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Radio science for Humanity / Radiosciences au service de l'humanité

Foreword

URSI (*Union Radio-scientifique internationale*) is a renowned worldwide body under the umbrella of the International Council for Science, formerly International Council of Scientific Unions (ICSU). This scientific society has a longstanding tradition of fostering and coordinating, on an international basis, scientific studies, research, applications, exchanges, and communication in the fields of radio science and, more generally, on all aspects of electromagnetism. One of the URSI's roles is to promote research using interdisciplinary and multidisciplinary resources.

URSI-France, officially the *Comité national français de radioélectricité scientifique* (CNFRS), like the international scientific Radio Union, aims to stimulate and coordinate, at the national level, areas of scientific studies, telecommunications and electronics, in order to promote and organize research requiring national and international cooperation. Furthermore, it encourages the adoption of standards of measurements as well as the assessment of methodology and the calibration of measuring instruments used in scientific works.

URSI-France is placed under the authority of the French Academy of Science, represented by the *Comité français des unions scientifiques internationales* (COFUSI).

URSI-France organises annually a national Workshop. The one of 2017 had the theme "Radio-Sciences for serving Humanity", a very broad theme, indeed! The scientific committee sought to deal with eclecticism by selecting presentations from eight areas. A total of nine invited talks brought synergetic views necessary for the widening the scope of the selected subjects. This, however, resulted in a densely packed conference program.

Electromagnetism, telecommunications, electronics, and photonics are an essential pivot of our modern society. The developments of these activities benefit humanity in a wide range of issues, ranging from extreme situations to the simple comfort of our daily lives. In this fast-moving area, we are interested in the fundamental and conceptual aspects as well as the technological developments and the resulting applications. Thus, the conference covered a wide range of topics: electromagnetic waves and fields, both from the point of view of metrology, theory, propagation effects, and modelling of communication systems and their applications. The treatment of electromagnetic wave propagation included the monitoring of the environment (surface and sub-surface), the ionosphere, and even applications in radio astronomy. Electromagnetics in biology and medicine, also present in the aforementioned areas, were duly addressed.

A session in tribute to François Lefeuvre gave us an opportunity to trace both his scientific work and his activities at URSI, amongst others as president of URSI-France (1996–1999) and then vice-president of URSI and finally president of URSI (2005–2008 and 2009–2011).

The scientific developments and the resulting technical applications necessarily pose a dialectic between technological innovation and their purpose of application. The confluence of these activities, in turn, reflect ethical issues and dilemmas.

Without pretending to overestimate the scope of the conference contribution in these difficult broad areas, the theme of the 2017 URSI-France scientific meeting was chosen to remind us that, in the end, even these URSI subjects impact upon the global technical-cum-scientific developments in serving humanity.

The theme of public protection and disaster relief is clearly an illustration of what high-performance scientific applications can offer to deal with distressful events.

Note that the URSI and ISPRS Unions decided (2017) to join efforts by establishing an *ad hoc* committee before the AG 2020 of the ISPRS[1] due to be held in Nice (France).

Beyond all these applications, the plurality of the subjects of the conference facilitates the representation that everyone can have of the microscopic as well as macroscopic worlds. These aspects, including ethical issues, have been addressed since a long time. We can quote, for example, Max Planck during his conference "Physics in struggle for a representation of the world".[2]

[1] ISPRS, General Assembly, July 2016, Prague, Czech Republic.

[2] Max Planck, Die Physik im Kampf um die Weltanschauung, 6 March 1935, Johann Ambrosius Barth ED, Leipzig 1937.

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This issue presents a sample of the contributions from the areas of radio-wave interaction and scientific-cum-technical challenges to achieve well-designed systems and devices. The authors were selected by an ad hoc committee (listed below), created specifically for the occasion, whom we thank wholeheartedly. Seven of them were then invited to submit extended, proofread, peer-reviewed revised versions in accordance with the rules of the journal *Comptes rendus Physique*.

The first article, entitled "Conforming discretizations of boundary element solutions of the forward problem electroencephalography", written by Lyes Rahmouni, Simon B. Adrian, Kristof Cools, and Francesco Paolo Andriulli, concerns the electroencephalography (EEG) of scalp potentials, as one of the main non-invasive techniques to map and study the electrical activity of the brain. EEG imaging is of crucial importance in the electrical characterization of seizures. This is particularly true for patients affected by focal lesions, when the localization and characterization of the source of epilepsy is a key step in the pre-operative examinations preceding the removal of the brain area that contains an abnormal electrical activity. The authors provide a basis for solving Poisson's equations representing the electrical activity of the brain. After a detailed treatment of three different formulations based on the classic discretizations, they adopt the simplest stable discretization involving combinations of basic linear piecewise-constant functions. Some aspects of errors in these approaches to the problem of spherical layers (for which an exact solution exists) are presented.

The second article, "DEMETER observations of man-made waves which propagate in the ionosphere", written by Michel Parrot, is a review of the airwaves, due to human activity, observed by the ionospheric satellite DEMETER. This concerns the waves radiated by the transmitter in very low-frequency band (VLF in English, TBF: 3 kHz to 30 kHz) and extremely low-frequency bands (EBF, ELF in English: 3 Hz to 30 Hz) from radio stations, from power lines, and other active devices. For the first time recorded examples of radiation emitted by EBF transmitters are shown. These waves propagate to the magnetosphere and they can be observed at the points of magnetic dipole from their region of emission. According to their frequencies, they disturb the ionosphere, and the particles in the radiation belts thus triggering new emissions.

This contribution, therefore, describes systematically all the results observed by the ionospheric satellite DEMETER. It deals with the waves emitted by terrestrial VLF and ELF transmitters from broadcasting stations, by harmonic radiation from the power lines, industrial RF noise and active devices. The record of a wave produced by an ELF transmitter is also presented.

The third article, "Solar radio astronomy and space weather", is authored by Karl-Ludwig Klein, Carolina Salas Matamoros, and Pietro Zucca. It deals with the activities of the solar corona, ejections of large amplitude plasma, and the magnetic field, causing major disruptions that can seriously affect the Earth's free-space environment. This activity is characterized by massive coronal bursts (CME) and the projection of high-energy particles (SEP). The consequences on the functioning of satellites, and even ground infrastructure, are of such importance that indicators for predicting the arrival of CME and SEP effects are actively sought. This article shows how the observation of solar microwave sources can lead (i) to estimate the speed of a CME and its time of arrival on the earth surface, (ii) to forecasting of SEP events reaching the Earth. This contribution explores a promising way based on the analysis of the RF signals emitted by the Sun. The results presented are based on an uninterrupted emission of microwave fluxes (5 and 9 GHz) measured by the authors over a period of 13 months (December 2011 to December 2012).

In the fourth article, entitled "The double Brewster angle effect", Laetitia Taylor-Lefèvre and Régis Guinvarc'h, after detailing the properties of Brewster effect and particularly the double Brewster angle, which were widely studied at optical wavelengths, demonstrate that a similar approach can be used in the X-band radar frequencies. Employing the values of the Brewster angle that lead to the characteristics of the materials and their permittivity, a radar approach was identified in order to ascertain the nature of the reflecting materials (concrete, bitumen, forest, etc.) or to detect possible artifacts marring the radar measurements.

The described method is of interest and importance in the field of remote sensing and radar signal analysis. It allows the extraction of additional information from observed radar images. In this sense, the proposed method offers possibilities. to characterize the nature of the observed elements. The contributed paper lays the foundations for an original methodology leading to the development of a new tool for remote sensing.

The fifth contribution, whose title is "From quantum physics to digital communication: Single-sideband continuous phase modulation", is written by Haïfa Fares, D. Christian Glattli, Yves Louêt, Jacques Palicot, Christophe Moy, and Preden Roulleau. The authors propose to reduce the spectral occupation of signals generally used in digital communications by using the Single Side Band Frequency Shift Keying – Continuous Phase Modulation (SSB–CPM).

The proposed feature of Continuous Phase Modulation (FSK–CPM) having the feature of single sideband (SSB) provided a very compact bandwidth occupation. First of all, the original principle, inspired by quantum physics (levitons), is presented. Then the authors address the problem of this new waveform based on low complexity method exploiting the orthonormality of the wave functions used to perform matched filtering for demodulation. They show that the proposed modulation can operate using existing digital communications, given the availability of operational technology. Finally, they develop simulations of this continuous-phase single-sideband modulation.

The sixth article, "RFI: a key technology for Humanity", is written by Yvan Duroc and Smail Tedjini. The objective of this contribution is to provide a synthesis of RFID and its applications (with the given focus), as well as of the current and associated perspective approaches. It is not merely a comprehensive description of applications; instead, the paper takes through a significant number of examples, both to show the utility of RFID in this area, and to highlight the most common standards, before putting the current trends and new opportunities into perspective.