

**Program for 2017 URSI GASS  
(November 28, 2016)**

In case of query, please contact the Commission Chair.

**Commission A Program**

**Commission A Chair:** Prof. Yasuhiro Koyama (Japan); koyama@nict.go.jp

Commission A Tutorial Dr. Judah Levine: “Distributing Time and Frequency Data: Requirements and Methods”

Convener: Yasuhiro Koyama

There are many commercial, financial, and industrial applications that depend on accurate time and frequency information. High frequency trading of stocks and commodities, telecommunications, and the control and synchronization of the electrical power grid are just a few examples. The level of accuracy that is required to support these applications is relatively modest from the perspective of the internal time scales of most National Metrology Institutes and timing laboratories, but satisfying the requirements becomes much more challenging when the need for extreme reliability and the limitations of many of the common distribution channels are included. I will describe the near-term future requirements and the solutions that have been proposed to satisfy them. None of the solutions is completely adequate now and all of them will have increasing difficulty in the future, and I will discuss methods that could address these limitations.

**Commission A “Measurements of Isotropic and Anisotropic Magnetodielectrics”**

Conveners: Steven Weiss, Amir I. Zaghoul

The use of magnetodielectric materials with prescribed or tunable values of permittivity and permeability is becoming an important enabling technology for device enhancements (e.g., low-profile antennas). This session addresses measurement techniques to evaluate various properties of magnetodielectric materials that are isotropic or anisotropic in construction.

**Commission A “Linear and Nonlinear Measurements for Communications Systems”**

Conveners: Pedro Miguel Cruz, Nuno Borges Carvalho

Cognitive Radio (CR), 5G communications and the Internet of things (IoT) are rapidly moving to all-digital implementations largely powered by software-defined radios (SDRs). SDRs facilitate frequency agility, operation over several frequency bands and different modulation formats. To characterize and model those systems and circuits, linear and nonlinear measurement strategies are of paramount importance. Moreover, the inclusion of 5G microwave and millimeter-wave standards will necessitate new measurement techniques and test benches of wafer MMIC devices. This session will focus on current developments and some classic views of linear and nonlinear measurements and adequate test and measurement strategies, concentrating on applications such as SDR/CR, 5G, satellite payloads, etc

**Commission A “Space Metrology”**

Conveners: Liu Min, Pedro Miguel Cruz

Space metrology is required to assure unified and accurate measurements of space equipment and systems. There are three themes for Space Metrology. The first is in-orbit, embedded and automatic calibration of the spacecraft platform. The second applies to the space measurement instruments (the payload). These need be calibrated and include solar observation instruments, electromagnetic field measurements etc. The third addresses basic metrology theory that necessitates the reconsideration of the application of SI units in the space environment. According to general relativity, gravity affects

the frequency of atomic clock, and then influences length, voltage and mass at scales of  $1/c^2$ . Timekeeping in space is a new topic and is an important issue in navigation and astronomical observations. This session will focus on in-orbit calibration of equipment in space, calibration of space environment simulations, space metrology theory in the context of general relativity etc.

#### **Commission A “SI Units”**

Conveners: Felicitas Arias, Carl Williams

SI units are fundamental to all scientific measurements and to metrology. Various electromagnetic measurement methods are essential for the definition and realization of SI units, and various SI units are used in all electromagnetic measurements. The SI is evolving towards new definitions of units based on physical constants. This session solicits papers regarding the definition, realization, and improvements of SI units in connection with Electromagnetic Metrology.

#### **Commission A “Metrology in the THz Region”**

Conveners: Chen Kunfeng, Masatoshi Kajita

In recent years, terahertz science and technology has become one of the most attractive research fields. With the development of this field, the related metrology is getting more and more concern. This session will focus on the metrology of terahertz power, frequency, spectroscopy, imaging and also other related aspects.

#### **Commission A “Time and Frequency Standards”**

Conveners: Felicitas Arias, Masatoshi Kajita

In this session, we discuss recent progress on the development of Time and Frequency standards. Papers on experimental results of precise measurement of transition frequencies of atoms, molecules, and ions in all frequency area (microwave, optical, infrared, THz) are expected. Also theoretical papers giving new sights on precise measurements are welcome.

#### **Commission A “Advanced Time and Frequency Transfer Techniques”**

Conveners: Felicitas Arias, Demetrios Matsakis

Ever-improving frequency standards and the technological growth of our civilization is generating and sustaining a need for more precise, accurate, robust, and secure time and frequency transfer than currently available locally, globally, and extra-terrestrially. Improvements to existing operational technologies such as GNSS, two way satellite time and frequency transfer, NTP, and PTP can help solve the problem, as can development of newer technologies involving optical fibers, optical transmissions from ground or space, VLBI observations of radio sources, and differential observations of pulsars and x-ray sources. Papers are solicited in all these fields, as well as any other areas that involve time and frequency transfer.

#### **Commission A “Education and Training in Electromagnetic Metrology”**

Conveners: Demetrios Matsakis, Patrizia Tavella

Education and training play an important role in the dissemination of the metrology culture and in forming skilled metrologists. URSI Commission A recognizes the high potential of electromagnetic metrology in different fields of application and the need for appropriately educated young scientists is deemed fundamental. Many countries run university courses in metrology and/or electromagnetic measurements, including masters courses, PhD programs, and specialized summer schools. This session seeks to promote the discussion and sharing of information and teaching material, and to support similar initiatives in education and training in different countries with possible teaching cooperation.

### **Commission A “Advances in Sensor Development and Applications”**

Conveners: C. Zerrouki, Andon Lazarov

The session will focus on a broad range of sensors, technologies and applications. These can be categorized by the sensing material, frequency of the electromagnetic waves, principles, technique and technology of development, and the sensor network protocols and application domain. The session will include papers on all of these subjects. In particular: 1, methods for sensor deployment; instrumentation and models for deployment of sensors networks; sensor architecture; micro and nano devices; biosensors; optical sensors; smart sensors; acoustic sensors; microwave sensors, synthetic aperture radars; sensor prototypes; sensor node components; sensor interfaces; actuators; independent component analysis; design of cost effective and economical sensors; smart material applications to design sensors; integration of sensors into engineered systems; hardware platforms; test-beds incorporating multiple sensors; operating system and middleware support. 2. Wireless Sensor Communications; Network connectivity & longevity; tracking objects; geo-location problems; network coverage; algorithms for sensor localization and tracking; detection, classification and estimation; physical layer impact on higher level protocols; directional and smart antennas for sensor networks; coverage maintenance; transceiver and antenna design; ubiquitous wireless connectivity. 3. Applications and demonstrations of sensor networks; software platforms development tools; architectural design and optimization tools for sensor nodes; computation and programming models of sensor networks; languages and operating systems of sensors; programming and interfacing; programming abstraction; programming models for sensors; programming methodology for sensor environments; intelligent sensor theory and applications; machine learning applications to sensor networks; wireless sensor applications; applications for sensor network management; software tools for chip programming; application requirements; application evaluation and comparison; demos and prototype testing.

### **Commission A “Metrological Analysis of Material Properties”**

Conveners: Noshawan Shoaib, Imran Shoaib

This session will focus on the material measurements and the associated uncertainty evaluation using the time and frequency domain measurement systems. The traceability of uncertainty analysis to the International System of Units (SI) is important to establish in order to evaluate the validity of the results obtained using different measurement systems. The papers for this session should analyze the permittivity measurements and associated uncertainty for magnetic or non-magnetic materials over the frequencies ranging from few MHz up to the THz. The comparisons between the results obtained from different measurement systems are highly encouraged.

### **Commission A “Metrology for Wireless Power Transmission Solutions”**

Conveners: Nuno Borges Carvalho, Ke Wu

In this session the main issues to be addressed are measurements and instrumentation for wireless power transmission and electromagnetic energy harvesting, including IoT and RFID devices. Papers should focus on these themes spanning from material characterization to antenna measurements and nonlinear active device components.

### **Commission A “Microwave Frequency Standards and Applications”**

Conveners: Amitava Sen Gupta, Fang Fang

This session will focus on research on topics related to the following: (a) Microwave Atomic Frequency Standards, (b) Atomic Clocks for Space Applications, (c) Vapor-cell Atomic Clocks (d) cell-based Sensors and Instruments, (e) Atomic Interferometers, (f) Fundamental Physics Tests with Clocks, and Other Applications.

### **Commission A “Time Dissemination for Critical Applications”**

Conveners: Marina Gertsvolf, Leon Lobo

In the past few years the need for traceable and accurate time dissemination at sub-millisecond and sub-microsecond levels has been fast growing. New technologies drive tight technical time synchronization demand followed by new regulations. In this session the papers will be focused on high accuracy time dissemination methods for the power industry (e.g. smart grids), wireless communications (e.g. LTE), financial sector and scientific applications (e.g. VLBI). The papers will address different dissemination methods (e.g. fibre, GNSS, MW) and solutions.

### **Commission A “Open Session”**

Conveners: Yasuhiro Koyama, Patrizia Tavella

This session is open for all papers related to the following list of topics of interests.

Interaction between EM field and living tissue (bio-effects, biological affects, medical applications.)

EM Fields (EM-field metrology, EMC and EM pollution, Impulse radar, interconnect and packaging).

Materials (material characterization, metrology of material).

Measurements and calibration (propagation, microwave to sub-millimeter measurements/standards, millimeter-wave and sub-mm wave communications, noise, noise measurement standards, planar structures and microstrip circuits, quantum metrology and fundamental concepts, RFID, scattering calibration and references, signal enhancement for EM metrology, space plasma characterization, time and frequency, time domain metrology, Techniques for remote sensing).

Statistical measurements (turbulent media, rough surfaces, stratified media).

### **Commissions AE “Mode-Stirred Chambers”**

Conveners: Luk R. Arnaut, Tian Hong Loh

Electromagnetic reverberation chambers (RCs) (also known as mode-tuned or mode-stirred chambers) are now common RF test facilities used primarily for electromagnetic compatibility (EMC) measurements and evaluation of wireless communication performance. They are enclosed screen room typically equipped with mode stirrer(s). Ideal chambers have intrinsic properties of statistical isotropy and statistical homogeneity that provide several unique features for testing. To obtain statistically uniform electromagnetic fields and hence the desired information, the modes of the chamber are normally perturbed by either mechanical stirring or frequency stirring. Comparing with other types of RF testing facility, the cost of RC construction is relatively low and the test configurations inside RCs is relatively non-critical with regard to position and orientation. Nevertheless the relevant data analysis and interpretation is more complex. Recent advances in reverberation chamber metrology and statistical theory have added other electromagnetic investigations into the mix, particularly antenna efficiency measurements and multi-path propagation in high-mobility EM environments. Still some theoretical and metrological problems are open, as well as practical aspects in the lower frequency use. This session focuses on presenting the recent advances in the theory and the applications of RC technology, RC test facilities, measurement techniques, RC simulation and modelling, and EMC applications.

### **Commissions CA “Channel Measurements, Characterization and Verification through Electromagnetic Metrology and Measurement Post Processing”**

Conveners: Jeanne Quimby, Sana Salous

The session will address development and refinement of channel measurements, characterization and verification through new and refined measurement techniques and calibrations; physical or statistical representation of the propagation channel; comparison of channel sounder systems to vector network analyzers, multiple channel sounders or standards; and measurement post processing for channel verification through new and novel techniques.

### **Commissions DA “Optical Frequency Metrology”**

Conveners: Ekkehard Peik, Kazumoto Hosaka

The development of frequency-stable lasers with sub-Hertz linewidth, of optical frequency standards with uncertainties in the low E-18 range based on laser cooled and trapped atoms or ions, of femtosecond lasers as optical frequency comb generators for the measurement of optical frequencies and frequency ratios, and the establishment of telecom fiber based optical carrier frequency transfer of high stability over long distances is opening new opportunities for the metrology of time and frequency and for various applications in basic and applied science. The session will solicit presentations that address the fascinating challenge to establish, improve and confirm the precision of frequency measurements in this new regime and to develop novel applications of optical frequency metrology in fields like navigation, geodesy, tests of fundamental physics, or other areas.

### **Commissions DA “Optical Methods for Microwave Metrology”**

Conveners: Mark Bieler, Yang Chuntao

The operating frequency and bandwidth of microwave devices is steadily increasing. Especially the development of novel communication technologies, sensors, and transducers imposes the need for exact and reliable measurements in this frequency range. This is mainly because devices cannot be improved if their functionality cannot be accurately characterized. Optical methods are well suited for characterization since (i) they offer an unprecedented bandwidth that is not accessible with purely electrical devices, (ii) allow for quasi-non-invasive measurements due to contactless probing, and (iii) enable straightforward traceability of the time and frequency axes to the unit of time. This session addresses such optical techniques, which can be employed for the measurement of electric, magnetic, and thermal signals and form the basis for microwave metrology.

## Commission B Program

**Commission B Chair:** Prof. Ari Sihvola (Finland); Ari.Sihvola@aalto.fi

### **Commission B Tutorial Sergei Tretyakov: “Metasurfaces: Synthesis for Perfect Refraction and Reflection of Waves into Arbitrary Directions”**

Convener: Ari Sihvola

Electrically thin composite layers (metasurfaces) can be used to realize extremely thin absorbers, lenses, focusing reflectors, and more. In this tutorial talk we will discuss metasurfaces optimally designed for application-required transformations of electromagnetic fields. We will explain what physical properties of metasurface unit cells are responsible for various field transformations and illustrate the potentials of this technology by several examples from our experimental work. The main focus of the lecture will be on surfaces for perfect refraction or reflection of plane waves into desired directions. Conventionally, design of transmitarrays and reflectarrays has been based on assuring the desired reflection or transmission properties at every point of the metasurface area, using the generalized laws of refraction and reflection. However, this approach does not lead to exactly the required performance. In this talk we will explain how it is possible to create metasurfaces which function exactly as is required by the design specification and show experimental results.

### **Commission B “Electromagnetic Theory”**

Conveners: Daniel Sjöberg, Ben Zion Steinberg

This session addresses the most recent advances in electromagnetic theory. It includes all aspects of electromagnetics, and all frequency ranges from statics to optics, including both time and frequency formulations. Of special interest are advances in mathematical and material modeling, solutions of canonical problems, analytic identities, guided waves, mathematical aspects of numerical methods, random and complex media, asymptotic methods, and antenna theory. Owing to the wide scope of URSI and to the multi-disciplinary nature of contemporary research in electromagnetism, an extended view of the topics above is also welcome. This includes classical theories, as well as the incorporation of electromagnetism and quantum theory on the nano-scale. We expect contributions in this session to present unexpected phenomena, new paradigms or new interpretations of fundamental concepts, new solution methods, or to address questions with respect to well-posedness of different problems and models.

### **Commission B “Solutions to Canonical Problems”**

Conveners: Andrey Osipov, Paul Smith

The session will address solutions of Maxwell's equations, in frequency and time domain, in the presence of canonically shaped bodies. In addition to exact solutions, approximate, low- and high-frequency, as well as semi-numerical and numerical solutions are invited. Solutions for structures involving engineered materials (e.g. negative refractive index materials, metamaterials and metasurfaces) are particularly welcome. The geometries of interest may include (but are not limited to) spheres, cylinders, wedges or variants of cloaking structures. Applications may range over the whole electromagnetic spectrum, from microwaves to visible light.

### **Commission B “Multiphysics and Multiscale Problems”**

Conveners: Weng Cho Chew, Qing Huo Liu, Levent Gurel

The goal of this special session is to share cutting-edge research ideas on solvers for multi-scale and multi-physics problems. Multi-scale systems are frequently encountered in real-life applications, where fine details may coexist with orders-of-magnitude larger structures. Multi-physics occurs

within the Maxwellian system itself, with circuit physics, wave physics, and ray physics coexisting in a multi-scale environment. But multi-physics can also occur across disciplines. For example, this could be co-simulation of Maxwell's equations together with quantized electromagnetic field, Schrodinger equation, heat equation, acoustic equation, elastic equation, transport equations, etc. Applications can be derived from various disciplines, such as quantum information, information technology, nano-technology, clean energy, and biotechnology. Papers in this special session can describe new methodologies for solving such systems, physical insight, applications, and designs. Potential topics may include (but are not limited to):

- Fast and accurate solvers
- Hybrid solution techniques
- Equivalence principle algorithm (EPA)
- Domain decomposition methods
- Complex multi-scale structures
- Coexisting and interacting multi-physics problems
- New mathematical techniques
- Parallel computing

### **Commission B “Advanced Algorithms in Computational Electromagnetics”**

Conveners: Vladimir Okhmatovski, Pasi Ylä-Oijala

Numerical simulations and modeling play a crucial role in many 3D electromagnetic research & development tasks. More and more sophisticated algorithms and solvers have been developed and applied to find solutions for complicated and challenging real-world engineering problems. Despite of these great advances there still exist problems that are difficult to solve or are unattainable with presently available techniques. The algorithms may be plagued with severe shortcomings such as numerical instabilities, inaccuracies, and ill-conditioned linear systems or the solution of the problem requires too many degrees of freedom. The focus of this session is on advanced algorithms in computational electromagnetics which find remedies for these challenges. These algorithms can be based on both methodology developments and improvements as well as on application oriented solutions. Potential topics may include (but are not limited to): - Preconditioning techniques

- Parallelization
- High-order methods
- Error-controllable algorithms
- Fast iterative and direct solvers
- EM optimization and design
- Time-domain solvers
- Domain decomposition methods
- Matrix compression techniques

### **Commission B “Integral Equation, Hybrid, and Fast Methods”**

Conveners: Thomas Eibert, Francesco Andriulli

Integral equation solutions provide usually very accurate and robust results of scattering, radiation and field transformation problems. Due to their global nature, they lead, however, to fully-populated operator equations, which in turn result in field solvers with a bad numerical complexity. Fast integral solvers aim at reducing the bad solution complexity and this can be achieved by a variety of different techniques. The focus of this session is primarily on integral equation formulations and corresponding hybrid methods as well as on fast iterative and direct solvers, which reduce the solver complexity of the operator equations in the context of radiation, scattering, or field transformation problems, where free-space or other Green's functions (as e.g. for layered media) are used. Improvements of existing techniques are as welcome as completely new approaches. The techniques can be based on purely algebraic, but also on physics motivated procedures. They can work in time-

domain or in frequency domain, where low-frequency, high-frequency, and very wideband techniques are of interest.

### **Commission B “Staffan Ström Memorial Session”**

Convener: Gerhard Kristensson

This session is organized to commemorate the life and work of Professor Staffan Ström (1934-2016), who passed away in August 2016. Staffan was a well-known scientist in radio science both in Sweden and internationally. The invited talks in the session will concentrate on areas which were close to Staffan and where he worked actively: wave scattering and propagation, interaction of electromagnetic waves with materials, and mathematical fundamentals of radio science.

### **Commission B “Metasurface Engineering”**

Conveners: Tie Jun Cui, Anthony Grbic, Stefano Maci

Metasurfaces have been overwhelmingly investigated in recent years. Compared to the bulk metamaterials, metasurfaces have many advantages such as low profile, low loss, low cost, and easy conformation to curved objects. Combining with the classical electromagnetic theories such as the Babinet principle, Snell's law, and Huygens principle, and surface/leaky wave theory, metasurfaces have shown powerful abilities to control the electromagnetic waves, constructing a lot of new physical phenomena like anomalous reflections and refractions, optical vortexes, light bending, photonic spin Hall effect, polarization and beam shaping controls, etc. In this special session, we propose to include the most recent advances on metasurfaces, concentrating on the methods, designs, and applications with emphasis to microwave engineering. The metasurfaces include scalar (isotropic), vector (uniaxially anisotropic), and tensor (fully anisotropic) distributions of impedance and (or) index of refraction to provide extreme controls of electromagnetic radiations, propagations, scattering, and polarization.

### **Commission B “Time-Domain Electromagnetics”**

Conveners: Alexander Yarovoy, Natalia Nikolova

Such applications as autonomous driving, robotic vision, medical imaging, ground penetrating radar, synthetic aperture radar, concealed weapon detection and others require high-resolution object imaging or material properties profiles. Typically electromagnetic waves with ultra wide bandwidth or/and large spatial diversity are used to provide required performance. The session will provide an overview of recently developed electromagnetic methods capable to achieve high-resolution target characterization and illustrate these methods on a variety of applications.

### **Commission B “Novel Mathematical Methods in Electromagnetics”**

Conveners: Kazuya Kobayashi, Yuri Shestopalov

This session will cover recent achievements in the area of advanced analytical and numerical methods as applied to various problems arising in all branches of electromagnetics. Topics of interest include, but are not limited to, the following areas: analytical regularization methods; antennas and radiation; approximate boundary conditions; canonical problems; computational electromagnetics; electromagnetic theory; fast solvers; gratings and periodic structures; guided waves; high-frequency techniques; integral equation methods; inverse problems; inverse scattering and imaging; metamaterials; nano-electromagnetics; nonlinear phenomena; novel mathematical techniques; numerical methods; plasmonics; propagation; radar cross section; random media and rough surfaces; remote sensing; scattering and diffraction; time-domain methods; visualization of electromagnetic fields; waves in complex media.

### **Commission B “Scattering and Diffraction”**

Conveners: Ludger Klinkenbusch, Giuliano Manara

The session will review topics covering a wide range of scattering and diffraction problems, including edge diffraction, high-frequency methods, hybridization with high-frequency methods, use of artificial structures for optimal control of wave propagation, scattering from disordered media, and potential applications. Study of scattering from non-linear/anisotropic media as well as mathematical problems will also be emphasized. In addition, scattering and diffraction by canonical structures will be considered. Of interest might be different types of illuminating fields, such as plane waves, rays, and beams.

### **Commission B “Small Antennas from Nano to Macro Scales”**

Conveners: Samel Arslanagic, Richard Ziolkowski

The proposed session will focus on recent advances in the field of passive and active small antennas from the nano-scale (nano-antennas) to the macro scale (electrically small antennas). It will include invited theoretical, numerical and experimental contributions from imminent researchers presenting not only reviews of their past and current exciting developments, but also their views into future directions.

### **Commission B “Advanced Antenna Concepts”**

Conveners: John Volakis, Christos Christodoulou

This session focuses on reconfigurable, multiband, and wideband antenna concepts for software and cognitive radio systems. Applications include specific waveforms and coding methods for spectrum sharing and MIMO concepts for high data rate communications.

### **Commission B “Inverse Scattering and Imaging”**

Conveners: Matteo Pastorino, Lianlin Li

Electromagnetic wave techniques, both active and passive, are gathering strong attention in sensing and imaging related to security applications. They include landmine detection, identification of intruders, finding human bodies in disaster events, vehicle collision avoidance, security checking at airports, etc. Used wavelength now ranges from radio to X-ray waves. One of recent driving forces is the use of UWB (Ultra Wideband) signals, which dramatically improves the range resolution, and thus extends the applicability of radar technique to targets with very short ranges, such as indoor and medical imaging. Many of these applications require super resolution and/or very fast computation in order to provide real time images with high quality and reliability. Advanced inverse scattering algorithms and imaging techniques are the key issues of the session. Theoretical investigations and studies aiming to other type of applications are of course welcome.

### **Commission B “Recent Advances in Metamaterials”**

Conveners: Ari Sihvola, Ismo Lindell

The recent turn of the century saw the appearance of metamaterials into the scene of radio science. Metamaterials form a class of media whose properties emerge from their structural constellations. Despite the fact that the definition of metamaterials is fluid, the developments of research on these complex media within the domain of electromagnetics has been extremely rapid and full of unanticipated results and applications. This session is open to all new developments within electromagnetic metamaterials: their fundamental theory, computational modeling, and applications in radio science.

### **Commission B “Open Session”**

Conveners: Ari Sihvola , Kazuya Kobayashi

This session will accept any papers falling within the terms of reference of Commission B and not covered elsewhere.

### **Commissions BD “Advances in Antennas for RFID 1”**

Conveners: Ville Viikari, Smail Tedjini, Apostolis Georgiadis

RFID technology continues its rapid development and is seen as a viable solution for the implementation of the last few meters of the paradigm of internet of things. In particular UHF passive tags can reach a read range in excess of 20m. Besides the properties of RFID chips the role and the properties of the tag antennas are very effective in the design of augmented tags that can allow more than ID. In this session we focus on the design of specific antennas for tags and readers in the context of RFID system. So miniaturization, conforming and adapting to the environment are important and relevant issues for the designers. New antennas concepts, properties and operation are welcome in this session.

### **Commissions CB “5G Communication Systems”**

Conveners: Ozlem Kilic and, Amir I. Zaghoul

With the need for high bandwidth and data rate along with uninterrupted connectivity, 5G systems will heavily rely on adaptive antennas both at user end and stations. Ability to utilize other users who may be idle as relays is one of the many approaches to optimally utilize the system. The session includes papers on communication and network systems, as well as antennas and propagation perspectives.

### **Commissions CDB “Exploitation of Non-Linearities for Passive Wireless Sensors”**

Conveners: Yvan Duroc, Ville Viikari, Ke Wu

With the increasing interest of the concepts of Smart Cities, Smart Buildings and the Internet of Things, one of major challenges is the sensor nodes power management in order to provide autonomy to the large amount of devices. Energy harvesting solutions, wireless power transmission techniques, RFID tags, harmonic transponders, intermodulation sensors, and etc. offer solutions based on nonlinear components. The nonlinearity is beneficially used for rectification, harmonic generation and (inter)modulation. This session focuses on the exploitation of nonlinearities in the context of passive wireless sensors. The expected contributions cover all aspects from optimization of energy sources to new passive approaches to transfer data.

### **Commissions DB “Fibers and Waveguide Optics”**

Conveners: Günter Steinmeyer, Vincenzo Galdi

This topic includes, but is not limited to fundamental optical effects like optical parametric processes, harmonic generation, nonlinear wave mixing, self- and cross-phase modulation, and stimulated scattering effects. Particular emphasis is on nonlinear optics in guided geometries and micro- or nanostructured materials, including waveguides, fibers, and metamaterials, quasi-phase matched devices as well as self-guiding such as in filaments. Applications of these effects include nonlinear wavelength conversion, continuum generation, optical solitons, nonlinear spectroscopy, pulse generation, mode-locking, pulse shaping, and any other novel applications of nonlinear phenomena, novel materials, and structures.

### **Commissions DB “Microwave and Millimeter Wave Identification and Sensing”**

Conveners: Smail Tedjini, Ville Viikari, Arnaud Vena

Radio-frequency identification (RFID) is a relevant technology based on communication and monitoring by means of reflected electromagnetic waves. Nowadays it has thousands of applications

in numerous professional domains and more and more in our everyday life. The concepts and technologies behind RFID are rapidly evolving from Identification to sensing capabilities, which allow the emergence of cognitive devices and systems. This session should attract papers on the design of advanced RFID systems and devices and the new ideas and concepts in this very fruitful domain of radioscience. It should cover the main aspects of physics and technology behind RFID systems. A special attention will be given to the evolution of this identification passive technology to passive sensing capabilities and energy efficiency involving study on material and nanomaterial. This session is open to studies on novel manufacturing techniques such as printing electronics and their compatibility with the realization of efficient radio frequency identification tags. This session covers also emerging researches on chipless based identification technology and higher frequency identification systems (millimeter wave, THz).

### **Commissions DBC “Wireless Power Transmission”**

Conveners: Apostolos Georgiadis, Naoki Shinohara

Wireless power transmission is finding wide application in powering devices from low power wireless sensor network nodes to larger appliances such as computers, mobile phones and even vehicles. This session highlights new applications addressing different charging requirements and operating frequency, as well as circuitual and system challenges in improving the performance of such systems, such as increasing efficiency, operating range and sensitivity to misalignments or variations in load and power.

### **Commissions EB “Chaos and Complexity”**

Conveners: G. Gradoni, G. Tanner, A. Shivola

Statistical electromagnetics and wave chaos aim at characterizing and understanding the field propagation in complex circuits and environments. In particular, chaotic dynamics offers a unique platform for modeling wave systems with an arbitrary number of degrees of freedom. Recent studies in wave chaos have attracted researchers in electromagnetic theory and universal statistical properties have been used to study large electromagnetic systems without solving the full-wave problem. Circuits within printed circuit boards are now modeled as complex statistical sources that can be treated through semi-classical as well as random matrix theories. Novel theoretical models have been developed describing fields through complicated electromagnetic environments - including electromagnetic reverberation chambers - also accounting for coupling through apertures and including losses at both microwave and mmWave regimes.

### **Commissions FB “EM Modeling and Applications of Underground Imaging”**

Conveners: Lorenzo Capineri, Motoyuki Sato

Underground imaging based on ground penetrating radar is a widespread method for the investigation of soil characteristics and for the detection and characterization of buried objects. The scanning method based on a single or multiple (array) antennae has an important role in the final quality of the images as the coupling of antenna element with the soil can be variable from point to point due to the different geometrical characteristics of the surface. The EM modeling of the antenna coupling and solutions for the mitigation of detrimental effect on the image reconstruction are topics of interest for the session.

### **Commissions FB “Electromagnetic Problems Involving Volume Scattering”**

Conveners: V. Chandrasekar, Ari Sihvola

Volume scattering processes form the basis for understanding and interpreting electromagnetic measurements appropriate to integrated effects from numerous scatterers, such as rainfall, snowfall and the volume of snow on the ground. This session will enable a forum for exchange of ideas related to fundamental research problems in volume scattering including, dielectric constant in

mixtures, interpretation of multiple-polarization volume scattering signatures of ice/snow, hail/rain, soil/water mixtures, inversion problems in volume scattering.

**Commissions KBE “Uncertainty Management and Stochastic Methods in Experimental and Numerical Electromagnetism, Environmental Exposure Assessment and Dosimetry”**

Conveners: Joe Wiart, Tonging Wu, Ari Sihvola, Gabriele Gradoni

The increasing use of RF wireless communication system is supported by complex and agile technologies and network architectures. It has also induced large variability of usages. The management of such complexity has requested innovative approaches experimental and Numerical Electromagnetism, environmental exposure assessment and dosimetry. This session is devoted to recent progress and application of methods based on advanced statistical methods (e.g., Surrogate modelling, Polynomial Chaos, Kriging, Machine Learning, Sensibility analysis, etc. ) in experimental and Numerical Electromagnetism and dosimetry

**Commissions KBF “Electromagnetic Inversion for Biomedical, Geophysical, Non-destructive Testing, and Antenna Characterization Applications”**

Conveners: Aria Abubakar, Puyan Mojabi,

Electromagnetic inversion is the process by which some properties of an investigation domain are inferred from external electromagnetic observations. Several application areas, which span a wide range of frequencies from a few hertz to optical frequencies, utilize electromagnetic inversion algorithms and techniques to reconstruct the properties of interest, such as complex permittivity profiles of biological tissues, conductivity profiles in geophysical surveys, or equivalent current distributions of antennas. This special session is focused on bringing together recent advances in quantitative electromagnetic inverse scattering and inverse source algorithms/techniques in these application areas to enhance the achievable reconstruction accuracy, resolution, or efficiency of the computational process. The enhancement can be obtained by methods such as properly incorporating prior information into the inversion algorithm, appropriate numerical modelling and calibration, and new advances in inversion algorithms.

## Commission C Program

**Commission C Chair:** Prof. Sana Salous; sana.salous@durham.ac.uk

### **Commission C Tutorial Sana Salous: “5G Radio Channel Models to Standardization”**

Convener: Amir Zaghloul

5G radio systems will use higher frequency bands to enable high data rate applications. This tutorial will cover various aspects of 5G radio systems including deployment scenarios, propagation issues and standardization.

### **Commission C “Sub-Nyquist Sampling for Green Radio”**

Conveners: Yves Louet, Sumit Darak

Radio frequency (RF) allows modulation of narrow band signals with a high carrier frequency. In some cases, signals can be sparse as they are composed of a small number of narrow band transmissions spread across a wide spectral band. However, current wireless applications put severe requirements and constraints on spectrum and energy efficiency. To meet these objectives, analog to digital converter (ADC) design and associated signal processing has received a lot of attention in the past few years. This led to sub-Nyquist sampling of wideband signals so as to minimize energy and complexity. This session aims to cover all work related to sub-Nyquist sampling. It includes ADC architectures, signal processing (including non uniform sampling but not limited to reconstruction) and applications (cognitive radio, 5G mobile communications, radio-astronomy etc).

### **Commission C “Communications for the Smart Grid”**

Conveners: Jacques Palicot, Kostas Berberidis

The electrical grid will become a smart system. Introducing smartness is all about increasing communications between local entities in order to coordinate all the elements of the global system. Indeed, it is mandatory to refer to communications when we talk about the Smart Grid. The data volume exchanged by the different actors is such that it would be impossible to transport the data without a reliable and distributed communication system. The final communication architecture for the Smart Grid has not yet been really decided even if a particular model is often mentioned. It comprises : Home Area Network (HAN) that communicates with various smart devices such as smart meters in order to provide information to the customers. Neighborhood Area Network (NAN) that connects multiple HANs networks via HAN gateway to a single NAN gateway. NAN gateways make the links between transmission and distribution networks; Wide Area Network (WAN) that provides communication links between the NANs and utilities. The WAN makes the link between the data center or control center and the transmission network. The communication technologies will be different according to the area network HAN, NAN and WAN and researchers from the Smart Grid community argue on which technology has to be used in those networks. But a point on which they almost all agree is: instead of making huge research on creating one single technology/standard to achieve the communication in the Smart Grid, to create standards that will bring interoperability between existing technologies. From this point of view Cognitive radio could be an efficient way to transport the data without overloading the frequency spectrum and to offer this interoperability. This session will discuss the communication problem of smart grid and the different possibilities to solve this problem.

### **Commission C “Application of Machine Learning in Radio Communications”**

Conveners: Ruisi He, Qingyong Li, Wei Fan

Machine learning was introduced in the late 1950’s as a technique for artificial intelligence. It explores the study and construction of algorithms that can learn from and make predictions on data.

In recent years, modern communications networks of 4G and 5G have been seen as big, evolving distributed databases full of context and information. Machine learning techniques have been thus used extensively for a wide range of tasks including clustering, classification, sensing, regression, and density estimation in a variety of application areas such as cognitive radio, compressed sensing, traffic analysis, routing, big data, cloud communications, social networking, green communications, spectrum sensing, wireless access techniques, radio resource management, and radio channel modeling. The algorithms and techniques used come from many diverse fields including statistics, mathematics, neuroscience, and computer science. The focus of this session is to showcase a unified vision for the application of machine learning in radio communications, including all technologies above and other relevant aspects.

### **Commission C “Wireless Communications for the Future Transportation Systems”**

Conveners: Bo Ai, David W. Matolak, Ruisi He

Future transportation systems (FTSs) are advanced applications which aim to provide innovative services relating to different modes of transport and enable various users to be better informed and make safer. Compared with the Intelligent Transportation Systems which are mainly defined in the field of road transport, FTS will refer to all modes of transport such as railway, road, air, water, and space, and the field is divided into infrastructure, vehicles and operations. Recent advances in FTS have led to requirements for improvements and enhancements to systems used for radio communications. The focus of this session is to showcase a unified vision for the FTS including all modes of transport, with an emphasis on radio communications and other relevant aspects.

### **Commission C “Ultra-High Bit Rate Radio Communications Engineering at Tera Hertz”**

Conveners: C. Balocco, A. Gallant

The increasing rate at which today's society creates and consumes information must be accompanied by higher data-rates in wireless technologies to be sustainable. Physical-layer solutions operating in the THz region of the electromagnetic spectrum (0.1 - 10 THz) are envisioned as the key to future wireless systems with terabit-per-second (Tbps) capacity. This session will focus on recent advances in the electronic, plasmonic and electromagnetic devices which underpin the operation of communication systems at THz frequencies.

### **Commission C “Application of Radio Propagation Research Results in Radio System and Signal Design”**

Conveners: Robert Bultitude, Yves Lostanlen, Edward S. Rogers Sr.

This session has the objective of providing a forum for the presentation and discussion of research involving the direct application of radio propagation research results in the work done by members of Commission C. More specifically, papers are invited that describe the direct use of propagation measurements, electromagnetic simulations, theoretical electromagnetics, methods for the analysis of radio measurements, or the verification by measurements and electromagnetic theory of models and assumptions, for application in systems and signal design. Emerging wireless applications and technologies will require new or enhanced radio propagation characterizations and modeling to be efficiently designed and operated (millimeter waves, aggregated frequency bands and spectrum database, high altitude platforms to serve terrestrial communications, indoor and outdoor dense multipath environments). It is envisaged that a generic model for papers in the session would include a description of the objectives, of the propagation research, the methodology for employing the results thereof, and results and conclusions from subsequent research on systems and signal design based upon the reported radio propagation research.

### **Commission C “Enabling Technologies for Smart Cities”**

Conveners: Shengrong Bu, Richard Yu, Hongjian Sun

Cities are growing at an unrivalled pace. Currently about 50% of the world's population lives in an urban environment, and this number is expected to be up to 70% by 2050. This dense population creates new challenges for both people and governments. "Smarter" solutions are needed to meet the increasing strain on urban environments, and there is a great need for sustainable strategies for city development. However, the problems of the urban environment and complex and their solutions must bring together many disciplines. Advances in information and communication technology, including mobile crowdsourcing, internet of things, big data analytics tools and cloud services, have the potential to act as enabling technologies to make cities smart. These technologies can help streamline the delivery of a city's core services, including health care, transit, utilities, and environmental management. Fundamental research on the combination of these technologies and their application to the smart city must be undertaken to meet these challenges. This track aims to facilitate these research efforts and enhance international collaboration by disseminating cutting-edge research results. Participants will be able to share perspectives and novel research findings, and further identify new directions in the emerging research areas of smart cities.

### **Commission C “Quantum Communications and Networks”**

Conveners: Grace D. Metcalfe and Amir I. Zaghloul

The impact of quantum mechanics in the "first quantum revolution" is pervasive and profound, laying the foundation for modern electronics as well as breakthroughs in devices such as lasers and MRI imagers. The current "second quantum revolution" relies upon the manipulation of quantum superposition and entanglement for the development of advanced technologies such as quantum secure communications systems. This Special Session will focus on such quantum technologies for communications capabilities beyond what is classically possible. Topics will include entangled networks for data transmission, secure quantum communications protocols, quantum radar, quantum imaging and signal processing.

### **Commission C “Spectrum Sharing, Issues, Co-Existence, and Interference”**

Conveners: Jeff Reed, Anthony Martone

Crowded spectrum in the unlicensed bands creates a number of issues that have to be resolved. LTE, wireless and radar users compete for the assigned bands with the consequence of interference and timing limitations. The session will address co-existence and interference between the different users and their effects on the quality of service.

### **Commission C “Compressive Sensing and its Applications in Detection and Tracking of Objects in Motion”**

Conveners: Ozlem Kilic and Aly Fathy

Compressive Sensing can significantly reduce the data acquisition time in detection and tracking of moving objects. The session will address both hardware development and theoretical approaches for these applications of compressive sensing.

### **Commission C “5G Small Cell Networks”**

Conveners: Jie Zhang, Andres Glazunov, Xiaoli Chu

With rapidly growing usage of smart phones and tablets, mobile operators have experienced tremendous data traffic increase in the last few years. It is predicted that this trend will continue at least until 2020 with a CAGR of 60-100%. Hence, the traffic (mostly data) carried by a mobile operator's network in 2020 could be over 1000 times of that in 2010. This exponential traffic growth

presents a huge challenge to the mobile industry. On top of meeting this traffic increase, operators have obligations to cut energy consumptions, which normally compromise spectrum efficiency in macrocell scenarios. Dense small cell deployment is one of the most promising ways to meet the exponential traffic growth. In this session, we will solicit contributions from both academia and industry to discuss the challenging issues arising from dense small cell deployment, including but are not limited to:

- mmWave channel modelling for typical small cell deployment scenarios;
- massive MIMO mmWave antennas for small cells;
- interference management in small cell/HetNets;
- SON for small cell networks;
- small cell backhaul;
- green small cell networks;
- joint indoor-outdoor small cell deployment;
- device-to-device communications;
- pCell;
- LTE-LAA/WiFi co-existence.

The session will encourage industry and academia interactions, and will be very attractive for network operators, telecom vendors and research institutions.

### **Commission C “Radio Signal Processing and Radar Systems”**

Conveners: Daiyin Zhu, Shilong Pan, Qihui Wu

Recent advances in technology have led to the development of Commercial Off-The-Shelf (COTS) sensing devices capable of providing high performances in terms of both energy-efficiency and measurement precision. Such techniques have possible applications in target monitoring, air and coastal surveillance, target localization, and radio navigation. This Special Session will focus on innovative radio signal processing techniques (radar, target detection, target tracking, radio localization, and radio navigation) and systems in the face of new and challenging operating scenarios that naturally arise from modern technological advances. Topics will include advanced techniques for radar systems, target detection, target tracking, radar imaging, radio localization, and radio navigation.

### **Commission C “Massive MIMO”**

Convener: Ian Glover

This session is open to papers addressing any aspect of massive MIMO technology including, but not limited to, its use for increased data rate, improved reliability, enhanced signal-to-interference ratio and improved energy or spectral efficiency. Application may be to existing, emerging or entirely new services. Papers may treat any area of massive MIMO theory and practice including fundamental principles, channel modelling and measurements, theoretical and practical limitations, signal processing algorithms, complexity and economic considerations and hardware implementations.

### **Commission C “Open Session”**

Conveners: Sana Salous, Amir Zaghoul

This session will accept any papers falling within the terms of reference of Commission C and not covered elsewhere.

### **Commissions CA “Channel Measurements, Characterization and Verification through Electromagnetic Metrology and Measurement Post Processing”**

Conveners: Jeanne Quimby, Sana Salous

The session will address development and refinement of channel measurements, characterization and verification through new and refined measurement techniques and calibrations; physical or statistical representation of the propagation channel; comparison of channel sounder systems to vector network analyzers, multiple channel sounders or standards; and measurement post processing for channel verification through new and novel techniques.

### **Commissions CB “5G Communication Systems”**

Conveners: Ozlem Kilic and, Amir I. Zaghoul

With the need for high bandwidth and data rate along with uninterrupted connectivity, 5G systems will heavily rely on adaptive antennas both at user end and stations. Ability to utilize other users who may be idle as relays is one of the many approaches to optimally utilize the system. The session includes papers on communication and network systems, as well as antennas and propagation perspectives.

### **Commissions CDB “Exploitation of Non-Linearities for Passive Wireless Sensors”**

Conveners: Yvan Duroc, Ville Viikari, Ke Wu

With the increasing interest of the concepts of Smart Cities, Smart Buildings and the Internet of Things, one of major challenges is the sensor nodes power management in order to provide autonomy to the large amount of devices. Energy harvesting solutions, wireless power transmission techniques, RFID tags, harmonic transponders, intermodulation sensors, and etc. offer solutions based on nonlinear components. The nonlinearity is beneficially used for rectification, harmonic generation and (inter)modulation. This session focuses on the exploitation of nonlinearities in the context of passive wireless sensors. The expected contributions cover all aspects from optimization of energy sources to new passive approaches to transfer data.

### **Commissions DBC “Wireless Power Transmission”**

Conveners: Apostolos Georgiadis, Naoki Shinohara

Wireless power transmission is finding wide application in powering devices from low power wireless sensor network nodes to larger appliances such as computers, mobile phones and even vehicles. This session highlights new applications addressing different charging requirements and operating frequency, as well as circuitual and system challenges in improving the performance of such systems, such as increasing efficiency, operating range and sensitivity to misalignments or variations in load and power.

### **Commissions DC “Optical Telecommunications”**

Conveners: Asghari, Azana

The future of telecommunications, switching networks and information processing platforms, with ever-increasing speed and bandwidth requirements, demands the development of innovative, higher performance approaches for high-speed signal processing units. Photonic solutions are among the most promising and widely studied candidates for this severe problem; these solutions are capable of operation on signals at THz speeds and above, well beyond the reach of their electronic counterparts. Trending photonic technologies that drive the needed innovation in optical telecommunications include ultrafast optical signal measurement, low-noise and noiseless optical amplification, ultrafast optical signal processing, optical waveform generation, and microwave photonics. This session focuses on recent advances in these technologies and their application to optical telecommunications.

### **Commissions ECJ “Spectrum Management”**

Conveners: J. Pedro , A. Tipaldy, A. Shukla, H. Liszt

The focus of this session on spectrum management and spectrum utilization is of high interest to the community. We expect to give a short report of the related WG06 activities during the last period, along with our views on spectrum management, and on hot topics of today. International and local Chinese contributors will be invited such that first-hand reports on controversial spectrum management issues will be presented.

### **Commissions FC “Multi-Parameter Radars and Wave Propagation for Remote Sensing and Disaster Management”**

Conveners: Tullio Tanzi, Madhu Chandra, Eric Mokole

Radio Science, including wave propagation, plays a central role in shaping the evolution of radar remote sensing in the context of disaster management. In the field of multi-parameter radars methods we are witnessing advances in polarimetry, application of smart and reconfigurable digital beam forming antennas, ever increasing bandwidths, and the application of waveform diversity. In terms of systems, we are seeing the rapid development of compact radar systems that can be mounted on autonomous drones and UAVs. In particular, drone mounted ground-penetrating radar systems capable of detecting victims buried in debris are sought. The requirements of humanitarian surveillance and disaster management applications are posing new challenges on the detection of objects and features mingled within diverse clutter signals e.g. forests, debris and buildings. This session welcomes contributions in this interdisciplinary and trans-disciplinary session on multi-parameter radar and disaster management.

### **Commissions KC “EM Human Exposure and Future 5G and LPWA Networks”**

Conveners: Benoit Derat, Long Lee

Mobile communications sector is one of the strongest growing markets in the world. This growth is not expected to slow down with the proliferation of laptops, tablets, wearables and the variety of applications being supported by 5G communications, the Internet of Things (IoT) and Low Power Wide Area Networks (LPWA). Innovative technologies will allow the future networks to exceed the existing limitations in bandwidth, data rate and enable new applications and usages. Novel technologies and usages result in new challenges in assessing electromagnetic (EM) human exposure. The evaluation of EM exposure is discussed for conditions which involve frequencies higher than 6 GHz and up to several tens of GHz, uplink MIMO and beamforming or innovative devices or device usages. The resulting research and development for new phantoms, measurement techniques or numerical modeling approaches are central topics of this session.

## Commission D Program

**Commission D Chair:** Prof. Günter Steinmeyer; [steinmey@mbi-berlin.de](mailto:steinmey@mbi-berlin.de)

### **Commission D Tutorial J Leuthold: “The Path towards 100 Gbit/s Wireless Communications”**

Convener: Günter Steinmeyer

100 Gbit/s wireless communications is emerging as a solution to overcome the access network bottleneck. Yet, capacities above 100 Gbit/s require new technologies and photonic-electronic devices that can handle sub-THz carrier frequencies that allow for fast beam steering of pencil beams and that can process novel modulation formats. This tutorial session will review recent progress in the field and highlight the impact of novel technologies such as plasmonics to overcome the technological challenges on the path to Tbit/s wireless communications

### **Commission D “Microwave Photonics”**

Conveners: Stavros Iezekiel, Jianping Yao

Microwave photonics (MWP) is an interdisciplinary field which as the name implies involves elements of both microwave engineering and photonics, typically for the generation, transmission and signal processing of microwave signals in the optical domain. The large time-bandwidth product and relatively low propagation losses of photonics have been a key motivation in the development of many MWP systems, allowing functionalities that would either be complex or not feasible with standard microwave components and techniques. This session will focus on some of the emerging applications and technologies in microwave photonics, such as 5G and integrated photonics.

### **Commission D “Modeling of Electronic, Photonic and Plasmonic Devices”**

Conveners: Ayhan Demircan, Jeremy Gulley

Advances in electro-photonic and plasmonic devices are critical for the further development of applications in computing, communications, and defense related technologies. Modern experiments with novel electro-photonic materials frequently require simulations to interpret the significance of physical processes. This is particularly important in several cases. One is the case of device interactions with strong external fields, where nonlinear effects play a decisive role in the material response. Another is the case of ultrafast processes, which require fully time-resolved modeling of the material evolution on the femtosecond or attosecond time scale. Still a another case is micro- and nano-electronics, where the quantum mechanical effects in the device largely determine its behavior. This session should attract papers advancing the fundamental understanding of electronic, photonics and plasmonic devices through theory and simulations. Specific topics of interest include strong field interactions with micro- and nano-electronics, electronic thermalization, nonlinear optics and photonics, propagation, and ultrafast processes in semiconductors and dielectrics.

### **Commission D “Carbon-Based Photonics and Optoelectronics”**

Conveners: Frank Wang, Fabian Rotermund

Graphene and carbon nanotubes (CNTs) both exhibit fascinating optical properties, e.g. ultrafast carrier relaxation, broadband light absorption. While new physical insights into the photo-excitations in these carbon-based materials are still being revealed, they are exploited in an ever broadening range of photonic devices including light-emitting diode, optical modulators, photodetectors, sensors and other emerging functional devices. This session aims to give an overview of recent advances in these fields.

### **Commission D “Terahertz and Millimeter Waves”**

Conveners: Günter Steinmeyer, Tahsin Akalin

The Terahertz range covers the range between about 300 GHz and 30 THz, with wavelength ranging from 10 microns up to one millimeter. This range has long been a gap in our technological capabilities to generate and detect coherent radiation. Modern generation methods include optical rectification, photoconductive antenna structure, quantum cascade lasers, and free-electron lasers. Applications range from medical imaging over security applications to first demonstrations of wireless data transmission with THz waves. This session reviews the latest developments in generation, detection, and application in this wavelength range.

### **Commission D “Terahertz Generation and Applications”**

Conveners: Christoph Hauri, Mona Jarrahi

The development of advanced Terahertz sources in the technologically hard to access 0.1-15 THz range has opened novel opportunities in science and industry. These applications range from controlling material properties on a sub-cycle time-scale to selective mode excitation and towards the realization of the next-generation short-distance wireless network operating at unprecedented transfer rate. The session shall give an overview on recent advances in those fields.

### **Commission D “Electric Field Synthesis at Photonic Frequencies”**

Conveners: Bruno Schmidt, Eleftherios Goulielmakis

The past few years have witnessed a remarkable progress in ultrafast science lying at the interface between electronics and photonics. Laser fields can be used for instance to generate coherent currents in bulk solids reaching unprecedented frequencies and laser controlled electrons can give rise to new coherent optical fields. These exciting possibilities open the way to bridging electronics and photonics in the years to come. This year's commission D is focused on exploring further the prospects of this new area which may turn out to be influential in the advancements of both electronics and photonics.

### **Commission D “Open Session: Plasmonics and Metamaterials”**

Conveners: Günter Steinmeyer, Apostolos Georgiadis

Plasmonics forms an important bridge between electrical engineering and optics, enabling the controlled excitation of electromagnetic waves at the nanometer scale. This session focuses on design, manufacturing, and characterization of novel plasmonic devices and their application in measurement and sensing. Topics include the exploitation of surface plasmons in metamaterials for obtaining optical properties that can otherwise not be seen in nature, e.g., negative refraction. The scope of this session encompasses all regions of the electromagnetic spectrum from microwaves to visible wavelengths and beyond.

### **Commission D “Plasmonics”**

Convener: C. Lienau

Surface plasmons are interfacial electromagnetic modes that can be exploited to control the propagation and local oscillation of electromagnetic energy. This topical conference will explore fundamental and applied plasmonic concepts, the control and manipulation of local and propagating surface plasmons, plasmon dynamics, and novel plasmonic nanostructures for sensors and antennas applications, nanophotonics scenarios, and plasmonic beam manipulation.

### **Commission D “Material and Metamaterials for Microwave to Optical Wave Applications”**

Conveners: Benjamin Williams, Tatsuo Itoh

During recent years, substantial progress and diversification have been reported on the metamaterials research. In addition to the left hand materials, various forms of engineered materials have been

explored including cloaking materials, periodic structures and metasurfaces. This convened session intends to review state of the art on these subjects with emphasis on applications involving hardware. The range of frequency is from microwave to optics. Applications at THz region are of particular interest.

#### **Commission D “CMOS Compatible Photonics”**

Conveners: Roberto Morandotti, Milos Popovic

This session will target the burgeoning field of CMOS compatible photonics, based on silicon and silicon-compatible materials. Application areas within the scope of this sections, based on both linear and nonlinear devices, as well as passive and active components, are very broad and include, but are not limited to: optical tele-communications and data-transmission; optical interconnects, switching and storage; data and information processing; integrated quantum circuits, sources and detectors; and optical monitoring and sensing (e.g., integrated frequency combs), spanning the visible to the Mid-IR range of wavelengths.

#### **Commission D “Open Session: Recent Advances in Electronics and Photonics”**

Conveners: Günter Steinmeyer, Apostolos Georgiadis

Electronics and photonics are ultimately different facets of Maxwell's equations. Optical radiation exhibits carrier frequencies in the range of several hundred terahertz whereas current microwave generation schemes are limited to a few hundred gigahertz at best. In between these two regions, there is a range of about three orders of magnitude where neither optical nor electronic synthesis or detection schemes appear easily applicable. This session features recent advancement in the field of electronics or photonics with particular emphasis on novel schemes to close the gap and to connect electronics with photonics. Contributions include photonic schemes for the implementation of electronic functionalities, electronic schemes that overcome frontiers, photonic signal processing schemes, optoelectronic and electro-optic applications. A particular focus is on electronics and photonics devices, circuits and systems for the purpose of implementing either previously unattainable functionalities or for improving the performance of current electronic-only or photonic-only technologies.

#### **Commissions DA “Optical Frequency Metrology”**

Conveners: Ekkehard Peik, Kazumoto Hosaka

The development of frequency-stable lasers with sub-Hertz linewidth, of optical frequency standards with uncertainties in the low E-18 range based on laser cooled and trapped atoms or ions, of femtosecond lasers as optical frequency comb generators for the measurement of optical frequencies and frequency ratios, and the establishment of telecom fiber based optical carrier frequency transfer of high stability over long distances is opening new opportunities for the metrology of time and frequency and for various applications in basic and applied science. The session will solicit presentations that address the fascinating challenge to establish, improve and confirm the precision of frequency measurements in this new regime and to develop novel applications of optical frequency metrology in fields like navigation, geodesy, tests of fundamental physics, or other areas.

#### **Commissions DA “Optical Methods for Microwave Metrology”**

Conveners: Mark Bieler, Yang Chuntao

The operating frequency and bandwidth of microwave devices is steadily increasing. Especially the development of novel communication technologies, sensors, and transducers imposes the need for exact and reliable measurements in this frequency range. This is mainly because devices cannot be improved if their functionality cannot be accurately characterized. Optical methods are well suited for characterization since (i) they offer an unprecedented bandwidth that is not accessible with purely electrical devices, (ii) allow for quasi-non-invasive measurements due to contactless probing, and

(iii) enable straightforward traceability of the time and frequency axes to the unit of time. This session addresses such optical techniques, which can be employed for the measurement of electric, magnetic, and thermal signals and form the basis for microwave metrology.

### **Commissions DB “Fibers and Waveguide Optics”**

Conveners: Günter Steinmeyer, Vincenzo Galdi

This topic includes, but is not limited to fundamental optical effects like optical parametric processes, harmonic generation, nonlinear wave mixing, self- and cross-phase modulation, and stimulated scattering effects. Particular emphasis is on nonlinear optics in guided geometries and micro- or nanostructured materials, including waveguides, fibers, and metamaterials, quasi-phase matched devices as well as self-guiding such as in filaments. Applications of these effects include nonlinear wavelength conversion, continuum generation, optical solitons, nonlinear spectroscopy, pulse generation, mode-locking, pulse shaping, and any other novel applications of nonlinear phenomena, novel materials, and structures.

### **Commissions DB “Microwave and Millimeter Wave Identification and Sensing”**

Conveners: Smail Tedjini, Ville Viikari, Arnaud Vena

Radio-frequency identification (RFID) is a relevant technology based on communication and monitoring by means of reflected electromagnetic waves. Nowadays it has thousands of applications in numerous professional domains and more and more in our everyday life. The concepts and technologies behind RFID are rapidly evolving from Identification to sensing capabilities, which allow the emergence of cognitive devices and systems. This session should attract papers on the design of advanced RFID systems and devices and the new ideas and concepts in this very fruitful domain of radioscience. It should cover the main aspects of physics and technology behind RFID systems. A special attention will be given to the evolution of this identification passive technology to passive sensing capabilities and energy efficiency involving study on material and nanomaterial. This session is open to studies on novel manufacturing techniques such as printing electronics and their compatibility with the realization of efficient radio frequency identification tags. This session covers also emerging researches on chipless based identification technology and higher frequency identification systems (millimeter wave, THz).

### **Commissions DBC “Wireless Power Transmission”**

Conveners: Apostolos Georgiadis, Naoki Shinohara

Wireless power transmission is finding wide application in powering devices from low power wireless sensor network nodes to larger appliances such as computers, mobile phones and even vehicles. This session highlights new applications addressing different charging requirements and operating frequency, as well as circuital and system challenges in improving the performance of such systems, such as increasing efficiency, operating range and sensitivity to misalignments or variations in load and power.

### **Commissions DC “Optical Telecommunications”**

Conveners: Asghari, Azana

The future of telecommunications, switching networks and information processing platforms, with ever-increasing speed and bandwidth requirements, demands the development of innovative, higher performance approaches for high-speed signal processing units. Photonic solutions are among the most promising and widely studied candidates for this severe problem; these solutions are capable of operation on signals at THz speeds and above, well beyond the reach of their electronic counterparts. Trending photonic technologies that drive the needed innovation in optical telecommunications include ultrafast optical signal measurement, low-noise and noiseless optical amplification, ultrafast

optical signal processing, optical waveform generation, and microwave photonics. This session focuses on recent advances in these technologies and their application to optical telecommunications.

### **Commissions DJ “Special Session on Gravitational Wave Detection”**

Conveners: Roman Schnabel, Lisa Borsotti, Willem Baan

The first observation of gravitational waves on September 14, 2015, by the two detectors of the Laser Interferometer Gravitational-Wave Observatory (LIGO) heralded the field of gravitational-wave astronomy. It is expected that this field will provide information about the universe that was previously not accessible at all. Although gravitational-wave observatories are already extremely sensitive measurement devices, there are many ideas for further enhancements to increase the event rate by several orders of magnitude and to target specific sources of gravitational waves. A particular goal is reaching a sensitivity that will allow us to listen to the gravitational-wave background originating from the Big Bang.

### **Commissions BD “Advances in Antennas for RFID 1”**

Conveners: Ville Viikari, Smail Tedjini, Apostolis Georgiadis

RFID technology continues its rapid development and is seen as a viable solution for the implementation of the last few meters of the paradigm of internet of things. In particular UHF passive tags can reach a read range in excess of 20m. Besides the properties of RFID chips the role and the properties of the tag antennas are very effective in the design of augmented tags that can allow more than ID. In this session we focus on the design of specific antennas for tags and readers in the context of RFID system. So miniaturization, conforming and adapting to the environment are important and relevant issues for the designers. New antennas concepts, properties and operation are welcome in this session.

### **Commissions CDB “Exploitation of Non-Linearities for Passive Wireless Sensors”**

Conveners: Yvan Duroc, Ville Viikari, Ke Wu

With the increasing interest of the concepts of Smart Cities, Smart Buildings and the Internet of Things, one of major challenges is the sensor nodes power management in order to provide autonomy to the large amount of devices. Energy harvesting solutions, wireless power transmission techniques, RFID tags, harmonic transponders, intermodulation sensors, and etc. offer solutions based on nonlinear components. The nonlinearity is beneficially used for rectification, harmonic generation and (inter)modulation. This session focuses on the exploitation of nonlinearities in the context of passive wireless sensors. The expected contributions cover all aspects from optimization of energy sources to new passive approaches to transfer data.

### **Commissions JD “AstroPhotonics”**

Conveners: Martin Roth, Peter Maat, Stefan Minardi

Optical fibers and integrated optical devices are increasingly being used as key technologies to improve the performance of radio- and optical- astronomical interferometers and, in general, any optical astronomical instrument. To highlight the rapid development and growing importance of this specific area of applied photonics, the term AstroPhotonics has been recently devised. Beam forming devices, integrated optics delay lines, and clock distribution based on optical fiber networks are now commonly used to enhance the precision of radio-interferometric measurements, while reducing the impact of environmental electromagnetic noise and infrastructure cost. Recent advances in optical comb technologies bear promise to replace atomic clocks by much more accurate optical clocks, which could be easily interfaced to optical fiber networks to time the radio-telescopes. In the domain of optical interferometry, integrated optics multi-telescope beam combiners for near-infrared light are currently delivering the highest precision visibility measurements and enable reliable image retrieval of astronomical targets ranging from stellar surfaces to proto-planetary disks.

Extension of these technologies to the visible and mid-infrared bands is currently an active research area, along with feasibility studies and on-field tests of direct telescope connection by means of optical fiber links. The aim of this session (including both invited and contributed talks as well as posters) is to bring together the radio- and optical-AstroPhotonic communities by presenting recent advances and new application concepts based on photonic technologies for astronomical interferometry. Differences and similarities between the photonic technologies and their applications employed by the two communities will be highlighted, in order to promote a fruitful cross-contamination of ideas and interdisciplinary collaboration. Eligible topics include: integrated optics devices and components for stellar interferometry (e.g. beam forming devices, homodyne and/or heterodyne interferometric beam combiners, integrated phase and/or amplitude modulators), all-optical delay lines, frequency combs generation, optical clocks, optical fiber networks and their opto-electronic management, long-haul interferometric fiber links.

## Commission E Program

**Commission E Chair:** Dr. David Giri; Giri@dv giri.com

### **Commission E Tutorial William Radasky: “EMC Aspects in Smart Grids”**

Convener: D. V. Giri

Smart Grids are being contemplated and portions of them implemented in some nations. This tutorial talk deals with the EMC aspects of the smart grids.

### **Commission E “EMC in Complex Systems (1)”**

Conveners: P. Degauque, F. Silva

The session addresses one of the central issues in electromagnetic compatibility and interference, namely the treatment of complexity. Complex systems consist of many interacting components participating to the EM interaction response. The complexity of a system increases with the number of distinct components, the sophistication of the components and their interactions. The scope of the session is to present work which focuses on modeling, simulation and experimental characterization of complex systems, the effects of ground on electromagnetic coupling phenomena and the coupling of electromagnetic waves through the structures.

### **Commission E “High-Power Electromagnetics”**

Conveners: D. V. Giri, R. L. Gardner

The sessions address intentional electromagnetic interference (IEMI), or the intentional malicious generation of electromagnetic energy introducing noise or signals into electric and electronic systems, thus disrupting, confusing or damaging these systems for terrorist or criminal purposes. The technical area of HPE consists of the physics and engineering associated with electromagnetic sources where nonlinear effects associated with high-field regions (and air breakdown) must be included in the analysis and design. This includes EMP simulators, high-power narrowband and mesoband sources and antennas, and hyperband (impulse) sources and antennas.

### **Commission E “Intentional Electromagnetic Interference”**

Conveners: M. Bäckstrom, W. Radasky, L. Shi

The sessions address intentional electromagnetic interference (IEMI), or the intentional malicious generation of electromagnetic energy introducing noise or signals into electric and electronic systems, thus disrupting, confusing or damaging these systems for terrorist or criminal purposes. This session will mainly deal with the impacts of IEMI on different types of equipment and systems including the means to protect against this threat.

### **Commission E “Stochastic/Statistical Techniques in EMC”**

Conveners: L. Arnaut, S. Pignari

The EMC community is increasingly interested in the development of analysis and design techniques which take account of the inherent uncertainty of system parameters. In fact, the system response is affected by the statistics of such parameters, and varies widely within a distribution. Typical areas of interest include effects due to unknown wave parameters of interfering signals, statistical nature of fields inside metallic enclosures, uncertainty in the location of conductors inside multiwire structures and routing of bundles in metallic enclosures, values of termination impedances, values of stray parameters and material parameters, etc. The session will address these issues and give updated information on developments in EMC characterization and testing based on statistical analysis and design techniques.

### **Commission E “EMC in Wired and Wireless Systems”**

Conveners: F. Rachidi, F. Gronwald, M. Haridim, J. Gavan

The session addresses the propagation of signals and interference in wired and wireless systems, with particular focus on ADSL and PLC.

### **Commission E “Lightning and Related Phenomena”**

Conveners: V. Rakov, S. Yoshida

The session addresses the characterization of terrestrial and planetary electromagnetic noise, as well as natural noise from terrestrial and extra-terrestrial sources with a view towards the interests of CCIR and the advancement of knowledge.

### **Commission E “EMC for PCB and Package”**

Conveners: C. Holloway, E. P. Li

Rapid growth and convergence of digital computing and wireless communication have resulted in complex EMC which cannot be easily addressed by conventional methods. This session will address the various techniques for modelling and simulation of EMC problems, such as Signal integrity/power integrity, numerical modelling of automotive EMC, aerospace EMC, integrated circuit EMC. In addition, the material property on electromagnetic performance, aging effects, thermal-electrical coupling.

### **Commission E “EMC of Power Electronics”**

Conveners: Yu-Kang Lo, C. Voltaire

Advantages in semiconductor technology drive power electronics to higher efficiencies and compact systems designs. This progress comes along with increasing effort to comply with EMC requirements. Integration as a response to the market demands intensifies the challenges. With dense placement electromagnetic coupling between components raises influence on system behavior. The design becomes more complex and leads to significantly higher development costs. This session deals with the EMC in Power Electronics.

### **Commission E “EMC in Power Engineering”**

Conveners: X. Cui, J. He

This session addresses the environmental effects of ac and dc power transmission systems, including electrical and magnetic fields, radio interference and the special ion current phenomena generated by dc transmission lines. The electromagnetic interferences on secondary systems in substations or converter stations are also included.

### **Commission E “Measurement Techniques”**

Conveners: R. Serra, C. Lemoine

The session addresses the raft of techniques that are involved in making electromagnetic compatibility measurements. The wide variety of available measurement techniques and the ever-increasing challenges faced by development and test engineers makes the measurement and analysis of EMC phenomena a significant discipline. The scope of the session is to contribute with original research work spanning the whole spectrum of measurement techniques

### **Commission E “Geomagnetic Disturbances (GMD) and Effects”**

Conveners: W. Radasky, E. Savage

A geomagnetic storm is a temporary disturbance of the Earth's magnetosphere caused by a solar wind shock wave and/or a cloud of magnetic field that interacts with the Earth's magnetic field. The increase in the solar wind pressure initially compresses the magnetosphere. The solar wind's magnetic field then interacts with the Earth's magnetic field and transfers charged particles into the

lower ionosphere creating high levels of current flow which in turn causes fluctuating B-fields at the Earth's surface. These B-fields can induce significant currents into long conducting lines, such as power and communications lines, thereby affecting the operation of the related systems. This session deals with GMDs and their effects on critical infrastructure components such as the power grid.

### **Commission E “New Concepts in Wireless Communications”**

Conveners: G. Gradoni, G. Tanner

Physics-based approaches are entering and complementing information theoretic formulations for wireless communications, assisting them in the description of non-thermal noise and describing propagation mechanisms in complex environments. Large scale, multiply connected indoor scenarios are challenging to be tackled with conventional ray tracing algorithms at mmWave regimes, as they converge slowly and become inaccurate in presence of boundary roughness, diffraction and diffusion in the (very) high frequency limit. Statistical phase-space methods aim at compensating those drawbacks by borrowing concepts developed in semi-classical analysis and wave chaos. A wide range of applications can be described accurately, new collective phenomena exploited for an efficient energy transfer, path loss and clustering dynamics can be enriched and understood better. 5G and chip-to-chip communications constitute a new where small-scale wireless communications take over as a building block for large-scale telecommunications.

### **Commission E “Time Reversal in Electromagnetics”**

Conveners: F. Monsef, J. Derosny

The time reversal technique is based upon a feature of the wave equation known as reciprocity: given a solution to the wave equation, then the time reversal (using a negative time) of that solution is also a solution. This occurs because the standard wave equation only contains even order derivatives. Time reversal techniques can be modelled as a matched filter. The focus of this session is to discuss many aspects of time reversal methods as applied to problems in electromagnetics.

### **Commission E “Solar Power Satellites”**

Conveners: M. Haredim and J. Gavan

This session addresses the concept of the Solar Power Satellite (SPS) systems proposed by P. Glaser in the 1970s. This multidisciplinary project issue is to produce in huge satellites in space a big amount of energy from the sun with maximum conversion efficiency due to the space environment. This energy is transformed in the satellites to a microwave (MW) beam reaching terrestrial stations by Wireless Power Transmission (WPT) using huge rectifier antennas (RECTENNAs) arrays to produce efficiently big amount of green Electrical energy for human use. These SPS systems could contribute to replace polluted limited sources of coal and gas energy by green unlimited energy source from the sun. The required satellites constructed by future robots could be Low Earth Orbit (LEO) satellites at an altitude of several hundred km which supply the ground station for a limited short time each earth orbit or better Geostationary satellites in an orbit around the equator at an altitude of 36000km for a permanent supply of energy. A lot of R&D activities were done especially in Japan and by the NASA, also two special issues of the URSI RSB were dedicated to this subject, but the implementation of this project can still take several decades of efforts. This session achievements could be enhanced by dealing also with the implementation of long distance WPT of lower power levels and of shorter distances in the atmosphere from space to ground or from ground to space where MW is a must or between two space stations where LASER may be preferred. The main contributions of Commission E to the session are: The analysis and development of EMI mitigation techniques of WPT systems to the operating communication, RADAR or other wireless services, to the design and control of the MW beam to be safe, not to exceed power density limits and obtaining optimal power conversion from sun energy to output electric power on the terrestrial station.

### **Commission E “Open Session”**

Conveners: D. V. Giri, F. Gronwald

This session will accept any papers falling within the terms of reference of Commission E and not covered elsewhere.

### **Commissions EB “Chaos and Complexity”**

Conveners: G. Gradoni, G. Tanner, A. Shivola

Statistical electromagnetics and wave chaos aim at characterizing and understanding the field propagation in complex circuits and environments. In particular, chaotic dynamics offers a unique platform for modeling wave systems with an arbitrary number of degrees of freedom. Recent studies in wave chaos have attracted researchers in electromagnetic theory and universal statistical properties have been used to study large electromagnetic systems without solving the full-wave problem. Circuits within printed circuit boards are now modeled as complex statistical sources that can be treated through semi-classical as well as random matrix theories. Novel theoretical models have been developed describing fields through complicated electromagnetic environments - including electromagnetic reverberation chambers - also accounting for coupling through apertures and including losses at both microwave and mmWave regimes.

### **Commissions ECJ “Spectrum Management”**

Conveners: J. Pedro, A. Tiplady, A. Shukla, H. Liszt

The focus of this session on spectrum management and spectrum utilization is of high interest to the community. We expect to give a short report of the related WG06 activities during the last period, along with our views on spectrum management, and on hot topics of today. International and local Chinese contributors will be invited such that first-hand reports on controversial spectrum management issues will be presented.

### **Commissions EFGH “Natural Electromagnetic Noise and Radio Sensing Applications in Terrestrial and Planetary Environments”**

Conveners: Y. Hobara, C. Price, T. Ushio, M. Fullerkrug

This joint session aims at presenting recent works on electromagnetic noise and phenomena in the terrestrial atmosphere and upper atmosphere (ionosphere/magnetosphere). Different kinds of electromagnetic noises will be dealt with, including atmospheric noises originated in lightning discharges (ELF Schumann resonances, mesospheric optical emissions etc.), man-made noise and noise due to wave-particle and wave-wave interactions. Corresponding electromagnetic noise environments on other planets are welcome. We are particularly interested in applications of natural EM observations in remote sensing such as monitoring, detecting and forecasting natural hazards, such as thunderstorms, severe weather, space weather and seismic events.

### **Commissions EFGHJ “One-Day Workshop on RFI Mitigation and Characterization”**

Conveners: F. Gronwald, R. Bradley, T. Bullet, H. Rothkaehl, D. Le Vine, A. Maitra, M. Haredim, J. Gavan, V. Deniau, P. de Matthaëis

It is the aim of this workshop to bring together researchers, engineers and users from all radio science disciplines to consider how RFI affects their respective fields, to develop mitigation strategies, and to foster cooperation and collaboration. Particular attention will be given to the impact of new and future sources of RFI, spectrum management challenges, and new technology developments. Recent progress towards the ultimate goal of being able to do observations with real-time mitigation of the undesired signals, while leaving the desired signals minimally affected, will be discussed.

### **Commission E “Short Course on IEMI and Cyber threats for Wireless Communications”**

Conveners: V. Deniau and C. Kasmi

Intentional Electromagnetic Interference (IEMI) can degrade both voice and data wireless communication systems. This workshop will discuss the main characteristics of such interference, including smart IEMI threats, also known as cyber threats.

### **Commissions AE “Mode-Stirred Chambers”**

Conveners: Luk R. Arnaut, Tian Hong Loh

Electromagnetic reverberation chambers (RCs) (also known as mode-tuned or mode-stirred chambers) are now common RF test facilities used primarily for electromagnetic compatibility (EMC) measurements and evaluation of wireless communication performance. They are enclosed screen room typically equipped with mode stirrer(s). Ideal chambers have intrinsic properties of statistical isotropy and statistical homogeneity that provide several unique features for testing. To obtain statistically uniform electromagnetic fields and hence the desired information, the modes of the chamber are normally perturbed by either mechanical stirring or frequency stirring. Comparing with other types of RF testing facility, the cost of RC construction is relatively low and the test configurations inside RCs is relatively non-critical with regard to position and orientation. Nevertheless the relevant data analysis and interpretation is more complex. Recent advances in reverberation chamber metrology and statistical theory have added other electromagnetic investigations into the mix, particularly antenna efficiency measurements and multi-path propagation in high-mobility EM environments. Still some theoretical and metrological problems are open, as well as practical aspects in the lower frequency use. This session focuses on presenting the recent advances in the theory and the applications of RC technology, RC test facilities, measurement techniques, RC simulation and modeling, and EMC applications.

### **Commissions GEH “Seismo Electromagnetics (Lithosphere-Atmosphere- Ionosphere Coupling)”**

Conveners: Sergey Pulnits, Yasuhide Hobara, Hanna Rothkaehl

The results of electromagnetic and ionospheric monitoring do not leave the place to doubts on the electromagnetic and ionospheric anomalies existence and their connection with seismic activity. Quasistationary electric fields, electromagnetic emissions in wide band of electromagnetic spectrum, anomalies of radio wave propagation, ionospheric anomalies are now the hot spots at all conferences of geophysical thematic. But still we lack the physical substantiation of many of registered effects. Multi- parameter measurements in seismically active regions and cross validation of results obtained by different groups will help to understand the background physics of the observed anomalies. This session will accept papers demonstrating progress in understanding the ionospheric and electromagnetic effects preceding strong earthquakes including experimental findings and theoretical papers on lithosphere-atmosphere-ionosphere coupling.

### **Commissions HGE “Atmospheric, Ionospheric, Magnetospheric and High Energy Effects of Lightning Discharges”**

Conveners: S. Celestin, N. Liu, M. Fullekrug

The recent discovery that lightning discharges can cause energetic radiation, relativistic particles, and transient luminous events has marked a profound advance in our understanding of the Earth's atmospheric electrodynamic behaviour. This session explores these novel processes and their impact on the atmosphere and the near-Earth environment. The session solicits contributions which advance knowledge in the areas of the global atmospheric electric circuit, lightning physics, transient luminous events, energetic radiation, relativistic particles, and their impact on the Earth's atmosphere, ionosphere and magnetosphere. One key focus of the session will be novel observations on board space platforms, such as the lightning imagers on geostationary satellites, the TARANIS

satellite, the ASIM payload on the International Space Station, and related ground based observations and their modelling. Interdisciplinary studies which emphasize the connection between atmospheric layers and the relation between atmospheric electricity and climate change are particularly welcome.

**Commissions JEF GH “Characterization and Mitigation of Radio Frequency Interference”**

Conveners: Frank Gronwald, V. Deniau, Richard Bradley, Terry Bullet, Hanna Rothkaehl, David LeVine, Amit Kumar Mishra, M. Haredim, J. Gavan

In this session, radio frequency interference (RFI) issues will be discussed that are of particular importance for observational sciences such as radio astronomy, microwave remote sensing of the Earth, and solar and ionospheric studies where highly sensitive measurements are necessary.

**Commissions KBE “Uncertainty Management and Stochastic Methods in Experimental and Numerical Electromagnetism, Environmental Exposure Assessment and Dosimetry”**

Conveners: Joe Wiart, Tonging Wu, Ari Sihvola, Gabriele Gradoni

The increasing use of RF wireless communication system is supported by complex and agile technologies and network architectures. It has also induced large variability of usages. The management of such complexity has requested innovative approaches experimental and Numerical Electromagnetism, environmental exposure assessment and dosimetry. This session is devoted to recent progress and application of methods based on advanced statistical methods (e.g., Surrogate modelling, Polynomial Chaos, Kriging, Machine Learning, Sensibility analysis, etc. ) in experimental and Numerical Electromagnetism and dosimetry.

**Commissions KE “EMC in Biomedical Applications”**

Conveners: Frank Gronwald, Lars Ole Fichte

Modern medical technology combines different engineering, scientific, technical, and medical knowledge to a field of activity which is indispensable for the health industry, one of the largest industrial sectors of the world. Due to its strong development, medical technology is counted among the ten high potential technologies of the 21st century. Since medical technology establishes a cross-disciplinary connection between medicine and the engineering sciences, this session welcomes submissions from the medical-instrument sector with EMC-related aspects of system engineering, electronics, sensor systems, computer and material sciences.

## Commission F Program

**Commission F Chair:** Dr. Simonetta Paloscia; S.Paloscia@ifac.cnr.it

### **Commission F Tutorial Dr. Luca Baldini: Modeling Rain Medium for Weather Radar and Propagation**

Convener: Simonetta Paloscia

Abstract: Modeling rain for weather radar and propagation applications is generally accomplished through modeling the drop size distribution (DSD) and its variability and drop shapes. The DSD is defined to be the number of drops per unit volume of air and per unit of drop diameter interval and often is modeled with a three-parameter gamma distribution. Instruments called ‘disdrometers’ can measure the diameter distribution of drops reaching the ground, from which volume DSD are derived. On the other hand, active instruments, such as vertical profilers or weather radar can estimate DSD aloft based on different measurement principles. From measured or theoretical distribution of DSD, using electromagnetic simulation models, radar and propagation variables can be obtained. Obviously, measured distributions can be considered as more representative of the natural variability of rain in a given location than theoretically derived distributions, but are affected by different sources of errors. The impact of DSDs, estimated by different instruments or theoretically derived, on weather radar retrievals or in predicting propagation effects will be analyzed.

### **Commission F “Microwave Remote Sensing of the Cryosphere”**

Conveners: Martti Hallikainen, Jianchen Shi

Global information on the extent and characteristics of snow and ice can best be acquired by remote sensing. This session will focus on new scientific results obtained by using microwave, and joint microwave/optical methods. Topics will comprise physical models and retrieval algorithms, field experiments for validation purposes, and the use of data from advanced spaceborne and airborne sensors. Contributions related to the use of remotely sensed snow and ice products for climate change and regional comparative studies are also welcome.

### **Commission F “Millimeter-Wave Propagation and Remote Sensing”**

Convener: Al Gasiewski

The progress in observation and data inversion techniques, as well as transceiver technology from radio frequencies to the higher microwave frequencies, has generated increased interest in using the millimeter-wave spectrum (i.e., frequencies above 30 GHz) for remote sensing. This session focuses on new developments in millimeter-wave propagation models and experiments, including the effects of reflection, refraction, emission and scintillation, along with their application in passive and active remote sensing. Passive systems for remote sensing include atmospheric sounders, surface imagers and path-dependent transmissometers that can be realized by using real aperture antennas, aperture synthesis or interferometers. Active systems for remote sensing include monostatic, bistatic, and multistatic radars, as well as, all forms of phased-, and digitally beamformed arrays and synthetic aperture systems.

### **Commission F “Remote Sensing from Nano-Satellites”**

Conveners: Steve Reising, Todd Gaier, JPL. At least 300 nano-satellites have been launched into space since 2000. 255 of them in the past three years alone. In the next five years or so some 1,000 nanosats, as small satellites of 1-10kg are called, are expected to be launched. Some will be smaller than a cubesat; others bigger and heavier. Some are like a matryoshka doll: the Russian launch included a satellite that launched eight smaller ones, including four PocketQubes (a 5cm cube

format). One of these smaller satellites, developed in Peru, released its own tiny bird. Small satellites benefit from the constant improvements in price and performance being achieved by the consumer-electronics industry, particularly in smartphones. Although many satellites already circle the globe taking pictures, some of the images may not be updated for days, months or even years. Commercial services can provide relatively rapid satellite images on demand, a number of them taking pictures down to a resolution of 50cm. They could, for instance, be used to track environmental conditions, illegal tree-felling or changes in the course of rivers

#### **Commission F “Remote Sensing Measurements of Precipitation”**

Conveners: V. Chandrasekar, L. Baldini

Remote Sensing of precipitation is an active and vibrant field with numerous accomplishments resulting in practical applications such as world wide deployment of weather radars, in-situ monitoring devices, space borne radars and radiometers for observation of precipitation. Numerous advancements are being made every day evidenced by the research advancement and development of new instruments. This session will feature, papers devoted to remote sensing of precipitation ranging from theoretical models of precipitation, all the way to advanced instruments such as multiple polarization radar networks and space borne radiometer and radar observations of precipitation as well as retrieval algorithms. Papers are also solicited sharing observations from field experiments monitoring precipitation.

#### **Commission F “Outdoor Propagation and Channel Modeling in Built-Up Areas, with Special Interest in the Effects of Vegetation”**

Conveners: Robert Bultitude, Saúl A. Torrico

Session topics: Radiowave propagation and channel modelling for radio communications through vegetation, in vegetated residential environments, in urban environments with and without isolated trees, in other vegetated and built-up areas, scattering from trees, reflections and scattering from buildings, and the dynamic channel effects of moving terminals and vegetation moving in wind. Session The objective of the session is to provide a forum for the discussion and dissemination of results from the latest research on radiowave propagation and radio channel modelling for wireless applications in vegetated and build-up areas. A deeper understanding of these topics is considered a requirement, since present and future generation of wireless applications will depend heavily on the interaction of buildings/houses and vegetation. This session will present that opportunity to gather researchers in one session and exchange ideas on related current problems.

#### **Commission F “Microwave Remote Sensing of Vegetation”**

Conveners: Simonetta Paloscia, Mehmet Kurum

Vegetation biomass estimates are important at both global and local scales for climate change studies and carbon cycle monitoring. Passive and active microwave sensors can contribute significantly to these goals due to their high sensitivity to water content in the observed bodies and their independence on sunlight. Although microwave radiometers from space are hampered by the coarse spatial resolution, the large swath allows daily observations of the same area, whereas SAR systems provide very precise local measurements, but with somewhat limited revisit time. Multiple observation frequencies are an advantage for investigating different layers of vegetation: from the surface (Ku and X bands) to the ground beneath crops (C and L bands), by thus taking also into account the contribution from soil. In this way, different goals can be achieved including land cover classification and the generation of vegetation biomass and soil moisture maps. Daily progress is being made evidenced by the research advancement in modeling complicated media and development of new instruments.

### **Commission F “Microwave Remote Sensing of Vegetation and Terrestrial Snow”**

Conveners: Simonetta Paloscia, Jianchen Shi, Paolo Pampaloni

Vegetation biomass and snow cover are two important parameters of the water cycle and are involved in many vital processes related climate change studies and natural disaster monitoring. Passive and active microwave sensors provide a significant contribution to the monitoring of these two factors, although with different spatial resolutions and revisit times. Multiple observation frequencies are an advantage for investigating various characteristics of the Earth’s surface with different sensitivity: higher frequencies (i.e. Ka, Ku, and X bands) are mainly sensitive to snow cover and depth and to agricultural crop biomass, whereas lower frequencies (i.e. C and L bands) to forest biomass and soil moisture under the vegetation.

### **Commission F “Radio-Frequency Interference (RFI) in Passive Microwave Remote Sensing”**

Conveners: Paolo de Matthaéis, Yann Kerr

Passive microwave remote sensing is under increasing threat from unwanted man-made emissions, referred to as Radio Frequency Interference or RFI. Focusing on Earth surface applications, this session will include presentations on the current status of RFI contamination worldwide, RFI impact on science results, detection techniques, current issues in spectrum management and protection of passive remote sensing bands, and future steps to be taken to improve the situation.

### **Commission F “Remote Sensing of Sea Surface Salinity”**

Conveners: Roger Lang, David Le Vine

Salinity is important for understanding ocean circulation, climate and the global water cycle. Three recent L-band instruments, SMOS, Aquarius and SMAP, have demonstrated the potential for measuring surface salinity from space. But there is much to be learned such as how best to correct for surface roughness, radiation from the Sun and the effects of rain. This session will focus on issues of calibration and the retrieval algorithm including status of salinity retrievals from the three instruments.

### **Commission F “Microwave Sensing of Soil Moisture”**

Conveners: Yann Kerr, Simon Yueh

Recent advances in Passive microwave remote sensing over land at low frequencies: from modelling to applications and from forests to bare soils, with a focus on the main results obtained from the SMOS Aquarius and SMAP missions.

### **Commission F “Propagation Modeling for Aerospace Applications”**

Conveners: Carlo Capsoni, Animesh Maitra

High throughput satellite communication systems (HTS) providing multimedia service as well as space science missions can greatly benefit from the use of very high frequency carriers (in the millimetre or even infrared bands), in order to take advantage of the larger bandwidths made available. Aeronautical applications aimed at providing to future travellers continuous global access to high-speed Internet also share the interest in these bands. The drawback of using very short wavelengths is the definite impact of the impairments caused by the troposphere which requires the use of very sophisticated Fade Mitigation Techniques.

### **Commission F “Remote Sensing in Complex and Random Media”**

Conveners: Saba Mudaliar, Akira Ishimaru

Remote sensing of land, atmosphere, ionosphere, and oceans need adequate understanding of the propagation and scattering characteristics of complex and random media. Applications abound in geophysical and biological sciences as well. This session addresses theoretical, experimental, and simulation studies on wave phenomenology in complex and random media employed in these

applications. Both forward and inverse problems are within the scope of this session. Modelling aspects, validation, and imaging techniques are subtopics of special interest. We welcome both fundamental theoretical papers and papers for practical applications.

### **Commission F “Open Session”**

Conveners: Simonetta Paloscia, V. Chandrasekar

This session will accept any papers falling within the terms of reference of Commission F and not covered elsewhere

### **Commissions FB “EM Modeling and Applications of Underground Imaging”**

Conveners: Lorenzo Capineri, Motoyuki Sato

Underground imaging based on ground penetrating radar is a widespread method for the investigation of soil characteristics and for the detection and characterization of buried objects. The scanning method based on a single or multiple (array) antennae has an important role in the final quality of the images as the coupling of antenna element with the soil can be variable from point to point due to the different geometrical characteristics of the surface. The EM modeling of the antenna coupling and solutions for the mitigation of detrimental effect on the image reconstruction are topics of interest for the session.

### **Commissions FB “Electromagnetic Problems Involving Volume Scattering”**

Conveners: V. Chandrasekar, Ari Sihvola

Volume scattering processes form the basis for understanding and interpreting electromagnetic measurements appropriate to integrated effects from numerous scatterers, such as rainfall, snowfall and the volume of snow on the ground. This session will enable a forum for exchange of ideas related to fundamental research problems in volume scattering including, dielectric constant in mixtures, interpretation of multiple-polarization volume scattering signatures of ice/snow, hail/rain, soil/water mixtures, inversion problems in volume scattering.

### **Commissions FC “Multi-Parameter Radars and Wave Propagation for Remote Sensing and Disaster Management”**

Conveners: Tullio Tanzi, Madhu Chandra, Eric Mokole

Radio Science, including wave propagation, plays a central role in shaping the evolution of radar remote sensing in the context of disaster management. In the field of multi-parameter radars methods we are witnessing advances in polarimetry, application of smart and reconfigurable digital beam forming antennas, ever increasing bandwidths, and the application of waveform diversity. In terms of systems, we are seeing the rapid development of compact radar systems that can be mounted on autonomous drones and UAVs. In particular, drone mounted ground-penetrating radar systems capable of detecting victims buried in debris are sought. The requirements of humanitarian surveillance and disaster management applications are posing new challenges on the detection of objects and features mingled within diverse clutter signals e.g. forests, debris and buildings. This session welcomes contributions in this interdisciplinary and trans-disciplinary session on multi-parameter radar and disaster management.

### **Commissions FK “Radio Wave Propagation Aspects in Body Area Networks”**

Conveners: Slawomir Ambroziak, Luis M. Correia

Wireless Body Area Networks (WBANs) are playing an increasingly important role in the next generation of wireless systems, as they will allow for the integration of the various handheld and wearable devices with the surrounding environment and infrastructure. Thus, an important challenge is to increase the connection reliability of the in-, on- and off-body links. In order to boost the overall system performance, a good and deep understanding of the radio channel in WBANs is

required. This has to be made possible by studying propagation channels via measurements, simulations and developing models considering various scenarios (e.g., antenna type and placement, body type, movements, and environments). This session will give the possibility to exchange views on various methodologies of channel modelling, including simulation and measurements, and to discuss approaches to integrate results in order to build flexible channel models for WBANs.

### **Commissions EFGH “Natural Electromagnetic Noise and Radio Sensing Applications in Terrestrial and Planetary Environments”**

Conveners: Y. Hobara, C. Price, T. Ushio, M. Fullerkrug

This joint session aims at presenting recent works on electromagnetic noise and phenomena in the terrestrial atmosphere and upper atmosphere (ionosphere/magnetosphere). Different kinds of electromagnetic noises will be dealt with, including atmospheric noises originated in lightning discharges (ELF Schumann resonances, mesospheric optical emissions etc.), man-made noise and noise due to wave-particle and wave-wave interactions. Corresponding electromagnetic noise environments on other planets are welcome. We are particularly interested in applications of natural EM observations in remote sensing such as monitoring, detecting and forecasting natural hazards, such as thunderstorms, severe weather, space weather and seismic events.

### **Commissions EFGHJ “One-Day Workshop on RFI Mitigation and Characterization”**

Conveners: F. Gronwald, R. Bradley, T. Bullet, H. Rothkaehl, D. Le Vine, A. Maitra, M. Haredim, J. Gavan, V. Deniau, P. de Matthaëis

It is the aim of this workshop to bring together researchers, engineers and users from all radio science disciplines to consider how RFI affects their respective fields, to develop mitigation strategies, and to foster cooperation and collaboration. Particular attention will be given to the impact of new and future sources of RFI, spectrum management challenges, and new technology developments. Recent progress towards the ultimate goal of being able to do observations with real-time mitigation of the undesired signals, while leaving the desired signals minimally affected, will be discussed.

### **Commissions GF “Radio Studies on Polar Aeronomy”**

Conveners: Giorgiana De Franceschi, V. Chandrasekar, Luca Baldini

At high and low latitudes, the ionosphere can be particularly perturbed and this can be exacerbated around solar activity maxima (but not only). Ionosphere can in turn significantly affect L band (and lower frequency) remote sensing radar systems for Earth science dedicated to observations of surface deformation, cryosphere dynamics, etc. To pose a solid bridge between the ionosphere and remote sensing communities, this session solicits contributions to facilitate exchange of information on their respective states of the art as well as on their future needs. Contributions are welcome on ionosphere and lower troposphere research at high latitudes from GNSS and satellites in situ data dealing with ionospheric irregularities, scintillation, total electron content (TEC) gradients, as well as water vapor measurements. Papers dealing with the assessment and mitigation of "atmosphere" impacts on different applications such as positioning, space weather and remote sensing are highly encouraged. Papers focusing on data processing to support models development are also welcome, as are those based on a multi- instrument approach. Finally, contributions highlighting differences and similarities at high and low latitudes are also appreciated.

**Commissions JEF GH “Characterization and Mitigation of Radio Frequency Interference”**

Conveners: Frank Gronwald, V. Deniau, Richard Bradley, Terry Bullet, Hanna Rothkaehl, David LeVine, Amit Kumar Mishra, M. Haredim, J. Gavan

In this session, radio frequency interference (RFI) issues will be discussed that are of particular importance for observational sciences such as radio astronomy, microwave remote sensing of the Earth, and solar and ionospheric studies where highly sensitive measurements are necessary.

**Commissions KBF “Electromagnetic Inversion for Biomedical, Geophysical, Non-destructive Testing, and Antenna Characterization Applications”**

Conveners: Aria Abubakar, Puyan Mojabi,

Electromagnetic inversion is the process by which some properties of an investigation domain are inferred from external electromagnetic observations. Several application areas, which span a wide range of frequencies from a few hertz to optical frequencies, utilize electromagnetic inversion algorithms and techniques to reconstruct the properties of interest, such as complex permittivity profiles of biological tissues, conductivity profiles in geophysical surveys, or equivalent current distributions of antennas. This special session is focused on bringing together recent advances in quantitative electromagnetic inverse scattering and inverse source algorithms/techniques in these application areas to enhance the achievable reconstruction accuracy, resolution, or efficiency of the computational process. The enhancement can be obtained by methods such as properly incorporating prior information into the inversion algorithm, appropriate numerical modelling and calibration, and new advances in inversion algorithms.

## Commission G Program

**Commission G Chair:** Prof. Iwona Stanislawska; stanis@cbk.waw.pl

### **Commission G Tutorial Tim Fuller-Rowell: “Will We Ever be Able to Model and Forecast the Ionosphere Well Enough to Support the Needs of the Radio Wave Users?”**

Convener: Iwona Stanislawska

### **Commission G “Data Assimilation Modeling”**

Conveners: Ivan Galkin, Bruno Nava, Robert Schunk

Space weather disturbances can adversely affect numerous systems and operations, and many of the applications pertain to the ionosphere and upper atmosphere. Space weather can affect over-the-horizon (OTH) radars, HF communications, surveying and navigation systems including Satellite Based Augmentation Systems (SBAS), surveillance, spacecraft charging, power grids, pipelines. As with meteorology and oceanology, data assimilation has become an important tool for specifying and forecasting space weather disturbances, particularly with regard to the Ionosphere-Thermosphere-Electrodynamics (I-T-E) system. The increased use of data assimilation techniques is a result of both the availability of numerous empirical and physics-based models that can be used to describe the background state and the significant increase in the data available for assimilation. Currently, there are several thousand ground-based GNSS receivers that provide slant TECs, numerous satellites that provide radio occultation measurements, hundreds of ionosondes/digisondes that yield bottom-side electron density profiles, and satellites that provide both ultraviolet (UV) emission data and in situ electron density measurements. The session will focus on research related to data assimilation techniques, background models, data sources, and validation.

### **Commission G “International Reference Ionosphere – Improvement, Validation and Usage”**

Conveners: Dieter Bilitza, David Themens

The URSI/COSPAR International Reference Ionosphere (IRI) is an empirical model built on a large volume of space- and ground-based data, with modelling and improvement inputs from a working group of now over 60 international experts, including members of the ground and space observations communities. This session invites talks and posters that report on improvements, validation, and usage of the IRI model. Contributions are encouraged that present new modelling approaches for the parameters currently represented by the IRI and suggestions for additional parameters that should be provided by the model. Of particular interest are applications of the IRI model in scientific studies or operational environments. The IRI model represents spatial and temporal variations of electron density, ion composition, electron temperature, and ion temperature in the altitude range of 50km to 2000km. Additional parameters include total electron content, the probability of the occurrence of spread-F and of an F1 layer, and a representation for the auroral boundaries. Contributions regarding the modelling of any of these parameters are welcome. Of special interest are studies that present extensions of the IRI model parameters to plasmaspheric heights.

### **Commission G “Science with Modern Ionosondes and Associated Instrumentation and Models”**

Conveners: Ivan Galkin, Anna Belehaki, John Bosco Habarulema

Eighty five years after the inaugural F-region sounding at Slough observatory, ionosondes are back in the focus of attention. Modern HF ionosphere sounder has evolved into one of the very few providers of the reliable real-time sensor data for several important research and application domains. Space weather nowcast, sensing dynamics of the plasma irregularities, geolocation of HF emitters, ranging over the radio horizon are only a few scenarios in which the ionosondes are

uniquely instrumental to the task. The session will review the state-of-art ionosonde-related science and engineering advances, including digital HF technologies, intelligent systems for data interpretation, detection and evaluation of the traveling ionospheric disturbances, information science for timely network data acquisition and dissemination, assimilative modelling of 3D plasma distribution in the ionosphere, sensing the vertical and horizontal plasma transport, concepts and designs for topside ionospheric sounding, and other relevant topics. We welcome contributions on cooperative ionosonde observations with other instrumentation for monitoring the ionospheric plasma.

### **Commission G “Advances in Irregularities and Scintillation Studies”**

Conveners: Emanuel Costa, Archana Bhattacharyya

This session emphasizes the latest developments in the study of ionospheric irregularities and scintillation. Papers that focus on the problems of scintillation on satellite-based communication and navigation systems at low and high latitudes, together with the description of models aimed at combating its effects, are particularly welcome. This session's scope also includes new developments in the theory of scintillation, in statistical studies of scintillations, and multi-technique observations of irregularities including in situ observations, relevant to possible prediction of scintillations.

### **Commission G “Incoherent Scatter Radar”**

Conveners: Ingrid Mann, Emma Spanswick, Mike Kosch

This session will focus on advances in the field of incoherent scatter radar (ISR) measurement of the geospace environment, the study of the ionosphere and its coupling to the lower atmosphere and magnetosphere. It provides a platform to present results from previous multi-radar experiments and to discuss future plans for coordinated observations with existing and future facilities. This includes long-period co-ordinations similar to the International Polar Year, and the future of the World Day programme, as well as the discussions how to further harmonize the data formats. Contributions are also welcome on planning observations with and making best use of future advanced ISR facilities.

### **Commission G “Design and Application of HF and OTH Radar Systems”**

Conveners: Manuel Cervera, Mike Rhouonemi, Todd Parris

This session is focused on sky-wave High Frequency radar, including operational over-the-horizon radars and the SuperDARN ionospheric research radars and their support instruments. Research topics include: - Antenna design,

- HF waveforms (radar and sounders),
- HF digital receivers and signal processing techniques
- HF radio wave propagation in the ionosphere
- Space weather monitoring with HF radar observations
- HF sounding of the ionosphere at all latitudes
- Ionospheric disturbances and their impacts on HF and OTH systems
- Application of satellites to HF propagation studies
- Coordinate registration and multi-mode management
- Ionospheric Absorption (measurements and modeling)
- Directional HF noise and interference (measurements and modeling)
- HF mapping of the terrestrial surface

### **Commission G “Ionospheric Space Weather”**

Conveners: Sandro Radicella, Anthea Coster

This session will focus on the ionospheric and space weather events that may impact telecommunications and navigation systems. It will also cover all areas of ionospheric space weather research including modeling and novel observations, using in particular radio waves techniques. Of

special interest are papers describing assessment and validation of space weather models, and the justification of the need for new ground and space-borne measurements. Studies and investigations addressed to modeling, forecasting and/or mitigations of ionospheric phenomena due to space weather events, such as ionospheric medium- and small-scale irregularities as revealed by different radio and optical techniques, are also welcome.

### **Commission G “GNSS Applications in Radio Science”**

Conveners: Matthew Angling, Seebany Datta-Barua

Global Navigation Satellite Systems (GNSS) such as the Global Positioning System (GPS), Galileo, and Beidou rely on L band trans-ionospheric radio signals for positioning, navigation, and timing (PNT). Such signals are susceptible to ionospheric propagation effects (i.e. phase advance, group delay) that can alter the received signal properties at the receiver. Thus, the ionosphere can affect PNT services. Conversely, the variations in signal properties can be used to probe the ionosphere. This session welcomes papers on: ionospheric science in order to improve future GNSS services; on ionospheric effects on current GNSS services; and on the use of GNSS signals of opportunity for ionospheric remote sensing. Of particular interest are papers on the new GNSS signals that are now available (i.e. Galileo E5a/E5b and GPS L5).

### **Commission G “Improvement of GNSS Radio Occultation Techniques”**

Norbert Jakowski, Keith Groves

In the last two decades it has been shown that GNSS radio occultation measurements on board Low Earth Orbiting (LEO) satellites provide a powerful tool for monitoring key parameters characterizing the vertical structure of the ionosphere and neutral gas such as the electron density, temperature and/or water vapor, respectively. The effective sounding of the ionosphere and neutral atmosphere was convincingly demonstrated the first time by the GPS-Met experiment onboard Microlab-1, and afterwards by subsequent LEO missions such as CHAMP, GRACE, SAC-C, Formosat/COSMIC and C/NOFS. In the meantime, challenges have arisen concerning the accuracy and reliability of the radio occultation technique for deriving ionospheric and neutral gas parameters. Upcoming missions like COSMIC II and others represent enhanced opportunities to further exploit RO capabilities for monitoring and forecasting ionospheric and tropospheric weather. Thus, to fully utilize these new capabilities the retrieval techniques should be improved in a corresponding manner. Accordingly, we encourage presentations addressing irregularities and gradients of the refractive index, higher order effects of refraction and ray path bending, and assimilation techniques utilizing the basic RO observables. Furthermore, improvements to the specification of upper boundary conditions for ionospheric inversions and the extension of the altitude for neutral gas retrievals are also of interest. Generally speaking, we encourage presentations describing innovative methodologies that address current challenges in RO techniques and synergies of ionospheric and neutral atmosphere retrievals.

### **Commission G “Radio Studies of Mid and Low Latitude Aeronomy”**

Conveners: Cesar Valladares, Babatunde Rabi

The low-latitude ionosphere has long been considered a region that is continuously forced by thermosphere tides and waves that are able to vary the regional and global distribution of the plasma density and seed plasma instabilities. Recently, the mid-latitude ionosphere has also been identified as a region that has an unsettled character due to the development of plasma instabilities (MSTIDs) and the high control that prompt penetration electric fields and the disturbed dynamo exert on the neutral wind and current system. We solicit presentations dealing with recent advances on the stability, dynamics and the MIT coupling of the low and/or mid latitude ionospheres using active or passive radio diagnostics during quiet and disturbed magnetic conditions. We also seek presentations that emphasize the importance of multiple-sensor measurements, regional coverage, and continuous (24/7) operations. Presentations addressing conjugate observations using networks

of instruments, coordinated distributed observatories, or others that combine ground- and satellite-instrumentation are also welcome in this session. This session will also discuss future plans in observing mid- and low-latitude aeronomy with various radio instrumentation and planned coordinated radio observations.

### **Commission G “International Beacon Satellite Studies”**

Conveners: Patricia Doherty, Andrzej Krankowski, Bruno Nava

This session welcomes papers relevant to the interests of the Beacon Satellite Studies Group of Commission G. The session will begin with a historical view of this studies group and its goals for the future. It will also recap the success of the most recent Beacon Satellite Symposium that was held in 2016. Additional papers are invited that will include all aspects of satellite signals observed on the ground and by receivers on-board satellites. This may include distributed arrays of multi-instruments used for ionospheric monitoring and scientific investigations that span all regions of the globe together will more focused regional investigations. Papers from the developing world are also encouraged.

### **Commission G “Open Session and Recent Results”**

Conveners: Iwona Stanislawska, John Mathews, Patricia Doherty

This session welcomes all papers related to the Commission G terms of reference, particularly those not covered by the other G and G/H sessions. The session also welcomes the latest and perhaps more controversial results. Topics may include papers on the radio science of scattering, on the global morphology, theory, modeling and modification of the ionosphere, on the development of tools and networks to measure ionospheric parameters and trends, on the theory and practice of ionospheric radio propagation, and on the application of ionospheric knowledge to radio systems.

### **Commissions GEH “Seismo Electromagnetics (Lithosphere-Atmosphere- Ionosphere Coupling)”**

Conveners: Sergey Pulinet, Yasuhide Hobara, Hanna Rothkaehl

The results of electromagnetic and ionospheric monitoring do not leave the place to doubts on the electromagnetic and ionospheric anomalies existence and their connection with seismic activity. Quasistationary electric fields, electromagnetic emissions in wide band of electromagnetic spectrum, anomalies of radio wave propagation, ionospheric anomalies are now the hot spots at all conferences of geophysical thematic. But still we lack the physical substantiation of many of registered effects. Multi- parameter measurements in seismically active regions and cross validation of results obtained by different groups will help to understand the background physics of the observed anomalies. This session will accept papers demonstrating progress in understanding the ionospheric and electromagnetic effects preceding strong earthquakes including experimental findings and theoretical papers on lithosphere-atmosphere-ionosphere coupling.

### **Commissions GF “Radio Studies on Polar Aeronomy”**

Conveners: Giorgiana De Franceschi, V. Chandrasekar, Luca Baldini

At high and low latitudes, the ionosphere can be particularly perturbed and this can be exacerbated around solar activity maxima (but not only). Ionosphere can in turn significantly affect L band (and lower frequency) remote sensing radar systems for Earth science dedicated to observations of surface deformation, cryosphere dynamics, etc. To pose a solid bridge between the ionosphere and remote sensing communities, this session solicits contributions to facilitate exchange of information on their respective states of the art as well as on their future needs. Contributions are welcome on ionosphere and lower troposphere research at high latitudes from GNSS and satellites in situ data dealing with ionospheric irregularities, scintillation, total electron content (TEC) gradients, as well as water vapor measurements. Papers dealing with the assessment and mitigation of "atmosphere"

impacts on different applications such as positioning, space weather and remote sensing are highly encouraged. Papers focusing on data processing to support models development are also welcome, as are those based on a multi- instrument approach. Finally, contributions highlighting differences and similarities at high and low latitudes are also appreciated.

### **Commissions GH “Meteors, Collisional EMPs, and Other Highly-Transient Space Plasma Events”**

Conveners: John Mathews, Asta Pellinen-Wannberg

This session includes meteoroid impact EMP generation on satellite and planetary surfaces as well as the role of micrometeoroid processes (e.g., sputtering, fragmentation, ablation) and the mass flux on the upper atmosphere and ionosphere, as well as other related highly-transient phenomena. The radio and radar signatures of these processes are also considered.

### **Commissions GH “Plasma Instabilities in the Ionosphere”**

Conveners: Frank Lind, Ron Pfaff

Plasma instabilities in the high, middle, and low latitude ionosphere play a key role in the development and evolution of structures in the Geospace environment, including processes in both the E and F regions. They often are associated with irregularities which can be experimentally observed using radar and radio techniques, as well as in-situ observations. Linear and non-linear theory is often used to predict instability thresholds, amplitudes, and velocities. Simulations have recently been quite successful in the detailed study of irregularity micro-structure, time evolution, and k-space behavior. This session will encourage discussion of new developments in the theoretical, simulation, and experimental observations relevant to the study and understanding of ionospheric plasma instabilities. The effects of ionospheric instabilities on other Geospace phenomena will also be of interest. This includes coupling to the magnetosphere and impacts of the lower atmosphere

### **Commissions GHJ “Workshop on Extreme Space Weather Environments”**

Workshop Chair: Mike Hapgood, Workshop Co-Chair: Terry Onsager, Conveners: Tony Mannucci, Viviane Pierrard, Mauro Messerotti, Ludwig Klein

Over recent years extreme space weather has been recognized as a global risk with significant societal and economic risks affecting many domains, including but not limited to electrical power grids, satellites, aircraft passengers and crew, avionics, GPS, Galileo and other GNSS positioning, navigation and timing systems and communications systems. In order to evaluate the consequences of space weather on these systems it is essential (a) to identify what are the factors in space weather environments that interact with the systems at risk, and then (b) to estimate what are reasonable worst cases for these factors. This workshop will bring together experts and other interested parties to review and refine a process for developing an internationally agreed set of specifications for the extreme space weather environment, and to test the process by applying it to a number of key domains. It is hoped that this will be the first of a series of workshops, hosted by different organizations and fora, developing these specifications.

The workshop will be led by Professor Mike Hapgood of the Rutherford Appleton Laboratory and will be hosted by URSI Commissions G, H and J. The focus will be on environments appropriate to the work of these Commissions, namely neutron, proton and electron fluxes, solar radio fluxes, ionospheric electron density enhancements, TEC and related electron gradients and radio scintillation. Talks and related presentations will be by invitation only, however, there will be plenty of opportunities for discussion and possibly for showing targeted data and information. Poster papers will be accepted.

The workshop will require additional registration on the URSI web site (but there is no additional cost). Additional preparatory materials will be sent out prior to the meeting.

### **Commissions EFGH “Natural Electromagnetic Noise and Radio Sensing Applications in Terrestrial and Planetary Environments”**

Conveners: Y. Hobara, C. Price, T. Ushio, M. Fullerkrug

This joint session aims at presenting recent works on electromagnetic noise and phenomena in the terrestrial atmosphere and upper atmosphere (ionosphere/magnetosphere). Different kinds of electromagnetic noises will be dealt with, including atmospheric noises originated in lightning discharges (ELF Schumann resonances, mesospheric optical emissions etc.), man-made noise and noise due to wave-particle and wave-wave interactions. Corresponding electromagnetic noise environments on other planets are welcome. We are particularly interested in applications of natural EM observations in remote sensing such as monitoring, detecting and forecasting natural hazards, such as thunderstorms, severe weather, space weather and seismic events.

### **Commissions EFGHJ “One-Day Workshop on RFI Mitigation and Characterization”**

Conveners: F. Gronwald, R. Bradley, T. Bullet, H. Rothkaehl, D. Le Vine, A. Maitra, M. Haredim, J. Gavan, V. Deniau, P. de Mattheais

It is the aim of this workshop to bring together researchers, engineers and users from all radio science disciplines to consider how RFI affects their respective fields, to develop mitigation strategies, and to foster cooperation and collaboration. Particular attention will be given to the impact of new and future sources of RFI, spectrum management challenges, and new technology developments. Recent progress towards the ultimate goal of being able to do observations with real-time mitigation of the undesired signals, while leaving the desired signals minimally affected, will be discussed.

### **Commissions HG “Active Experiments”**

Conveners: V. Sonwalkar, R. Moore, N. Jackson-Booth, T. Pedersen

This session will cover recent advances in active space experiments, including ionospheric perturbations, disturbances or other effects on the space environment actively produced by high-power RF waves, chemical releases, rocket exhaust, ion engine propulsion systems or other means. In addition to presentations of observations and measurements from recent or novel experiments, theoretical and modeling developments that advance theory beyond the prevailing qualitative and descriptive state toward quantitative and predictive capabilities will also be welcomed. Topics of interest include wave generation stimulated by or propagation modified by artificial effects. Presentations on technologies, such as RF sources or chemical reactions, which may enable new or improved applications in active space experimentation, are also sought. This session will also cover the latest technical and scientific results on and concepts of space-borne radio sounding in terrestrial and extra-terrestrial ionospheres and magnetospheres including previous, current, and planned spaceborne sounders. The basic physics of plasma-wave propagation and of active or passive antennas, in magnetoplasmas in laboratory or space, are important related topics. Investigations of geospace plasma density structures using injected whistler-mode and Z-mode waves are also solicited, as are reviews of earlier radio-sounding accomplishments highlighting outstanding questions yet to be addressed by radio sounders. There is a close connection between active experiments and space-borne sounding: near-field interactions with antennas in a plasma are very similar to high-power radio wave heating and stimulate a variety of resonances which need to be understood to optimize system function and which can also be used for diagnostic purposes. Contributions on such overlapping research areas are especially welcome.

### **Commissions HGE “Atmospheric, Ionospheric, Magnetospheric and High Energy Effects of Lightning Discharges”**

Conveners: S. Celestin, N. Liu, M. Fullekrug

The recent discovery that lightning discharges can cause energetic radiation, relativistic particles, and transient luminous events has marked a profound advance in our understanding of the Earth's atmospheric electrodynamic behaviour. This session explores these novel processes and their impact on the atmosphere and the near-Earth environment. The session solicits contributions which advance knowledge in the areas of the global atmospheric electric circuit, lightning physics, transient luminous events, energetic radiation, relativistic particles, and their impact on the Earth's atmosphere, ionosphere and magnetosphere. One key focus of the session will be novel observations on board space platforms, such as the lightning imagers on geostationary satellites, the TARANIS satellite, the ASIM payload on the International Space Station, and related ground based observations and their modelling. Interdisciplinary studies which emphasize the connection between atmospheric layers and the relation between atmospheric electricity and climate change are particularly welcome.

### **Commissions JEF GH “Characterization and Mitigation of Radio Frequency Interference”**

Conveners: Frank Gronwald, V. Deniau, Richard Bradley, Terry Bullet, Hanna Rothkaehl, David LeVine, Amit Kumar Mishra, M. Haredim, J. Gavan

In this session, radio frequency interference (RFI) issues will be discussed that are of particular importance for observational sciences such as radio astronomy, microwave remote sensing of the Earth, and solar and ionospheric studies where highly sensitive measurements are necessary.

### **Commissions JG “Ionospheric Models and their Validation”**

Conveners: Stefan Wijnholds, Sean Elvidge

The ionosphere has a profound effect on the propagation of radio waves, making measurements of distortions of RF signals an effective tool for ionospheric research. These same distortions hamper ground-based radio astronomical observations of cosmic source structure and position, in particular at frequencies below 1 GHz. Radio astronomers are, therefore, using different ionospheric models to reduce the number of parameters required for calibration of instrumental and environmental effects affecting their observations. In turn this calibration process provides information on the ionospheric conditions above the array, such as turbulence scales, TID wavelengths and TID velocity. This session aims to bring low-frequency radio astronomers and ionospheric researchers together to stimulate cross-fertilization between these two fields with emphases on the modelling of RF propagation through the ionosphere, the ionospheric models themselves and validation of those models.

## Commission H Program

**Commission H Chair:** Prof. Ondrej Santolik; [ondrej.santolik@mff.cuni.cz](mailto:ondrej.santolik@mff.cuni.cz)

### **Commission H Tutorial Craig Rodger: “Drivers, Detection, and Wider Significance of Precipitation from the Radiation Belts”**

Convener: O. Santolik

Wave particle interactions are a fundamental physical mechanism driving change in the Van Allen radiation belts. Growing evidence indicates that cyclotron resonance between VLF whistler-mode waves and energetic electrons play crucial roles for the acceleration of electrons to relativistic energies. It has long been recognised that the same resonances also pitch-angle scatter electrons, moving them towards the loss cone and causing loss of these electrons into the atmosphere through precipitation. Particle precipitation into the atmosphere is believed to be one significant mechanism for the loss of energetic electrons from the radiation belts. Wave-particle interactions involving ULF through to VLF waves are understood to be the most important drivers of these loss events. The majority of these waves are naturally generated, but manmade waves from large communications transmitters can also play a role, particularly in the inner radiation belt. There is growing interest in energetic electron precipitation (EEP). This is partially because of the need to include both acceleration and loss processes in radiation belt predictive models. There is also a new focus on the impact of the energetic electron precipitation on the polar atmosphere, with increasing evidence of significant changes in upper-atmospheric chemistry, and coupling to polar-surface climate. In this talk I will provide an overview of the fundamental processes driving precipitation, discuss the properties of observed EEP, and discuss its wider significance to the Earth's system. I will also attempt to include some open questions in this area.

### **Commission H “Macro/Micro-Scale Kinetic Processes at Natural Boundary Layers in Terrestrial and Planetary Environments”**

Conveners: B. Lembège, I. Shinohara and G. Lakhina

Intricate microscopic/macrosopic processes take place over micro/meso/macro-scales. at natural boundary layers. These layers play a important role in the energy and momentum transfer between the solar wind and the planetary magnetosphere and/or between different regions within the magnetosphere itself. These processes are based on various wave-particle interactions, nonlinear effects and nonstationary mechanisms, which control the overall dynamics of these frontiers. The present session welcomes the discussion of recent results issued from theory, mono/multi-dimensional numerical simulations and experimental data obtained from various space missions. The comparison between these approaches is possible thanks to refined measurements obtained on board of recent multi-spacecraft missions (e.g., Cluster, Themis) and to improved simulations. Comparison with data issued from other missions (Geotail, Wind, Double Star etc) are also encouraged. Applications include magnetospheric, ionospheric and space plasma physics. Examples of boundary layers include: (i) collisionless shocks, (ii) the magnetopause, (iii) plasma sheet currents, (iv) nearby/far magnetotail dynamics (including substorms), (v) plasmopause, (vi) potential drops in the ionosphere and cusp dynamics, (vii) basic particle acceleration processes, and (viii) dynamics of interfaces in active space experiments. Any contributions related to these topics are very welcome. Comparative analysis of results dedicated to terrestrial and planetary environments are also strongly encouraged, in order to approach a more synthetic view of their understanding.

### **Commission H “Remote Sensing and Modeling of the Earth’s Plasmasphere and Plasmopause”**

Conveners: A. M. Jorgensen, V. Pierrard, B. Heilig

The plasmasphere is a dynamic system consisting of cold dense plasma controlled by solar activity and coupled by electromagnetic fields, currents and particle fluxes to the ionosphere and atmosphere. The plasmasphere also plays an important role in Earth's space weather. Plasma density and plasma density gradients are key parameters in wave-particle interactions in the radiation belts. Information about the plasma density distribution is now always known with sufficient spatial and temporal resolution so determine the wave power, which is a major contributor to radiation belt particle acceleration and loss. Recent advances in modeling the plasmasphere, including physics based, empirical and data assimilative approaches, improve our understanding on the dynamics of this region. These modeling efforts are based on ground based as well as in-situ measurements. Opportunities for ground-based remote sensing have grown rapidly with the deployment of many instrument arrays, while in situ observations are facilitated through multi-satellite missions. This session invites presentations on modeling and observations of the plasmasphere. Especially welcome are ground-based and space-based remote-sensing and in-situ observations, as well as new modeling and data assimilation approaches which show promise for improving understanding of plasmasphere dynamics.

### **Commission H “Wave-Particle Interactions and Their Effects on Planetary Radiation Belts”**

Conveners: R. Horne, C. Kletzing, D. Shklyar

In recent years much attention has turned to the physics of the radiation belts of the Earth and other planets. New space-borne assets as well as advances in theory and simulation have led to progress in our understanding of the wave-particle physics of acceleration, loss, and transport of energetic particles in the inner magnetospheres of the planets. This session focuses on the broad range of topics of planetary radiation belts including plasmaspheres and plasmopause properties, ring current evolution, wave properties, and energetic electron and ion populations. Presentations on theory, simulation, and data studies are encouraged.

### **Commission H “Drivers, Detection, and Ionospheric Impacts of Precipitation from the Radiation Belts”**

Conveners: C. Rodger, M. A. Clilverd

Particle precipitation into the atmosphere is believed to be one of the dominant mechanisms for the loss of energetic electrons from the Van Allen radiation belts, as well as losses of ring current ions. Wave-particle interactions with ULF through to VLF waves are thought to be important drivers of these loss-processes. This session is targeted at both ground-based and satellite experimental observations, as well as theoretical investigations, into the precipitation of energetic (>10 keV) to relativistic energy electrons or precipitation of ring current ions. Papers considering wave-particle interactions driving losses, measurement of loss fluxes, or the effects of this precipitation on the ionosphere are welcome. We welcome studies from existing ground, balloon or space based experiments. Note that studies directed towards radiation belt electron acceleration or transport are likely better suited to the complementary session H3.

### **Commission H “Laboratory Simulations”**

Conveners: A. Fredriksen, T. A. Carter

The plasma environments surrounding the Earth and other solar system bodies display a rich variety of plasma phenomena, such as a zoo of waves and instabilities, turbulence, reconnection, particle acceleration and beam formation to mention a few. These phenomena can now be observed with unprecedented spatial and temporal resolution by modern space probes and ground-based observatories. While high-resolution observations can provide tantalizing snapshots of events and

statistical overviews of dynamical behaviour, repeatable experiments under strictly controlled conditions are not possible in space. Laboratory experiments can provide useful insight in space phenomena by investigating the underlying physics under appropriately scaled, controlled plasma conditions. Among these are experimental studies of wave propagation characteristics, wave-particle interactions, and nonlinear dynamics and instabilities. Papers on basic and applied laboratory studies addressing such space plasma processes are solicited.

### **Commission H “Radio Science for Space Weather”**

Conveners: M. Messerotti, V. Pierrard

Space weather perturbations are triggered by plasma processes that occur at the originating sources, e.g. magnetic reconnection causing heating, particle and plasmoid acceleration. Further plasma processes occur during propagation through the interplanetary medium, where shocks and particle beams are formed. Finally a wealth of processes occur upon interaction with planetary magnetospheres and ionospheres. All these processes are characterised by radio emissions specific to each plasma process. Hence, radio science represents a key investigative tool for space weather phenomena including triggering, propagation and interaction. Both radio physics and radio instrumentation are conceptual and, respectively, experimental tools that are needed to provide a complete analysis framework. This session is open to contributions on radio physics applied to space weather phenomena detection, characterisation, analysis and forecasting as well as to ongoing and planned projects for space- and ground-based radio studies in this field.

### **Commission H “Open Session”**

Conveners: O. Santolik, J. Lichtenberger

This session solicits papers on all aspects of waves in space and laboratory plasmas that do not easily fit into other sessions within Commission H, including solar, planetary, and interplanetary plasmas, spacecraft-plasma interactions, applications to space weather, the use of space as a laboratory, spacecraft and laboratory instrumentation, and latest results from recently launched spacecraft missions and laboratory experiments.

### **Commissions HG “Active Experiments”**

Conveners: V. Sonwalkar, R. Moore, N. Jackson-Booth, T. Pedersen

This session will cover recent advances in active space experiments, including ionospheric perturbations, disturbances or other effects on the space environment actively produced by high-power RF waves, chemical releases, rocket exhaust, ion engine propulsion systems or other means. In addition to presentations of observations and measurements from recent or novel experiments, theoretical and modeling developments that advance theory beyond the prevailing qualitative and descriptive state toward quantitative and predictive capabilities will also be welcomed. Topics of interest include wave generation stimulated by or propagation modified by artificial effects. Presentations on technologies, such as RF sources or chemical reactions, which may enable new or improved applications in active space experimentation, are also sought. This session will also cover the latest technical and scientific results on and concepts of space-borne radio sounding in terrestrial and extra-terrestrial ionospheres and magnetospheres including previous, current, and planned spaceborne sounders. The basic physics of plasma-wave propagation and of active or passive antennas, in magnetoplasmas in laboratory or space, are important related topics. Investigations of geospace plasma density structures using injected whistler-mode and Z-mode waves are also solicited, as are reviews of earlier radio-sounding accomplishments highlighting outstanding questions yet to be addressed by radio sounders. There is a close connection between active experiments and space-borne sounding: near-field interactions with antennas in a plasma are very similar to high-power radio wave heating and stimulate a variety of resonances which need to be

understood to optimize system function and which can also be used for diagnostic purposes. Contributions on such overlapping research areas are especially welcome.

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Conveners: S. Celestin, N. Liu, M. Fullekrug

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### **Commissions HJ “Solar, Planetary, and Heliospheric Radio Emissions”**

Conveners: P. Galopeau, G. Mann, H. O. Rucker, Y. Yan, S. White, T. Bastian

The Sun, solar system magnetized planets, and the heliosphere are sources of intense non-thermal radio emissions. Thus solar system radio astronomy and plasma physics provide most important tools that complement those of other space- or ground-based observations in Gamma rays, X-rays, EUV/UV, and the visible, etc., for understanding these non-thermal processes and energetic particles occurring in solar bursts and their influence from the solar surface to heliospheric space. New generation or upgraded radio telescopes, either solar-dedicated or non-solar-dedicated, have (will) come into use, including ALMA, E-OVSA, EVLA, GMRT, LOFAR, MUSER, and MWA, as well as the Ukrainian radio telescopes UTR-2, URAN, and GURT, the radio spectrometers aboard Stereo spacecraft, and the future SKA. These instruments provide new possibilities to measure the non-thermal radiation in an unprecedented way and open new windows for a better understanding of the radio emission processes in space (with applications to astrophysical objects, like supernovae remnants or active galactic nuclei). They also provide diagnostic tools for extrasolar planets, since these processes are the same basic plasma processes in space. Complementary studies are highly welcome including analysis from spaceborne experiments (e.g. Cassini, Galileo, Ulysses, Wind, Juno), laboratory and experimental studies, theoretical investigations devoted to the generation mechanisms and particle acceleration processes, and preparatory studies of forthcoming space missions (such as Bepi-Colombo and JUICE). Resonance, Solar Orbiter, Solar Probe, Taranis). This session will provide an important platform for solar radio astronomers, plasma physicists, planetary scientists, astrophysicists, and radio scientists to communicate and discuss a wide range of interesting and exciting topics, including the recent progress of radio observations of the Sun, solar wind, and planets, spacecraft measurements, data processing, theories, new technologies, and beyond.

### **Commissions EFGH “Natural Electromagnetic Noise and Radio Sensing Applications in Terrestrial and Planetary Environments”**

Conveners: Y. Hobara, C. Price, T. Ushio, M. Fullerkrug

This joint session aims at presenting recent works on electromagnetic noise and phenomena in the terrestrial atmosphere and upper atmosphere (ionosphere/magnetosphere). Different kinds of electromagnetic noises will be dealt with, including atmospheric noises originated in lightning

discharges (ELF Schumann resonances, mesospheric optical emissions etc.), man-made noise and noise due to wave-particle and wave-wave interactions. Corresponding electromagnetic noise environments on other planets are welcome. We are particularly interested in applications of natural EM observations in remote sensing such as monitoring, detecting and forecasting natural hazards, such as thunderstorms, severe weather, space weather and seismic events.

#### **Commissions EFGHJ “One-Day Workshop on RFI Mitigation and Characterization”**

Conveners: F. Gronwald, R. Bradley, T. Bullet, H. Rothkaehl, D. Le Vine, A. Maitra, M. Haredim, J. Gavan, V. Deniau, P. de Matthaëis

It is the aim of this workshop to bring together researchers, engineers and users from all radio science disciplines to consider how RFI affects their respective fields, to develop mitigation strategies, and to foster cooperation and collaboration. Particular attention will be given to the impact of new and future sources of RFI, spectrum management challenges, and new technology developments. Recent progress towards the ultimate goal of being able to do observations with real-time mitigation of the undesired signals, while leaving the desired signals minimally affected, will be discussed.

#### **Commissions GEH “Seismo Electromagnetics (Lithosphere-Atmosphere- Ionosphere Coupling)”**

Conveners: Sergey Pulinets, Yasuhide Hobara, Hanna Rothkaehl

The results of electromagnetic and ionospheric monitoring do not leave the place to doubts on the electromagnetic and ionospheric anomalies existence and their connection with seismic activity. Quasistationary electric fields, electromagnetic emissions in wide band of electromagnetic spectrum, anomalies of radio wave propagation, ionospheric anomalies are now the hot spots at all conferences of geophysical thematic. But still we lack the physical substantiation of many of registered effects. Multi- parameter measurements in seismically active regions and cross validation of results obtained by different groups will help to understand the background physics of the observed anomalies. This session will accept papers demonstrating progress in understanding the ionospheric and electromagnetic effects preceding strong earthquakes including experimental findings and theoretical papers on lithosphere-atmosphere-ionosphere coupling.

#### **Commissions GH “Meteors, Collisional EMPs, and Other Highly-Transient Space Plasma Events”**

Conveners: John Mathews, Asta Pellinen-Wannberg

This session includes meteoroid impact EMP generation on satellite and planetary surfaces as well as the role of micrometeoroid processes (e.g., sputtering, fragmentation, ablation) and the mass flux on the upper atmosphere and ionosphere, as well as other related highly-transient phenomena. The radio and radar signatures of these processes are also considered.

#### **Commissions GH “Plasma Instabilities in the Ionosphere”**

Conveners: Frank Lind, Ron Pfaff

Plasma instabilities in the high, middle, and low latitude ionosphere play a key role in the development and evolution of structures in the Geospace environment, including processes in both the E and F regions. They often are associated with irregularities which can be experimentally observed using radar and radio techniques, as well as in-situ observations. Linear and non-linear theory is often used to predict instability thresholds, amplitudes, and velocities. Simulations have recently been quite successful in the detailed study of irregularity micro-structure, time evolution, and k-space behavior. This session will encourage discussion of new developments in the theoretical, simulation, and experimental observations relevant to the study and understanding of ionospheric

plasma instabilities. The effects of ionospheric instabilities on other Geospace phenomena will also be of interest. This includes coupling to the magnetosphere and impacts of the lower atmosphere

### **Commissions GHJ “Workshop on Extreme Space Weather Environments”**

Workshop Chair: Mike Hapgood, Workshop Co-Chair: Terry Onsager, Conveners: Tony Mannucci, Viviane Pierrard, Mauro Messerotti, Ludwig Klein

Over recent years extreme space weather has been recognized as a global risk with significant societal and economic risks affecting many domains, including but not limited to electrical power grids, satellites, aircraft passengers and crew, avionics, GPS, Galileo and other GNSS positioning, navigation and timing systems and communications systems. In order to evaluate the consequences of space weather on these systems it is essential (a) to identify what are the factors in space weather environments that interact with the systems at risk, and then (b) to estimate what are reasonable worst cases for these factors. This workshop will bring together experts and other interested parties to review and refine a process for developing an internationally agreed set of specifications for the extreme space weather environment, and to test the process by applying it to a number of key domains. It is hoped that this will be the first of a series of workshops, hosted by different organizations and fora, developing these specifications.

The workshop will be led by Professor Mike Hapgood of the Rutherford Appleton Laboratory and will be hosted by URSI Commissions G, H and J. The focus will be on environments appropriate to the work of these Commissions, namely neutron, proton and electron fluxes, solar radio fluxes, ionospheric electron density enhancements, TEC and related electron gradients and radio scintillation. Talks and related presentations will be by invitation only, however, there will be plenty of opportunities for discussion and possibly for showing targeted data and information. Poster papers will be accepted.

The workshop will require additional registration on the URSI web site (but there is no additional cost). Additional preparatory materials will be sent out prior to the meeting.

### **Commissions JEF GH “Characterization and Mitigation of Radio Frequency Interference”**

Conveners: Frank Gronwald, V. Deniau, Richard Bradley, Terry Bullet, Hanna Rothkaehl, David LeVine, Amit Kumar Mishra, M. Haredim, J. Gavan

In this session, radio frequency interference (RFI) issues will be discussed that are of particular importance for observational sciences such as radio astronomy, microwave remote sensing of the Earth, and solar and ionospheric studies where highly sensitive measurements are necessary.

## Commission J Program

**Commission J Chair:** Prof. Willem Baan; baan@astron.nl

### **Commission J Tutorial Lars-Ake Nyman: “The Atacama Large Millimeter Array (ALMA)”**

Convener: Willem Baan

### **Commission J “Very Long Baseline Interferometry”**

Conveners: Huib-Jan van Langevelde, Hideyuki Kobayashi

At an age of 50, the VLBI technique is still advancing thanks to the developments in digital instrumentation. An increasing amount of bandwidth can be sampled, using wide-band receivers, increasing the sensitivity of VLBI networks. New solutions are becoming available for storing large amounts of raw telescope data and transporting it to the correlator. And innovations are even foreseen for distributing timing references that are more economic and accurate than maser clocks. There are also various options to implement correlators efficiently and provide more flexibility than in the past. The science communities that use VLBI are presented with more capabilities, but also some additional complexity, as many different economic solutions are adopted on a regional scale. But there is in fact a global case for more intercontinental VLBI collaboration, as unique science cases require the highest possible resolution and new telescope arrays (ALMA, SKA and its pathfinders) are coming on-line. Common data interfaces, software standards and operational practices will be in demand. As the plans for the next generation radio instrumentation are becoming a reality, there are certainly many scientific options and technical challenges for the VLBI community to discuss.

### **Commission J “The Square Kilometre Array”**

Conveners: Robert Braun, Justin Jonas, Douglas Bock

The Square Kilometre Array concept has grown from the answer to a simple question: What size radio telescope would it take to permit us to read the history of the Universe as written in the language of its most abundant constituent, Hydrogen? What has become apparent, is that the same radio telescope that will answer fundamental questions about our cosmic origins and fate will also permit a wealth of other discoveries to be made, in areas as diverse as the formation of planets similar to the Earth, detection of gravitational distortions of Space-Time, the origin of cosmic magnetic fields and understanding the formation and growth of Black Holes. In this session we provide an update on the progress toward realising the Square Kilometre Array Observatory, as well as highlighting early outcomes from precursor telescopes on the two SKA sites, the MeerKAT facility in South Africa and the ASKAP in Australia.

### **Commission J “Millimeter/Submillimeter Arrays”**

Conveners: Jongsoo Kim, Lars-Ake Nyman

The mm/submm arrays, CARMA, SMA, NOEMA and ALMA, have continuously provided unprecedented images and spectra for the study of gas and dust structures in the Universe. ALMA has now revolutionized our understanding of the formation of planets, stars and galaxies as well as created a new ecosystem from proposal handing to data archiving for around 3000 world-wide astronomers. These arrays have also improved the sensitivity, resolution and spectral coverage of this type of observations. In this session, highlights of science cases and on-going as well as future upgrade plans will be presented. The new ecosystem of ALMA will be also presented.

### **Commission J “Single Dish Instruments”**

Conveners: Karen O’Neil, Ettore Carretti, Zhiqiang Shen

While recent years have seen a rapid development of large radio telescope arrays; there are many single dish instruments planned or operated in the world, which will be making significant impacts within astronomy. Session J4 will look at current and planned single dish telescopes, focusing on their unique science and technical developments within the era of the SKA. Related technical issues and concerns will also be covered (RFI, antenna metrology, active surface controls, etc.).

### **Commission J “Historical Radio Astronomy”**

Conveners: Richard Wielebinski, Ken Kellermann, Richard Schilizzi

Radio astronomy has a rich heritage of interferometers and arrays that have transformed our view of the universe. Each of these projects has accumulated a wealth of experience in the technical, managerial and political domains, which will be distilled in invited and contributed presentations. The definition of “past” is a fluid concept since most instruments are in a continual state of upgrade, but we define it to mean projects that are or have been operational for science using the full array for which construction funding was received. The presentations should be of interest for those interested in the history of radio astronomy as well as for those involved in the new telescope projects expected to further deepen our understanding of the cosmos.

### **Commission J “Receivers and Radiometers: Design and Calibration”**

Conveners: S. Srikanth, Miroslav Pantaleev, Arnold van Ardenne, Roberto Neri

In order to meet emerging challenges in receiver technology, there is a need for global collaboration of the astronomical community. The new generation of receivers for radio telescopes needs to have increased bandwidth, wider field of view and enhanced sensitivity. This session will focus on progress and advances in receiver and radiometer technology. Suggested topics include design and construction of cryogenically cooled heterodyne and bolometers receivers, receivers with LNAs at ambient temperature for traditional multi-beams and phased array feeds (PAF), radiometers, RFI mitigation using PAFs, narrow band filters, HTS filters etc., technology development in the areas of improved dynamic range, time response, spectral bandwidth, spectral resolution, compactness in size etc. Calibration techniques for single telescopes, interferometers and array receivers will also be covered.

### **Commission J “Digital Signal Processing Hardware”**

Conveners: Albert-Jan Boonstra, Dan Werthimer

Exciting recent technological advances in digital processing hardware have contributed to better sensitivity, larger bandwidths, larger fields of view, and higher spatial resolution for the radio astronomer. These advances allow, for example, correlation of larger numbers of telescopes and phased-array processing. For the first time they make processing of phased-array feed systems feasible, and they increasingly allow accelerated processing further downstream. This session aims to highlight state-of-the-art hardware systems planned or recently deployed at radio telescopes, for example but not limited to the SKA radio telescope and its precursors and pathfinders. Session papers are invited that address new architectures and new instrumentation, including beam-formers, correlators, spectrometers, and systems for pulsar search and timing, FRB search, VLBI, and SETI.

### **Commission J “Detection of Short-Duration Transients and Pulsars”**

Conveners: Ben Stappers, Vicky Kaspi, Joeri van Leeuwen

The focus of this session will be on the use of interferometers for time-domain detection of fast radio transients, such as Rotation Radio Transients (RRATs) and Fast Radio Bursts (FRBs), as well as on radio pulsars. Instruments to be considered are Apertif, CHIME, JVLA, LOFAR, Meerkat, MOST, SKA, etc.

### **Commission J “Recent and Future Space Missions”**

Conveners: Fabrice Herpin, Martin Giard

The session aims at presenting the most recent and future (from the end of the 2000s till 2030s) far-infrared space observatories. Radioastronomy covers indeed a domain beginning at large wavelengths but also extending to the far IR, opening the window to inaccessible molecules and transitions from the ground, e.g., water. The different talks foreseen here will show the main results of the wonderful Herschel Space Observatory whose mission ended in 2013, but also of the current facility SOFIA, the only observatory in activity in this domain for a long time. The future space mission projects such as SPICA, Millimetron, and FAR-Surveyor will be presented in details. Beyond the expected science results from these missions, the speakers will also present the different innovative technologies used or to be used.

### **Commission J “Latest News and Observatory Reports”**

Conveners: Richard Bradley, Willem Baan

This session will have contributions of the latest news, exciting late submissions, interesting papers that did not fit in the other sessions, and observatory reports.

### **Commissions JD “AstroPhotonics”**

Conveners: Martin Roth, Peter Maat, Stefan Minardi

Optical fibers and integrated optical devices are increasingly being used as key technologies to improve the performance of radio- and optical- astronomical interferometers and, in general, any optical astronomical instrument. To highlight the rapid development and growing importance of this specific area of applied photonics, the term AstroPhotonics has been recently devised. Beam forming devices, integrated optics delay lines, and clock distribution based on optical fiber networks are now commonly used to enhance the precision of radio-interferometric measurements, while reducing the impact of environmental electromagnetic noise and infrastructure cost. Recent advances in optical comb technologies bear promise to replace atomic clocks by much more accurate optical clocks, which could be easily interfaced to optical fiber networks to time the radio-telescopes. In the domain of optical interferometry, integrated optics multi-telescope beam combiners for near-infrared light are currently delivering the highest precision visibility measurements and enable reliable image retrieval of astronomical targets ranging from stellar surfaces to proto-planetary disks. Extension of these technologies to the visible and mid-infrared bands is currently an active research area, along with feasibility studies and on-field tests of direct telescope connection by means of optical fiber links. The aim of this session (including both invited and contributed talks as well as posters) is to bring together the radio- and optical-AstroPhotonic communities by presenting recent advances and new application concepts based on photonic technologies for astronomical interferometry. Differences and similarities between the photonic technologies and their applications employed by the two communities will be highlighted, in order to promote a fruitful cross-contamination of ideas and interdisciplinary collaboration. Eligible topics include: integrated optics devices and components for stellar interferometry (e.g. beam forming devices, homodyne and/or heterodyne interferometric beam combiners, integrated phase and/or amplitude modulators), all-optical delay lines, frequency combs generation, optical clocks, optical fiber networks and their opto-electronic management, long-haul interferometric fiber links.

### **Commissions JEF GH “Characterization and Mitigation of Radio Frequency Interference”**

Conveners: Frank Gronwald, V. Deniau, Richard Bradley, Terry Bullet, Hanna Rothkaehl, David LeVine, Amit Kumar Mishra, M. Haredim, J. Gavan

In this session, radio frequency interference (RFI) issues will be discussed that are of particular importance for observational sciences such as radio astronomy, microwave remote sensing of the Earth, and solar and ionospheric studies where highly sensitive measurements are necessary.

### **Commissions JG “Ionospheric Models and their Validation”**

Conveners: Stefan Wijnholds, Sean Elvidge

The ionosphere has a profound effect on the propagation of radio waves, making measurements of distortions of RF signals an effective tool for ionospheric research. These same distortions hamper ground-based radio astronomical observations of cosmic source structure and position, in particular at frequencies below 1 GHz. Radio astronomers are, therefore, using different ionospheric models to reduce the number of parameters required for calibration of instrumental and environmental effects affecting their observations. In turn this calibration process provides information on the ionospheric conditions above the array, such as turbulence scales, TID wavelengths and TID velocity. This session aims to bring low-frequency radio astronomers and ionospheric researchers together to stimulate cross-fertilization between these two fields with emphases on the modelling of RF propagation through the ionosphere, the ionospheric models themselves and validation of those models.

### **Commissions DJ “Special Session on Gravitational Wave Detection”**

Conveners: Roman Schnabel, Lisa Borsotti, Willem Baan

The first observation of gravitational waves on September 14, 2015, by the two detectors of the Laser Interferometer Gravitational-Wave Observatory (LIGO) heralded the field of gravitational-wave astronomy. It is expected that this field will provide information about the universe that was previously not accessible at all. Although gravitational-wave observatories are already extremely sensitive measurement devices, there are many ideas for further enhancements to increase the event rate by several orders of magnitude and to target specific sources of gravitational waves. A particular goal is reaching a sensitivity that will allow us to listen to the gravitational-wave background originating from the Big Bang.

### **Commissions ECJ “Spectrum Management”**

Conveners: J. Pedro, A. Tiplady, A. Shukla, H. Liszt

The focus of this session on spectrum management and spectrum utilization is of high interest to the community. We expect to give a short report of the related WG06 activities during the last period, along with our views on spectrum management, and on hot topics of today. International and local Chinese contributors will be invited such that first-hand reports on controversial spectrum management issues will be presented.

### **Commissions EFGHJ “One-Day Workshop on RFI Mitigation and Characterization”**

Conveners: F. Gronwald, R. Bradley, T. Bullet, H. Rothkaehl, D. Le Vine, A. Maitra, M. Haredim, J. Gavan, V. Deniau, P. de Mattheis

It is the aim of this workshop to bring together researchers, engineers and users from all radio science disciplines to consider how RFI affects their respective fields, to develop mitigation strategies, and to foster cooperation and collaboration. Particular attention will be given to the impact of new and future sources of RFI, spectrum management challenges, and new technology developments. Recent progress towards the ultimate goal of being able to do observations with real-

time mitigation of the undesired signals, while leaving the desired signals minimally affected, will be discussed.

### **Commissions GHJ “Workshop on Extreme Space Weather Environments”**

Workshop Chair: Mike Hapgood, Workshop Co-Chair: Terry Onsager, Conveners: Tony Mannucci, Viviane Pierrard, Mauro Messerotti, Ludwig Klein

Over recent years extreme space weather has been recognized as a global risk with significant societal and economic risks affecting many domains, including but not limited to electrical power grids, satellites, aircraft passengers and crew, avionics, GPS, Galileo and other GNSS positioning, navigation and timing systems and communications systems. In order to evaluate the consequences of space weather on these systems it is essential (a) to identify what are the factors in space weather environments that interact with the systems at risk, and then (b) to estimate what are reasonable worst cases for these factors. This workshop will bring together experts and other interested parties to review and refine a process for developing an internationally agreed set of specifications for the extreme space weather environment, and to test the process by applying it to a number of key domains. It is hoped that this will be the first of a series of workshops, hosted by different organizations and fora, developing these specifications.

The workshop will be led by Professor Mike Hapgood of the Rutherford Appleton Laboratory and will be hosted by URSI Commissions G, H and J. The focus will be on environments appropriate to the work of these Commissions, namely neutron, proton and electron fluxes, solar radio fluxes, ionospheric electron density enhancements, TEC and related electron gradients and radio scintillation. Talks and related presentations will be by invitation only, however, there will be plenty of opportunities for discussion and possibly for showing targeted data and information. Poster papers will be accepted.

The workshop will require additional registration on the URSI web site (but there is no additional cost). Additional preparatory materials will be sent out prior to the meeting.

### **Commissions HJ “Solar, Planetary, and Heliospheric Radio Emissions”**

Conveners: P. Galopeau, G. Mann, H. O. Rucker, Y. Yan, S. White, T. Bastian

The Sun, solar system magnetized planets, and the heliosphere are sources of intense non-thermal radio emissions. Thus solar system radio astronomy and plasma physics provide most important tools that complement those of other space- or ground-based observations in Gamma rays, X-rays, EUV/UV, and the visible, etc., for understanding these non-thermal processes and energetic particles occurring in solar bursts and their influence from the solar surface to heliospheric space. New generation or upgraded radio telescopes, either solar-dedicated or non-solar-dedicated, have (will) come into use, including ALMA, E-OVSA, EVLA, GMRT, LOFAR, MUSER, and MWA, as well as the Ukrainian radio telescopes UTR-2, URAN, and GURT, the radio spectrometers aboard Stereo spacecraft, and the future SKA. These instruments provide new possibilities to measure the non-thermal radiation in an unprecedented way and open new windows for a better understanding of the radio emission processes in space (with applications to astrophysical objects, like supernovae remnants or active galactic nuclei). They also provide diagnostic tools for extrasolar planets, since these processes are the same basic plasma processes in space. Complementary studies are highly welcome including analysis from spaceborne experiments (e.g. Cassini, Galileo, Ulysses, Wind, Juno), laboratory and experimental studies, theoretical investigations devoted to the generation mechanisms and particle acceleration processes, and preparatory studies of forthcoming space missions (such as Bepi-Colombo and JUICE). Resonance, Solar Orbiter, Solar Probe, Taranis). This session will provide an important platform for solar radio astronomers, plasma physicists, planetary

scientists, astrophysicists, and radio scientists to communicate and discuss a wide range of interesting and exciting topics, including the recent progress of radio observations of the Sun, solar wind, and planets, spacecraft measurements, data processing, theories, new technologies, and beyond.

## Commission K Program

**Commission K Chair:** Prof. Joe Wiart; wiart@enst.fr

### **Commission K Tutorial Tahera Emilie van Deventer: “International EMF Project to Assess Health and Environmental Effects of Exposure to Static and Time Varying Electric and Magnetic Fields in the Frequency Range 0-300 GHz.”**

Convener: Joe Wiart

The processes for assessing health risks and developing exposure guidelines for electromagnetic fields have evolved to reflect the rigorous and systematic use of evidence as the basis for public health policies. This talk will provide an update on the activities of the World Health Organization and address the opportunities and challenges faced in analyzing the current scientific evidence and in developing standards that are useful to and applicable by regulatory authorities.

### **Commission K “Biological Effects and Related Mechanisms of EMF Exposure”**

Conveners: Guglielmo d’Inzeo, Alexandre Legros

The experimental and theoretical assessment of possible health hazards resulting from non-ionising electromagnetic fields is central from a health and safety perspective. In spite of the long history of this research, there are still uncertainties concerning the thresholds for acute neurophysiological effects, as well as for possible biological effects due to low level exposures. New approaches for breakthrough have been conducted to obtain scientific evidences for or against those possible effects. Studies have been in general in focusing on frequencies and waveforms used for electric power transmission and for wireless communications. New technologies using different frequencies and waveforms aiming for translational applications have also emerged. Moreover, the possible beneficial use of electromagnetic field effects has become of more interest for the development of novel applications in biotechnology and medicine. This session calls for papers on recent developments of theoretical and experimental studies on biological effects of electromagnetic fields using various and innovative scientific approaches.

### **Commission K “Biomedical Applications of Low Frequency (including IF) EMF”**

Conveners: Frank Prato, Terry Thompson

This session focuses on recent advances of static, ELF, and pulsed magnetic field applications in imaging and therapy including but not limited to: TMS (Transcranial Magnetic Stimulation), DBS (Deep Brain Stimulation), MRI (Magnetic Resonance Imaging), and MPI (Magnetic Particle Imaging)

### **Commission K “Therapeutic Application of RF EMF”**

Conveners: Luis Mir, Koichi Ito

This session is devoted to recent progress in therapeutic applications of electromagnetic radiation ranging from radio waves to infrared. Specific applications would include ablation, coagulation, hyperthermia, oncothermia, and other biomedical applications involving tissue temperature elevation. Basic, applied and clinical research papers are welcome.

### **Commission K “Biomedical Applications and EMF Exposure of IoT”**

Conveners: Shoogo Ueno, Nam Kim

Biomedical applications of electromagnetic fields (EMFs) have been widely studied for medicine and basic research. The introduction of “the Internet of Things (IoT)” has triggered a new era of global society where the Internet is connected to physical world via ubiquitous sensors. This session focuses on topics in recent advances in biomedical applications and EMF exposure of IoT. The

topics include transcranial magnetic stimulation (TMS), deep brain stimulation (DBS), transcranial direct current stimulation (tDCS), magnetic resonance imaging (MRI), regenerative medicine, and other diagnostic and therapeutic applications using electromagnetic techniques. The brain-machine interface, remote healthcare systems, and other biomedical applications are also discussed. Assessments and safety aspects of EMF exposures of IoT are also focused.

### **Commission K “EMF Standards and Health Protection”**

Conveners: Akimasa Hirata, Kenneth Foster

The electromagnetic environment has become more and more complex due to the development of emerging wireless technologies. This session highlights the recent knowledge about exposure from environmental electromagnetic fields in the real world, which is related to human health. It will also handle the EMF standardization activities regarding assessment methods for the recently emerging wireless devices.

### **Commission K “EMF Exposure Assessment and Dosimetry for New Technologies (WPT)”**

Conveners: Teruo Onishi, Samyoung Chung

Wireless power transfer attracts attentions of researchers and engineers in various fields with expectation to become a common technology of practical use. Safety issue should be investigated prior to the introduction to daily lives. This session deals with interaction of electromagnetic fields emitted from wireless power transfer systems with human body or medical equipment and EMF reduction technologies of WPT system as well. Aside from the WPT, newly introduced technologies, such as LTE-Advanced carrier aggregation technologies, MIMO, etc. which basically use the RF frequencies should be considered in this session to share research activities to find out more elaborate assessment methods.

### **Commission K “EMF Exposure Assessment and Dosimetry and EMC for WBAN and Implanted Devices”**

Conveners: Jianqing Wang, Ping Jack Soh

The introduction of Wireless Body Area Networks (WBAN) for various applications in healthcare and medical monitoring, emergency response, search and rescue, military, etc. have triggered an extensive research effort into utilizing flexible and bio-compatible materials towards realizing an on- or in-body system setup. However, placement of such radiating structures inside or in close-proximity to the human user poses various challenges, especially when a reliable link is needed for a biomedical monitoring system. Besides being able to predict and cater to the variation in worn/implanted device's performance, there is a large possibility that the electromagnetic (EM) sources generated by such devices will be absorbed by the human tissue. This then raises concerns of the safety of such devices for use in the on- or in-body environments. One of the most investigated parameter in determining a safe operation for such devices is the specific absorption rate (SAR). Regulatory compliance of communication devices typically involves those made from conventional printed circuit boards (PCB) operating near the human head or hands. Several examples of recent techniques for SAR reduction in wearable devices are by using ferrites, electromagnetic bandgap structures (EBG), or resistive sheets. Besides in the human body or head, SAR levels in unique body tissues such as the human eye, in a fetus in a pregnant woman, etc. due to these devices is becoming more important. Another important issue is the electromagnetic compatibility (EMC), due to the environmental EM fields, which may cause significant interference with the WBAN and implanted devices. Their safe use without malfunction is especially essential in the healthcare and medical applications. The objective of this convened session is to present state-of-the art research related to EM dosimetry and EMC for WBAN antennas and devices. This topic is already of increasing importance, which also fits the focus areas of the URSI General Assembly (URSI-GASS) and URSI Commission K.

### **Commission K “Electromagnetic Biomedical Imaging”**

Conveners: Joe LoVetri, Milica Popovic

This session is devoted to non-ionizing electromagnetic (and hybrid-electromagnetic) systems for breast imaging, tissue characterization, and the detection/identification of tumors. Much progress has been made on the development of such systems ranging from very low frequencies all the way up to optical frequencies. Examples include electrical impedance tomography, microwave imaging, near-infrared tomography, and THz imaging. Specific topics of interest include, but are not limited to, tomographic and other image construction algorithms and experimental results from laboratory and clinical imaging systems. Breast imaging is the principal topic but other applications of similar principle are also acceptable.

### **Commission K “Latest Development in Measurement and Applications of Dielectric Spectroscopy”**

Conveners: Theodore Samaras, Niels Kuster

Measurements and biomedical applications of dielectric spectroscopy, including the difficulties in measuring tissue properties at the two extremes of the spectrum (static-LF and mmW), the calibration techniques/liquids proposed, tissue mimicking materials for experimental phantoms, medical applications of dielectric spectroscopy (cancerous/healthy tissue distinction), use of dielectric properties of skin in cosmetology (aesthetic medicine) etc

### **Commission K “Open Session”**

Conveners: Joe Wiart, Samyoung Chung

This session will accept any papers falling within the terms of reference of Commission K and not covered elsewhere

### **Commissions KBE “Uncertainty Management and Stochastic Methods in Experimental and Numerical Electromagnetism, Environmental Exposure Assessment and Dosimetry”**

Conveners: Joe Wiart, Tonging Wu, Ari Sihvola, Gabriele Gradoni

The increasing use of RF wireless communication system is supported by complex and agile technologies and network architectures. It has also induced large variability of usages. The management of such complexity has requested innovative approaches experimental and Numerical Electromagnetism, environmental exposure assessment and dosimetry. This session is devoted to recent progress and application of methods based on advanced statistical methods (e.g., Surrogate modelling, Polynomial Chaos, Kriging, Machine Learning, Sensibility analysis, etc. ) in experimental and Numerical Electromagnetism and dosimetry

### **Commissions KBF “Electromagnetic Inversion for Biomedical, Geophysical, Non-destructive Testing, and Antenna Characterization Applications”**

Conveners: Aria Abubakar, Puyan Mojabi,

Electromagnetic inversion is the process by which some properties of an investigation domain are inferred from external electromagnetic observations. Several application areas, which span a wide range of frequencies from a few hertz to optical frequencies, utilize electromagnetic inversion algorithms and techniques to reconstruct the properties of interest, such as complex permittivity profiles of biological tissues, conductivity profiles in geophysical surveys, or equivalent current distributions of antennas. This special session is focused on bringing together recent advances in quantitative electromagnetic inverse scattering and inverse source algorithms/techniques in these application areas to enhance the achievable reconstruction accuracy, resolution, or efficiency of the computational process. The enhancement can be obtained by methods such as properly incorporating

prior information into the inversion algorithm, appropriate numerical modelling and calibration, and new advances in inversion algorithms.

### **Commissions KC “EM Human Exposure and Future 5G and LPWA Networks”**

Conveners: Benoit Derat, Long Lee

Mobile communications sector is one of the strongest growing markets in the world. This growth is not expected to slow down with the proliferation of laptops, tablets, wearables and the variety of applications being supported by 5G communications, the Internet of Things (IoT) and Low Power Wide Area Networks (LPWA). Innovative technologies will allow the future networks to exceed the existing limitations in bandwidth, data rate and enable new applications and usages. Novel technologies and usages result in new challenges in assessing electromagnetic (EM) human exposure. The evaluation of EM exposure is discussed for conditions which involve frequencies higher than 6 GHz and up to several tens of GHz, uplink MIMO and beamforming or innovative devices or device usages. The resulting research and development for new phantoms, measurement techniques or numerical modeling approaches are central topics of this session.

### **Commissions KE “EMC in Biomedical Applications”**

Conveners: Frank Gronwald, Lars Ole Fichte

Modern medical technology combines different engineering, scientific, technical, and medical knowledge to a field of activity which is indispensable for the health industry, one of the largest industrial sectors of the world. Due to its strong development, medical technology is counted among the ten high potential technologies of the 21st century. Since medical technology establishes a cross-disciplinary connection between medicine and the engineering sciences, this session welcomes submissions from the medical-instrument sector with EMC-related aspects of system engineering, electronics, sensor systems, computer and material sciences.

### **Commissions FK “Radio Wave Propagation Aspects in Body Area Networks”**

Conveners: Slawomir Ambroziak, Luis M. Correia

Wireless Body Area Networks (WBANs) are playing an increasingly important role in the next generation of wireless systems, as they will allow for the integration of the various handheld and wearable devices with the surrounding environment and infrastructure. Thus, an important challenge is to increase the connection reliability of the in-, on- and off-body links. In order to boost the overall system performance, a good and deep understanding of the radio channel in WBANs is required. This has to be made possible by studying propagation channels via measurements, simulations and developing models considering various scenarios (e.g., antenna type and placement, body type, movements, and environments). This session will give the possibility to exchange views on various methodologies of channel modelling, including simulation and measurements, and to discuss approaches to integrate results in order to build flexible channel models for WBANs.