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The

RADIOSCIENTIST

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Czechoslovak Subsatellite for ACTIVE experiments

A small satellite of about 50 kg mass has been developed for wave and particle injection experiments in near-Earth cosmic plasmas. Its main task is to serve as an independent diagnostic package being launched together with the active mother satellite by a common launch vehicle. Experience with the MAGION subsatellite launched in 1978 as part of the INTERCOSMOS 18 satellite project has been used in the subsatellite design for active experiments.

As part of the INTERCOSMOS cooperation program two active satellite projects are realised. The first one, called ACTIVE, which uses a VLF transmitter on board the INTERCOSMOS 24 as the main source of plasma energisation, was launched on 28 Sept, 1989, and on October 3 the subsatellite MAGION 2 was separated from its mother satellite INTERCOSMOS 24. The name MAGION has been proposed for the small satellites in the ionosphere–magnetosphere research program of the Geophysical Institute of the Czechoslovak Academy of Sciences. Apart from some technological problems which occurred namely during the first phase after separation, MAGION 2 is still in operation.

Using the experience with MAGION 2 another small satellite, based on the same constructive principles, is now being prepared for the APEX (Active Plasma EXperiment) to be launched in 1991. The proposed orbital parameters are 500/3200 km altitude and 83° inclination. The subsatellite will be an only slightly modified version of MAGION 2: total mass about 52 kg; main satellite body diagonal 560 mm, deployed booms diagonal about 2 m.

Subsystems:

Power: solar batteries, 12 Watts; 2 nickel–cadmium batteries 12 V, 4 Ah; DC/DC converters, synchronized.

Telemetry: 137 and 400 MHz transmitters; digital data rate 40 kbit/s; analogue information (waveforms) 60 kHz bandwidth.

Telecommand: 256 command combinations, programming ability, 128 bits/s.

Housekeeping: 196 items (status, temperature, voltages, currents). Orbit adjustment ability using pressurized gas system (0.2 N).

Welcome to the *Radioscientist!* This inaugural issue is quite independent of URSI apart from my connection and this free distribution at URSI XXIII. However, it is *for* URSI scientists and if we can meet the publication costs of future issues from paid advertisements, the future issues will also be free except for mailing costs.

Attitude: magnetic stabilization, solar sensors, magnetometer.

Payload:

Magnetometer: three axis fluxgate, 0 – 20 Hz, sensitivity up to 2 nT.

Electric fields: frequency range 0.01 – 20 Hz, dynamics 0.05 – 8000 mV/m.

Wave experiment: searchcoil magnetometers 10 Hz – 40 kHz; doubleprobe electric component sensors 0.1 Hz/120 kHz; frequency analyzer 1 – 120 kHz and filterbanks 20 Hz/15 kHz; broadband analogue waveforms (ELF–VLF).

Radiospectrometer: 0.01 – 10 MHz.

Cold Plasma experiments: Langmuir probe (Te, Ne), Rf–probe (Te and anisotropy of Te); Ion-trap (Ni and Ni/Ni).

Hot plasma experiments: 0.01 – 20 keV electrons and protons in 16 energy levels; solid state detectors 20 keV – 1 MeV, 8 energy levels.

Photometer: 630 and 577.7 nm.

International cooperation: The subsatellite has been developed in Czechoslovakia under close cooperation with other INTERCOSMOS country participants. In the service subsystems development, especially in the construction of the separation mechanics and pressurised gas thruster, in cooperation with several USSR organizations and in the scientific payload also in cooperation with scientific teams in Bulgaria, Germany, Hungary, Poland and Rumania. For optimum comparability between the subsatellite and main satellite scientific data, the diagnostic payloads of both spacecrafts are similar and both had essentially the same team developing the instruments so that each experiment common to both uses identical sensors, calibration methods, etc.

PAVEL TRISKA

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The *Radioscientist* is not an official URSI publication for official reports and paper calls.

Scanning the *Radioscientist* — from the Editor

As I said on the front page box, this inaugural issue is quite independent of URSI apart from my connection. If URSI likes this first issue and grants "sponsorship", future issues will carry the familiar URSI logo as does (or soon will) the AGU journal, *Radio Science*, but the *Radioscientist* will continue to be editorially independent of URSI so that URSI cannot be held responsible, directly or indirectly, for anything in these pages.

The future of *URSI NEWS* is entirely up to URSI to decide, but I hope it stays in existence to provide a safety net for the *Radioscientist* in the meantime. The continued existence of either depends on radioscientists like yourself writing articles for either. As editor of both at present, I will regard contributions received as offered for possible publication in the *Radioscientist*, *URSI NEWS*, (and the *AP-S Magazine* — see below) unless the contributor says otherwise. The list above of Associate Editors are those who have acted in a similar way for *URSI NEWS* as well as some others I have approached for *URSI NEWS*. I will shortly (mostly during URSI XXIII in Prague) appoint more Associate Editors for the *Radioscientist*. These will be like the "Regional Editors" of *URSI NEWS* with two important differences: (i) as they do not represent URSI Member Committees, they will not be appointed by them; (ii) the role of the Associate Editors is to provide articles from their colleagues, and this requires actively seeking them.

The lead article is by **Pavel Triska**, in whose city and country we are guests. A more important reason for making it the lead article is that it is an excellent example of what we need for the Radioscientist — news articles about big experiments and engineering projects of interest to radioscientists. Another article of this type, about *Freja* the successor to *Viking*, by **Rickard Lundin and Gerhard Haerendel** appears later on. There must be exciting things the rest of you are involved in, so how about an article?

We have made an arrangement with **Ross Stone**, Editor of the IEEE Antennas & Propagation Society *Magazine*, to exchange articles between our *Radioscientist* and his *Magazine*. The first of these is about **Francesco Grimaldi**, S. J. , the inventor of diffraction (he coined the name) and is by **Roberto Cecchini** and **Giuseppe Pelosi** of the University of Florence. The scale size separating the geometrical optics regime from the Fresnel diffraction regime is not the wave length but the geometric mean of the wave length and the path length. Over the URSI spectrum, this ranges from about 10 m (house size) for centimetre wavelengths over 10 km paths to 400 km (mountain ranges and ionospheric structures) for global path lengths at VLF.

There are two articles by **Rudolf Treumann**. The first is about the magnetosphere where the action is for URSI–H people. It may seem too specialised for others but I would like to see articles of this sort frequently in the future, without becoming a mini journal with peer refereeing.

If you are bored at one of the URSI XXIII sessions and time seems to pass slowly, maybe it really *is* passing slowly, as **Rudolf Treumann** tells us in his second article. But should you then believe your watch?

The first use of radar outside ionospheric research and for target location was a little over 50 years ago though the first use of the acronym, RADAR, was a little under. Just on 50 years ago, radar was playing a vital role in defense of Britain so this may be a good time for reminiscence. **J. H. Cloete** sent the South African experience from a talk given in 1974 by **F. J. Hewitt.** As you will see, New Zealand had a role here too, so perhaps I can extract another reminiscence from down here. How about an article from the other side?

The **NEWS IN BRIEF** section needs no introduction from me but it needs more input from you! Surely all radioscientists are doing something exciting sometime. Share it! Even a paragraph will do.

Diffraction — The first recorded observation

Geometrical optics, the oldest and most widely used theory of light propagation, fails to account for certain optical phenomena called diffraction [1]. —J. B. Keller

Probably, diffraction is one of the phenomena more familiar to the members of the electromagnetic community, and this, also, thanks to the success of the Geometrical Theory of Diffraction. What perhaps are not so well known are the etymology of the word, the first observation of the phenomenon, and its discoverer.

What we would like to do in this short paper is just to contribute to the diffusion of this knowledge, which, we think, could interest the readers of this magazine.

De Lumine

Even if the first hints about the diffraction phenomenon can be found in the works of Leonardo da Vinci, its discovery is unanimously accredited to the Jesuit, Francesco Maria Grimaldi [2]. He described the experiments which led to its discovery in the book De Lumine [3] — first published in Bologna in 1665, two years after the author's death — and gave the phenomenon the name by which it is still called. The etymology of the word is from the Latin verb *diffringere* (dis + frangere), which means "to break in different directions" [4].

The book *De Lumine* — in Latin, as that was the official language of the scientific community in those times — with its strange mixture of modern experimental spirit and old scholastic philosophy, is a very important testimony to the philosophical and scientific renaissance of those years. This was a process which was strongly opposed by an extremely conservative milieu, averse to every form of innovation. A careful reading reveals the didactic and scientific authoritarianism which still ruled in the higher education fields and, at the same time, the advance of the modern Galilean principles against the old Medieval dogmatism.

In the two parts of his book, Grimaldi presents two possible hypotheses about the nature of light: substance or accident (i.e., a quality of another substance) even if his preferences, as can be deduced from the Preface, are for the second one. However, even if the two parts contain contrasting views about the nature of light, in both Grimaldi opposes the corpuscular theory of light. He is deeply convinced that light is a fluid (a substance or accident of some other fluid substance), and that colours are a modification of it. The phenomenon of diffraction is the main point in favour of this hypothesis.

Grimaldi's Life

Grimaldi lived in the years which saw the rise of modern science: a transitional period, in which strong remnants of

PHYSICO-MATHESIS
DE LVMINE,
COLORIBVS, ET IRIDE,
ALIISQVE ADNEXIS
LIBRI DVO,
In quorum Primo afferuntur Noua Experimenta, & Rationes ab ijs deductæ pro Substantialitate Luminis.
In Secundo autem dissoluuntur Argumenta in Primo adducta, & probabiliter sustineri posse docetur Sententia Peripatetica de Accidentalitate Luminis.
QVA OCCASIONE
De hactenus incognita Luminis Diffusione, de Reflexionis, Refractionis, ac Diffractionis Modo & Causis, de Visione, deque Speciebus Intentionalibus Visibilium & Audibilium, ac de Substantiali Magnetis efluuio omnia corpora peruadente, non pauca scitu digna proferuntur, & speciali etiam argumento impugnantur Atomistæ.
AVCTORE
P. FRANCISCO MARIA GRIMALDO
SOCIETATIS IESV.
OPVS POSTHVMVM.
BONONIÆ, M.DC.LXV.
Ex Typographia Hæredis Victorij Benatij. Superiorum permissu.
Impensis Hieronymi Berniæ Bibliopolæ Bononiensis.

the Medieval mentality coexisted with the new way of thinking and working. The situation was worsened by religious struggles: the Council of Trent (Counter Reformation) was held from 1545 to 1563.

These are just a few dates to help the reader to set his work and life against their historical background.

1600. Giordano Bruno was burned at the stake.
1609. Kepler published *Astronomia Nova*, in which he expounds his theory about the ellipticity of planetary orbits.
1632. Galileo Galilei published his *Dialogo Sopra i Due Massimi Sistemi del Mondo.*
1633. After a trial by the Holy Office, Galileo recanted his theories.
1687. Isaac Newton published his fundamental work *Philosophiae Naturalis Principia Mathematica* in London.

Most of the information about the life of Father Grimaldi come from the *Elogium perbreve* (a brief panegyric) written by Father G. B. Riccioli at the end of *De Lumine.* His father was a silk merchant who worked in Bologna, where he was born in 1618, fourth of six children. Grimaldi entered the Society of Jesus in 1632, studied in Parma and Ferrara, then settled in Bologna, where he died of consumption in 1663 at the age of 45. He first taught Philosophy and then Mathematics in the College of Santa Lucia, where he earned a great reputation as a teacher and scientist. His many scientific activities were theoretical and experimental (Father Riccioli tells that he used to build his own instruments): from astronomical observations — he originated the practice of naming lunar regions after astronomers and physicists; some still bear his names — to anatomy, physiology, geography, and optics. Perhaps his more important contribution to the astronomical sciences is a selenograph of the moon [5] , which was surprisingly accurate for its times.

Experimental Observations

Grimaldi was extremely conscious of the importance of the phenomenon discovered, as can be seen by the relevance he gave to it in De Lumine. Actually, he began his book with these words:

PROPOSITIO I.

Lumen propagatur seu diffunditur non solùm Directè, Refractè, ac Reflexè, sed etiam alio quodam Quarto modo, DIFFRACTÈ.

(The light propagates or scatters not only directly, by refraction and reflection, but also in a fourth way, by diffraction).

The phenomenon is demonstrated by two experiments whose results sharply contrast with the fundamental principle of geometrical optics: the principle of the rectilinear propagation of light. These two experiments, and the author's subtle arguments to exclude reflections or refractions from the possible causes, occupy the first 11 pages (of 535!) of *De Lumine,* and constitute his main contribution to the science of Optics.

In the first experiment, Grimaldi described the anomalous shadow (according to the geometrical optics principles!) cast by a small opaque body in a sun ray from a very small aperture in a closed window. In some regions he noticed the diffraction fringes, which he called *seriae lucidae* — the name *fringes* was used by Newton some years later [6].

In the second experiment he found that a cone of light through two very small apertures produces, on a white screen, a spot much larger than the one predicted by the theory of geometrical optics.

Grimaldi even tried to formulate a theoretical explanation of the phenomenon. Of course the scientific knowledge available in his day was insufficient: the true explanation of the phenomenon would only come from A. Fresnel, 150 years later.

The Use of the Term *Diffraction*

Newton was familiar with Grimaldi's work, and even if he only quoted him in his book Opticks [7], he probably knew it well before [8]. Unfortunately, the phenomenon of diffraction conflicted with his theory of the corpuscular nature of light and, in this case, his behavior was not very scientific: he ignored the Jesuit's findings! Specifically, he made many very clever experiments which confirmed and perfected Grimaldi's results, but he attributed the causes of the diffraction *fringes* (a term introduced by him) to reflections and refractions at the borders of the objects in the ray path: exactly what Grimaldi had excluded by a long series of considerations (in Proposition One of Book One). Moreover, Newton ignored the name Grimaldi had given to this new phenomenon — he used the word *inflexion* instead [9] — and the word *diffraction* disappeared from use for the duration of his dominion over Optics [10].

We'll have to wait 'till the second decade of the XIX century, when Augustin Fresnel will explain the phenomenon with his theory on the wave nature of light, to see Grimaldi's term used again [11].

Acknowledgements

We would like to thank Dr. A. Lumini of the Central National Library of Florence for her precious help in bibliographic research.

References and Notes

[1] Joseph B. Keller, Geometrical Theory of Diffraction," *J. Opt. Soc. of America*, vol. 52, no. 2, pp. 116-130, 1962.

[2] For an exhaustive review of Grimaldi's life and works — including the ones not related to diffraction — see the entry in Charles C. Gillispie, ed., *Dictionary of Scientific Biography*, Charles Scribner's Sons, New York (1970-1980), and the references therein. Another useful work is C. Sommervogel, *Bibliothéque de la Compagnie de Jésus*, Seconde Partie: Historie, Oscar Schepens, Bruxelles (1892).

[3] *Dis* is a prefix which denotes separation, interruption (see the Greek δια). *Frango* means to break (in a physical and moral sense), and its roots can be found in the Gothic *brikan* and the Sanscrit word *bhanakti*. The verb *diffringere* is used by various authors, mainly with reference to things. The first testimonies about its use in a literary text are in Plautus — the author of comedies who lived in the III II century B.C. (see *Thesaurus Linguae Latinae*, Lipsiae: B. G. Teubner, 1910).

[4] The complete title is *A physico-mathematical treatise on light, colours and the rainbow, and other related topics in two books, in the first new experiments are described and arguments are deduced from them in favour of the substantiality of light. In the second, however, the arguments introduced in the first are confuted and it is shown that the Peripatetic theory of the accidentality of the light might be true.*

[5] The selenograph is a table in the *Almagestum Novum* by G. B. Riccioli, with the title *Selenographia P. Francisci Mariae Grimaldi Soc. Iesu*, signed: "Delineavit ipse P. Grimaldus at Dominicus Fontana Sculp. Bononiae ano 1651." As a curiosity, the isolated black crater on the extreme left bears Grimaldi's name.

[6] Isaac Newton, *Opticks*, New York: Dover, 1979 (based on the fourth edition of 1730).

[7] Isaac Newton, *Ibid.*, p. 317.

[8] *De Lumine* was reviewed in *Philosophical Transactions of the Royal Society of London*, vol. 6, no. 79, pp. 3068-3070, 1672.

[9] The term *inflexion* was used for the first time by Hooke, who performed his first experiments on diffraction in 1672, after the review of Gimaldi's work in the *Philosophical Transactions*.

[10] For Grimaldi's influence on Newton's theory of diffraction, see Roger H. Steuer, *Isis*, vol. 61, p. 188-205, 1970.

[11] Augustin *J. Fresnel, Ann. Chim. et Phys.*, vol. 1, no. 2, p. 239, 1816.

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Diffusion Processes at the Earth's Magnetopause

Wave processes are believed to be heavily involved in the anomalous diffusion process of plasma across the magnetic field. One particularly well suited place to study these processes in space is the magnetopause and its low latitude boundary layer. This layer, which has been shown in the past to exist over long time periods interrupted only by strong magnetospheric disturbances when the boundary layer plasma is depleted rapidly, is much wider than the magnetopause itself. One therefore expects diffusion of magnetosheath plasma from the magnetosheath into the magnetosphere to be at work here.

Since the magnetopause manifests itself as a steep density gradient rather than a magnetic field gradient and at the same time selects between solar wind and magnetospheric particle populations, there are many possibilities for excitation of different kinds of waves. Whistler waves and electrostatic electron cyclotron waves may be excited by particle anisotropies caused by the presence of the boundary. Electrostatic and electromagnetic ion cyclotron waves may be excited by similar mechanisms as well. Macroscopic instabilities such as Kelvin-Helmholtz instabilities may cause momentum transport, enhance density, current and field gradients and thereby decrease the thresholds for other microinstabilities which could serve as drivers of the diffusion process or even produce eddies or be the cause of local reconnection yielding flux transfer events. Most of these processes have been barely understood up till now though numerical simulations seem to indicate that some of them may work simultaneously and cooperate. Opinions about the respective importance of different kinds of waves diverge strongly.

Among the various waves which may be of importance in the general diffusion, lower-hybrid waves are of special interest. For these waves it is known that they yield a high anomalous collision frequency. Actually in a magnetised plasma their collision frequency is of the order of the lower hybrid frequency itself and can thus be of crucial importance in the diffusion process. The waves are easily excited by the lower hybrid drift instability which becomes unstable under very weak conditions in the magnetopause region. Using the theoretical diffusion coefficient for this instability, we have estimated the diffusion time and have found it marginally sufficient for generating the magnetopause boundary layer. The estimated diffusion coefficient based on the known wave intensities obtained by several spacecraft (ISEE, AMPTE IRM) at the magnetopause is slightly less than the required diffusion coefficient of *Sonnerup* (*J. Geophys. Res.*, 1980) for a steady boundary layer but comparable to the reconnection diffusion coefficient. Hence, the lower hybrid drift instability seems to be capable of generating the magnetopause boundary layer. The theoretical wave saturation level, on the other hand, yields diffusion times of minutes, at least one order of magnitude shorter than the measured time.

The coincidence between the measured and the required diffusion coefficients is interesting. However, computer simulations (*Gary et al.*, 1990, *Geophys. Res. Lett.*) of the lower hybrid drift instability at the magnetopause show instead of diffusion an increase in wave length of the waves and some modulation of the wave intensity. Due to computer time restrictions, as one can show (*Treumann et al.*, 1990, in prep.) these simulations do not reach the diffusive state. They probably demonstrate that the instability leads to condensate formation of wave energy at long wave length and subsequent modulational instability resulting in larger vortices and spatially restricted enhancements in density. When the diffusive regime is finally reached, one can expect that these blobs in density start diffusing as entire entities across the magnetopause to form the boundary layer. These blobs might have some relation to observed density enhancements (magnetic holes) in the vicinity of the magnetopause (*Luhr and Klocker*, 1986, *Geophys. Res. Lett.*, *Treumann et al.*, 1990, *J. Geophys. Res.*).

RUDOLF TREUMANN

Some thoughts about Physical Time

Many physicists as well as many philosophers have recognized that time is one of the physically least understood subjects in the world. Since time seems to be something which underlies all processes, physical as well as nonphysical, and precedes physical laws, it is not obvious how it could be derived from the laws of physics. A large number of physicists have reflected about time. The most prominent was probably Einstein who showed that time does depend on the state of motion of a body; but his theories of both Special and General Relativity say nothing about the nature of time but only about its properties of transformation.

The direction of time in particular cannot be explained by any of the known physical laws with the exception of the Second Law of thermodynamics which, however, is alien to the whole of physics. So attempts have concentrated on finding a relation between time and entropy. The state of the art is probably best reviewed in the new book of Roger Penrose, *The Emperor's New Mind* (Cambridge Univ. Press, 1989). Very constructive attempts to find the mysterious relation can be found in Prigogine's popular book *From Being to Becoming* (Freeman,1983). Meanwhile there has been some new developments in the theory of highly complex nonlinear systems which have led to the field of so called deterministic chaotic systems also known under *strange attractors* and other names.

Since it has turned out that the central point in this theory is the production of information in such highly complex systems, I tend to prefer the name *Information Dynamics* for this whole field. This name has been coined by us in conversations about nonlinear dynamics. It has indeed been shown in the recent past when the systems enter the deterministically chaotic regime. As it is now known, this is the regime where structure is created in physical systems which are still deterministic. The basic quantity describing the character of such systems is the so-called Kolmogoroff-Sinai entropy rate K which is the sum of all *positive* Lyapunov exponents of the system.

Methods have been invented in recent years to determine this quantity from measured time series or other equivalent ordered series, so that it can be considered a known and measurable quantity for any physical or even nonphysical system. It has further been demonstrated that K determines the production rate of *internal information I* inside a system. Now, this information and the increase of information is available and measurable. The relation $d\tau = dI/K(I)$ between information and Kolmogoroff-Sinai entropy, which otherwise gives the increase in information with time, can be taken as the equation of definition of a *physical time* interval $d\tau$. The interesting point about this time is that it is intuitively understandable and maps to psychological time. For, only systems which have $K(I) \neq 0,\infty$, i. e. $\infty > K(I) > 0$ contribute to the production of time. $K = 0$ are usually clocks (periodic systems), while $K \rightarrow \infty$ are stochastic systems.

This means only deterministically chaotic systems contribute to generation of time. This is why clocks can be used to measure time,because they do not contribute anything to its production.

Now, only intervals when information is produced yield time. When no information is produced, we have an interval of boredness, which is entirely forgotten and not memorised, while intervals when much information is produced turn out to be memorised as long time intervals in agreement with the notion that much time has been generated during these intervals.

The world can therefore be considered as a system consisting of levels of information, and when a step is done from one level to the next higher one, we generate time while time keeps standing when information stops. It is very interesting to think about the consequences of this new view of time. Many question arise:

• When and how much cosmological time has been generated?

• How do different times in different systems communicate?

• What is the transformation property of this physical time?

• How does it look like in relativistic formulation?

• What are the consequences for Quantum Mechanics?

• Where is most of the time generated today?

• How does the expansion of the Universe fit into the picture of this time?

It is impossible to answer any of these and other questions here, but this kind of new approach to an old and badly understood field of human thinking is very interesting and most exciting and may have consequences which so far are neither visible nor feasible.

RUDOLF A. TREUMANN

50 YEARS OF RADAR in South Africa

I must ask you to forget that we are in the Seventies where the achievements of science are taken for granted, and to think back to the late thirties when the Spanish Civil War made it clear to the British public that, in any major war in Europe, they would be in the front line. In the absence of any method of detecting and observing the movements of aircraft there appeared to be no real defence against the bomber by day, let alone by night. How then was the problem of airborne attack on Great Britain largely solved and, in the latter part of the War, a major bombing offensive against occupied Europe maintained? Radar certainly was not solely responsible for this achievement, but radar, or more strictly superiority in radar, played an altogether indispensable role in both defence and offence. Radar also played an indispensable role in antisubmarine warfare which was equally vital to Britain's survival.

Radar, in fact, dates back to before World War 2 though it was not known as such then. As with all good inventions, at least four countries claim the credit for it – the French, the British, the Americans and, of course, the Russians.

It all depends on what we mean by radar. The definition can become complicated if we try to be too precise. I shall take the simplest. I regard radar as a system for indicating the presence and position of an object by means of the scattering of echoing of radio waves by that object. Radar involves the measurement of the time the radio waves take to travel from their origin to the scattering object, and back. This time element is vital in the definition of radar. By knowing the travel time and the speed of travel of the waves, the range can be determined.

Once we accept that radar involves the transmission of radio waves, the detection of the echo and the measurement of the travel time, we have little difficulty in saying that radar was an American invention. In 1923 two American scientists, Breit and Tuve, used this method for measuring the height of the layer of ionised gas high up in the earth's atmosphere, the ionosphere. They measured the time taken for the waves to reach it and return, which was about a thousandth of a second. Knowing the speed of travel of radio waves, they calculated the height of the layer to be about 160 km.

The word radar, coined some 20 years later, is derived from Radio Detection and Ranging.

As far as military devices are concerned, the position of the United Kingdom is quite clear. As the war clouds gathered in the late thirties, the need for some means of detecting the approach of enemy bombers was becoming more and more pressing. However, the concept of radar arose indirectly. There was then, as there still is today, talk of a death ray as the ultimate weapon and there were various claims in this regard. The radio physicist, Watson Watt, at the National Physical Laboratory was thus asked by the British Government to report on the possibilities of a death ray. Watson Watt quickly expressed the view that at that time death rays were not a practicable proposition but added for good measure that it should nevertheless be possible to detect the presence of aircraft by reflection of radio waves from them. He was immediately invited to demonstrate this and he did so at short notice by using radio signals from one of the Daventry shortwave radio transmitters. Watson Watt himself was an expert on the ionosphere and fully familiar with the method Breit and Tuve. The next step to pulsed transmissions was obvious to him and he pursued the matter so vigorously and with such support from the Government and the RAF that by early 1939 there was a chain of operational radar stations along the east coast of England – a chain of stations which remained operational, without any great changes, throughout the war. Watson Watt was knighted at the end of the war for his services, and died recently. I had the privilege of experiencing his remarkable knowledge and ability on many occasions. As far as I am concerned he was the father of radar.

I would like to convey to you something about the South African story but at this stage I must, in the main, give you *my* story. The whole South African story has yet to be written or, if it has been written, I am not aware of it. My involvement started in January 1940 when I reported as a raw physics graduate to the then Dr Basil Schonland, at the Bernard Price Institute of Geophysical Research at the University of Witwatersrand. Sir Basil, as I shall call him, had by that time become a world-recognised expert on lightning and I had originally been offered a post with him for lightning research, but late in 1939 Sir Basil had been approached by the Department of Defence and he had put himself and his Institute at their disposal. What had happened was that the British Government had notified Commonwealth countries, in extreme secrecy, of the development of a system for the detection and location of aircraft, RDF (Radio Direction Finding) as it was then called, and had invited them to send senior scientists to the United Kingdom with a view to acquainting them with the principles, so that each country could build up a team who could in due course assist in the introduction of RDF systems as and when they became available.

Sir Basil did not go the United Kingdom. No one went from South Africa, but instead it was arranged that Sir Basil should meet the distinguished New Zealand scientist, Sir Ernest Marsden, on his return from the United Kingdom to New Zealand. Sir Basil, in fact, met Marsden's ship in Cape Town and travelled round the coast to Durban. Marsden had some rather vague documents in his possession. Copies of these and notes made by Sir Basil on their discussions while at sea were all Sir Basil had to work on.

Those of you who may have known Sir Basil will realise that he was not interested in gathering a team in preparation for the arrival of equipment from overseas. He gathered a team without delay – but with the object that they should design equipment themselves and, in fact, they did this with such success that the first radar echo was 'seen' on 16th December, 1939. The echo was thought to be from the Northcliff Water Tower. My guess is that it was from the whole of Asvogelskop, but who is to argue that now? The team who did this consisted of Sir Basil Schonland, Professor Bozzoli (now Vice–Chancellor of the University of Witwatersrand), Dr P.Gane (a geophysicist at the BPI), Professor W.Phillips (now Deputy Vice–Chancellor of the University of Natal) and Noel Roberts from the University of Cape Town. One can only have the very highest regard for their achievement. All they really received from the United Kingdom in the way of guidance was that it could be done and the broadest description of 'how'. They had none of the more advanced electronic components or test equipment that was available in the United Kingdom. For components they bought what was available in Johannesburg on the amateur radio market. Of test equipment and instruments they had very little indeed. They had to improvise for all measurements except the most conventional.

Thus it was that on 2nd January, 1940 I was privileged to join this team, a physicist by training, but fortunately a radio enthusiast, not in the amateur radio sense, but I had designed and built reasonably advanced radio receivers. Without this experience I would have been lost. I find it difficult to believe now that for the first week I was not told what the team was doing. I was put to studying ultra short wave radio techniques and elementary electronics, the average physics graduate in those days being lucky if he had seen a radio valve, let alone designed circuits and built them. However, this lasted only a week and I can still remember the thrill I experienced when I was the radar echo from Northcliff. It was not long before test flights with aircraft were arranged. Within six months we had built equipment which could be usable in the field, provided that specialist maintenance personnel were available. It was to be my job to be responsible for the operation of the first set to be deployed for military purposes, but more of that later.

Our first sets worked on a wavelength of about 3 $^1/_2$ m, not far off the wavelength of our present FM service in this country. At that time it was about the shortest wavelength at which we could generate a reasonable amount of power. The valves we used were bought in Johannesburg and were Eimac 250 THs. I can remember this number after 30 years but cannot remember today's date! We were able to generate about five kilowatts with a pulse length of twenty microseconds (twenty millionths of a second). Developing a transmitter to do this was no easy task. The techniques for generating such short pulses were very different from those used in communications and broadcasting. Looking back at this transmitter now, I realise that just about everything was wrong with it, but it worked!

The pulses of radio waves generated by the transmitter (50 per second and too low for efficiency by present day standards) were then radiated by an aerial system which sent out waves in a wide beam – 30° or so wide. This beam could be pointed in any direction by the operator by rotating the whole set–up mechanically. In the early days, a second, identical aerial system was used to receive the very weak echo signals. It had to be pointed in the same direction.

To amplify the very weak echoes a very sensitive radio receiver was necessary. Here at least there was some experience in the form of television receiver design to help the team. Electronic TV had been in use in the United Kingdom for some years and designs were available in the popular technical press. The main problem, not encountered in TV was the 'blast' from the transmitter, on the same frequency and of necessity for convenience, very close by. This problem was not properly solved for several years. We called it paralysis as the receiver would be paralysed at the critical period during which echoes could be expected. To display the echo signals a cathode ray tube was used with the so–called type A display – range/amplitude.

With the presence of the object established and its range measured, only its direction is needed to fix its position. The direction of the aerial system gave the bearing. At that stage of development we had not indication of height. Such then was our simple radar set. It was called the JB and consisted of two racks of equipment each a couple of feet wide and about 1.5 m tall. Today it would go into a large shoe box. Unfortunately I have not yet found one of these racks nor even a photograph. We took a set of this equipment to Durban in, I think, July 1940, perhaps earlier, Sir Basil, Dr Gane, S/Sgt Anderson (a post office technician) and I. We installed the set in a Fire Observation Post at Avoca and operated it for about three weeks. We saw very few aircraft but we learnt quite a lot about detecting shipping – which at that time was not our object. On one occasion we saw a number of echoes well beyond the horizon. Now radio waves of this wavelength do not normally get down even to the horizon so we were dubious, but the behaviour of the echoes (their course and speed) was exactly that of shipping not aircraft. Sir Basil bet us a dinner at the Cumberland, at that time *the* latest hotel, that they were not ships. The convoy arrived in Durban Bay at dawn and we got our dinner. Later of course disillusionment came – such over–the–horizon performance was not normal. We had experienced what later became known as super–refraction due to abnormal meteorological conditions – frequent in the tropics but rare in cold climates. In those days we were seriously handicapped by lack of test equipment. We were not able to make tests on the set itself which proved conclusively that it was working properly. Thus changing conditions like this could be most confusing.

Successful trial period

After this short trial period which had really been very successful, we packed up the station and waited for sea transport to Mombasa. Sir Basil flew up. We travelled on SS *Rajula* with, I think, a Transvaal Scottish Regiment of the 1st Division. We were odd men out. We had had no time for military training but were in a military unit with military ranks. I had done the normal ACF (Active Citizen Force) training pre–war ending up as an NCO but had no officer training. At Mombasa, Movement Control had never heard of us and packed us off to Nairobi, though we knew we were destined for the protection of Mombasa and the convoys supplying the South African Forces in East Africa. At Nairobi we were promptly sent back to Mombasa – not the last time in the next five years that such things were to happen.

Back at Mombasa, attached to the 1st Anti–aircraft Brigade, things were better organised. After a few days we moved up to Mambrui some 10 miles north of Malindi and about 100 miles north of Mombasa, where we were to establish the station. Here we encountered serious technical problems. We had not previously operated off a diesel generator and the voltage fluctuations of the single cylinder engine wrought havoc with the timing circuitry – the precision of timing having to be of the order of a millionth of a second. I think that sorting this out in the field was the start of my real relationship with Sir Basil. Over the next 15 years or more he had a very significant effect on my career, our final close association being in the early fifties when, at his suggestion, I was developing radar for the study of lightning – the full circle.

Our first test flight was disastrous. Half–way through it, there was a smell of burning and a transformer failed. The cause was poor circuit design and we had to make a modification in the field. From then on things went reasonably well and we achieved reasonable serviceability. Our job at Mambrui was to detect possible Italian bombers proceeding down the coast to attack Mombasa. Theory had it that this would take place at dawn and dusk. We, therefore, operated for about fourteen hours a day, with priority for the dawn and dusk periods and the moonlight hours. Only once did we see Italian aircraft. They bombed the airstrip at Malindi 16 km away. We did not see them coming in but we saw them going out to sea afterwards for 56 km and then lost them because of our restricted coverage arc of 180°. So much for the theory of their flying along the coast. As a result of this we modified our aerials to cover the full 360° – and thenceforth had endless trouble with breaking feeders.

Operationally the station was linked to Mombasa Fortress by HF radio and later an indifferent telephone. The HF radio was also indifferent. We passed plots using an elementary code. The idea was to alert the gun crews and get fighters up. At that time we were not thinking of guiding interceptions. In more active theatres of war such techniques were perforce being developed.

While we were in East Africa work proceeded apace at home. More sets were built, many improvements were introduced and the first steps at the improved handling of the plots from a number of stations by a filter room were taken. In fact, by the end of 1940 when sets were sent up for the protection of Nairobi, a filter room was included. I assisted briefly with the installation of a set at Thika near Nairobi and then went to Mombasa where an entirely different type of set had arrived from South Africa. This was designed to guide searchlights by providing an accurate bearing and to give accurate range to anti-aircraft guns. It had a claimed bearing accuracy of about a degree and a range accuracy of several hundred metres, far in excess of what otherwise was available, but the set was not properly developed and, for mechanical reasons in particular, it had to be abandoned.

I went up to Egypt in April 1941 in preparation for the move of the East African stations to the Middle East. These were to be fully integrated with the RAF and together we selected sites on the coast of Sinai. The stations at El Arish, Rafa and El Midan were operational by mid–1941. We passed our plots to the RAF filter room at Ismailia and we had our first experience of real operations. The stations performed well and much better than in Nairobi because, at this wavelength, performance over the sea is better than over land. We frequently plotted hostile bombers at ranges of around 120 km and the stations operated there for year or so. I left in November 1941, and the stations closed in the course of 1942, I think, and were replaced by very large RAF stations.

In South Africa during this time the Unit, the Special Signals Service, had grown considerably. Stations were established at the four ports using South African built equipment initially, though with British CD/CHL sets introduced at Signal Hill, Cape Town and in Durban early on. The South African Stations were used originally for the tracking of shipping but, with the return of personnel from the Middle East, procedures were adopted for aircraft observations as well. These radar sets (RDF at that time) were very simple. Other developments were coming thick and fast. The first we encountered in South Africa as the ASV (air to surface vessel). This was a lightweight set carried in aircraft for coastal patrol duties. In the early days its range on shipping was perhaps 16–32 km and it could see a surfaced submarine but not a periscope. Our main problem lay in aerial installations – aeroplanes and large aerials are scarcely compatible. If I remember rightly, mid–1942 involved some of my colleagues heavily in installing ASVs in the first Lockheed Venturas.

Cavity magnetron

Beside the ASV there were many exciting developments in the United Kingdom where applied research was active as never before. I was fortunate in being sent to the United Kingdom in 1942 to study a completely new development, microwave radar. A brilliant achievement at the University of Birmingham had led to the possibility of radar at a wavelength of ten centimetres. This made possible very narrow beams, freedom from the effects of ground and performance from small aerials never obtained before. This invention was the cavity magnetron.

In the United Kingdom microwave radar made possible really effective airborne radar, known as AI (Air Interception) for night fighters for defence against night bombers, but it was quickly proved to be a major weapon of offence as a navigation and bombing aid of unprecedented versatility. This system was known as H_2S. Microwave radar in a bomber presents the pilot with a map–like picture of the ground over which he is flying. Coastlines, rivers, towns and even large bridges can be seen. Such a system, of course, is entirely independent of ground radio stations and aircraft could thus operate beyond the range of the precise radio position fixing systems that had also been developed, such as Gee, H and Oboe. These three systems were closely related to radar and had quite unprecedented accuracy, but their range was limited. These radar devices, highly accurate up to the range of the ground stations, less accurate but invaluable beyond the range of the ground stations, were the key to the whole night bomber offensive of the RAF. I think the invention of the magnetron, vital to H_2S and AI and in due course ASV, is recognised as the most significant invention of the war. Churchill himself in his World War 2 memoirs refers to the 'decisive role played by H_2S' and deals with the whole subject in surprising detail. Many of the famous Churchill memos deal with radar.

My interest in centimetric radar in the United Kingdom was firstly to study the completely new techniques involved and a microwave radar set developed for naval use for the detection of surfaced submarines. Sir Basil Schonland had persuaded the Royal Navy to make available two such sets to be installed in the Cape. He argued that such a set on the top of Table Mountain would have a range on a surfaced submarine of nearly 160 km. Back in South Africa in 1943, we installed the sets on Signal Hill and at Cape Point where they gave excellent results and greatly strengthened the coverage provided for the previous year or so by the South African sets. We did, however, have many operational problems. We had no way of distinguishing fishing boats from other small objects. There was no control on fishing boat movements and aircraft, sent out to identify suspicious echoes, became annoyed at finding fishing boats. We felt it hardly fair that radar should be blamed. Also our South African sets in particular were notoriously inaccurate in their bearings and at times would produce erratic tracks with apparent bursts of high speed on the part of the target, solely due to inaccuracies. I was posted to Cape Town at the beginning of 1943 as Company Commander fresh back from the United Kingdom and centimetric radar, and within the first two weeks three large ships went aground. Each had been plotted by the coastal radar system for some two hours before it struck. One ship went aground right in Camps Bay. You can imagine the post–mortems. It was quite a baptism of fire for me. Hasty measures were introduced by the operational people to warn ships approaching the coast of possible danger. A few weeks before we installed a centimetric radar at Saldanha Bay, another ship went aground right next to the harbour entrance. It was carrying two further centimetric radars for us. We managed to get on board the ship and salvaged the sets which had then been immersed in a mixture of sea water and potassium permanganate for several weeks. Surprisingly enough, in due course, we got one to work.

At about this time a most sophisticated anti–submarine radar arrived unheralded in South Africa in the first Lockheed P VI aircraft to come to this country. This was a three centimetre radar known as ASD. Beautifully designed and constructed, it was one of the first products of the American electronics industry after the concept of the cavity magnetron, referred to earlier, had been given to the United States by the United Kingdom. This set was used extensively on coastal patrols. Towards the end of the war one of these ASD sets was specially fitted to Field Marshal Smut's York, not for anti–submarine purposes but for navigation in the way mentioned earlier for the airborne radar used in bombers. These three–centimetre wavelength sets were also excellent for detecting thunderstorms and heavy rain and were invaluable for flying through the topics at night. Improved versions of this type of set are, of course, fitted in all modern civil aircraft largely for this purpose.

Equipment

In South Africa, for our coastal defence purposes, we thus relied for the first two or three years of the war on our locally designed and built equipment. Gradually larger and more sophisticated sets became available from the United Kingdom. By late 1943 we had a fairly extensive system for the detection of surfaced submarines, surface vessels, low– and high–flying aircraft. We also had limited facilities for directing fighter aircraft to intercept unidentified aircraft detected by the radar system. This particular facility was provided by a special type of set known as a GCI (Ground Control Interception). It had been developed in the United Kingdom in the critical 1940/41 era for night bomber interception. Basically it was a conventional radar set as described previously but the aerial system, and hence the beam it transmitted, rotated several times a minute providing the controller with an elementary picture of the tracks of all aircraft within range. By means of this and knowing which aircraft was the fighter the controller could issue instructions as to how to intercept. The stations we installed here were relatively elementary. The threat of air attack had decreased by then and the more sophisticated equipment used in the United Kingdom towards the end of the war was never installed in South Africa during the war. When our South African stations in Sinai were dismantled the crews were in the main attached to the RAF and operated GCIs of this nature in the Italian campaign. I had no personal experience of this.

Other activities in which we were involved in South Africa were special types of radar for anti–aircraft fire control and for coastal artillery fire control. One of these sets known as the GL II (Gun laying), a relatively long wavelength radar of British origin, somewhat outdated even then but excellently engineered to its maximum potential, had borne the brunt of the anti–aircraft fire control for the defence of London during the early blitz. I remember seeing remarkable figures of 'rounds per bird', as they call it, in the various phases of the blitz. If I remember rightly, in the early stages prior to the GL II something like 75 000 rounds of anti–aircraft ammunition were fired for each aircraft shot down. Using GL II anti–aircraft fire–control once the techniques had been developed, this figure came down to about 2 000. Later with the centimetric fire–control the figure was about 800. The flying bomb (an ideal target, because of its flying straight and at a constant speed) with centimetric fire–control and electronic predictor and proximity–fused ammunition, was almost a sitting duck. But of course the flying bombs did not always fly within range of the batteries – they flew so low. I mention these figures from London in what is essentially a South African talk because, in fact, South Africa played a part here through Sir Basil Schonland. He was on loan to the British Government at the time and was the Superintendent of the Army Operating Research Group. His Group played a major part in analysing anti–aircraft fire–control practices and in developing procedures to increase the accuracy. I myself was in the United Kingdom during 1944/45, reporting to him on other duties, so I was aware at least of what he was doing. For this reason also I am not well informed on the closing phases in South Africa in so far as radar is concerned. As far as the overseas story is concerned my remarked have been most superficial for the subject is vast and complicated.

My remarks have largely been directed at the technical side with very little about the personnel involved. Two names must be mentioned – Col Hodges, previously Professor Hodges of the University of Natal, who took over command of the Unit concerned late in 1940 after the first of us had gone to East Africa. He came up to Nairobi at the turn of the year and was OC whilst we were operating in Sinai. Later he returned to South Africa as activities at home increased. I must also mention the name of Brigadier F.C.Collins, Director of Signals through the whole period. His confidence in a Unit with so many academics in key positions was remarkable.

The technical staff initially consisted mainly of Electrical engineering graduates and as many electronic technicians as could be found. There was a sprinkling of physicists and mechanical engineers. Operators initially were a great problem. In East Africa and the Middle East we had men from all walks of life. Some were very bright and some were not. I remember an operator who had never read the time to closer than the nearest five minutes and we expected him to read ranges based on measurements to microseconds, and to plot ranges and bearings accurately and read off co-ordinates to three significant figures. In South Africa the problem was solved by using women operators. A very high standard of recruit was attracted and a high level of operating efficiency was achieved under conditions which frequently must have been both boring and tiring.

I have placed prime emphasis on the technical side because I believe the early technical achievements were most remarkable. Having been associated with electronics and telecommunications research and development ever since, I never cease to wonder at the pace achieved in the late 1939 early 1940 phase in a field full of baffling problems. There was, in fact, a happy post–war sequel. Six junior members of this team formed the basis of the Telecommunications Research Laboratory set up by Sir Basil Schonland as part of the CSIR, in 1946. This team remained together for more than 10 years and, in fact, in 1957 when Sputnik 1 was launched unheralded, the team showed it had not lost touch.

Within two days (a weekend in fact), tracking equipment was improvised and the orbit of the satellite was established. Within a fortnight one of the members (since then unfortunately emigrated to the USA) calculated the expected lifetime of the satellite in terms of this orbit, and published his results in *Nature*. He thus gave the world the first and, I think, only reasonably accurate prediction of the lifetime of Sputnik 1 — an event that proved him correct to within 15 per cent. Quite remarkable! The team subsequently dispersed; perhaps just as well as electronics technology is essentially a young man's field.

F. J. HEWITT (1974)

The FREJA scientific satellite under construction

The FREJA scientific satellite project is a "follow up" of the very successful first Swedish satellite VIKING that was launched in 1986. FREJA follows the concept of inexpensive satellites applied for e.g. S3–3, AMPTE, and VIKING. This has had the consequence that the costs incurred are in the range of "expensive" sounding rockets or single instruments in ESA/NASA missions. More important, the scientific return from inexpensive satellite projects has proved to be no less than that from major agency projects in this field.

The scientific objectives for FREJA are in many respects similar to those for VIKING, i.e. to study the interaction between the hot magnetospheric plasma with the topside atmosphere/ionosphere. This interaction leads to a strong energization of magnetospheric and ionospheric plasma and an asociated erosion, and loss, of matter from the Terrestrial exosphere. Previous mid-altitude projects such as S3–3, DE–1/2, Viking and more recently EXOS–D, have demonstrated that important fundamental plasma physics processes takes place in the altitude range ≈500 km to ≈15000 km above the Earth's auroral zones, leading to among other things the occurrence of bright auroral displays and a strong outflow of ionospheric plasma into outer space.

FREJA, with an orbit inclination of 63° – 68° and an altitude ≈ 650 – 1800 km, will cover the lower edge of the auroral acceleration region. This altitude range also hosts processes that heats and energizes the ionospheric plasma above the auroral zone, leading to the formation of large density cavities.

Table 1: Freja Scientific Payload

Experiment		Principal Investigator
F1	Electric Field Experiment	Göran Marklund, KTH, Stockholm, Sweden
F2	Magnetic Field Experiment	Lawrence Zanetti, JHU/APL, Laurel, USA
F3	Particle Experiment	
	Hot Plasma	Lars Eliasson, IRF, Kiruna, Sweden
	Cold Plasma	Brian Whalen, NRC, Ottawa, Canada
F4	Wave Experiment	Bengt Holback, IRF, Uppsala, Sweden
F5	Auroral Imager	John S Murphree, Univ of Calgary, Canada
F6	Electron Beam Experiment	Götz Paschmann, MPE, Garching, FRG
F7	Correlator Experment	Manfred Boehm, MPE, Garching, FRG

FREJA will be uniquely suited to study the impact of the auroral acceleration process on the topside ionosphere. This uniqueness is due to novel instrumentation with capabilities to increase the spatial/temporal resolution orders of magnitudes better than what has been achieved on satellites before. For instance, in burst mode waveforms will be measured up to MHz frequencies and electric field structures with a time resolution better than 1 ms, corresponding to less than 10 m of satellite orbit. Full 2–D particle distribution functions will be obtained with temporal and spatial resolutions of ≈10 ms and ≈80 m respectively. Auroral structures will be imaged with a spatial resolution of the order 1 km. This will allow FREJA to resolve the fine-structure of e.g. discrete auroral displays, a performance hitherto reserved for sounding rockets only. A high data rate (250 – 500 kbits/s) combined with "burst memory" capabilities will make this all possible. The FREJA payload comprises a full complement of high-resolution plasma diagnostic and a fast auroral imager. Table 1 lists the individual instruments and Principal Investigators. FREJA is a sun-pointing, spin stabilized (≈10 rpm) S/C with magnetic attitude control. Its design life-time is 1–2 years. The S/C is planned to be launched "piggy back" on the Chinese rocket Long March 2 from the Jiuquan Satellite Launch Center, China, in the third quarter of 1992.

FREJA is an international collaborative effort involving scientists from the Nordic countries, Germany, France, UK, USA, and Canada. Funds for the project were raised mainly within Sweden and the Federal Republic of Germany (FRG). The project is managed by the Swedish Space Corporation.

RICKARD LUNDIN (FREJA PROJECT SCIENTIST FOR SWEDEN)
GERHARD HAERENDEL (FREJA PROJECT SCIENTIST FOR GERMANY)

NEWS IN BRIEF

EISCAT

The Tromsø HF high power heating facility in northern Norway, which is owned and operated by the Max-Planck-Institut für Aeronomie in cooperation with the University of Tromsø, is at present having one of the antenna arrays upgraded to provide a narrower beam (7°) at frequencies centred on 6.6 MHz. The original array, which was the largest of three covering the range 2.7 to 8 MHz, was damaged in a storm in 1985. Originally it contained 36 crossed full wave dipoles; now it is being re-built with 144 dipoles to give a 6 dB increase in gain on top of the original 24 dB. Maximum effective radiated power should then be about 1.2 GW. This upgrade, called Superheating, should be completed in the summer of 1990 when it will be used for the first time.

Plans are now well under way for the transfer of the Heating facility to the EISCAT Scientific Association which operates two incoherent scatter radars at the same site as Heating. The formal transfer date is envisioned to be 1 January 1993 with EISCAT staff training starting in 1991. This means that after this date all Heating experiments will be performed by EISCAT staff on the behalf of experimenters from the associate countries (Finland, France, Germany, Norway, Sweden and UK). The transfer, which will allow wider and more flexible access to the heating facility, will make the EISCAT UHF and VHF radars together with the HF high power facility the single most sophisticated assembly of ground based instrumentation for ionospheric research in the world.

M.T.RIETVELD, EISCAT,
RAMFJORDMOEN

VERSIM

The IAGA/URSI Joint Working Group on Passive Electromagnetic Probing of the Magnetosphere has proposed that it be renamed the JWG "on VLF ELF Remote Sensing of the Ionosphere and Magnetosphere (VERSIM)". The proposal will now be put to the parent bodies, namely IAGA and URSI. It was felt by members of the working group that its name no longer reflected well the interests of the group members, due to changes in both techniques and scientific emphasis in the years since the working group was established. Thus much work now, such as the various imaging networks, rely heavily on the use of VLF transmitters and thus the technique is not truly passive. It was also felt desirable to specify the frequency range of interest, i.e. VLF/ELF, in the title, to avoid any overlap with for example the ULF community.

Other news reported to the JWG. G. Tarcsai reported on work in Hungary. He described work in progress to use digital matched filtering to elucidate whistler fine structure and ducting mechanisms. He described the SAS experiment on the ACTIVE satellite which would be used to study VLF propagation. The wave normal directions will be computed from the five components observed by SAS, by using a new technique – the matched filter parameter estimator method. Supporting VLF observations on the ground at Halley, Antarctica and at Lake Inari in Finland are planned. Whistler recording has continued at Tihany, the data being used in studies of plasmaspheric electron densities. A new project studying wave induced particle precipitation has been initiated.

On behalf of U.S.Inan who could not be present, A.J.Smith reported on activities of the Stanford University group. These included broadband whistler recordings at Palmer (Antarctica), South Pole, and Lake Mistissini (Quebec); ELF/VLF measurements on board the DE–1 satellite, and intensive use of subionospheric remote sensing, using a widely spaced network of VLF/LF transmitters and receivers, as a means of investigating the trimpi effect as an indicator of whistler induced particle precipitation. Future plans included the deployment of a major active VLF/ELF experiment in Antarctica – the proposed Wave Injection Facility (WIF) – and participation in PENGUIN – a network of AGOs (Automatic Geophysical Observatories) in Antarctica.

A.J.Smith reported on current and future activities of the British Antarctic Survey. Observations being made were: broadband VLF observations at Halley and Faraday; a VLF imaging network for precipitation mapping (in collaboration with the University of Otago, New Zealand), using OPAL (Omega phase and amplitude logger) receivers; group travel time and Doppler shift measurements of whistler mode signals from VLF transmitters using SCODAR (Spectrographic COrrelative Direction and Ranging), for monitoring plasma density and drift characteristics in the plasmasphere; and digital whistler recordings for studying whistler fine structure. Future plans included participation in international programmes such as ISTP, CLUSTER, ACTIVE, etc, and deployment of an AGO network in Antarctica.

M.Parrot described work based on VLF observations by the low altitude satellite ARCAD-3. This included a study of the geographical distribution of ELF/VLF emissions, including a possible link to the location of powerful VLF transmitters, and also the use of bicoherency technique for determining the characteristics of the observed waves.

J.P.S.Rash reported on VLF work by his group at Durban and at Sanae, Antarctica.

M.Hayakawa (Nagoya University, Japan) sends the following information on recent activities:

1. A wave particle interaction experiment at L = 1.9, in collaboration with IZMIRAN and the University of Otago, using special transmissions from the ALPHA transmitter at Komsomolskamur and ground based observations near the conjugate at Ceduna, Australia, was carried out in August 1989. Transmissions from the NWC transmitter to New Zealand, which passed close to Ceduna, were recorded in Dunedin and Wellington as a possible means of detecting transmitter induced precipitation.

2. VLF emissions and whistlers at low and medium latitudes. The frequency drift of low latitude VLF emissions is being studied. The propagation mechanisms for equatorial whistlers, are being investigated by data from a network of VLF direction finding receivers in China (in conjunction with Wuhan University), and modelling using the wave distribution function method.

3. In situ studies of magnetospheric waves. Chorus in off-equatorial regions, half gyrofrequency VLF emissions, role of hiss in triggering chorus etc, are being studied using data from the Aureol-3 satellite (in collaboration with the LPCE group). Non-linear wave-wave interactions are investigated using Isis reception of signals from Siple and Omega transmitters (in collaboration with Stanford, CRL, and Chiba University).

News from Dr L.R.Piazza (CRAAE, San Paulo). The group has been operating a modified VLF Tracor receiver at the Brazilian Antarctic station, since February 1989, in an experiment to detect trimpi events.

A. J. SMITH

Supercomputer

The first maxi-cluster based, multiprocessing system ever to be commissioned (designed and built) in South Africa, was recently installed at the University of Stellenbosch.

The supplier, Concurrent Technology Systems (CTS), is a joint venture between Technifin and Altech. CTS is operating in the field of parallel processing currently using transputers from Inmos, with products which are locally designed and supported.

The MC^2 system uses the standard PC platform as a host (user interface) and can therefore interface to many existing hardware installations. CTS products will also interface with other industry standard work-stations in the future. The MC^2 system consists of clusters of processors remotely coupled to the host via an interface module.

CTS Managing Director, Graham Lawson, says that although there is virtually no limit to the amount of clusters that can be grouped together, at this stage CTS does not foresee MC^2 systems of more than 256 processors.

The supercomputer installed at the University of Stellenbosch numbers 64 processors (i.e. transputers). This parallel processing platform is capable of a sustained performance of 640 Mips and 100 Mflops.

The university will be using the MC^2 system for computational fluid dynamics, computational electromagnetic simulation work, finite element work, as well as a number of other applications which require significant computational power.

J. H. CLOETE

Royal Society of?

This may be news only to me. In my congratulations to Peter Clarricoats (URSI NEWS, June, 1990) on attaining "FRS", I gave the full name of "The Royal Society" incorrectly. The following from the Royal Society Yearbook was sent by Dr. Argent. My thanks and apologies! (The spelling in the quotations was presumably correct in 1660).

The origins of the Royal Society date back to the middle of the seventeenth century when a group of scholars made a habit of meeting together in London from about 1645 to discuss the, then, new or experimental philosophy. The Civil War and the Protectorate interrupted these meetings. Some of the group went to Oxford, in particular Robert Boyle and John Wilkins, where these meetings were continued in the rooms of the latter in Wadham College: others remained in or near London. After the Restoration the meetings were resumed in London. At one of them, on 28 November 1660, after hearing Mr Wren's lecture at Gresham College the company present withdrew into Mr Rooke's apartments "for mutuall converse. Where amongst other matters that were discoursed of, Something was offered about a designe of founding a Colledge for the Promoting of Physico-Mathematicall, Experimentall Learning." Those present at that meeting, which is the first to be recorded in the Journal Book, were "The Lord Brouncker, Mr Boyce, Mr Bruce, Sr Robert Moray, Sr Paul Neile, Dr Wilkins, Dr Goddard, Dr Petty, Mr Ball, Mr Rooke, Mr Wren, Mr Hill." These twelve can be taken as being the Original Founder Fellows.

Charles II became interested in the Society through Sir Robert Moray and two years after its foundation the King granted the Society its first Charter on 15 July 1662. In this the Society is "called and named The Royal Society". It is not known who first named the infant society "The Royal Society" but the first time this appears in print is in John Evelyn's preface to his translation of Gabriel Naude's Instructions Concerning Erecting of a Library published in November 1661.

A second Charter, granted on 22 April 1663, extended the Society's privileges and at the same time made the grant of the Arms. The motto chosen by the Society, *Nullius in verba*, was an expression of determination to withstand dogma and to verify all statements by an appeal to facts. **In this second Charter the Society is referred to as "The Royal Society of London for Improving Natural Knowledge", which is its full title.**

CRRES

Launch of the Combined Release and Radiation Effects Satellite (CRRES) was expected in late July (as we went to press). Scheduled to be placed into a highly elliptical, geosynchronous transfer orbit of approximately 217 by 22,236 miles, CRRES is to conduct complex scientific research in what is referred to as "Earthspace" — the space environment just above Earth's atmosphere which, far from being empty, includes the ionosphere and magnetosphere containing a dynamic ocean of invisible magnetic and electrical fields and particles.

Much as a high school physics student spreads iron filings around a magnet to "see" its invisible magnetic field, CRRES will carry 24 canisters of various chemicals into orbit and release the chemicals over a period of time. When released, the chemicals will be ionized by the Sun's ultraviolet light creating large luminous clouds that will elongate along Earth's magnetic field lines, briefly "painting" these invisible structures. By observing the motion of the clouds, scientists will be able to measure electric fields in space and "see" how they interact with charged particles to form waves and to better understand how the Earth extracts energy from the solar wind. The luminous clouds also will be studied from the ground, from specially equipped aircraft and from CRRES itself. The CRRES releases will be augmented by chemical releases from 10 sounding rockets launched from Puerto Rico and the Marshall Islands. Under a launch services contract between NASA and General Dynamics, launch of the joint NASA/U.S.Air Force payload was to take place from Complex 36B, Cape Canaveral Air Force Station, Fla., aboard an Atlas I (Atlas/Centaur-69) launch vehicle. NASA's Marshall Space Flight Center, Huntsville, Ala.; the U.S.Air Force Space Systems Division, Los Angeles; and Ball Aerospace Systems Group, Boulder, Colo. — prime contractor of CRRES — are principal spacecraft participants in the upcoming mission. Atlas I launch services, with technical oversight by NASA's Lewis Research Center, Cleveland, and Kennedy Space Center, Fla., will be provided by General Dynamics Space Systems Division, San Diego, Calif. The Lewis Research Center manages the NASA-General Dynamics launch services contract and is responsible for launch vehicle/spacecraft integration activities.

CRRES OBJECTIVES

CRRES will carry 24 canisters containing various chemicals. For each experiment, one or two canisters will be ejected by the spacecraft. Approximately 25 minutes later, after the canister and spacecraft are far enough apart to prevent contamination, the canister will release its chemical vapors. The chemical will be ionized by the Sun's ultraviolet light, creating luminous clouds initially about 60 miles in diameter. The clouds will elongate along Earth's magnetic field lines, briefly "painting" these invisible structures so that they become visible. By observing the motion of the clouds, scientists will be able measure electric fields in outer space, to "see" how these fields interact with charged particles to form waves and to better understand how the Earth extracts energy from the solar wind. These clouds will be studied by instruments on the ground, in specially equipped aircraft and aboard CRRES itself. The CRRES releases will be augmented by releases from sounding rockets to conduct further experiments.

NASA PRESS RELEASE

Voyager Status

The Voyager 1 spacecraft continues to collect routine cruise science data. One frame of high-rate Plasma Wave (PWS) data was recorded on June 26. High-rate Ultraviolet Spectrometer (UVS) observations were conducted on June 22, 26 and 28. There was sufficient Deep Space Network (DSN) coverage to capture all of the data.

On June 25 an AGC/Command test was performed over the 34 meter antenna in Australia (DSS 42) and downlinked over the 34 meter antenna in Goldstone, California (DSS 12). The test indicated that there has been no apparent change in the spacecraft receiver or command threshold since launch.

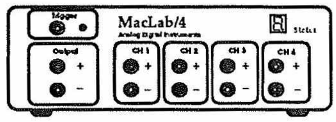
Also on June 25 the Attitude and Articulation Control Subsystem (AACS) Sun Sensor heater B was powered on and heater A turned off as the heater switch was made to avoid a Sun Sensor low temperature limit violation. Following stabilization, the Sun Sensor temperature was +4 degrees C above the predicted value.

A pre Computer Command Subsystem-B (CCSB) Refresh checksum was downlinked from the spacecraft on June 27; real-time commands were subsequently transmitted to initiate the CCSB refresh activity and reset the CCS status telemetry. Successful completion of the refresh, which included the area of memory in which the Command Processor and Error routines reside, was verified by the received checksum value; the CCS status telemetry reset was also successful.

A Magnetometer Calibration (MAGCAL) was conducted on June 28. Data quality was good. Cruise data appeared normal for the Fields and Particles instruments on Voyager 1.

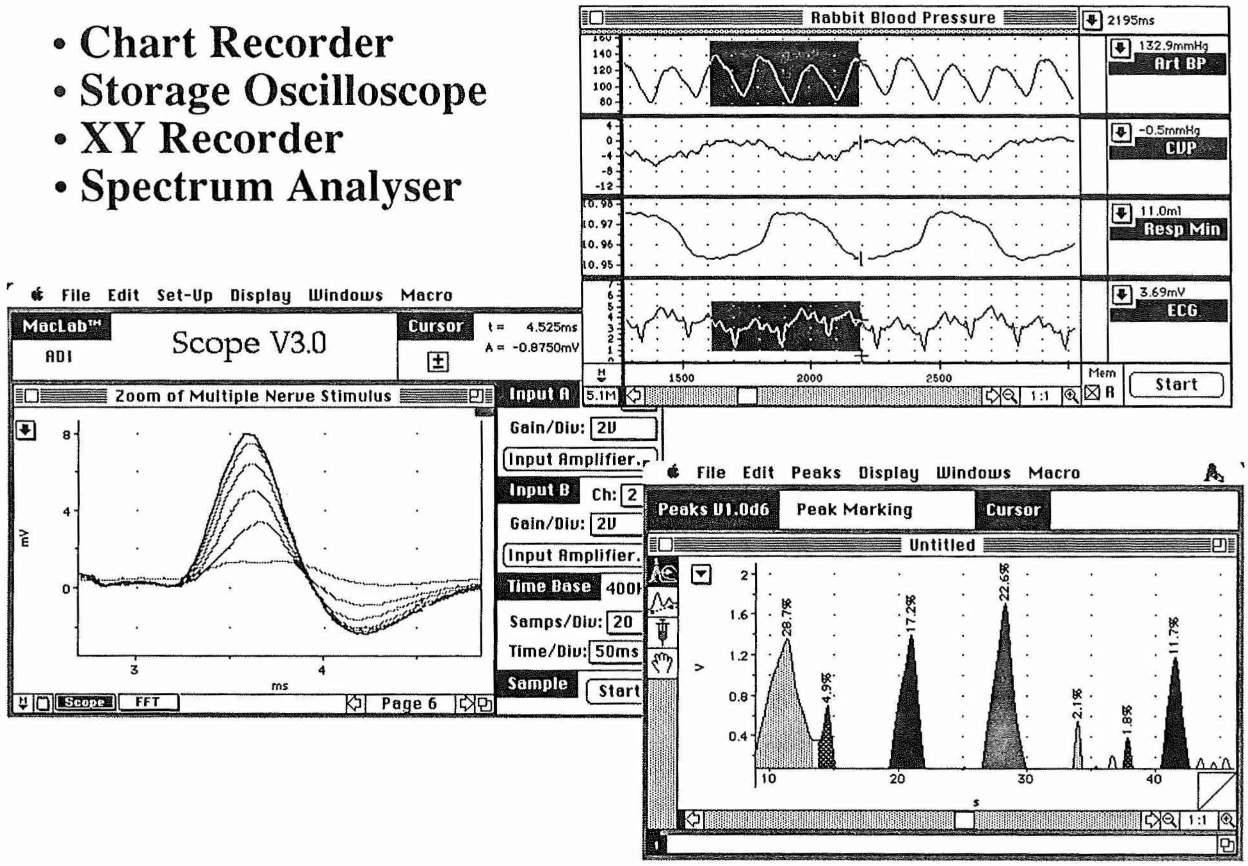
RON BAALKE, JPL

MacLab™



■ The MacLab system is a computer based data recording and display system designed to exploit the intuitive user interface of the Apple Macintosh family. MacLab gives a flexible and economic solution for data acquisition in Physical and Life sciences as well as educational environments. MacLab is designed to emulate a number of standard laboratory instruments including:

- **Chart Recorder**
- **Storage Oscilloscope**
- **XY Recorder**
- **Spectrum Analyser**



■ The range of MacLab hardware will record data on any of 4 to 8 analog channels from 1mV to 10V full scale at up to 100kHz. Additional software controlled front-end modules extend the range of the MacLab into specialist areas.

■ For more information:

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