COMMISSION TUTORIALS

Commission A

Title	Lecturer name, affiliation
Challenges and applications of ambient RF Energy Harvesting systems	Kyriaki Niotaki, Telecom Paris, France Apostolos Georgiadis, Heriot-Watt University, UK
The self-sustainable operation of low-power devices is a major challenge towards the long-scale Internet of Things (IoT) deployment. A potential solution to overcome this challenge is to harvest energy from ambient energy sources, such as photovoltaic, thermoelectric and Radio Frequency, and utilize this energy to supply the power for these devices. This tutorial will focus on the possibility of harvesting energy from the existing Radio Frequency (RF) transmissions. The general structure of an RF energy harvesting system will be presented, with a main emphasis on the rectenna design challenges from the antenna to the rectifier and their joint optimization as well as their integration with other harvesting technologies such as solar or thermal. Furthermore, performance limits and application scenarios will be discussed and many circuit implementation examples will be provided.	

Commission B

Title	Lecturer name, affiliation
Physical bounds for functional surfaces and materials	Daniel Sjöberg, Lund University, Sweden
A common approach to realizing functionality such as absorption, frequency or polarization selectivity, artificial magnetic conductivity etc, is to construct a periodic structure in the xy-plane with finite extent in the z-direction. With three-dimensional periodicity, we usually talk about metamaterials. The bulk properties of the structure, such as the reflection or transmission coefficient, can be controlled by the microstructural geometry or temporal dispersion of the component materials. For linear, passive, time invariant systems such properties can be associated with Herglotz functions, whose asymptotic values in the low and high frequency limit represent physical constraints such as the total thickness of the structure. In this tutorial, we demonstrate how to use the analytical properties of Herglotz functions to provide physical bounds restricting the desired functionality, typically in terms of the product of bandwidth and performance level being constrained by the total thickness of the structure in wavelengths. Similar bounds apply also to the temporal dispersion of metamaterials. Many of the bounds are tight, and hence provide a direct estimation of the best possible performance of the structure, regardless of geometry or material being used.	

Commission C

Title	Lecturer name, affiliation
Cognitive Radar	Kumar Vijay Mishra United States Army Research Laboratory, USA
In the past few years, novel approaches to radar signal processing have been introduced which allow the radar signal detection and parameter estimation using much smaller number of measurements than required by Nyquist sampling. These systems exploit the fact that the target scene is sparse facilitating the use of recent advances in compressed sensing methods. This talk will introduce recent developments in reduced-rate sampling that break the link between common radar design trade-offs such as range resolution and transmit bandwidth; dwell time and Doppler resolution; spatial resolution and number of antenna elements; continuous-wave radar sweep time and range resolution. For each of these ideas, we present state-of-the-art hardware prototypes that we have designed and developed to demonstrate the real-time feasibility. We examine extensions to diverse applications such as cognition, spectral coexistence, matrix completion, autonomous driving, ground penetration radar, multiple-input-multiple-output and synthetic aperture radars. Finally, we connect the cognition in radars to some interesting applications of deep learning.	

Commission D

Title	Lecturer name, affiliation
Radiofrequency identification against COVID-19: How state of the art RFID technology and research may help facing pandemics	Gaetano Marrocco University of Roma Tor Vergata
COVID-19 pandemic is abruptly changing the way we live, starting from social interactions and healthcare, up to transportation and recreation. While waiting for the massive immunologic effects of the vaccine, whose distribution has recently started revealing sensible logistic issues related to packaging tamper-proof, storage temperature, traceability and adverse effects, worldwide existing technologies as well as discoveries, have been quickly redirecting to mitigate the infection risks and contribute to a rapid recovery of activities and normal daily life. In particular, the fight against the infection outbreak can benefit from pervasive wireless things, like electronic labels and wearable devices, that can be specialized in a fan of options sharing the same infrastructures, standards, and expertise. This keynote will show how the assessed pillar of the Internet of Things, namely the Radiofrequency Identification (RFID) technology, and in particular the emerging class of sensor-oriented devices and services, could be used in the short term to support the fight against COVID-19 and the pandemics of the future. Based on the pillars of antiCOVID countermeasures, three macro-topics will be addressed: i) Personal Protective Equipment (PPE) - supply, usage, and management; ii) Access control, contact tracing and indoor ambient quality; iii) Predictive and Preventive Healthcare. For each topic, the keynote will resume the state of the art of RFID devices and will describe the processes that have been already implemented for that application, as well as those technologies that have been applied to different scenarios but could deserve a try in the fight against pandemics. The overall purpose of the speech is hence to draw a picture of what could be immediately applied, as well as to identify challenges for the finalization of current researches based on Radiofrequency Identification.	

Commission E

Title	Lecturer name, affiliation
Monitoring and predicting terrestrial and space environments using electromagnetic methods	Yasuhide Hobara, The University of Electro-Communications, Tokyo, Japan
In this tutorial lecture, I would like to introduce how observations of both natural and man-made electromagnetic (EM) noise are contributing to monitor terrestrial and environments and mitigate natural disasters. I will focus on three different topics such as (1) lightning discharges, (2) electromagnetic phenomena associated with seismic activities, and (3) space weather. Interdisciplinary approach is highly required to tackle problems related to these topics, and so we should closely collaborate with various URSI scientific commissions such as EFGH.	

Commission F

Title	Lecturer name, affiliation
Radio-waves for Remote sensing of the Earth	Luca Baldini, Institute of Atmospheric Sciences and Climate, Italy
In the last half century, remote sensing methods have been increasingly adopted to provide measurements for many applications that range from the local scale, such as the support in mitigation of weather emergencies such as severe storms and floods to the global scale helping in improving our knowledge of the geophysical and biological processes of the earth system. Earth remote sensing uses wavelengths ranging from acoustic to optical spectrum. For many applications related to atmosphere, land, and ocean, methods based on the use of radio frequencies have carried decisive advantages with respect to methods using different frequencies. The tutorial provides a survey on how radar radio frequency active and passive remote sensing has evolved up to day, starting from pioneering research to the development of operational ground based or satellite-borne systems for Earth monitoring.	

Commission G

Title	Lecturer name, affiliation
Ionospheric Imaging with Assimilative IRI	Ivan Galkin, University of Massachusetts Lowell, USA

Remote sensing of the near space plasma environments of the Earth using radio waves has become the realm of research and applications; however, rarely we see it described in the imaging terms. Even if a visual presentation of the sensor data is an image, e.g., a plasmagram recorded by NASA radio plasma imager (RPI) for IMAGE mission, a non-expert would struggle to intuitively associate signatures in such "images" with the physical phenomena that they represent.

One important step towards true radiowave imaging of the plasmas is presentation of the measurements in a more familiar language outside the experts' box. The paper presents one successful attempt to abstract from the wave data peculiarities and synthesize a clear global picture of the Earth's ionosphere dynamics by assimilating sensor-provided data into a 3D timeline of the ionospheric plasma dynamics. In turn, the 3D density specification admits significantly more intuitive presentations such as 2D global maps in Figure 1.

PEAK DENSITY, F2 LAYER   PEAK HEIGHT, F2 LAYER   HALF-THICKNESS, F2 LAYER

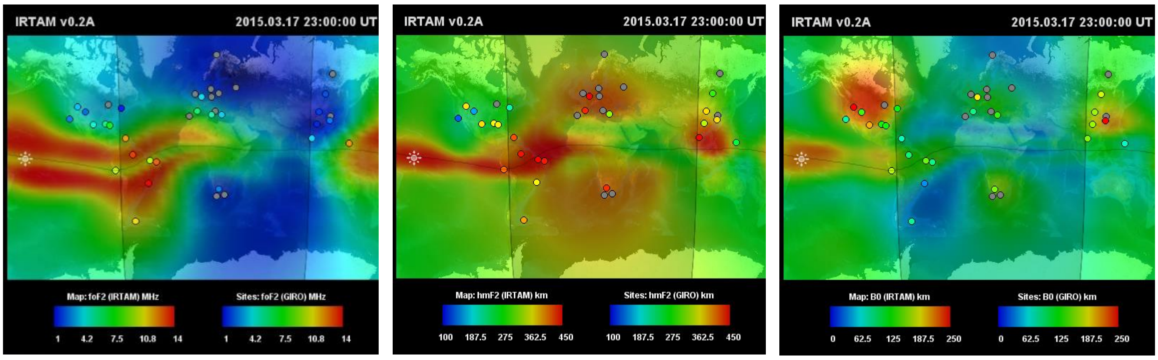

Figure 1: Imaging the ionospheric F2 layer during the Halloween storm, 2015.03.17 23:00 UT, using IRTAM global weather nowcast (color surface) driven by GIRO ionosonde measurements (dots).

In Figure 1, color surfaces correspond to the 2D maps of the key F2 layer parameters computed by IRI-based Real-Time Assimilative Model (IRTAM) [1] that smoothly transforms ("morphs") the underlying International Reference Ionosphere (IRI) climatology into agreement with the low-latency measurements from ionosondes of the Global Ionosphere Radio Observatory (GIRO) [2], for a rapid look at the ionospheric weather timeline.

Under the hood of IRTAM, the Non-linear Error Compensation Technique with Associate Restoration (NECTAR) [3] analyses the ionospheric dynamics over the 24-hour period preceding the computation in order to sense the diurnal harmonics of plasma variability. The NECTAR view of the ionosphere in terms of its internal, periodic planetary-scale "eigen" basis allows it to associate the activity fragments at the sparse GIRO sites with unveiling grand-scale weather processes of the matching temporal scales, as the observatories co-rotate with the Earth. The IRTAM team actively pursues two new collaborative projects to enhance its ionosphere imaging capability: (a) multi-site GNSS VTEC data service to retrieve the slab thickness of the ionosphere and to distinguish ionosphere/plasmasphere contributions to the weather variability and (b) COSMIC-derived radio occultation profiles for improved peak height representation and extended IRTAM coverage to the topside ionosphere.

References:

[1] Galkin, I. A., B. W. Reinisch, and D. Bilitza (2018), Realistic Ionosphere: real-time ionosonde service for ISWI, Sun and Geosphere, 13, No.2, doi: 10.31401/SunGeo.2018.02.09.

[2] Reinisch, B.W. and I.A. Galkin (2011), Global Ionospheric Radio Observatory (GIRO), Earth Planets Space, vol. 63 no. 4 pp. 377-381, doi:10.5047/eps.2011.03.001.

[3] Galkin, I. A., B. W. Reinisch, et al., (2020), Assimilation of Sparse Continuous Near-Earth Weather Measurements by NECTAR Model Morphing, (submitted to Space Weather, 2020SW002463).

Commission H

Title	Lecturer name, affiliation
Machine learning in space physics and space weather	Jacob Bortnik University of California at Los Angeles

The volume of space physics data continues to rise exponentially, and promises to accelerate its growth in the near future to the point that individual projects return on the order of a petabyte of data. At the same time, our analysis techniques have not kept pace with the rapid growth of data, and often do not exploit the capabilities of the data to their fullest potential. In this talk, we present a novel method based on machine learning technology, that aims to convert a sequence of point measurements of some given quantity Q made over a long period of time (for example observations made on a satellite), into a 3-dimensional dynamic spatiotemporal model of that quantity. As an example, we show a three-dimensional dynamic electron density (DEN3D) model in the inner magnetosphere, that can provide full coverage of the inner magnetosphere and in fact is sufficiently accurate that it points the way to new physical discoveries. For instance, we report, an unexpected plasmaspheric density increase at low L shell regions on the nightside during the main phase of a moderate storm during 12-16 October 2004, as opposed to the expected density decrease due to storm-time plasmaspheric erosion. Since plasmaspheric density values have been shown to be the largest source of error in radiation belt models, we also show reconstructions of whistler-mode chorus and plasmaspheric hiss waves, and show how these models can be used as inputs to downstream models, that can subsequently predict the dynamics of 'data starved' quantities, such as ultra-relativistic electron fluxes.

Commission J

Title	Lecturer name, affiliation
The Past, Present and Future of Phased Array Feeds in Radio Astronomy	Wim van Cappellen ASTRON, The Netherlands Institute for Radio Astronomy

Reflector antennas with multiple beams traditionally use several electrically large feeds (such as horn antennas) to optimize the antenna efficiency. Consequently, the beams that they provide are widely separated on the sky, leaving large angular gaps "unused". Research in the late 1970s and early 1980s provided the notion that the electromagnetic fields in the focal plane of a reflector antenna carry all the information to observe a contiguous field of view that is much larger than the single beam of traditional feed antennas. At that time, it was still unclear how this idea could be applied, but the mental seed was planted. In the following decades, the puzzle was solved step-by-step, enabled by new technologies becoming available, such as antennas to densely sample the focal fields over a wide frequency range, low-noise amplifiers, and algorithms and computing platforms to efficiently process the information. Nowadays, the antenna concept of a fully sampling receiver in the focal plane of a reflector is known as a Phased Array Feed, and the first radio telescopes using Phased Array Feeds are in science operations. The recent success of Phased Array Feeds in radio astronomy has generated interest in other domains, such as earth observation [1] and telecommunications [2,3]. The mobile fifth generation (5G) operates at higher frequencies. Compared to the previous generation, base stations require more antenna gain to compensate for the increased path-loss at mm-wave frequencies. Phased array feeds can deliver the required antenna performance while keeping the power dissipation under control.The future of Phased Array feeds is bright, and their development continues in various domains. In radio astronomy, the results and promises of Phased Array Feeds align closely with the ambitious goals of the Square Kilometre Array [4]. Key challenges are to reduce costs of RF electronics, data transport and data processing, to lower the noise temperature, and manage the operational complexity. These developments will make future Phased Array Feeds even more competitive in large and smaller dishes, and at frequencies above the L-band.

Commission K

Title	Lecturer name, affiliation
ICNIRP guidelines on RF EMF human exposure limitations	Rodney Croft University of Wollongong, Australia
The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has recently updated its radiofrequency (RF) electromagnetic field (EMF) guidelines. These Guidelines replace the 1998 RF EMF Guidelines, incorporate important improvements in the radiation protection science since 1998, and are particularly important to 5G as they include changes to the restrictions relating to frequencies above 6 GHz. This presentation will provide a background to ICNIRP and its RF EMF guidelines, with a particular focus on issues pertinent to 5G. It will cover this topic both from the perspective of the intention and adequacy of the guidelines to provide protection, as well as through consideration of how the guidelines deal with issues that are often raised by media.	