clearly the problem examined and the method used. Consideration of obtained results is also encouraged.

Accepted participants will be invited to submit a camera-ready copy of their full papers for the Symposium proceedings before 1 May 1997. Submission must be in Russian or English. The papers should preferably have double-column pages. Fax submissions cannot be accepted. Submission through e-mail is strongly encouraged. E-mail submissions should be addressed to: gssh@tiasur.tomsk.su. Hard copy submissions should be mailed (3 copies) to the following address:

Prof. German S Sharygin
Tomsk State Academy of Control
Systems and Radioelectronics,
40 Lenin Ave., Tomsk 634050, Russia.
Phone: [+7] (3822) 224 302
E-mail: gssh@tiasur.tomsk.su

Notification of acceptance or rejection will be mailed to the corresponding author by March 1 1997. Deadline for the registration form is June 1 1997.

URSI CONFERENCE CALENDAR

October 1996

International Conference on the Physics of Dusty Plasmas

Goa, India, 21 - 25 October 1996

Contact : Dr. Taramati Desai, Scientific Secretary, PDP'96, Laser Program, Centre for Advanced Technology, Indore 452 013, India, Tel. : 091 731 481 526/488471/488466, Fax: 091 731 481 426, e-mail : icdp96@cat.ernet.in
or, contact : Sylvia Flores, Scientific Secretary, PDP'96, Department of Electrical and Computer Engineering, University of California, San Diego, La Jolla, CA 92093, U.S.A., Tel. : 1 619 534 6484/2719, Fax : 1 619 534 2486, e-mail : flores@ece.ucsd.edu

December 1996

APMC'96 - Asia-Pacific Microwave Conference

Delhi, India, 17 - 20 December 1996

Contact : Dr. R.S. Gupta, Conference Secretary, APMC'96, Department of Electronic Science, University of Delhi, South Campus, New Delhi, India, 110021 India, Tel. : 91-11-601955, 91-11-602440, Fax : 91-11-6886427, 91-11-6885270, e-mail : bic_dusc@dbt.ernet.in

February 1997

COMMSPHERE'97

Lausanne, Switzerland, 11 - 14 February 1997

Contact : COMMSPHERE'97 - Secretariat, Swiss Federal Institute of Technology of Lausanne, CH-1015 Lausanne, Switzerland, Tel. : +4121 693 27 86, Fax : +4121 693 46 62, e-mail : marcela.lenz@lre.de.epfl.ch

EMC Zurich'97 - Electromagnetic Compatibility

Zurich, Switzerland, 18 - 20 February 1997

Contact : Dr. Gabriel Meyer, Symposium Chairman, EMC Zurich'97, ETH Zentrum - IKT, CH-8092 Zurich, Switzerland, Tel. : (+411) 632 27 90, Fax : (+411) 632 12 09, e-mail : gmeyer@nari.ee.ethz.ch, WWWsite at : <http://www.nari.ee.ethz.ch/>

April 1997

ICAP'97 - Tenth International Conference on Antennas and Propagation

Edinburgh, U.K., 14 - 17 April 1997

Contact : , ICAP'97 Secretariat, Conference Services, Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, United Kingdom, Tel. : (+44) (0)171 344 5467/5473, Fax : (+44) (0)171 240 8830, e-mail : lhudson@iee.org.uk, mswift@iee.org.uk

Radio Emission From Galactic and Extragalactic Compact Sources

Socorro, New Mexico, U.S.A., 21 - 26 April 1997

Contact : Dr. J.A. Zensus, National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA, 22903, U.S.A., Tel. : (804) 296-0231, Fax : (804) 296-0278, e-mail : azensus@nrao.edu

March 1997

The Fifth International School/Symposium for Space Simulations (ISSS-5)

Kyoto, Japan, 13 - 19 March 1997

Contact : Hiroshi Matsumoto, Chairman of the Organizing Committee, ISSS-5, Radio Atmospheric Science Centre, Kyoto University, Uji, Kyoto 611, Japan, Tel. : +81-774332532, Fax : +81-774318463, e-mail : iss@kurasc.kyoto-u.ac.jp

May 1997

International Symposium on Electromagnetic Compatibility EMC-97

Beijing, China, 21 - 23 May 1997

Contact : Ms. Fang Min, Secretariat, EMC'97, Chinese Institute of Electronics, P.O. Box 165, 100036 Beijing, China, Tel. : (86) 10 68283463, Fax : (86) 10 68283458, e-mail : shaz@sun.ihep.ac.cn

June 1997

Second World Congress for Electricity and Magnetism in Biology and Medicine

Bologna, Italy, 11 - 13 June 1997

Contact : Prof. Paolo Bernardi, Università "La Sapienza" di Roma, Dipartimento di Ingegneria Elettronica, Via Eudossiana 18, I-00184 Roma, Italy, Tel.: +39-6-4742647, Fax : +39-6-44585855, e-mail : bernardi@tce.ing.uniroma1.it

July 1997

Seventh International Conference on HF Radio Systems and Techniques

Nottingham, United Kingdom, 7 - 9 July 1997

Contact : HF Radio '97 Secretariat, Conference Services, Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, United Kingdom, Tel. : (+44) (0)171 344 8425/5469, Fax : (+44) (0)171 240 8830, e-mail : conference@iee.org.uk (please quote HF Radio 97 in your message)

August 1997

IGARSS'97 - International Geoscience and Remote Sensing Symposium

Singapore, 4 - 8 August 1997

Contact : IEEE Geoscience and Remote Sensing Society, 2610 Lakeway Drive, Seabrook TX 77586, U.S.A., Tel. : +17132919222, Fax : +17132919924, e-mail : tstein@phoenix.net

International Symposium on Radiowave Propagation

Qingdao, China, 12 - 16 August 1997

Contact : Professor Zong Sha, Chinese Institute of Electronics, P.O. Box 165, 100036 Beijing, China, Tel. : (86) 10 68283463, Fax : (86) 10 682834 58, e-mail : ZSha@Sun.Ihep.ac.cn

June 1998

14th International Wroclaw Symposium on Electromagnetic Compatibility

Wroclaw, Poland, 23 - 26 June 1998

Contact : EMC Symposium, Box 2141, 51-645 Wroclaw 12, Poland, Fax : +4871 728878, e-mail: emc@ita.pwr.wroc.pl

July 1998

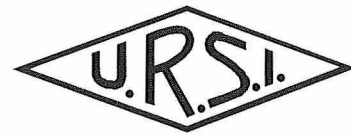
CPEM98 - Conferences on Precision Electromagnetic Measurements

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. (301) 975-4223; FAX (301) 926-3972; email katherine.magruder@nist.gov., WWW site : <http://www.eeel.nist.gov/cpem98/>

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

Triannual Reports from the Commissions



COMMISSION A

As regards the Review of Radio Science (RRS), the Commission A Vice-Chair, Dr. Motohisa Kanda, is the Commission A Editor for RRS. Commission A will contribute seven chapters to the RRS, namely:

- "Conventional Microwave Frequency Standards: Cs-, H-, and Rb-Clocks",
- "Primary Atomic Frequency Standards: New Developments",
- "Optical-Frequency Standards",
- "Methods for Distributed Time and Frequency: Review",
- "Optical Power and Fiber Optics Metrology",
- "Developments of Automatic Network Analyzer Calibration Methods", and
- "EM Metrology for Guided Waves".

Luc Erard (LCIE, France) is the Editor for the Disk.

A large part of the activities of the Commission consists in the realization of the biennial Conferences on Precision Electromagnetic Measurements (CPEM), for which URSI Commission A is one of the main permanent sponsors. The conference has received an outstanding reputation over more than three decades as an international forum for precision electromagnetic measurements. It is held every two years either in the USA (or Canada), or in a country outside North America. Traditionally, it is organized mainly by members of the hosting national institute of metrology, but individual members of URSI are involved in a considerable part. The Commission A Chairman is a member of the CPEM Executive Committee.

CPEM'94 took place in Boulder, CO, USA from 27 June to 1 July 1994. In 38 sessions, more than 270 papers were presented. A large part of the sessions was dedicated to topics such as cesium beam and optical frequency standards and metrology and time keeping and transfer as well as to the different aspects of quantum metrology and fundamental constants. About 60 papers covered topics such as microwave and millimeter wave metrology, noise metrology, time domain measurements, antennas and EMC network analysis as well as material measurements. A session on lightwave communication metrology also aroused lively interest. The papers were well received, followed by a considerable amount of discussions, which indicated the significance of the themes chosen. The conference was very well attended by more than 470 participants, this also showed the increasing interest of companies and national calibration services in precision electromagnetic metrology. Sixteen Young Scientists from nine different countries were given financial travel support.

CPEM'96 will be held in the Civic Hall of Braunschweig, Germany, from 17 to 20 June 1996. Up to now, over 370 papers from 51 countries have been submitted. URSI members (including the Commission A Chair) are involved in the organization as well. About 10 RF sessions with 70 papers are scheduled. Compared to the 1994 conference, the number of submitted papers on electric quantum standards and frequency standards has considerably increased. New sessions are those on novel sensors and automated measurement methods and their applications in precision metrology. Plenary speakers will be Klaus von Klitzing (Stuttgart, Germany), Konstantin K. Likharev (Stony Brook, USA) and Herbert Walther (Munich, Germany).

As the URSI representative to the Comité Consultatif d'Electricité (CCE), the Commission A Chairman took part in the meeting of the Working Group on Radiofrequency Quantities of the CCE, which was held at the BIPM in Sèvres, France, on 12 and 13 June 1995. This Group took over URSI responsibility in 1965. Since 1992, eight comparison measurements of different RF quantities covering frequencies up to 40 GHz have been completed, and good coincidence between measurements of the different national institutes of metrology has been found. Thirteen comparison measurements are continuing, to maintain further the equivalence between the primary RF measurement standards of national metrology institutes. In the future, key multilateral comparisons have to be identified and the intervals at which they should be repeated, in order to limit the comparisons to a economically justifiable number. A detailed report of comparisons will be given by L. Erard in the Session A2 of the forthcoming General Assembly of URSI in Lille.

The Comité Consultatif pour la Définition de la Seconde (CCDS) held at the BIPM its 12th meeting from 24 to 26 March 1993 and its 13th meeting on 12 and 13 March 1996. Representatives of Commission A were present at both meetings. The discussions focussed on the optimum use of available means for international synchronization of time-scales, namely satellite time transfer via GPS, GLONASS and telecommunication satellites. The driving force is the increasing need of synchronization between national realizations of UTC, the present goal being 100 ns. Another item has been to promote the development, evaluation and operation of primary frequency standards which should allow to maintain the scale unit of International Atomic Time TAI as close as possible to the SI second. It

was particularly welcomed that evaluations of four new primary standards have been made available recently, CS3 of PTB, NIST-7 of NIST, FO1 of LPTF, France, and MCS102 of VNIIFTRI, Russia. In 1996 it was decided that the frequency of primary clocks should be corrected for the AC Stark-effect due to the electric fields of the thermal background radiation. This effect has been predicted to yield a frequency shift of as much as $-1,7 \times 10^{-14}$ at room temperature. In the past no correction had been applied as no experimental verification of the effect had been available, a situation which has not changed until now.

Other Commission A related activities were reported at the 11th International Zurich Symposium and Technical Exhibition on Electromagnetic Compatibility, which was held at the Swiss Federal Institute of Technology, Zurich, Switzerland, from 7 to 9 March 1995. There were about 400 participants who attended the thematic technical sessions, workshops, tutorial lectures, open meetings, technical exhibition, technical excursions, and social programs which included guests' excursions to pleasant Swiss resorts. About 120 papers were presented in the thematic technical sessions, which covered in the technical areas of transient effects, EMC applications, power systems, transmission lines, EMC standards, spectrum management, EMC emission and immunity testing, EM field hazards, numerical techniques, lighting, EMP, shielding and coupling, ESD dynamics and

others. Perhaps more technical exciting Commission A related activities were reported at the International Symposium on Electromagnetic Compatibility that was held at the University Of Rome "La Sapienza", Rome, Italy, from 13 to 16 September 1994. There were about 700 participants who attended 26 technical sessions and several workshops and made about 100 oral presentations and 80 poster presentations. The technical sessions covered the technical areas in EMC standards and regulations, interconnecting and packaging structures, human exposure to EM fields, lighting, EMC standard testing, PCB and chip design, power systems, antenna and communication systems, modelling techniques, measurement and instrumentation, anechoic chambers and TEM cells, cables, EMC automotive, shielding, transients, propagation and coupling in transmission lines. The workshop provided a forum for the discussion on technical and scientific perspectives of strategic interest for EMC and EMC activities supported by the Commission of the EC.

A considerable amount of the work of Commission A is the organization of four scientific sessions and 10 joint scientific sessions with Commissions B, D, E, F and K in the forthcoming General Assembly of URSI. About 140 papers will be presented.

Dr. U. Stumper, Chair,
Dr. M. Kanda, Vice-Chair.

COMMISSION B

Commission B has had another active triennium with a similar format of events to previously. The Commission B worldwide community is large, active and eager to take part in international events. The study of electromagnetic theory and practice through microwaves and antennas benefits from international collaboration and URSI provides an excellent means of achievement. URSI has always been strongly supported by Commission B engineers and scientists. This continues in many ways. Conferences have been sponsored by both international URSI and national societies. The national sponsorships tend to go unreported but provide an important feeder of committed people for the international events. Particularly notable is the US National Committee for URSI which sponsors the annual summer APS/USNC meeting and the winter Boulder meetings. This triennium has also seen much greater interaction between electromagnetic scientist from the Former Soviet Union countries and western countries. The Commission B community in Russia and Ukraine is very large and URSI has contributed in the last three years to developing contacts between scientists.

The main event which Commission B organises between General Assemblies is the International Symposium on Electromagnetic Theory. The 15th Symposium in the series took place over four days in St. Petersburg, Russia from 23-26 May 1995. The decision to hold the 15th Symposium in Russia was made in 1992 shortly after the end of the Cold War and the collapse of the Soviet Union.

This led Commission members to warmly embrace the invitation from the Russian Commission B. The organisation presented considerable challenges but the results showed that it was successful, beneficial to participants and particularly rewarding to those in Russia and Ukraine who do not have many funds to travel to conferences.

A total of 348 participants took part in the Symposium from 33 countries with the largest contingent from the host country. The Technical Programme Committee received 456 synopses which led to the final presentation of about 270 papers. There were many novel and original presentations which were published in the 894 page Proceedings. A popular feature was the invited lectures which provided a good opportunity to hear an expert talk.

A Young Scientist Award Programme at the Symposium enabled 25 Young Scientists who would not otherwise have been able to go to St. Petersburg. Funds for the Awards came partly from the Commission B triennial allocation from URSI and partly from the general registration fees. The enthusiasm of the Young Scientists was very evident. They fully participated and made every opportunity to make the best use of their time to interact with other participants.

The Official Members were kept informed of Commission B activities with three news letters reporting meetings and highlighting information relevant to Commission B. Among the conferences sponsored over the triennium were: European Microwave Conference, 1993,

1994, 1995. 5th International Conference on Mathematical Methods in Electromagnetic Theory, Ukraine, 1994. [Commission B sponsoring twelve young scientists to attend this meeting]. Physics and Engineering of Millimetrewave and Sub-Millimetrewaves, Ukraine, 1994. Computational Electromagnetics and Its Applications, China, 1994. 8th Journées Internationales de Nice sur les Antennes, France, 1994. 6th Asia Pacific Microwave Conference, Japan, 1994. International Conference on Antennas and Propagation, The Netherlands, 1995. International Conference on Radio Science, China, 1995.

International workshop on Direct and Inverse EM Scattering, Turkey, 1995.

At the end of the triennium, the preparations for the Lille General Assembly took up considerable, but worthwhile, effort. Twenty Convenors have put together a wide ranging and comprehensive programme selected from the over 260 contributions submitted to the Commission B sessions - the largest number to any Commission. In addition the Commission is participating in nine joint sessions, promising a good completion to a successful triennium.

Prof. A.D. Olver, Chair

COMMISSION C

This report is intended as a brief summary of the activities of Commission C: Signals and Systems, of the International Union of Radio Science (URSI), for the period following the XXIV General Assembly, Kyoto, September 1993, until March 1996.

Commission C sponsored and supported a number of symposia and meetings during the period. These include the Second International Conference on Digital Signal Processing for Communications, Adelaide, Australia, April 1994; IGARSS, Pasadena, U.S.A., August 1994; Fifth International Symposium on Recent Advances in Microwave Technology (ISRAMT'95), Kiev, Ukraine, September 1995; European Conference on Synthetic Aperture Radar (EUSAR'96), Königswinter, Germany, March 1996; and Fourth International Symposium on Spread Spectrum Techniques and Applications, Mainz, Germany, September 1996. However the major commitments were to COMMSPHERE '95 and ISSSE'95.

COMMSPHERE '95 was organized by L. Barclay, United Kingdom, P. Delogne, Belgium, and J. Shapira, Israel, under the Chairmanship of Dr. Shapira, and in collaboration with ITU-R and IAU. It was held at Eilat, Israel, January 22-27, 1995. It is an international forum of leading scientists, experts and administrators, for discussion of the future of telecommunications and other electromagnetic radiation usages in view of the growing congestion of the spectrum. This was the third meeting. The program ranged over topics of interest to a range of commissions, but with the focus on telecommunications, was of special interest to Commission C. There were five plenary sessions and five workshops with 115 participants from 25 countries. The conference was a success and will be held again January 20-23, 1997 in Geneva, Switzerland with Dr. Shapira, Chair of the Technical Program Committee

The INTERNATIONAL SYMPOSIUM ON SIGNALS, SYSTEMS AND ELECTRONICS (ISSSE'95)

was jointly organized by Commissions D and C, and held in San Francisco, October 25-27, 1995. This was the third in the series of joint symposia which are being held every three years, and the first to be held outside of Europe. In addition to the URSI sponsorship, there was sponsorship from a range of IEEE societies and financial support from United States Government organizations. The conference was under the Chairmanship of J.W. Mink, with Vice Chairmen T. Itoh from Commission D and P. Wittke from Commission C. The technical program was under the direction of A.N. Willson, Jr., for Commission C and M. Shur for Commission D. Each day started with an outstanding keynote session. On the first day, Charles Rush of the United States spoke on "Global information infrastructures: challenges and realities", which described issues arising from the much-touted information superhighway. A. Viterbi of the United States, spoke on "Universal wireless communication: convergence of technology and market forces", and on the final day A. Seeds of the United Kingdom, gave the keynote address, "Mining the optical fibre bandwidth goldmine". The conference consisted of four parallel sessions on each of the three days and an evening poster session. The meeting was attended by 175 scientists and engineers including eight Young Scientists who received support.

During the past year major effort has been devoted to preparation for the upcoming General Assembly which will be held in Lille, France, August 28 - September 5, 1996. The programs for nine Commission C sessions have been organized covering the wide range of commission activity. There are an additional 7 joint sessions involving Commission C and Commission C is taking the lead in organizing two of these joint sessions. Professor R. Pickholtz, U.S.A., will give the commission tutorial on "Communications by Means of Low-earth Orbiting Satellites".

Prof. P.H. Wittke, Chair

In addition to its traditional character of being a "service" commission that provides technological background in the areas of electronics and photonics to other URSI Commissions for their benefit, Commission D has strengthened its stand-alone character. This is in response to an increased emphasis of the Union on telecommunication and wireless activities. Commission D has paid close attention to the new technological development in the respective scientific community. For instance, the low power electronic design of devices and circuits is gaining importance for wireless communication while the high bandgap semiconductor devices are seriously considered for high power microwave applications. The proposed Commission D program for the Lille General Assembly include these newer topics as well as more traditional subjects on electronics and photonics.

The major events during the past three years are the successful accomplishment of ISSSE '95 and the effort to collaborate with ICO (International Commission for Optics). In addition, Commission D supported a number of scientific and technical symposia and meetings throughout the world. These items are described below.

1. International Symposium on Signals, Systems and Electronics (ISSSE '95)

The ISSSE '95 (International Symposium on Signals, Systems and Electronics) was held at Parc Fifty Five Hotel in San Francisco on October 25-27, 1995. This meeting was organized jointly by Commissions C and D of URSI (International Scientific Radio Union). This is the third of the ISSSE series originated in Erlangen, Germany in 1989 while the second was held in Paris in 1992. The 1995 meeting was held for the first time outside Europe.

The meeting was financially supported by URSI and Commissions C and D. In addition, it attracted an impressive array of financial co-sponsorship. The IEEE Microwave Theory and Techniques Society provided co-sponsorship for 10% financial interest while United States Army Research Office and United States Office of Naval Research provided substantial financial grants. In addition, the following IEEE Societies provided cooperative sponsorship: Electron Devices Society (ED), Lasers and Electro Optics (LEOS), Circuits and Systems (C&S) and Communication (COM).

The meeting started with the opening session when Dr. J. Mink of North Carolina State University, General Chairman of the Steering Committee presented a short greeting that was followed by a congratulatory note by Dr. David Chang, President of Polytechnic University and Chairman of US National Committee of URSI. The first Keynote Session followed with Dr. Charles Rush of Compass Rose International on the topic "Global Information Infrastructures: Challenges and Realities. He described many issues and challenges related to the so-called information superhighway. The second and third days have also started a keynote session. On the second day,

the keynote address was given by Dr. Andrew Viterbi of Qualcomm on "Universal Wireless Communication: Convergence of Technology and Market Forces." On Friday, October 27, the keynote was presented by Professor Alwyn Seeds of University College London on "Mining the Optical Fiber Bandwidth Goldmine." All keynote sessions were extremely well attended.

After the keynote sessions, four parallel sessions were run in the late morning, early afternoon and late afternoon for each of the three days. These sessions were roughly divided equally to Commission C subjects and Commission D subjects, although the Commission boundaries were less clear in a number of sessions. In addition, there was a poster session on Thursday evening in a relaxed atmosphere during the wine reception. The meeting was attended by 175. This number includes 8 Young Scientists who were provided a partial financial support.

The Steering Committee consists of: General Chairman, J. W. Mink, North Carolina State University; Vice Chairmen, T. Itoh, UCLA (Commission D) and P. H. Wittke, Queen's University, Canada (Commission C); Technical Program, A. N. Willson, Jr., UCLA (Commission C), M. Shur, University of Virginia (Commission D); Local Arrangement, A. P. Khanna and R. Soohoo, HP Avanteq; Finance, H. J. Kuno, Quinstar; Publicity, J. Harvey and R. Trew, Army Research Office; Publication, W. Sander, Army Research Office; Executive Secretary, M. C. Wu, UCLA. Under the Technical Program Co-Chairmen, there was International Scientific Program Committee consisting of 22 scientists from US, Europe, Canada and Japan.

Due to the success of ISSSE '95, it is estimated that a loan of \$5,000 be returned to URSI Headquarters and some fund will be left for the next ISSSE in 1998. At the time of writing, the accounting of ISSSE was not finalized, however.

2. Conference Support

Commission D supported a number of scientific conferences and meetings during the past three-year period. They are classified into three types, (a) ISSSE as the main conference of the Commission, (b) Support with financial assistance, and (c) technical cooperation.

(a) ISSSE

Commission D provided \$4,000 which was matched by another \$4,000 from Commission C as ISSSE is a joint meeting.

(b) Financial Assistance to Scientific Meetings

Commission D provided financial support (not a loan) to the following :

- Physics and Engineering of mm and sub mm EM waves, June 7-10, 1994 in Kharkov, Ukraine, \$500
- International Symposium on Recent Advances in Microwave Technology (ISRAMT), September 11 - 16, 1995, in Kiev, Ukraine, \$1,500
- NATO Advanced Summer Institute on New Directions in Terahertz Technology to be held on July 1 - 11, 1996

at Chateau de Bonas, France, \$1,500

(c) Technical Cooperation

Commission D cooperate the following meetings on the technical aspects with technical liaison as listed :

- European Conference on Optical Communication (ECOC) 1993, 94, 95, 96. (Technical Liaison: Prof. A. Seeds)
- Asia Pacific Microwave Conference (APMC) 1994. (Technical Liaison: Prof. T. Itoh)
- European Microwave Conference (EuMC) 1993, 94, 95, 96. (Technical Liaison: Prof. R. Sorrentino)

3. Travel Grant Program for URSI Lille General Assembly

Because of favorable financial situation of Commission D due largely to the success of ISSSE '95, an amount of \$4,500 is left over in the Commission budget. Commission D has decided that this amount be used to partially defray the cost of some of the Convenors and Invited Speakers for Commission D Sessions including the joint sessions lead by Commission D. At the time of writing this report, Commission Chair and Vice Chair are finalizing the award recipients. It is planned that 5 Category I awards (\$500 each) and 8 Category II awards (\$250 each) be awarded based on the following criteria [1] Economic hardship, [2] Only one award to an institution, [3] As much as possible, distribute equally to all sessions, and [4] Geographical distribution. Award will be announced soon through the respective Convenors. The awardee will be given the fund after the Lille GA by way of bank transfer from URSI Secretariat based on the bank information provided during the General Assembly.

4. Collaboration with International Commission for Optics (ICO)

In December 1993, URSI President, Dr. P. Bauer, was approached by Dr. P. Chavel, General Secretary of the International Commission for Optics (ICO), about a possibility of turning this commission into a new Inter Union Commission from its present affiliation with IUPAP. Subsequently, Commission D was asked by URSI President to study the impact in sponsoring the creation of a new Inter Union Committee, because of the interest of Commission D in the area of Photonics.

Commission D has taken a positive step to study the possible strengthening of the relationship between the ICO and URSI, particularly Commission D. A special Subcommittee was created consisting on Professor A. J. Seeds (University College London), Professor A. Michelson (University of Colorado) and Professor D. Jaeger (University of Duisburg) with Professor Seeds as Chair to extensively study this issue. They have studied the three items. (1) Whether the ICO is a suitable body for URSI to collaborate with? (2) If so, what areas of the ICO's work align with the interest of Commission D? and (3) What would be a suitable mechanism for collaboration?

The subcommittee found positive nature of the alliance with ICO. As a first experiment, Commission D organized a joint session D-ICO on "Nonlinear Optical Phenomena and Devices in Transmission Systems," at the Lille General Assembly with Professor Seeds as Convenor.

The positive value of the alliance of URSI with ICO was reported to URSI President. Commission D recommended a positive step toward realization of this alliance.

Prof. Tatsuo Itoh, Chair

COMMISSION E

1. Chair persons

The chair-persons of the Commission were during this triennium :

Chairman : Professor Viktor Scuka
Vice-Chairman : Professor Masashi Hayakawa

2. General

The scientific activities of the Commission are conducted through the URSI national member countries organisations and through the Commission's seven Working Groups, which consist of the Working Group chairmen and the carefully selected members, experts in the relevant areas of research. Each working group is free to invite a certain number of WG-members according to the wanted scientific competence of the group. It is recommended to keep the number of group members at a level which can easily be administrated and which makes it easy to organise informal meetings. The chairmen of the groups are encouraged to organise different kinds of scientific activities on

international as well as on a national level. The chairmen are also responsible to inform the commission chairman on all performed events and to give a written scientific and administrative report of the group's activity each triennium and to make a plan of work for the next triennium. The chairman of the group is also obliged to each triennium give a comprehensive scientific review covering the relevant research area on a world-wide basis. It is therefore very important that the working group chairmen are experienced in the relevant research area, are familiar with the conventional practices in the international co-operation and have a good support from their professional "home organisation". It is of advantage if the chairman is well familiar with academic research and in the EMC-area also with industrial research. Of primary importance is a high scientific competence in the area of the WG's scientific programme, it is however of advantage if the members of the WG by their nationality cover a large geographical area.

It is the duty of the Commission chairman to arrange the distribution of the Triennium activity report of the Commission to all National Committees and to persons

showing their active interest in the research of Commission E, and to encourage the National Committees to report on their national research and development in the relevant preferential areas of Commission E research. It is of high value if the chair persons of the commission and the chairmen of the WGs and the WG members would visit some URSI member countries and in the frame of URSI give distinguished lectures on relevant scientific topics.

3. Preferences of the research

Commission E promotes the research and development in following areas :

1. Terrestrial and planetary noise of natural origin and man-made noise.
2. Composite noise environment.
3. Effects of noise on system performance.
4. Lasting effects of transients on equipment performance. This includes the nuclear electromagnetic impulse, NEMP and the effects of high power electromagnetic impulses.
5. Scientific bases of noise and interference control.
6. Spectrum utilisation.
7. EMC aspects of Earth's magnetic field in communications.

4. Scientific Working Groups

Commission E organises its scientific activities in dedicated Working Groups :

- | | |
|-------|-----------------------------------------------------------------------|
| WG E1 | Spectrum management and utilisation. |
| WG E2 | Non-Gaussian noise in communication. |
| WG E3 | High power electromagnetics. |
| WG E4 | Terrestrial and planetary electromagnetic noise. |
| WG E5 | Interaction with and protection of complex electrical systems. |
| WG E6 | Effects of transients on equipment. |
| WG E7 | Extra-terrestrial and terrestrial meteorologico-electric environment. |

A new scientific working group is under consideration :

- | | |
|-------|--------------------------------------------------------------|
| WG E8 | EMC-aspects of the Earth's magnetic field in communications. |
|-------|--------------------------------------------------------------|

5. Reports of the Working Groups

5.1. WG E1

Spectrum Management and Utilization

Chairpersons

Dr. Richard D. Parlow (USA)
Prof. Ryszard Struzak (Switzerland)

Objective

The objective of the WG E1 is to bring important issues and technical work that can effect the development of radio

communication services to the attention of the URSI scientific community. Through this process scientific work can be encouraged so that the spectrum management and scientific communities can benefit from this interchange of ideas, concepts and related research.

Programme

WG E1 has been active in numerous meetings and symposia under the sponsorship of URSI. These meetings have spanned a broad range of locations and time frames. At each meeting sessions were organized and papers were presented by a host of contributors from the global community.

Topics included :

- spectrum management and utilization
- spread spectrum applications to communications
- personal communication services
- space applications and interference assessment
- national and international regulatory issues
- spectrum planning
- spectrum efficiency and modulation
- economic aspects of spectrum attribution
- private sector role in spectrum management
- technology, cost and implementation trade-offs.

The goal in all of the sessions was to cover a number of topics that are cross disciplinary, that is of interest to the radio scientist, spectrum manager and the regulator. Through this process a range of ideas and views surface that otherwise couldn't be exploited for mutual benefit.

Work Methods

Work methods will continue to be by correspondence, personal contacts and through encouragement of individuals with broad experience to participate in the activities of the WG E1.

Past and Planned Activity

Sessions were organized and presented at meetings that were fully or partially sponsored by URSI national or international organizations. The traditional EMC International meetings were the main venues for the working group sessions. In particular, sessions were presented at the following meetings :

International Zurich Symposium on Electromagnetic Compatibility 1995 :

- R.G. Struzak; "Trends in Spectrum Management and Engineering", 26F1.
- Participation in the URSI Comm. E Open meeting.

Wroclaw Symposium on Electromagnetic Compatibility 1996 :

- Prof. R.G. Struzak was the Vice-chairman of the 13th Int. Wroclaw Symposium and Exhibition on EMC, June 25 -28, 1996
- Prof. R.G. Struzak, Chairman of Plenary Session I : "EMC-Globalisation : The Role of Scientific Societies".
- Prof. R. G. Struzak, Chairman of Session M, "Spectrum management, Engineering, Sharing, Monitoring" with 5 oral presentations.
- Plenary Session II : Prof. R.G. Struzak "Key Issues in Spectrum Management"

US National URSI Symposium in Boulder, Colorado 1996.
URSI GA in Lille 1996 :

- Scientific Session on "Spectrum Management and Utilization" under chairmanship of R.D. Parlow and R.G.Struzak with 10 oral presentations".
 - R.D. Parlow; "The World Radio Conference of 1995 - Results and Observations".
 - R.G. Struzak, "Key Issues in Spectrum Management"
- COMMS PHERE-2**

Consideration is being given to the organization of a round table session on key spectrum management, technical and regulatory issues that influence the timely development of global, regional and/or national telecommunication infrastructures.

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5.2. WG E2

Non-Gaussian Noise in Communication

Chairperson

Dr. A. D. Spaulding* (USA)

*Remark by Comm. Ch. : Dr. A.D. Spaulding passed away in 1995.

Objective

- Effect of noise (interference) on system performance.
- Means of overcoming the degrading effects of noise signal processing to combat noise system design in the presence of non-Gaussian interference.

Programme

Membership in the WG varies, as needed.

Members in the period 1990-1993 : D. Middleton, S. Giordano, G. Hagn, T. Roberts, S. Mackis, V. Kontorovic, and G. Boronichev.

Work Methods

Work methods will continue to be by correspondence and personal contacts.

Participation at international meetings, such as EMC Symposium in Zurich and in Wroclaw.

Past and Planned Activities

- A paper was presented at the Zurich Symposium 1993: Non-Gaussian Noise in Communication, by A.D. Spaulding.
- A successful session with joint Commission C was organized at the GA in Kyoto 1993 : Communication in the Presence of Non-Gaussian Noise and Interference; C : P.A. Matthews, USA and E : A.D. Spaulding, USA
- A paper was submitted to the GA in Kyoto 1993 for presentation in session EF : Radio Noise 0.1 Hz to 1 THz, A.D. Spaulding
- A special Memorial Spaulding Session was organised by the former chairman and initiator of URSI Commission E Prof. G.H. Hagn at the U.S. National Radio Science Meeting in Boulder CO, 1996. In the session the reach scientific work of Dr. A.D. Spaulding were reviewed.

5.3. WG E3

High Power Electromagnetics

Chairperson

Dr. R. L. Gardner (USA)

Objective

The objective of the WGE3 is to encourage research in high power electromagnetics.

Programme

Membership in the WG varies, as needed.

The WG is supported by the Permanent NEM Committee, USNC of URSI Commission E, various HPM working groups and individuals.

Work Methods

Informal organization of various members organizing sessions on HPE.

Past and planned Activities

Activities of the High Power Electromagnetics WG E3 over the last three years have revolved around several recurring technical meetings.

1. HPE session was organized in the GA of URSI 1993 and a report prepared for the Review of Radio Science.
2. There was an open meeting presentation in EMC-Zurich 1995 :
R.L. Gardner; "Some limitations in the use of statistics in the determination of large system vulnerability to high-frequency electromagnetic waves".
3. The Boulder meeting of USNC of URSI had an HPE session 1996.
4. NEM meeting in the USA, 1994.

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5.4. WG E4 Terrestrial and Planetary Electromagnetic Noise

Co-Chairpersons

Prof. Kawasaki (Japan),
Prof. E.K. Smith (USA)
Dr. Gavan (Israel)

Objective

- Part A (prepared by Prof. Z. Kawasaki)
To characterise terrestrial and planetary electromagnetic noise.
- Part B Natural Noise Above 30 MHz (prepared by Prof. E.K. Smith and Dr. J. Gavan)
To study natural noise from terrestrial and extra-terrestrial sources with a view towards the interests of CCIR and the advancement of knowledge.

Work Methods

- Co-operation with different scientific groups is planned to be established.
- Newsletter
- A list of member scientists from different countries is established.

Programme : Part A Terrestrial and planetary electromagnetic noise

Characterization of terrestrial EM noise :

- General characteristics of terrestrial noise of natural and man-made origin; ground and satellite measurements.
- Statistical description and modelling of terrestrial EM noise of both origins.
- Physical processes and mechanisms included in the generation of terrestrial noise.
- Effects of terrestrial noise on communications, biological systems etc.

Characterisation of planetary EM noise :

- General characteristics of planetary EM noise environment; measurements and modelling.
- Physical processes and mechanisms involved in the generation of planetary EM waves.
- Comparison of planetary noise environment with terrestrial environment.

EMC Zurich 1995 :

- Z.I. Kawasaki; "Terrestrial and planetary natural EM noise" given at the URSI Com. E Open Session.
- J. Gavan "Interference Intrastem Effects for Nano- and Pico-Cell Personal Communication", 30F5

EMC Wroclaw 1996 :

- J. Gavan "Co-sited Radio Systems Interference Effects Analysis and Computation"
- Session B on "ESD, Lightning, EMP" Chaired by V. Scuka with 4 oral presentations and 1 poster.
- Session D "Terrestrial EM Noise" chaired by M. Hayakawa with 5 oral presentations.

Programme : Part B Natural Noise Above 30 MHz

1. Make a computer model for atmospheric noise emission as a function of frequency and surface water, after examining the present model.
2. Summarize planetary emission.
3. Summarize terrestrial surface radiation from land as a function of frequency and terrain.
4. Summarize sea surface radiation from sea surface as a function of frequency, temperature and salinity.
5. A Newsletter should be issued at least once per year*. The content: membership, reports on scientific meetings of EMC closely related to the WG E4, activity reports from the research groups in the relevant field.
*Remark 96-07-30: The Newsletter has not yet reached the chairman of the Commission.
6. URSI GA in Lille, 1996 :
 - E.K. Smith, J. Gavan, E.R. Westwater and A.J. Gasiewski organised a session on "Radio noise and interference above 30 MHz" with 6 oral presentations.
 - J. Whiteoak and L.W. Barclay organised a session on "Interference problems in radio astronomy and communications - or cosmic ecology" with 10 oral presentations and 6 posters.

Past and Planned Activity

Topics of major importance will be selected and international co-operation on these topics will be promoted.

A list of selected topics :

New results of terrestrial EM noise :

- Recent findings of natural and triggered lightning; microphysics of lightning. This in co-operation with Inter. Conf. on Atmosph. Electricity, ICAE and the WG E3.
- Laser beam triggering of lightning; new direction of research to be promoted.
- Global distribution of lightning; This in co-operation with the WG E2.

Direction finding of radio noise :

- Direction finding for studying different kinds of EM-waves; near-by and distant lightning, space plasma waves, man-made noise.
- A comparison of the system accuracy of different direction finder systems should be made. This will be useful for all scientists working on different fields. Co-operations on different fields must be expected.
- A special session at EMC-Zurich could be proposed.
- A special session on lightning localisation is organised at the URSI Com. E sponsored Int. Conf. on Lightning Protection, ICLP, Florence, Italy, Sept. 1996.

URSI GA in Lille, 1996 :

- M. Hayakawa and A.P. Nikolaenko have organised a Session on "Terrestrial electromagnetic environment" with 13 oral presentations and 12 posters.
- Z.I. Kawasaki and V. Cooray have organised a session on "Electric discharges from cloud-top to the ionosphere" with 13 oral presentations.

- W.J. Borucki and M. Hayakawa have organised a session on "Planetary lightning and related phenomena" with 10 oral presentations.
- M. Parrot (H), O.A. Molchanov (H), T. Yoshino (E) and A.C. Fraser-Smith (G) have organised a session on "EM coupling between the ground (including seismic activity) and the upper ionosphere and magnetosphere" with 12 oral presentations and 14 posters.

A joint workshop between WG E4 and WG E7 was held 1994 in Tokyo with the aim to establish international co-operation.

Wroclaw EMC-Symposium 1996 :

- T. Yoshino has organised Session A "EM Emissions Associated with Seismic Activity" with 5 oral presentations.
- M. Hayakawa has organised Session D "Terrestrial EM Noise" with 5 oral presentations.

Appendix 2 :

Zen-Ichiro Kawasaki "Report of the WG E4 : Terrestrial and planetary electromagnetic noise", March 1996.

The report gives a review of the research in the relevant field of the WG E4 displayed in following sections :

- Lightning :
 - Terrestrial lightning
 - Cloud to ionospheric discharges
 - Planetary lightning, discharges and emissions
- Natural noise environment :
 - Terrestrial noise - Ionospheric and magnetospheric
 - Radio emission associated with earthquakes
 - Extraterrestrial and cosmic noise
- References; 58 in total.

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5.5. WG E5 Interaction with and Protection of Complex Systems

Co-Chairpersons

Dr. C. Baum, USA
 Prof. P. Degauque, France
 Prof. M. Ianoz, Switzerland

Objective

To study the effects of ground on electromagnetic coupling phenomena and to study the coupling of electromagnetic waves through the structures.

Programme

Effect of Ground

- Coupling in the presence of ground; some points remain to be clarified; transmission line & scattering approach.
- Effect of terrain topography; dimensions of the valleys, hills.
- Distortion of the EM interference fields; theory and experiment.

Coupling to Structures

- Penetration and coupling to subsystems. Some points remain to be studied.
 - Influence of the conductivity : assumption of Z_s and infinite conductivity is not valid.
 - Coupling to complex systems : topological approach : Efficient tools.
 - Examples of application to more complicated structures; advantages, drawbacks, numerical problems etc.
 - Protecting devices; modelling and measurements. Co-operation with WGE6.
 - Measurements on sub-systems and on complex structures.
 - Characterization of the immunity of the shielding effectiveness etc.
 - Application of the topological approach.
 - Protection concepts for complex systems.
 - Basic topological outline. Things to be done :
 - *fill out details of theory
 - *define experimental techniques to define the penetration parameters
 - *translate the above into specifications and standards
 - *develop algorithms, expert programs, to aid implementation by analysis.
 - Multiconductor transmission line theory.
 - Continue analytic development :
 - *commuting matrixes
 - *non uniform tubes.
 - Make measurements.
- #### *Coupling of HF-Waves; 1 GHz and above*
- Possible extension of the transmission line theory to the coupling of HF-waves to cables.
 - How to handle the problem :
 - *cables, joints, etc.
 - *structures.

Work Methods

Personal communication, symposia, lectures, papers in scientific journals, membership.

- Organising conferences, symposia and participating in scientific committees of international conferences, reviewing scientific papers for int. journals, giving invited lectures and consultations to different research groups.
- A special forum has been established for selecting the "EMP Fellows". A list is presented by C. Baum giving the names, date of election and citation for each EMC Fellow. On the latest list for 1996 includes 55 members.
- A "Best HPE Paper Awards Committee" has been established. The Committee members for 1996 :

Dr. Carl E. Baum
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Dr. Kelvin S.H. Lee (Chair)
Kaman Sciences Corporation
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Dr. D. Serafin
Centre d'Etude de Gramat
Gramat, France

The awards were given out at the AMEREM '96 Conference held in Albuquerque, New Mexico, May 27 -31, 1996 :

Best Basic Paper Award :

William J. Karzas, "Back Door Coupling of RF (Microwave) Energy to Spacecraft Interior Cabling," Interaction Notes, Note 513, February 1994.

Best Applied Paper Award :

J.P. Parmentier, V. Gobin, F. Issac; I. Junqua, Y. Daudy, J.M. Lagarde, "An Application of the Electromagnetic Topology Theory on the Test-Bed Aircraft, EMPTAC," Interaction Notes, Note 506, November 1993.

Past and Planned Activity

- Meetings of : NEM in 1994 and 1996
EMC-Zurich in 1995 and 1997
- Sessions on interaction, coupling and protection of systems against EMI are and will be organized even in the future in all EMC Symposia.
Apart from the "classical" well-established EMC symposia, new ones are organized to which WG E5 members are invited to participate actively.
- Coupling and protection problems represent one of the main study item in the European research program, "Science Program" in which 8 European universities are partners; Grenoble, Hamburg, Lausanne, Lille, Limoges, Rome, Stuttgart, Torino. A final report on the research results was presented in a special session during the EMC-Symposium in "Rome 94", September 1994. These eight universities have developed numerical models and have at their disposal experimental facilities to validate the models.
- Coupling and protection modelling and study results are applied, knowledge transfer, in WG1 of the SC77C

of IEC which task is to produce an EMP Standard, Appendix 7.

- WG4 of Study Committee 36 of CIGRE which task is to produce "Mitigation Guidelines" for the control and measurement equipment in Power Lines Substations is assisted by members of the URSI WG E5.
- Proposal for future :
To publish two papers in the Radio Science :
*New developments in the multiconductor transmission line theory" by C. Baum and Nitsch.
*General topology codes" by J. Ph. Parmentier
- A workshop on "The EM environment - Interference in communication and spectral monitoring" was organised (P. Degauque and M. Ianoz) at the COMMSPHERE-95 in Eilat, Israel.
- Prof. M. Ianoz was the member of the organizing committee of the 2nd Russian Int. Symp. on EMC, June 1995 in St. Petersburg. In total 30 papers on coupling, interaction and protection of electronics against the effects of transients were presented.
- At the Inter. Conf. on Electromagnetics in Advanced Applications, ICEAA, Sept. 1995 in Torino, a session on EMC/EMI/EMP was organised. Prof. M. Ianoz presented an invited paper on "Electromagnetic field coupling to lines, cables and networks.
- Prof. M. Ianoz presented a paper on "Lightning effects on telecommunication and electrical power equipment" at the IEEE/IEE/ABI Lightning Conf., May 1996 in Tel Aviv, Israel.
- WG E5 contributed actively to the organisation of the AMEREM-96 symposium in Albuquerque. The members of the election Comm. for the award of the "EMP Fellow" were : C. Baum, C. Giles and M. Ianoz. About 200 papers of relevance to the URSI Com. E were presented.
- EMC-Symposium and Exhibition, Wroclaw, 1996 :
*V. Scuka organised Session B "ESD, Lightning, EMP" with 4 oral presentations.
*M. Ianoz organised Sessions R "Lightning, EMP and LEMP - I" and U "Lightning, EMP and LEMP - II" with 6 oral presentations.
- M. Ianoz and F.M. Tesche have organized the joint Session EB : "Field propagation and coupling to structures" at the URSI GA in Lille 1996, with 9 oral presentations and 2 posters.
- C. Baum, J. Nitsch and R. Sturm will publish a paper "Analytical solution for uniform and non-uniform multiconductor transmission lines with sources" in the Review of Radio Science in connection with the URSI GA in Lille.

New Trends

- The power network community feels more concerned with EMC problems :
SC36 of CIGRE
organization of the first EMC CIGRE Symposium.
- New contributions are coming from countries from which little information on EMC activity was available, in particular Russia and Ukraine.

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5.6. WG E6

Effects of Transients on Equipment

Co-Chairpersons

Prof. V. Scuka, Sweden;
Prof. B. Demoulin, France

Objective

The objective of the WG E6 is to study the phenomena associated with the electromagnetic waves, radiated and conducted, interaction with equipment.

Further to develop models describing the electrical characteristics of components under extreme operational conditions.

To provide physical understanding of the associated processes.

To develop methods by which a controlled design of e.g. safety electronics will be possible.

Programme

It has been recognized that there exists a need of modernization of the design of digital and analogue circuits, which are exposed to disturbing electromagnetic interactions. Models and equivalent circuits, which take into account the properties of the components working outside normal specified working conditions, have to be developed. The manufacturers of equipment do not, in general, provide the characteristics of equipment for the extreme conditions caused by electrical transients.

It is necessary to specify which additional measurements should be performed so that we will be able to predict the behaviour of the equipment under electrically stressed conditions.

Further, the level of the reliability of electronic systems is today often defined by the electrical environment, and we have to find methods which more accurately determine these levels.

Work Methods

Personal communications, presenting papers in scientific journals, participation in symposia.

Continued co-operation between the groups of scientists in Lille and Uppsala with the ambition to later include also other groups into this cooperation.

Cooperation in special topics with WGE5 is expected.

Past and Planned Activity

- The results of the work has been reviewed at an open session of URSI Commission E at the EMC-Symposium in Zurich 1995 and at the EMC-Symposium and Exhibition in Wroclaw, 1996.
- A paper has been published in the URSI issue of Review of Radio Science 1996.
- V. Scuka has actively contributed to the work of IEC TC 81 - Lightning protection of structures :
 - General Principles
 - Application Guide
 - Protection against LEMP
- V. Scuka has organized sessions on lightning protection at the International Conference on Lightning Protection, ICLP in Budapest, Hungary 1994 and Florence, Italy 1996.
- V. Scuka was member of the Scientific Committee of the EMC-Symposium in Beijing 1994.
- A scientific session has been organized at the GA in Lille, France, 1996.
- The WGE6 will also in the future participate in different EMC-Symposia.

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5.7. WG E7

Extraterrestrial and Terrestrial Meteoroelectric Environment with Noise and Chaos

Chairperson

Prof. H. Kikuchi (Japan)

Objective

- To find new basic approaches to a number of atmospheric and meteorological phenomena involving or accompanying electric discharge, ionization and/or

electrification in the extra-terrestrial and terrestrial environment as described in terms of partially ionized gases, collision-dominant plasmas, dusty or dirty plasmas containing charged dust grains or aerosols, self-gravitational plasmas for instance on the basis of a new EHD, electrohydrodynamics and/or EMHD, electro-magnetohydrodynamics.

- To find new basic approaches to random noise fluctuations, and chaos accompanied by meteoroelectric phenomena mentioned above in the extraterrestrial and terrestrial environment on the bases of new statistical approaches to nonlinear and turbulent processes, for instance incorporating a new concept of self organizational processes in nonequilibrium media.
- To explain a number of new meteoroelectric phenomena in extraterrestrial and terrestrial environments such as planetary lightning, discharges and emissions, cometary and planetary dusts and/or rings, triggered lightning and ball lightning, atmospheric EHD vortices, whirlwinds, tornadoes, cold and jet fronts, hurricanes, tropical cyclones, typhoons and so on, hopefully collecting novel significant events and data in comparison with new models and theories through a coordinating work.

Programme

Coordination of the program with other working groups, e.g. WGE4 and with other URSI Commissions and with the Commission of Atmospheric Electricity of IAMAP.

Work Method

Participation in different EMC-Symposia.

Organizing special topics symposia and workshops.

Personal communication with interested scientists.

A list of interested members has been established*.

* The list has not yet reached the Chairman of the Commission, 1996 08 02.

Results

- Cosmic, atmospheric, meteorological, and laboratory environments involving or accompanying electric charging or electrification, electric discharge, ionization or recombination, particle disruption or coalescence, and space charge transport should be considered as dusty or dirty plasmas containing charged dust grains or aerosols. Such dusty and dirty plasmas can be described on the basis of a new gravito-electrodynamics, self-gravitational plasma dynamics, electrohydrodynamics, EHD, electromagnetohydrodynamics, EMHD, or kinetic theory extended to dusty plasmas.
- For tenuous dusty plasmas, particle descriptions for individual grains such as test particles theories or more generally gravito-electrodynamics have been employed to calculate the orbit dynamics of charged grains under the action of gravitational and electromagnetic forces.
- For dusty and dense dirty plasmas as a continuous medium, a new area of electrohydrodynamics, EHD, and electromagnetohydrodynamics, EMHD, has been explored with the aid of new physical concepts of "electric merging-reconnection" and "critical velocity"

as an extension of hydrodynamics, HD, and magnetohydrodynamics, MHD.

- For tenuous dusty plasmas, a variety of kinetic (distribution function) approach or dusty plasma physics have been developed particularly for collective effects, including a number of new dusty plasma waves and instabilities.
- Since dusty and dirty plasmas environments are composed of various forms of coherent and random noise and chaos, interactions between large and small scales of spacio-temporal structure associated with noise, fluctuations, and chaos are of basic importance, and have been elucidated and understood on the basis of new concepts of "self-organisation" and "chaos" with new statistical approaches to nonlinear, turbulent, parametric, and random fluctuational processes in nonequilibrium media.
- A number of new observations and theories of dusty and dirty plasmas in extraterrestrial and terrestrial environments and in the laboratory have been obtained as it may be seen in the book "Dusty and Dirty Plasma, Noise, and Chaos in Space and in the Laboratory" by H. Kikuchi, Plenum Press, 1994.

Prospect

- Particle description such as gravito-electrodynamics will be further employed to calculate a variety of orbit dynamics of charged dust particles for extraterrestrial environments such as cometary and planetary atmospheres.
- Fluid approach such as EHD or EMHD will be applied to a variety of cosmic, atmospheric, meteorological, and laboratory dusty or dirty plasma environments such as interstellar clouds, galactic vortices, X-rays sources, and planetary atmospheres for extraterrestrial environments, and thunderstorms, typhoons, hurricanes, cyclones, tornadoes, and sandstorms for terrestrial environments.
- For a spatio-temporal structure of dusty and dirty plasma environments, relation between self-organisation and chaos should be more elucidated and fully understood on the basis of nonlinear and turbulent processes in nonequilibrium media. On the other hand, basic theories and results are now ready for various applications to atmospheric and meteorologico-electric environments such as cyclones, typhoons, and hurricanes diagnostics.

Past and Planned Activity

- An open URSI Workshop on Electromagnetic environment with noise and chaos was held in Tokyo on may 13-14 1994
- An URSI sponsored session on "Noise, Fluctuations, Chaos, and EMC" was organised at the EMC-Wroslaw symposium 1994.
- An open URSI Symposium entitled "Second URSI-ICPIG-RIKEN Symposium on Critical Problems of Discharge and Plasma Physics and Electro-Plasmo-Meteorology" was organised in Tokyo on Sept. 7-8, 1995.
- URSI open meeting in Zurich in March 1995.

Reference

Hiroshi Kikuchi; "Activity report of URSI Commission E Working Group E7 on Extraterrestrial and Terrestrial Meteorologico-Electric Environment with Noise and Chaos", Appendix 5.

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5.7. WG E8*

The EMC-aspects of the Earth's magnetic field in communications

Chairperson

Dr. Risto Pirjola (Finland)**

* Proposed by V. Scuka and R. Pirjola and to be established during the GA in Lille, 1996.

** Proposed by V. Scuka and to be approved by the Commission E at its business meeting in Lille, 1996.

The following items are proposed to be preferential in the program of the WG E8 :

- Geomagnetically induced currents, GIC
- Interference control of geomagnetic fields
- Magnetically clean equipment

Appendix 6 : "Connection between research on the geomagnetic field and activities of the URSI Commission E", Risto Pirjola, Finland, May, 1995

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6. Reports from the National Committees of URSI Commission E

- National Committee of Canada, Toronto. Report missing.
- National Committee of Russia, Oleg Razinkov and Dr. V. Larkina, IZMIRAN. Appendix 9.
- Swedish National Committee meeting, RVK. "Radio Science and Communications 96, Luleå and Kiruna, June 3 - 6, 1996. Appendix 13
- Nordic Center for Lightning Research, Institute of High Voltage Research, Uppsala University, Uppsala. Appendix 12

- National Committee of Thailand, Post and Telegraph Department, Bangkok and Chulalongkorn Univ. in Bangkok. Ref. : Pipope Chooncharoen. Appendix 11
- U.S.A National Committee Meeting, Boulder, 1996. Report missing.

7. URSI Commission E sponsored int. meetings and conferences.

Appendix 8.

8. URSI GA in Lille, 1996. Scientific Sessions organised and sponsored by the URSI Commission E.

Appendix 10.

9. Appendices

- Appendix 1 : "Report of the Commission Chairman for the period 1990 - 1993", Viktor Scuka, EMC-95, OE1, Zurich, 1995. Report is not attached to this document.
- Appendix 2 : "Report of the WG E4 : Terrestrial and planetary electromagnetic noise", Zen-Ichiro Kawasaki, March 1996.
- Appendix 3 : "Report of the WG E5 : Interaction with and protection of complex electrical systems", Carl Baum and Michel Ianoz, March 1996.
- Appendix 4 : "Report of the WG E6 : "Effects of transients on equipment", B. Demoulin, March 1996.
- Appendix 5 : "Activity report of URSI Commission E Working Group E7 on Extraterrestrial and Terrestrial Meteorologico-Electric Environment with Noise and Chaos", Hiroshi Kikuchi.
- Appendix 6 : "Connection between the research on the geomagnetic field and the activities of the URSI Commission E", Risto Pirjola, Finland, May, 1995.
- Appendix 7 : "Report on the activity of the ad hoc committee on environmental consequences of nuclear war", Manuel Wik, Nov. 1995. Report is not attached to this document.
- Appendix 8 : List of the URSI Commission E sponsored int. meetings and conferences
- Appendix 9 : "Activity report for the Triennium 1994 - 1996 of the National Committee of Russia, Oleg Razinkov and Dr. V. Larkina, IZMIRAN.
- Appendix 10 : Scientific Sessions organised and sponsored by the URSI Commission E at the URSI GA in Lille 1996.
- Appendix 11 : "Report of the National Committee of Thailand, Post and Telegraph Department, Bangkok and Chulalongkorn Univ. in Bangkok. Ref. : Pipope Chooncharoen.
- Appendix 12 : "Report of the Nordic Center for Lightning Research, Institute of High Voltage Research, Uppsala University, Uppsala.
- Appendix 13 : "Report from the Swedish National Committee meeting, RVK" - "Radio Science and Communications 96, Luleå and Kiruna, June 3 - 6, 1996.

Viktor Scuka

COMMISSION F

Commission F was sponsor or co-sponsor of 18 meetings between the 1993 and 1996 URSI General Assemblies, with a 19th meeting planned immediately following the 1996 General Assembly. The general Commission F meeting between assemblies was the **Commission F Open Symposium**, held in Ahmedabad, India, in November 1995. Other meetings were more specialized.

Commission F, as usual, co-sponsored with IEEE Geoscience and Remote Sensing Society the **International Geoscience and Remote Sensing Symposia (IGARSS)**, the largest remote-sensing meetings. **IGARSS94**, held in Pasadena, California, and **b**, held in Lincoln, Nebraska, were co-sponsored by the U. S. Commission F. **IGARSS95** was in Florence, Italy. These meetings continue to draw more than 1000 papers.

Meetings primarily sponsored by Commission F were :

- Electromagnetic Scattering from Gases and Plasmas, Aussois, France, 20-25 March 1994.
- Specialist Meeting on Microwave Remote Sensing, Lawrence, Kansas, USA, 17-20 May 1994.
- CLIMPARA 94, Moscow, Russia, 31 May- 3 June 1994
- CLIMPARA 96, Oslo, Norway, June 1996

Other meetings co-sponsored with various groups, including other URSI commissions include :

- Physics and Engineering of mm and submm Waves, Kharkov, Ukraine, 7-10 June 1994, Ukrainian Academy of Sciences
- COMMSPPHERE, Eilat, Israel, 22-27 Jan. 1995, Comm. B
- International Conference on Antennas and Propagation ICAP, Eindhoven, the Netherlands, April 1995,

- Workshop on Atmosphere Research and Applications using observations based on the GPS/GLONASS System, Copenhagen, Denmark, 8-9 June 1995, Comm. A & Comm. G
- International Conference on Radio Science, Beijing, China, 10-12 Aug. 1995, URSI-China, CIE (Beijing), URSI-China, SRS (Taipei), Polytechnic U. (New York), Hong Kong Polytechnic U., City U. of Hong Kong
- International Workshop on Direct & Inverse EM Scattering, Turkey, 17-24 Sep. 1995, Scientific and Technical Research Council of Turkey, IEEE Turkish AP-MTT Chapter, DLR, Marmara Research Center
- Retrieval of Geo- and Bio-Physical Parameters from SAR data for Land Applications, Toulouse, France, 17-20 Oct. 1995, CNES
- 7th Workshop on Technical and Scientific Aspects of MST/ST Radar (MST7) and Second International School of Atmospheric Radar (ISAR2), Hilton Head Island, SC, USA, 5-11 Nov. 1995, Comm. G
- EUSAR'96, Königswinter, Germany, 26-28 March 1996, EUREL, IEEE, and DGON
- International Symposium on Antennas and Propagation ISAP, Chiba, Japan, 24-27 Sept. 1996, Comm. B, Institute of Electronic, Information and Communication Engineers, Japan.

Meetings sponsored in Mode B were the four Commission F meetings and Physics and Engineering of mm and submm Waves. IGARSS meetings are always Mode C, and the others were Mode A.

Prof. R.K. Moore, Chair

COMMISSION G

Members of the URSI Commission G organized the following conferences and meetings since the last General Assembly in Kyoto:

1. Electromagnetic Scattering from Gases and Plasmas, Aussois, France, 20-25 March 1994.
Organizer : C. Hanuise (official French representative for Com G)
2. Beacon Satellite Symposium, Aberystwyth, UK, 14-17 June 1994.
Organizer : R. Leitinger (Chairman of URSI WG G.2)
3. 8th International Symposium on Solar-Terrestrial Physics, Sendai, Japan, 5-10 June 1994.
Organizer : S. Oya (member of Japanese URSI Committee)

4. COSPAR - 30th Scientific Assembly,
Session D4.1 : Active Experiments in Space Plasmas
Session C.4 : The High Latitudes in the Internat. Reference Ionosphere,
Hamburg, 20 and 21 July 1994.
Organizer D4.1 : M. Rietveld (member of URSI WG G.3)
Organizer C.4 : W. Singer (member of German URSI Committee)
5. IV Suzdal URSI Symposium on Artificial Modification of the Ionosphere,
Uppsala, Sweden, 15-19 August 1994.
Organizer : B. Thide (member of Swedish URSI Committee)

6. Workshop on Low and Equatorial Latitudes in the Intern. Ref. Ionosphere, New Delhi, India, 9-13 January 1995.
Organizer : D. Bilitza (Chairman of IRI)
7. 9th International Symposium on Equatorial Aeronomy, Bali, Indonesia, 20-24 March 1995.
Organizer : S. Fukao (Chairman of URSI WG FG.1)
8. STEP-GAPS Workshop on Non-Linear Processes, Warszawa, Poland, 24-28 April 1995.
Organizer : A.W. Wernik (Chairman of URSI WG CGH.1)
9. Atmospheric Research and Applications using the GPS/GLONASS System, Copenhagen, Denmark, 8-9 June 1995.

Organizer : P. Hoeg (Chairman URSI WG AFG.1)
10. 7th MST Radar and ISAR2 Workshop, Hilton Head, USA, 5-8 November 1995.

Organizer : J. Röttger (member of URSI WG G.3)
All these meetings have been attended by many Commission G members and have also been sponsored in mode B.

In mode A, Commission G sponsored the International Conference on Radio Science Beijing, China, 10-12 Aug. 1995

In addition to these meeting activities several of the WGs issued their own newsletter. Four newsletters were additionally issued for the whole Commission G community by the Chairman.

Dr. K. Schlegel, Chair

COMMISSION H

During the last triennium, most of the Commission H activities have been devoted to the organisation of meetings and conferences and to the preparation of sessions for the Lille G.A. Most of the work has been done by the following working groups :

- VERSIM, Inter-Union (URSI/IAGA) working group on the VLF/ELF remote sensing of the ionosphere and magnetosphere,
- CGH1, Wave and Turbulence Analysis,
- GH1, Active Experiments in Plasmas,
- GH2, Computer Experiments, Simulation and Analysis of Wave Plasma Processes,
- EGH1, Electromagnetic Effects Associated with Seismic Activity

Newsletters have been distributed by VERSIM

Commission H has sponsored in Mode B (with financing) the following meetings :

- Electromagnetic Scattering from Gases and Plasmas, Aussois, France, 20-25 March, 1994,

- COSPAR Session, Hamburg, Germany, 16-21 July, 1994,
- Suzdal Symposium on Modification Ionosphere, Uppsala, Sweden, 15-20 August, 1994,
- STEP-GAPS Workshop on Non-linear Processes, Warsaw, Poland, 24-28 April 1995,
- Satellite Studies of Ionospheric and Magnetospheric Processes, Moscow, Russia.

and in Mode A (without financing) :

- 8th Int. Symposium on Solar-Terrestrial Physics, Sendai, Japan, 5-10 June, 1994,
- Int. Conference on Radio Science, Beijing, China, 10-12 August, 1995.

Two Commission H newsletters have been distributed : the first in March 1994 to organize the sessions, the second in March 1996 to prepare the business meetings in Lille.

Dr. F. Lefevvre, Chair

COMMISSION J

1. Formal account

All meetings and working groups, suggested by URSI at the Kyoto GA were successfully realized at the specified times. The triennium Budget was successfully used as well, only USD 800 left for the General Assembly. This may result in the some troubles at the coming GA.

2. Science report

I. Last triennium happened to be connected with 100 Years anniversary of the Radio. Commission J has 100 Year experience of exploration of the surrounding Space by radio waves. 1895- first very simple antenna device and receiver was used to explore the Electromagnetic Waves from the lightning, (A. Popov "Thunderstorm Marker"). It was the first case of receiving of the radio waves from the

Natural Source. 1932-Discovery of the Radio Emission from the Milky Way (K. Jansky) 1946-1952- Discovery of the numerous extragalactic objects, including Andromeda Nebulae and very distant objects, as CYG-A. 1967-Discovery of the Hot Universe Radio Waves, connected with the recombination of the gas at redshift about 1000, that is with less than 1 mln. yr. age of the Universe. In the Last 3 Years it was demonstrated, that only by Radio it is possible to penetrate into "Singularity Epoch", were all features of the present day Universe were in the "seed" form. First indications of the existence of the primordial "GENE" were communicated recently by Britain and USA groups and it opens an absolutely new way of understanding of Evolution of Universe, and, what is also very important, it can help to construct the complete Physical Theory of the

Natural Laws (TOE, Theory Of Everything) using "Singularity" as a Big Accelerator of ev. IOE19 energy. Last three Years were very successful in the increasing of the range, up to which discrete objects may be found. Absolute record was settled by VLA (USA), few micro-Jansky in flux density. At this level all powerful radio galaxies like CYG-a in principle can be observed at any distances up to recombination epoch, that is throughout the whole Universe!

II. Ground Based Radio Tools happened to be even more powerful in the solution of the "Black Holes" problem (which were suggested as the major source of energy in the Universe) than Hubble Space Telescope. The gravitational potential around the Giant B.H. candidate in one of the nearby active galaxy was studied using Water Masers very narrow line emission by several order of magnitudes more accurately, then by any other means and big point-like mass inside 0.1 pc volume in the nuclear of the galaxy was confirmed. (First observations of this kind were communicated by Japanese observers at URSI GA in Kyoto)

III. Great need in the more and more powerful Radio Astronomical instrumentation for very different targets presses strongly on the rate of the developments of the radio telescopes facilities. Practically "Ideal" radiometers appeared with noise, no greater than the sky noise (HEMT's up to 100GHz, He3 cryo bolometers at mm- submm. waves). Not only flux density sensitivity increased by factor about 10 during last 3 Years, but also resolution of the Ground Based radio astronomy by factor 3 and VLBI technique now possible even at 1 mm. During the Lille GA big jump

are expecting through VSOP Japanese Space mission, which will be followed by RADIOASTRON even more ambitious mission to break through the limitation of the Earth geometry. Greatly improved the single dishes and Ground Based arrays (e.g. : Arecibo, Jodrell Bank, Effelsberg, RATAN-600; VLBA and GMRT). Three WG's are discussing next generation instrumentation, which include the Space and Ground Based projects. Few sub-projects trying to use Lagrangian Point 2 as a site for the permanent observation of the CMB. Few sub-project connected with 10-100 fold increasing of the collecting area of the Ground Based Radio Telescopes (SKA; KARST). Several projects for very short waves are in preparation, some of them as big as 10 000 m.sq. VLBI technique may penetrate into the submm-IR- and even in optics domains in the next decade.

IV. Efficiency of the Radio Astronomy Community depend strongly on the interference level- exponential growth of the Energy consumption results in the exponential growth of the EM Pollution. Last decade the situation dramatically escalated due to the mobile communication technology and it is very likely that the range of the Radio Telescopes will collapse to the negligible value and in the next decade it will be impossible even to repeat experiments of the last decade. It is clear, that the boundary between "People-to-People" communication and "People-to-Universe" communication should be regulated at the much higher level (comparable with United Nations) and commercial considerations have to be balanced by others one, connected with the very existence of the "HOMO SAPIENCE", which is impossible without contact with the Sky.

Prof. Yuri Parijskij, Chair

COMMISSION K

1. Introduction

Commission K "Electromagnetics in Biology & Medicine" is the latest born among the URSI Scientific Commissions, formed in 1991 to follow the evolution of Radio Science with reference to the interactions of electromagnetic field with biological systems. Aim of the Commission was to promote the international research on the effects, the mechanisms, and the human health aspects of the bio-electromagnetic interaction both from the health protection and from the medical, diagnostic and therapeutic point of view.

The presence of Commission K among the URSI Scientific Commissions indicates the growing interest of the scientific community into the possible health effects of electromagnetic fields. This interest gave impulse to some collaborations that Commission K immediately started with other Societies, and with others URSI Commissions.

In the following the activities done by Commission K in the past three years are listed. These activities include among the others the collaborations we have just mentioned, the financial support done to different initiatives, and, of

course, culminate in the organization of the Commission K Sessions at the URSI General Assembly (Lille, August 28 -September 5, 1996). To outline the developments done by Commission K in these years, it is worth noting the organization of the URSI GA in Lille. In fact, in the next GA there will be a Commission K Session entirely devoted to the Wireless Communications thus evidencing the increasing importance of these communications into modern life. Moreover, together with the Joint Sessions organized in conjunction with Commission A ("Electro-magnetic Metrology") and Commission B ("Fields and Waves") already present in the URSI GA in Kyoto (1993), there will be a Joint Session organized in conjunction with Commission E ("Electromagnetic Noise and Interference") and devoted to the "Characterization of EM-sources and design of equipment for minimum coupling with the human body". The purpose of this Session is to stress the need of introducing, into the new electromagnetic system design processes, steps devoted to the reduction of the environmental impact and of the possible health consequences of these systems.

2. Collaborations with formal Societies

During the past triennium Commission K collaborated with the BioElectroMagnetic Society (BEMS), the European BioElectromagnetic Association (EBEA) and the IEEE for the organizations of special sessions and meetings. In particular,

- *BioElectroMagnetic Society (BEMS)*

It has been agreed on the organization of joint sessions during the BEMS meetings. This has led to the organization of a Session on "RF & Microwave Dosimetry" in the 1994 BEMS meeting;

- *IEEE*

1993: URSI Commission K co-sponsored the International Conference on Microwaves in Medicine

3. Organization of special Sessions in Congress

At many International Congresses Commission K has actively organized Special Sessions on subjects close to the terms of reference of the Commission. Besides the sessions already mentioned in the preceding paragraph, they are:

- *EMC '94 Rome (Italy)*

Table I: Commission K budget (1993-96)

SYMPOSIUM TITLE	OUR INITIATIVE	VENUE	DATE	BUDGET (USD)
Physics and Engineering of mm and submmEM waves		Kharkov, UKRAINE	7-10 June 1994	500
BEMS Meeting	Joint Session	Copenhagen, DENMARK	12-17 June 1994	0
EMC Conference		Wroclaw, POLAND	28 June - 1 July 1994	500
EMC'94 Rome	Workshop	Rome, ITALY	13-16 Sept. 1994	500
Commsphere	Workshop	Eilat, ISRAEL	23-27 Jan. 1995	1500
EMCInternational Symposium	Open Meeting	Zurich, SWITZERLAND	6-10 March 1995	0
COST 244 Workshop		Kuopio, FINLAND	3-5 Sept. 1995	1000
Biophysical Aspects of Coherence		Prague, CZECH REPUBLIC	11-15 Sept. 1995	1000
European Bioelectromag. Association (EBEA) + European COST 244	Two Joint Sessions	Nancy, FRANCE	28 Feb. - 3 March 1996	0
EMC Conference		Wroclaw, POLAND	1996	1000 (PROV)
EMC '96 Rome	Session, Tutorial	Rome, ITALY	Sept. 1996	1000 (PROV)

- *European BioElectromagnetic Association (EBEA)*

1993: URSI Commission K co-sponsored the 2nd EBEA Congress;

1996: at the 3rd EBEA Congress, URSI Commission K together with EBEA and COST Project 244 organized the Special Sessions on "Human Exposure in Mobile Communication Systems", and on "Biological Responses to ELF fields";

Session on "Human Exposure to EM Fields";

Workshop on "Electromagnetic Pollution and Bioelectromagnetic Interaction";

- *COMMSPHERE '95 Eilat (Israel)*

Workshop on "Radiation Hazards in Personal and Cellular Communication Systems";

- *EMC '95 Zurich (Switzerland)*

Open Meeting concerning the various domains of interest for the Commission.

4. Sponsored initiatives and financial support

In Table I the initiatives sponsored by the Commission and the budget given to each of them are listed. The initiatives that will be completed in this last year of the triennium are also present.

5. The "Review of Radio Science 1993-95" and the "Disk of references 1993-95"

In correspondence of the General Assembly a book reviewing the developments of Radio Science related to the triennium and a disk reporting the international literature published in the triennium are edited.

With reference to the "Review of Radio Science", the book is divided into chapters edited by the Vice-Chair of each URSI Commission. Commission K chapters are edited by J.C. Lin, University of Illinois at Chicago. The titles and the authors of these Chapters are:

- C.K. Chou and W.W. Wang, "Medical Applications of Electromagnetic Energy";
- R. de Sezel and B. Veyret, "Biological Effects of Electromagnetic Fields".

The Commission K part of the disk is edited by S. Pisa, University of Rome "La Sapienza", using contributions provided by the Commission K Official Members together with references selected from international journals and publications. It will be constituted of more than 500

references, each quoted with some key words. Although the disk is not intended to be an exhaustive bibliography for the years covered, it gives a broad representation of the international literature published in scientific journals, books, or as full papers (more than 3 pages) in the proceedings of international symposia.

6. Organization of URSI General Assembly (Lille, August 1996)

For the next General Assembly, Commission K scheduled 1 Tutorial, 4 Regular Sessions, and 3 Joint Sessions. Each Session is constituted by invited lectures, spontaneously submitted oral presentations, and posters. *For further information, we refer you to the Provisional Scientific Programme.*

The TUTORIAL will be held by M. Stuchly, University of Victoria (Canada) on "*Personal Communication Services - Technology and Health Concerns - Is there a Common Solution?*". It will discuss the argument that health protection and technology development have a common end-point in the case of wireless communication systems.

7. Activities still in progress

Commission K is organizing the following activities that will be completed after the URSI General Assembly : EMC'96 Rome (Italy) and COMMSPIHERE '97, Lausanne (Switzerland).

Prof. P. Bernardi, Chair,
M. Cavagnaro

THE SCIENTIFIC COMMITTEE FOR TELECOMMUNICATIONS

The Scientific Committee for Telecommunications was established in recognition of the importance of radio science in the development and exploitation of telecommunications. It provides a framework for the identification of topic areas where the results of new radio science are important for communications; or where the development of communications needs further studies of the underlying science.

The Scientific Committee for Telecommunications comprises the Commission chairmen, in some cases with the addition of nominated experts, and communications engineers nominated by the International Telecommunication Union, mainly the Geneva based engineer-counsellors within the ITU Radiocommunication Bureau. (These counsellors previously worked with the CCIR study groups; the work continues in the same way but the name "CCIR" has disappeared following an ITU reorganisation). In addition URSI has appointed individual members.

The Scientific Committee for Telecommunications has agreed terms of reference which permit activities focused on telecommunication matters between URSI Commissions

themselves, or between the URSI Commissions and the ITU-R Study Groups. There is no intention of duplicating the work already well organised by inter-commission conferences, seminars and workshops. Thus the Scientific Committee for Telecommunications has a low profile and does not seek to influence these activities. However the Scientific Committee for Telecommunications provides a mechanism for the establishment of task groups which would continue to study matters between meetings by correspondence.

The Scientific Committee for Telecommunications also provides a framework for studies involving both URSI scientists and ITU engineers. This may include both the establishment of task groups to work by correspondence and the organisation of meetings of joint URSI/ITU interest.

An important activity was the task group for "the characterisation of the mobile channel" under the leadership of Dr Shapira. A series of workshops were held during the 1990 to 1995 period. Since the 1993 General Assembly there have been the PIMRC-93 panel meeting, the Stockholm workshop following the VTC-94 conference and a workshop at Commsphere-95. In each case efforts were made to

attach the meetings to other events so as to reduce travel costs, and to arrange an event in keeping with the main organisational structure of the main conference. These workshops were important for scientists to air issues in depth, and have contributed to an understanding of the problem and by bringing together the international effort devoted to the channel characterisation topic. The task is by no means complete, with the diversification of wireless communications into satellite and personal communication services, the use of higher frequencies and higher data rates, and the task group will work in the future mainly by seeking to enhance communications between researchers and research groups, via workshops as the opportunity arises and by establishing an internet dialogue group. This somewhat ad-hoc activity cannot compete with the more structured research efforts, such as the European COST projects, but its task is to bridge the various group efforts in different parts of the world.

The second main activity is the establishment of the series of COMMSPPHERE conferences. COMMSPPHERE provides a forum for discussions between academicians, industry experts and telecommunication administrators on the future of telecommunications in the presence of the congested radio frequency spectrum. The ITU now has a regular series of decision making World Radiocommunication Conferences and COMMSPPHERE provide an excellent preparatory event, free from the decision making overtones.

COMMSPPHERE 95 was held in Eilat and included sessions on:

- spectrum management policies
- integrated wireless access networks
- MSS and LEO communication satellites
- communications for developing countries
- radio astronomy and the EM environment
- health protection in PCS and cellular systems
- signal processing
- the EM environment and interference
- personal satellite communications

The Conference was success and has been reported in the Radio Science Bulletin.

The next event in the series will be COMMSPPHERE 97 which will be held in Lausanne in February 1997. For this event the Conference chairman is Prof. Ianoz, and the Programme chairman is Dr Shapira. Announcement leaflets have been widely circulated and the detailed programme is now being assembled. Likely topics are:

- global information superhighway - the wireless arm
- development in spectrum management policies and techniques
- radio astronomy and the EM environment
- health effects of radio transmission
- personal communication satellites
- LEO/MEO/GSO systems and services
- communication development in developing countries
- the EM interference environment
- wave oriented space-time signal processing
- smart antennas in wireless communications.

In addition there have been a number of Commission organised meetings which have dealt with telecommunication issues. In these cases it has not been necessary for the Scientific Committee for Telecommunications to be explicitly involved, in line with the intention of not adding complications where an event is successfully fulfilling a need, although where appropriate the Scientific Committee for Telecommunications has provided background encouragement where this has been appropriate. A good example of such events is the series of CLIMPARA meetings organised within Commission F. The most recent of these was held in Oslo in June 1996.

Scientific Committee for Telecommunications in period after it was set up was to list items identified by the ITU where it was thought that additional radio science studies were needed. This list has been considered by the various commissions at previous General Assemblies. The ITU has recently reviewed and updated the Scientific Committee for Telecommunications, is now being included in the WWW pages of the ITU where it is hoped it will be possible to have easy access to information on the range of topics seen as being important for joint study.

Les Barclay

News from the URSI Community



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by **Stefan L. Hahn**

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Hilbert Transformers

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Transformers. Generation of Hilbert Transformers Using SSB Filtering. Digital Hilbert Transformers. FIR Hilbert Transformers. FIR Hilbert Transformers with Half-Band Filters. Recapitulation of Design Procedure of FIR Hilbert Transformers. Digital All-Pass Hilbert Transformers. Design of Hilbert Transformers Using Bilinear Frequency Transformation. IIR Discrete-Time Hilbert Transformers. Differentiating Hilbert Transformers. References. Appendix: Design Details of IIR Hilbert Transformers.

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Distribution. Generation of 2-D Random Fields. Definition of Electrical Power in Terms of Hilbert Transforms and Analytic Signals. Generalization of Notion of Power For Signals with Finite Average Power. References.

Multidimensional Complex Signals and Applications

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Stefan L. Hahn is Professor Emeritus and heads a research team at the Warsaw University of Technology, and was Professor and Chairman of the Radiocommunication Department there. He holds an M.S. and Ph.D. in Electronics from the- Warsaw University of Technology. He is a senior member of the IEEE, the Polish Academy of Science, and the New York Academy of Science.

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PROPAGATION OF RADIO WAVES

by **M. P. M. Hall, L. W. Barclay and M. T. Hewitt**

IEE, Michael Faraday House

ISBN 0 85296 819 1

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Readership; electrical, electronics and communication engineers; applied physicists; upper undergraduate and postgraduate; professional; reference.

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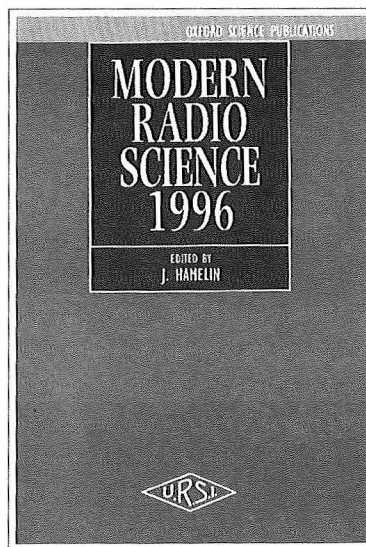
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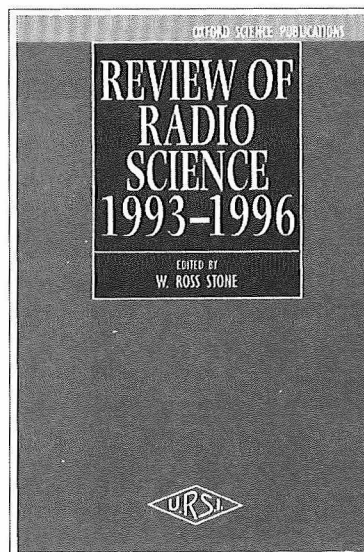


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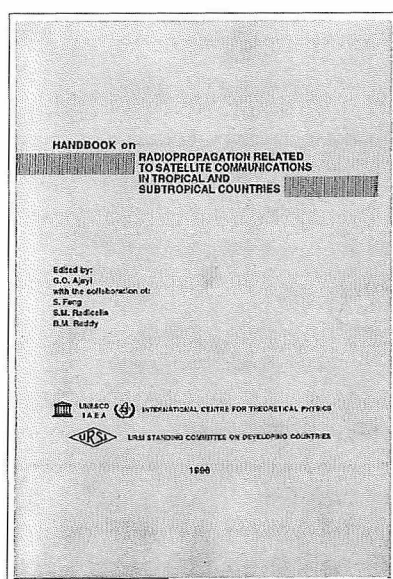


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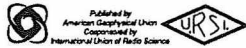
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