SHORT COURSES

SC1 (3H)	Lecturer name, affiliation
Data science and data engineering for modern weather radar	Renzo Bechini, Arpa Piemonte, Torino, Italy Luca Baldini, Istituto di Scienze dell’Atmosfera e del Clima, Roma, Italy Robert M. Beauchamp, Jet Propulsion Laboratory, CalTech, USA

The course will start teaching the fundamental principles of propagation and scattering in the context of dual-polarization Doppler weather radar.

A discussion of weather radar signals and advanced techniques of signal processing will follow, illustrating the peculiarities of distributed weather targets, relevant statistical models, and estimation of radar parameters.

The second part of the course will focus more on applications and the interpretation of polarimetric radar observations in a variety of meteorological contexts.

- Introduction to weather radar
- Propagation and scattering in precipitation media
- Weather radar signals
- Advanced signal processing techniques
- Precipitation processes relevant for dual-polarization measurements
- Interpretation of polarimetric Doppler weather observations

Discussion

SC2 (6H)	Lecturer name, affiliation
Resonant interaction between coherent whistler-mode wave packets and energetic particles in an inhomogeneous plasma (magnetosphere).	David Shklyar, Space Research Institute of RAS, Moscow, Russia

The course aims to cover basic ideas in the theory of resonant wave-particle interactions in an inhomogeneous plasma, and is strongly oriented to magnetospheric applications, in particular, to the energetic particle dynamics in the Earth’s radiation belts. Basic knowledge of plasma physics and wave propagation would facilitate learning the course, although is not indispensable, as all essential points necessary for understanding the subject matter will be explained during the lectures. The course will bring the audience to the state of the art in the theory of resonant wave-particle interactions in the magnetosphere and its applications to the physics of the radiation belts.

1. Wave modes involved in resonant wave-particle interactions (RWPI) in the magnetospheric plasma.
2. Whistler-mode waves: dispersion relation and polarization. Main features of whistler wave propagation in the magnetosphere: Storey’s theorem, Gendrin angle.
3. Main concepts of resonant WPI. Governing equations: equations for the wave field and resonant particle distribution function.
4. Resonant interaction in the case of parallel whistler wave propagation. The cases of strong and weak inhomogeneity.
5. General case of oblique propagation. Effects of RWPI: wave evolution and particle precipitation.
6. The nature of particle energization via RWPI in the inhomogeneous magnetospheric plasma.
7. Energy transfer from lower to higher-energy electrons in the radiation belts.

SC3 (3H)	Lecturer name, affiliation
Spectrum Management and Radio Frequency Interference in Microwave Remote Sensing	Paolo de Matthaeis, NASA Goddard Space Flight Center, Greenbelt, MD, USA Thomas von Deak, NASA spectrum manager-retired

The demand for radio frequency spectrum is continually increasing, particularly from commercial services such as wireless broadband communications. As a result, remote sensing instruments are experiencing Radio Frequency Interference (RFI) more and more often. RFI is a significant threat to effective microwave remote sensing and needs proper attention from scientists, engineers, and RF regulators.

This tutorial will consists of two parts. The first part will provide an overall review of spectrum management concepts specifically relevant to the protection of the electromagnetic spectrum used for scientific microwave remote sensing applications will be given. The second part will cover the current available techniques used to detect and mitigate RFI in both passive and active sensors.

This tutorial will be very useful for anyone interested in learning about RFI. The target audience is recent engineer graduates who seek a career development in the remote sensing community and mission managers looking for possible ways to address RFI.1. Wave modes involved in resonant wave-particle interactions (RWPI) in the magnetospheric plasma.

Spectrum Management:

- Basic Definitions: services, spectrum allocations etc.
- The International Radio Regulations and World Radiocommunication Conferences
- RFI reporting procedures

RFI in Microwave Remote Sensing:

- Overview and examples of interference
- Issues and algorithms in passive sensors
- Issues and algorithms in active sensors

SC4 (6H)	Lecturer name, affiliation
Uncertainty quantification for electromagnetic applications	Carlo F. M. Carobbi, University of Florence, Firenze, Italy Sébastien Lalléchère, Université Clermont Auvergne, France

In this short course methods for the quantification of uncertainty in measurement and computational modelling are reviewed. The current status of international standards relating to measurement uncertainty is provided, as well as a review of selected alternative methods and recent developments in the domain of computational modelling and empirical uncertainty quantification. Several examples of application of the abovementioned methods will be provided in the fields of radiofrequency, computational electromagnetics and electromagnetic compatibility. Attendees are not required to possess any previous knowledge on uncertainty quantification however familiarity with applied statistics and experimental data analysis, as learned in BSc and MSc university courses, eases comprehension and involvement. The topics under consideration will cover (with no restriction) fields of commissions A-C, E and K.

This short course will cover several topics of uncertainty quantification providing solid knowledge of the fundamental methods adopted in measurements and in computational modelling. More specifically, when dealing with uncertainty quantification in measurements the following topics will be presented and discussed: modelling, propagation of uncertainties, propagation of distributions, calculation of coverage intervals. Uncertainty quantification will be illustrated from examples in the fields of radiofrequency measurements, modelling of complex electromagnetic environments, reliability and sensitivity of electromagnetic systems, margins and risk assessments for electronics.

SC5 (3H)	Lecturer name, affiliation
Patents and Intellectual Property: a Wide-Open Door to Research	Luca Scorrano, Elettronica S.p.A., Rome, Italy

This short course is aimed at researchers and professionals willing to approach intellectual property and patents for the first time.

Patents are not a mere tool to keep safe owners’ rights on intellectual property but a wide open doors to new technology trends, inexhaustible source of inspirations and an effective tool to focus the attention of possible investors.

The course will include but it won’t be limited to:

- Patents and intellectual property basics (definitions, organizations, regulations);
- Prior art and search tools (how to perform a state of art research on a particular field by using patents, patents classification);
- Cost-benefit analysis of a patent (academic and industrial benefit of patents, economic enhancement of a patent);
- How to write a patent: hints and tips (structure and formalities of a patent);
- Patent management and maintenance.

SC6 (3H)	Lecturer name, affiliation
Fundamental role of magnetic field of Saturn for the rings origin: Diamagnetism and Quantum Phenomena. Why Maxwell was so close to solve this problem	Vladimir Viktorovich Tchernyi (Cherny), Modern Science Institute, SAIBR. Moscow, Russia

Here is presented origin of Saturn's rings due to Interaction of own magnetic field of Saturn with magnetized particles of protoplanetary cloud. It is based on the data of Cassini mission. After appearance of the magnetic field of Saturn all chaotic orbits of icy particles start to shift to the magnetic equator plane, where there is a minimum of their magnetic energy. It happened due to diamagnetic force of expulsion like Meissner phenomenon. Each particle comes to the stable position at Saturn's magnetic equator preventing its own horizontal and vertical shift. Particles are locked within three-dimensional magnetic well due to expelling magnetic field from them & due to Abrikosov quantum vortex phenomenon for superconductor. Final picture is similar to the picture of iron particles forms the same shape around a magnet on laboratory table.

Short course started with the history of problem from the time Galilei discovered rings of Saturn. Then listed world scientists with explanation what they contributed to the problem, such as Huygens, Cassini, Maxwell, Kuiper, Alfven, etc. Then follows description of the non solved yet problems & how we try to resolve them, method of solution of electromagnetic problem of the Saturn's rings origin, explanation why we have to take into account of diamagnetism & superconductivity of the rings particles, detailed consideration of the observed phenomena in the Saturn's rings & how we can explain them using our model & data of Cassini mission. Presentation is well illustrated by photo & video materials of observed phenomena of Saturn's rings, & by interpretation of them on the bases of our theory.. Presentation itself well understandable by professionals & people with high school education.

SC7 (8H)	Lecturer name, affiliation
2021 URSI Commission B School for Young Scientists - Wireless data and power transfer: approaching antenna near-field region from far field	Giuliano Manara, University of Pisa, Italy Paolo Nepa, University of Pisa, Italy

Conventional wireless applications are often characterized by a large distance in terms of wavelengths between the transmitting antennas and the receiving antennas or scatterers, allowing the application of far-field approximations, as well as standard characteristic parameters and measurement methods. Nonetheless, there is an increasing number of wireless systems where the far-field condition is not met and specific coupling models and ad-hoc antenna design criteria must be necessarily adopted to the end of optimizing system performance. Regarding near-field applications, we can mention wireless power transfer, near-field communications (NFC), RFID technology, antenna measurements, material sample characterization and non-destructive sensing, chip-to-chip wireless links, biomedical applications, body-centric communications, microwave imaging, among many others.

The course aims to present an overview of the properties of antenna near field, antenna design criteria for close-proximity wireless links, and simple yet accurate models for near-field coupling. The course also provides a survey of advanced near-field applications in the context of wireless links for communications, power transfer, identification and sensing.

- Features and properties of the antenna near field
- Review of near-field wireless applications
- Analysis and modeling of near-field coupling for short-range radio links
- Technologies for near-field antennas
- Proximity antenna design
- Synthesis techniques for focused arrays
- Near-field focused antennas: focal-spot shaping, multi-focusing and adaptive focusing

SC8 (3H)	Lecturer name, affiliation
Introduction to electromagnetic reverberation chambers – Theory, Applications and Research	Ramiro Serra, Eindhoven University of Technology, The Netherlands Philippe Besnier, Institut d'Electronique et de Télécommunications de Rennes, France

Reverberation chambers (RC) are laboratory-controlled electromagnetic environments that can generate random fields with known and predictable probability density functions. They are widely used for different electromagnetic compatibility measurements, antenna efficiency estimation, over-the-air tests for wireless systems, and electrical characterization of materials, among other uses and applications.

What are the basic principles of operation of RCs? How to model and predict the distribution of the fields in a RC? How to perform measurements in a RC and interpret the results? What are some of the latest developments and research questions in the field of RCs? This short course will provide some basic though fundamental answers to these questions. A live, hands-on experiment with a RC has been prepared and will give the attendees the opportunity to perform measurements as well.

- Introduction to RCs: basic principles of operation
- Statistical models:
    - Random modal overlap and the CLT (Kostas and Boverie)
    - Plane-wave integral representation and the principle of maximum entropy (Hill)
- The ergodic principle and the different stirring strategies
- Performance indicators and how to interpret measurement results in RCs
- An overview of the standardized uses and applications for RCs
- RCs in academia and industry
- Hands-on demonstration and experiments with the audience

<table>
<tr><td>SC9 (6H)</td><td>Lecturer name, affiliation</td></tr>
<tr><td>Mm wave propagation measurements and modelling for 5G and beyond</td><td>Sana Salous, University of Durham, UK
Andrés Alayon Glazunov, University of Twente, The netherlands
Vittorio Degli Esposti, University of Bologna, Italy</td></tr>
<tr><td colspan="2">In the course an overview of propagation scenarios for future wireless networks making use of mm-wave frequencies will be provided together with a critical discussion of the peculiar characteristics of mm-wave propagation vs. sub-6 GHz propagation. In particular, the electromagnetic characteristics of construction materials at mm-wave frequencies at various frequencies, penetration attenuation, diffuse scattering as well as blocking due to the human body and objects will be discussed. Propagation and channel models for mm-wave systems will also be illustrated, with particular focus on the trend toward deterministic propagation modelling and toward the use of machine learning in channel prediction applications.
The course will also cover propagation measurements methodologies and the extraction of empirical path loss models for various deployment scenarios which include indoor, outdoor and outdoor to indoor for penetration loss measurements. The requirements of wideband measurements for prediction of channel parameters such as delay spread are discussed with suitable channel sounder architectures.
5G and beyond wireless networks rely on the performance of multiple antenna systems. The design and characterization of these antenna systems must be performed cost and time efficiently to produce high quality products for the end-users. At the same time, the Over-The-Air (OTA) test and characterization methods must operate on the basis of meaningful figures of merit that can be measured with good repeatability and reliability. The course will cover various OTA characterization techniques, e.g., based on reverberation chambers and plane wave generators in rich isotropic multipath (RIMP) and random line-of-sight (Random-LOS) environments, respectively. OTA for cellular and automotive applications will be addressed.</td></tr>
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<tr><td>SC10 (3H)</td><td>Lecturer name, affiliation</td></tr>
<tr><td>Machine Learning approaches with GNU radio</td><td>Jonathan Villain, University Gustave Eiffel, Villeneuve d’Ascq, France
Virginie Deniau, University Gustave Eiffel, Villeneuve d’Ascq, France</td></tr>
<tr><td colspan="2">AI and Machine Learning are transforming the fundamentals of software development. For software engineers, software architects and software leaders, embracing these technologies and learning the core skills are critical components for capitalising on this new trend.
Machine learning is at the heart of data science and applies to a multitude of fields such as face recognition by computer, machine translation from one language to another,... In the electromagnetism domain, Machine learning is essentially oriented in its classification approach to identify different profiles of electromagnetic interferences, communication, propagation channel...
In this short course, we will introduce different machine learning approaches for classification. We will highlight the level of complexity and the type of data that are adapted for each learning approach.
We will deploy different approaches using python codes in GNU radio environment. GNU Radio is a free software development toolkit that provides signal-processing blocks to implement software-defined radios and signal-processing systems. It can be used with external RF hardware to create software-defined radios, or without hardware in a simulation-like environment.
By practical learning paths, this short course will present the essential tools, practices, and techniques, which each one will be able to use immediately. Get hands-on experience and engage in practical assessments to apply your learning.</td></tr>
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SC11 (3H)	Lecturer name, affiliation
The Theory and Application of Nano Plasmas: virtual optical applications with simulation tools	Taner Sengor, Retired, Yildiz Technical University, Istanbul, Turkey

The course will present a quicken but complete looking through the phenomena and techniques on the nanometer scale focusing on plasmas. The theoretical principles of nanobody-atomic-subatomic structures up to the laser clusters involving the interactions among them will be studied. Gaining a global view to scientific development will be focused from the approaches given in the contents of the course. Some examples related to the laser clusters will be given for design purposes. The topic of the course is an emerging new field of study, motivated by rapid advances of nanoscience and nanotechnology. These areas offer their need for adequate tools and strategies for fabricating, manipulating, and characterizing the devices at the nanometer scale.

The nanoscience is an active and evolving field at every major area. Also, any nano-topic related to electromagnetism is easily overlap with other fields such as quantum electrodynamics, physical optics, quantum optics, and thus the boundaries cannot be clearly defined. Any nano-topic is the first step providing the foundations of many fields of the contemporary sciences from the other point of view. A global point of view on scientific developments may be gained from the approaches given in the contents of the course.

- Introduction: Qed Vacuum And Induced Forces, Forces And Duality, Dipole Systems
- General Theory
- Magnetodielectric Bodies
- Atom-Field Dynamics
- Laser Driven Nano-Plasma
- Theories Of Nano-Plasma
- Nano-Optic
- Examples For Laser Cluster Production

SC12 (3H)	Lecturer name, affiliation
The Inflective Coordinates, Spaces, and Waves	Taner Sengor, Retired, Yildiz Technical University, Istanbul, Turkey

The inflection points raise some critical problems in electromagnetic phenomena. The course aimed to open the analytical insights behind the inflection points when the solutions of the basic field equations are asked by using different perspectives than the approaches in open literature and the analytical insights behind the inflection points when the solutions of the basic field equations are asked. The inflective coordinates family is defined and the essential analytical expressions for the solution of field and wave problems with inflection points are given. The evaluation is based to the inflective series defined and obtained by applying the extracted separation method. The applications of the method for some structures are given; i.e., the wave phenomena around the arrays involving inflection points in antenna applications.The structure intends overcoming the difficulties related to the embedded antenna structures dedicated for wideband propagation elements in integrated circuits, systems, and devices. Developing some useful radiation structures are studied.

- The inflective coordinates family and inflective spaces.
- The contribution of inflection points to fields and waves.
- Inflective wave concept.
- Inflective nanowires.
- Inflective waveguides.
- Inflective antennas: wire, array configurations.
- Inflective mechanisms in QED structures.