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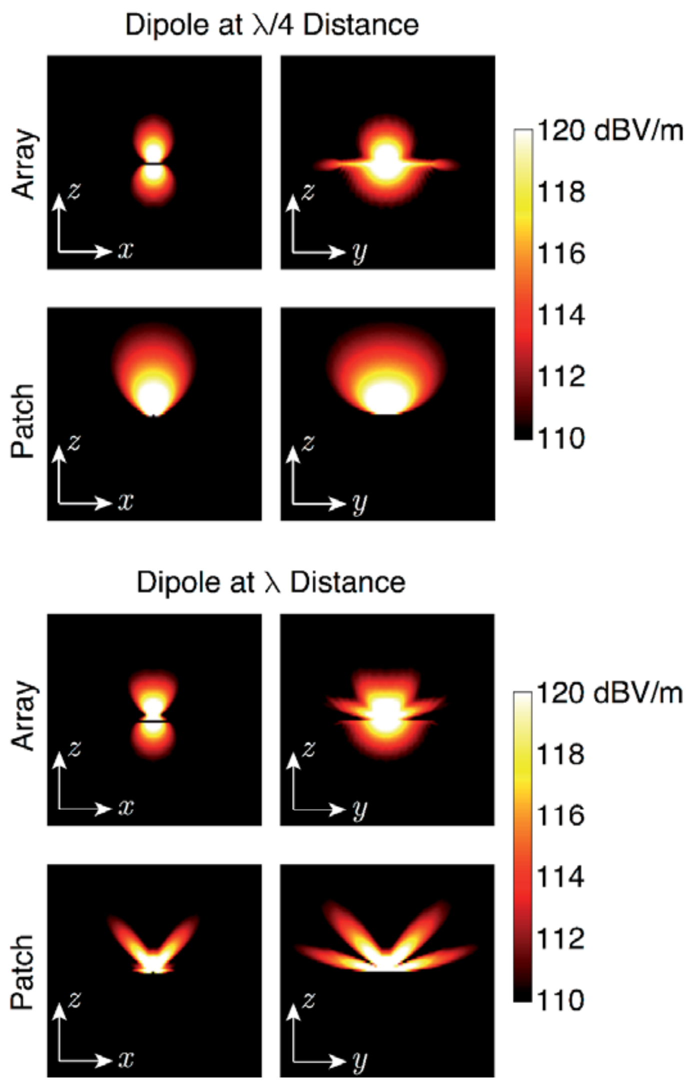

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Contents

Cover: The solutions of radiation problems involving a diamond-shaped array of dimensions $22.8\lambda \times 15.1\lambda$ with 7569 metallic strips and a diamond-shaped patch of the same size. The near-zone electric-field intensity distributions with respect to position are shown on different planes and for different excitations. See the Solution Box column by Sinan Emre Senem, Sena Alkış, and Özgür Ergül.(pp. 9-11)

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A Little Electromagnetic Humor

When Stefano Selleri submitted his paper that appears in this issue, he referred to it as a "short, humoristic" piece. While the basic premise of evaluating the electromagnetic shielding effectiveness of medieval chain mail is certainly humorous, the analysis and results are of scientific interest. It turns out the chain mail can be modeled as a periodic surface, which has different properties depending on whether it is assumed that the links are conductively isolated or connected. An analysis of the shielding effects was done over the frequency range from 100 MHz to 10 GHz. Having obtained these results, the author does have some fun applying them to possible use scenarios. It is my understanding that no knights were injured during this research....

Our Other Contributions

In his Et Cetera column, Tayfun Akgul gives us a look at some inventive ways for using certain cell-phone functions.

Krishnasamy Selvan is a guest author in the Ethically Speaking column in this issue, edited by Randy Haupt and Amy Shockley. The author looks at the relationship among science, faith, and openness in the workplace.

In her Women in Radio Science column, Asta Pellinen Wannberg presents an article by Patricia Doherty. Pat is the Chair of URSI Commission G, and is also Director of the Institute for Scientific Research at Boston College. She provides an interesting and "Seussian" look at her career and how it led to her being a radio scientist.

The GASS is Coming!

The 2020 URSI General Assembly and Scientific Symposium will be held August 29-September 5, 2020, at La Sapienza University, Rome. A call for papers will be issued soon. However, of more immediate importance, the URSI Commission topics and organized sessions will be determined at the meeting of the Coordinating Committee to be held at the URSI AP-RASC meeting in New Delhi, India, March 9-15, 2019. If you have a session you would like to organize or a topic you would like to see included in the program for the GASS, please get in touch with the appropriate URSI Commission Chair now, and certainly before the Coordinating Committee meeting. The URSI Commission Chairs and their contact information are listed in the directory in this issue, and also on the URSI Web page at www.ursi.org.

Ross

On the Electromagnetic Shielding Effectiveness of Chain-Mail Armor

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Chain-mail armor was a type of body protection that dates back to the fourth century BC. It was used extensively in times of war up to the advent of firearms. It had a limited use later on, but was still reported as being worn up to the 20th century.

The modern uses of chain mail are mostly civilian, such as protection for butchers, shark protection for divers, and, notably, for historical reenactment and live-action role-playing games. In these latter cases, there is no need that the chain mail really be weapon proof, and it is usually made of aluminum to reduce weight.

It is legitimate to ask ourselves if chain mail could be used as a wearable shield against electromagnetic radiation.

1. Electromagnetic Analysis Approach

Chain mail (Figure 1) is composed of interlocking rings. In the most common form, these are woven so that each ring is connected with four others (Figure 2). The rings are, of course, opened to allow weaving. They may be soldered or riveted for superior strength, or they may just have their ends juxtaposed.

The rings are usually quite small, usually between 3/8 in to 1/2 in (9.5 mm to 1.3 mm) diameter. This makes creating chain mail a long and tedious task, yet this also makes a planar chain-mail sheet a periodic surface. Under the

Figure 1a. The chain-mail armor and equipment of a Polish medium cavalryman, from the second half of the 17th century [Wikipedia, photo by Dariusz T. Wielec, Free Art License 1.3].

Figure 1b. A modern chain-mail coif [Wikimedia commons, photo by Immanuel Giel, public domain].

Figure 2. Modern chain mail. The four-in-one weaving pattern is apparent [Wikimedia Commons, photo by Matthias Kabel, Creative Commons Attribution-Share Alike 3.0 Unported license].

realistic hypothesis that such a sheet of mail is illuminated by an electromagnetic source far enough away in space so that the electromagnetic field can be assumed to have a plane-wave structure, the problem can be analyzed on a single periodic cell with appropriate periodicity boundary conditions (Figure 3 and [1]).

A simplified electromagnetic model is sketched in Figure 3. For completeness, two models were considered. The first was an "isolated" model, in which no electrical connection was present between rings, hence effectively simulating passivated or painted surfaces, allowing for capacitive coupling but not for current flow. The second was a "connected" model, in which the rings were touching, hence simulating electrical connection between rings and hence the possibility of current flow among them. In both cases, the rings were modeled as a toroid with a radius of revolution of 6 mm (0.23622 in) and a revolving section that was a circle. For the "isolated" case, the radius of the revolving section was 0.75 mm (29.52 mils), while for the "connected" case, the radius was 1 mm (39.37 mils) (Figure 3).

2. Numerical Results

The problem was hence reduced to that of a periodic cell illuminated by a plane wave, and was numerically solved. The results were given in terms of the transmitted intensity ratio and the reflected intensity ratio, in dB, for both connected and unconnected rings, over a 100 MHz to 10 GHz band (Figure 4). In the figure, the band from 300 MHz to 6000 MHz is highlighted, since it holds most mobile phone standards up to 3G and 4G, going up from 300 MHz to 2600 MHz [2, 3], as well as Wi-Fi, which, as described in IEEE Standard 802.11, covers the 2.4 GHz to 5.9 GHz band [4].

It was apparent from Figure 5 that for the lower part of the spectrum, the chain mail guaranteed at least 20 dB attenuation in the transmission up to 3 GHz, and that the connected mail gave about an extra 5 dB of protection. This was expected, since in the connected mail, current paths could freely cross rings, and not only through parasitic capacitances. In any case, resonances in the mail arose where the ring circumference (about 2 cm) started to be comparable with a wavelength. Indeed, resonances appeared at lower frequencies with respect to a single isolated ring, due to the reactive load of the neighboring rings, causing a significant reduction of shielding effectiveness at the top of the Wi-Fi band.

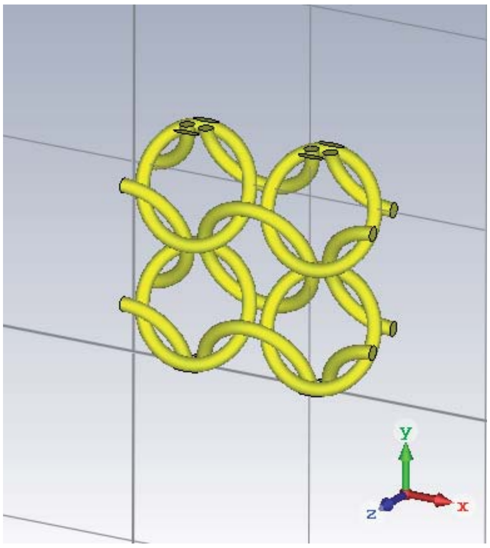

Figure 3a. The isolated-rings model

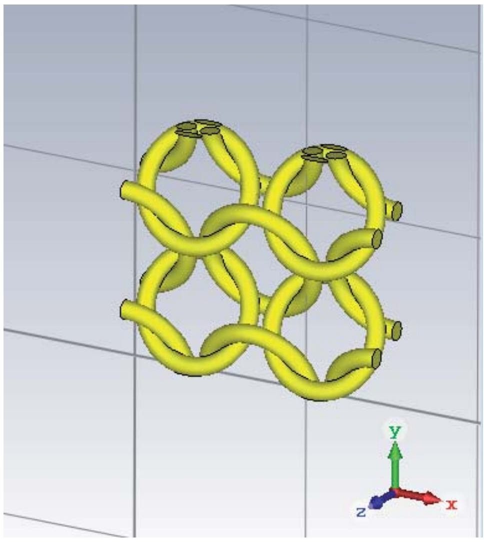

Figure 3b. The connected-rings model.

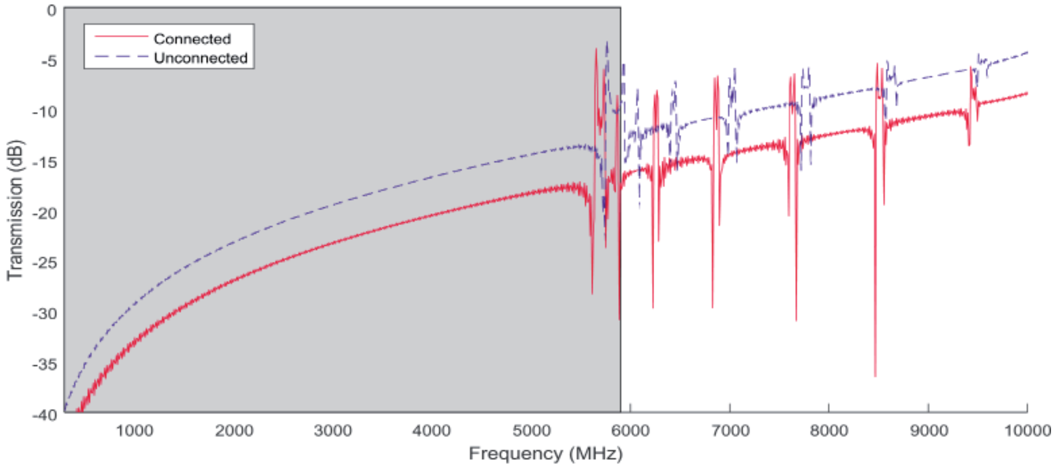

Figure 4. The transmission through the connected (solid line) and unconnected (dashed line) chain mail.

The shielding level (a few tens of dB) was much lower than that of a solid aluminum shield, the effectiveness of which may exceed 100 dB at these frequencies. A solid aluminum or other metal shielding can be provided by full-plate mail, which, unfortunately, is much less comfortable to wear.

3. Clinical Data

Although for ethical reasons it was inappropriate to have volunteers walk around in full chain mail all day long while using their mobile phones or surfing the Internet via Wi-Fi, some indirect proof of beneficial effects on health could be inferred from statistical data on mortality collected when chain mail was fashionable.

By browsing historical references, we have evidence of a large number of deaths during the Crusades (1095-1291) among people wearing various kinds of armor, typically chain mail [5]. However, deaths other than due to old age were credited to pestilences, battle, injuries, or starvation. The author could not find in the records a single case reporting brain cancer, or any other cancer, for that matter [6].

4. Conclusions

Wearing chain mail significantly lowers electromagnetic radiation absorbed by your brain or body. It is anyway advisable to keep the phone outside the coif when talking. Otherwise, radiation would occur within the shield, which would act as a low-*Q*-factor resonant cavity. That would enhance rather than diminish the effects of the radiation.

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IEEE RADIO 2019

IEEE RADIO 2019 CALL FOR PAPERS

IEEE Radio and Antenna Days of the Indian Ocean
23 – 26 September 2019, Reunion Island

IEEE

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The **2019** edition of the **IEEE Radio and Antenna Days of the Indian Ocean (IEEE RADIO 2019)** will be held from **23rd to 26th September 2019** in **Reunion Island**. **IEEE RADIO 2019** is the 7th edition of a series of conferences organized in the Indian Ocean region. The aim of the conference is to discuss recent developments, theories and practical applications covering the whole scope of radio frequency engineering, including radio waves, antennas, propagation and electromagnetic compatibility.

Prospective authors are invited to submit original contributions on their latest research activities. Student papers are strongly encouraged. **IEEE RADIO 2019** will feature three **Best Student Paper Awards**, a **Young Scientist Award** and an **Industrial Engineering Paper Award**. Proposals for special sessions, workshops and tutorials are welcome. A panel of distinguished researchers will deliver keynote speeches/invited talks on recent technology trends and advances.

Topics of the conference

1. Antenna theory
2. Wave propagation and scattering
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4. Analytical and numerical methods
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Language and Venue

The **working language** will be **English**.
The conference will be held in **Reunion Island**.

Important information

Submission of 2-pages paper: 15th May 2019

Proposals for tutorials, special sessions, workshops: 30th May 2019

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"It is always important to have the correct perspective in a selfie."

"The real reason smart phones have vibration mode."

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Science, Faith and Openness in the Workplace

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A rational thought system is defined to be based on "reason and logic, rather than emotion" [1]. Science is generally thought to be such a rational system, as opposed to, for example, religion, which is considered essentially a matter of faith. The implication is that the results obtained in the pursuit of science are objective, and there is no place for faith in accepting them as true.

However, in practice, faith appears to be a factor in the pursuit of science, as well. When a scientific body reports certain findings, there is a general expectation that the objectivity of those findings be taken for granted by those outside of the corresponding specialty and by the common public. It is natural that except for those involved in the research, others would either not have access to or not be able to understand the complex processes and methods involved. Now as is generally expected, if these other persons should take the findings for granted, it would be possible only if they choose to believe – or place *faith* – in the researchers and processes. Faith is thus inherent in science, as well.

One can argue that science has produced several success stories, and therefore its claim to objectivity can be considered a fact. However, as Karl Popper, one of the greatest philosophers of science of the twentieth century, said [2], "science often errs" as well. Even in respect of basic sciences, according to him [3], "*...all knowledge is provisional, conjectural, hypothetical* – we can never finally prove our scientific theories, we can merely (provisionally) confirm or (conclusively) refute them".

Given the above, if one can place faith in what are called scientific findings, it logically follows that one can also choose to place faith in, say, what a religious scripture says. Where one places faith is one's choice, and can be conditioned or necessitated by his or her exposure, knowledge, and other factors.

Scientific and religious faiths can and often do exist together, as evidenced by the lives of many well-known scientists. For example, Werner Heisenberg, one of the founding fathers of quantum physics, said [4]:

> It has repeatedly been claimed that scientific truth cannot be reconciled with the religious interpretation of the world. Although I am now convinced that scientific truth is unassailable in its own field, I have never found it possible to dismiss the content of religious thinking as simply part of an outmoded phase in the consciousness of mankind, a part we shall have to give up from now on. Thus in the course of my life I have repeatedly been compelled to ponder on the relationship of these two regions of thought, for I have never been able to doubt the reality of that to which they point.

To Michael Faraday, one of the greatest experimental scientists of the nineteenth century, in the words of his first biographer, Bence Jones [5],

> ...his religion was a living root of fresh humility, and from first to last it may be seen growing with his fame and reaching its height with his glory, and making him to the end of his life certainly the humblest, whilst he was also the most energetic, the truest, and the kindest of experimental philosophers.

Although wars have been fought over religion, technology, an offshoot of science, has played a significant role in them in recent times. Of course, this is no reason for being critical of either religion or science.

How then can we address the growing intolerance in society? It is possible by noting that any system of thought conceived by man, being always based on limited experiences and observations, gives scope for inevitable variety in views and perspectives. Thus perhaps "no thought systems conceived or conceivable by humans can be flawless and perfect," [6] and hence a true rational idea could be to entertain faith on one or several thought systems such as science, religion, or atheism, but never to be dogmatic about it, so that we never harm another living being in the name of that faith.

With specific reference to our professional sphere, such an attitude can significantly help one to be more open and less judgmental in the workplace. Besides reducing stress for the individual, this can also facilitate establishing a "deep connection to, or relationship with" colleagues, which is a "critical dimension of workplace spirituality" [7].

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13th International Congress on Artificial Materials for Novel Wave Phenomena

Metamaterials 2019

Rome, Italy, 16 – 21 September 2019

The *Thirteenth International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2019*, will comprise a **4-day Conference** (**16–19 September**), and a **2-day Doctoral School** (**20–21 September**). Organized by the *METAMORPHOSE VI AISBL* (www.metamorphose-vi.org), this Congress follows the success of *Metamaterials 2007-2018* and continues the traditions of the highly successful series of *International Conferences on Complex Media and Metamaterials* (*Bianisotropics*) and *Rome International Workshops on Metamaterials and Special Materials for Electromagnetic Applications and Telecommunications*. The Congress will provide a unique topical forum to share the latest results of the metamaterials research in Europe and worldwide. It will bring together the engineering, physics, applied mathematics and material science communities working on artificial materials and their applications in electromagnetism/optics, acoustics/mechanics, transport, and multi-physics.

Paper Submission

Papers should be 2-3 pages long and contain an abstract, a brief conclusion, and a main body where technical content and novelty of the work are clearly presented.
Papers should be submitted as camera-ready PDF files to the website:

http://congress2019.metamorphose-vi.org

Authors are requested to use the template provided on the Congress website when preparing their submission. Authors of accepted and presented papers will be given the option of publishing their work in IEEE Xplore subject to the manuscript compliance with the format and copyright requirements.

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Contact

contact@metamorphose-vi.org

Submission deadline

10 March 2019

Topics

We interpret metamaterials as rationally designed composites, the effective properties of which go beyond their bulk ingredients, qualitatively and/or quantitatively. **We accept papers in any combination out of the following 8 categories**:

Category 1 - Area
- Electromagnetic from DC to optical and beyond (including, e.g., metallic, dielectric, magnetic, and superconducting ingredients)
- Acoustic and mechanical (including, e.g., seismic)
- Transport (including, e.g., nanoelectronics, and thermal transport)
- Multi-physics

Category 2 - Geometry
- 1D, 2D, and 3D metamaterials and metasurfaces
- (1+1)D, (2+1)D, and (3+1)D space-time metamaterials and metasurfaces
- Individual meta-atoms
- Meta-systems (including, e.g., gradient metamaterials, metamaterials in architectures designed by coordinate transformations, as well as far-field and near-field imaging systems)

Category 3 - Arrangement
- Periodic
- Non-periodic

Category 4 - Frequency
- Static
- Dynamic (including wave propagation)

Category 5 - Type
- Passive
- Active

Category 6 - Status
- Fixed properties
- Tunable properties (including, e.g., modulators, switchable properties, software-defined, and adaptive properties)

Category 7 - Physical basis
- Classical (linear and nonlinear, including, e.g., multistable and programmable)
- Quantum

Category 8 - Technology Readiness Level
- Effective-medium theories and homogenization (including, e.g., high-frequency and high-contrast homogenization and spatial dispersion modelling)
- Design (including, e.g., analytical approaches, topology optimization, numerical methods, machine and deep learning, bio-inspiration)
- Fabrication and characterization (including, e.g., new manufacturing approaches, 3D additive manufacturing, parameter retrieval, reliability testing, and fatigue testing)
- Applications and commercialization (including, e.g., antennas, sensing, spectral and spatial filtering, civil engineering, marine engineering, biology, and earthquake protection)

In addition, we accept papers on composites, plasmonics, photonic crystals, phononic crystals, and invisibility cloaking if related to the scope of the congress in some way.

Solution Box

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SOLBOX-14

Sinan Emre Senem, Sena Alkış, and Özgür Ergül

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1. Introduction

Arrays are fundamental structures in all areas of electromagnetics and they are natural components of antenna systems, microwave components, and optical devices. Unsurprisingly, numerous electromagnetic analysis and solution techniques have been developed in the literature for arrays, leading to many implementations with diverse capabilities, e.g., from "instant" but approximate array-factor approaches, to time-consuming but accurate full-wave solutions. The suitability of a solver naturally depends on the array (e.g., array elements, positioning of elements, periodicity, electrical sizes, material properties), the existence of other structures (e.g., a platform on which the array is mounted, an object to be detected in radar scenarios, a human body that interacts with the array), as well as the required accuracy and preciseness of numerical solutions. Even an infinite model may perfectly work in some applications, while extremely sophisticated and elaborate techniques may be needed to analyze an array used in critical scenarios.

In SOLBOX-14, a relatively simple but still challenging set of problems involving arrays of strips are considered. Accurate solutions of the presented problems involve several challenges:

- They involve large numbers of elements (i.e., 7569 and 16,200).
- They are finite but electrically large (i.e., $> 20\lambda$, where λ is the wavelength).
- They are excited by nearby sources, i.e., dipoles located above them, so that array elements are excited quite nonuniformly.

Sample solutions, which are also presented in this issue, were obtained via a relatively direct approach using a full-wave electromagnetic solver, while the contributors believe that more-efficient and/or accurate solutions should be achieved by using alternative approaches. Please do not hesitate to send and share your solutions for SOLBOX-14, as well as for the previous problems defined in SOLBOX-01 to SOLBOX-13, in this column.

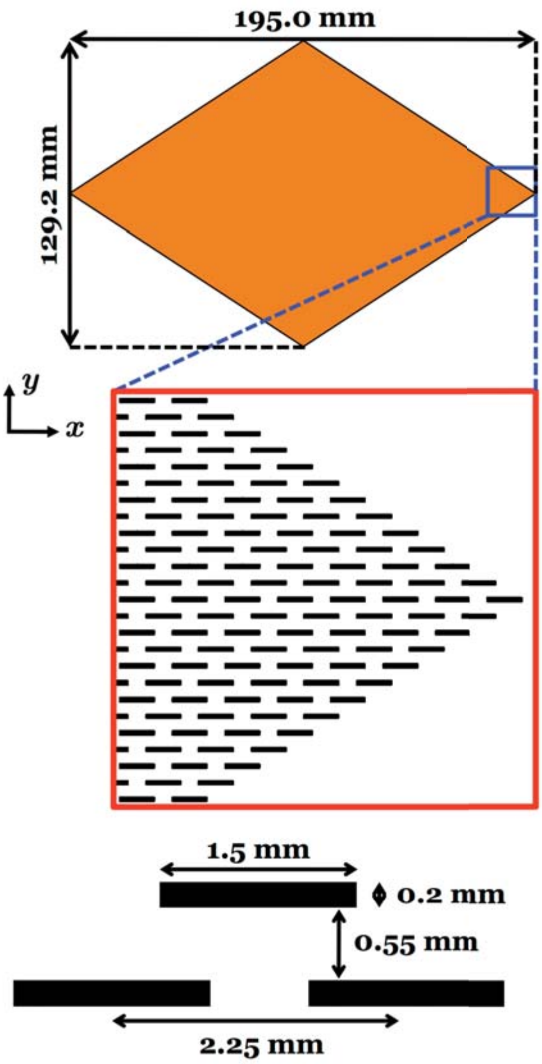

Figure 1. A diamond-shaped two-dimensional array of 7569 metallic strips.

2. Problems

2.1 Problem SOLBOX-14

(by *Sinan Emre Senem, Sena Alkış, and Özgür Ergül*)

Problem SOLBOX-14 involves two different arrays of metallic strips that are located on the *x-y* plane. Each strip has a length of 1.5 mm and a width of 0.2 mm, while their positioning with respect to each other was taken from [1]. Using the perfect-conduction assumption, the thicknesses of the strips can be assumed to be zero; however, they may also have nonzero thicknesses. As shown in Figure 1, the first array is an arrangement of 7569 strips in a diamond shape. The overall size of the array is 195.0 mm × 129.2 mm. The second array, shown in Figure 2, is an arrangement of 180 × 90 strips, leading to a structure with a size of 202.9 mm × 134.4 mm. Each array is excited by a small time-harmonic source, which can be modeled as a Hertzian dipole, located close to the strips. In the sample results, the Hertzian dipoles were assumed to be located symmetrically at a distance $\lambda/4$ or λ above the arrays, where λ is the wavelength at the selected operating frequency of 35 GHz. The arrays were expected to be simulated above 20 GHz, i.e., at the frequency ranges that have recently attracted great interest in the context of 5G applications. As to the simulation results, the near-zone or far-zone radiation characteristics, e.g., electric-field intensity distributions with respect to position, can be presented.

3. Solution To Problem SOLBOX-14

3.1 Solution Summary

Solver type (e.g., Noncommercial, commercial): Noncommercial research-based code developed at CEMMETU, Ankara, Turkey
Solution core algorithm or method: Frequency-domain MLFMA
Programming language or environment (if applicable): *MATLAB + MEX*
Computer properties and used resources: 2.5 GHz Intel Xeon E5-2680v3 processors (using 1 core)
Total time required to produce the results shown (categories:

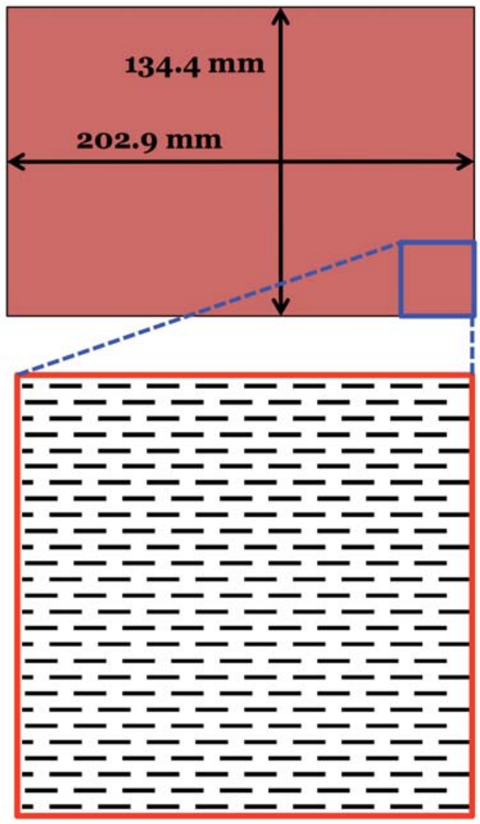

Figure 2. A rectangular two-dimensional array of 180 × 90 metallic strips.

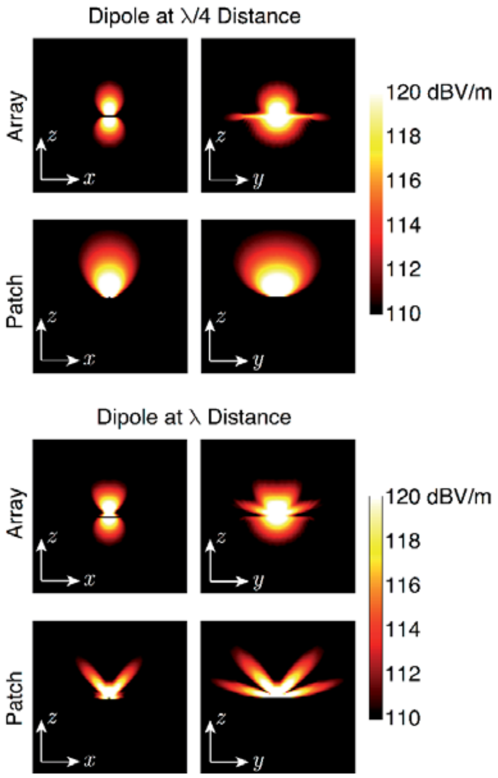

Figure 3. The solutions of radiation problems involving the diamond-shaped array depicted in Figure 1 and a diamond-shaped patch of the same size. The near-zone electric-field intensity distributions with respect to position are shown on different planes and for different excitations.

< 1 sec, < 10 sec, < 1 min, < 10 min, < 1 hour, < 10 hours, < 1 day, < 10 days, > 10 days) <1 hour for each solution

3.2 Short Description of the Numerical Solutions

The array problems described in SOLBOX-14 were formulated by using the electric-field integral equation in the frequency domain and solved by using the Multilevel Fast Multipole Algorithm (MLFMA) [2]. The frequency was set to 35 GHz, and the strips were assumed to be perfectly conducting. At this frequency, the size of the diamond-shaped array was approximately $22.8\lambda \times 15.1\lambda$, while the rectangular array had dimensions of $23.7\lambda \times 15.7\lambda$. A standard set of the Rao-Wilton-Glisson functions was used to expand the electric-current density induced on the strips. Using four triangles per strip for modeling, 30,276 and 64,800 triangles were used for the diamond-shaped and the rectangular arrays, respectively. As also mentioned in the problem definition, the excitations were modeled as Hertzian dipoles. The Generalized Minimal Residual (GMRES) algorithm was used for iterations, while the iterative convergence criteria was set to 0.001 in all solutions.

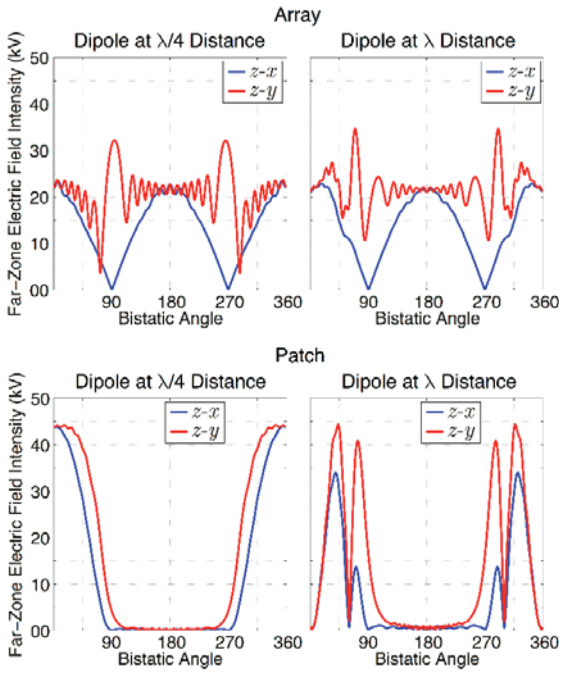

Figure 4. The solutions of radiation problems involving the diamond-shaped array depicted in Figure 1 and a diamond-shaped patch of the same size. The far-zone electric-field intensity values with respect to direction are shown on different cuts and for different excitations.

3.3 Results

Figures 3 and 4 present the results when the diamond-shaped array was excited by an *x*-directed Hertzian dipole with unit dipole moment located at $\lambda/4$ or λ above the array. For comparison, a perfectly conducting zero-thickness patch with the same dimensions was considered. Figure 3 includes the amplitude of the near-zone total electric-field intensity (in dBV/m) in the vicinity of the array/patch sampled on the *z*-*x* and *z*-*y* planes. The patch acted as a good reflector with vanishing field values below it, while the overall radiation in the *z* direction was enhanced. A single beam was observed when the dipole was $\lambda/4$ above the patch. However, when the distance was enlarged multiple beams were generated, as expected. On the other hand, as somewhat predicted, the array behaved quite differently. On the *z*-*x* plane, the structure seemed to be transparent so that the radiation of the dipole was slightly deformed. A good transmission across the array was also observed on the *z*-*y* plane, while the asymmetry was significant. In particular, when the dipole was at λ away from the array, good radiation was observed in the *z* direction (as opposed to the divided radiation of the patch case), in addition to two beams that were caused by reflections. In general, the array provided interesting radiation characteristics that superposed full-patch and no-patch (Hertzian dipole in free space) properties. Bistatic far-zone electric-field intensity graphs, shown in Figure 4, further demonstrated the interesting response of the array in comparison to the

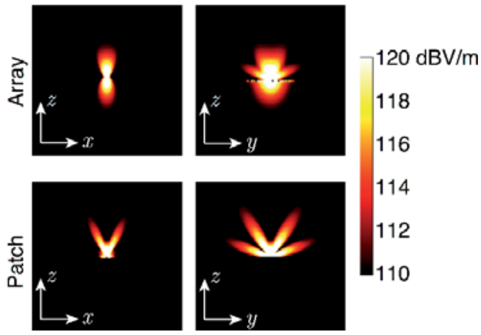

Figure 5. The solutions of radiation problems involving the rectangular array depicted in Figure 2 and a rectangular patch of the same size. The near-zone electric-field intensity distributions with respect to position are shown on different planes.

patch. For both cases (Hertzian dipoles at $\lambda/4$ and λ) the overall radiation was maintained in the z and $-z$ directions, as well as at off-axis directions on the z-y plane with many peaks and dips.

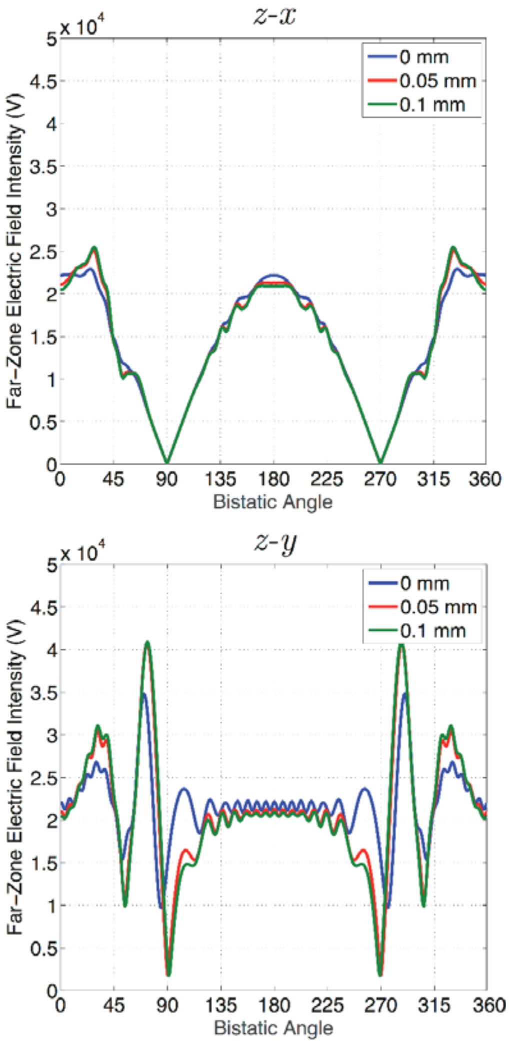

Figure 7. The sensitivity of the radiation characteristics of the rectangular array in Figure 2 to the thickness of the strips. The excitation was a Hertzian dipole located at λ above the array.

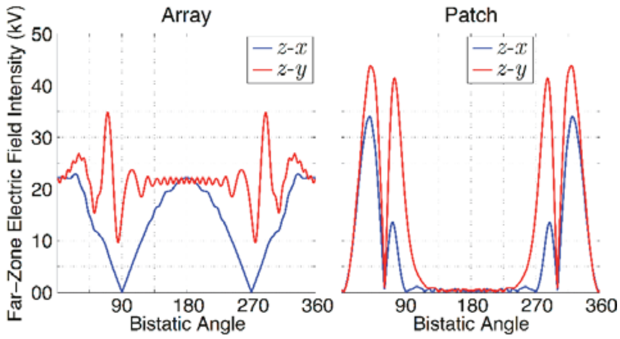

Figure 6. The solutions of radiation problems involving the rectangular array depicted in Figure 2 and a rectangular patch of the same size. The far-zone electric-field intensity values with respect to direction are shown on different cuts.

Figures 5 and 6 include results for the rectangular array, again in comparison to a patch of the same size (202.9 mm × 134.4 mm). Only one type of excitation involving an x-directed Hertzian dipole at λ was considered. The results were similar to those for the diamond-shaped array and the corresponding patch. On the z-y plane, the oscillatory nature of the radiation of the array with almost similar levels in the z and $-z$ directions is remarkable. The peaks occur at 70° and 290°, while strong dips were at 85° and 275°. Figure 7 further shows the sensitivity of the radiation characteristics of the rectangular array to the thickness of the strips used. Specifically, instead of assuming zero thickness, we also considered strips with 0.05 mm and 0.1 mm thicknesses. It could be observed that the major radiation characteristics did not change. However, the peaks and dips on the z-y plane become stronger as the thickness was introduced.

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European School of Antennas 2019

ESoA Board

COMPRESSIVE SENSING AS APPLIED TO ELECTROMAGNETICS
RIVA DEL GARDA, March 18,22
Coordinator: A. Massa, G. Oliveri

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AALTO - Espoo, May 6-10
Coordinator: A. Räisänen

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IMST, May 13- 17
Coordinator: W. Simon, D. Manteuffel

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Coordinators: D. Segovia

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Coordinator: Y. Hao

ANTENNA AND RECTENNAS FOR IOT APPLICATIONS
UCA - Nice, November 4-8
Coordinators: L. Lizzi

DISRUPTIVE ANTENNAS BASED ON EMERGING TECHNOLOGIES FOR NOVEL SATELLITE TELECOMMUNIACTION SCHEME (REVOLVE)
TAS, Rennes- , November 11-15
Coordinator: M. Ettorre, H. Legay

ESOA off-shore

ANTENNAS FOR RADIOTELESCOPES
SU-CSR, Stellen, November 18-22
Coordinators: D. de Villiers

ESoA Coordinator Prof. Stefano Maci
Dept. of Information Engineering and Mathematics
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Women in Radio Science

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This time I present Patricia Doherty, Director at the Institute for Scientific Research at Boston College, Massachusetts. Pat is the only female Commission Chair of the ten Commissions of URSI. Pat's Commission G comprises Ionospheric Radio and Propagation, in line with her interests in space weather and global navigation satellite systems with applications.

Pat's story is similar to those of several other female scientists of her generation. Due to talent in mathematics and technology, she chose at that time what was still an unusual career way for a woman. She did not continue directly in scientific research, and stayed a few years at home with kids. This prepared her well to go over to space research and make a wonderful career there. Here comes her story

Oh the Places You Will Go…

Patricia H. Doherty

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When asked to write this article, I thought whatever will I write? As a child, I did not have long-term goals of being a scientist. My goals were more immediate: get good grades, finish homework early to be able to go out to play, and generally have fun. My family was close – perhaps a little too close, as I grew up in a three-family home, with my grandparents on the first floor; my aunt, uncle, and cousins on the third floor; and my family sandwiched in the middle, on the second floor. My immediate family included my parents and my two brothers. Together with my brothers and cousins, we walked to the neighborhood Polish Catholic School; we worshipped at the neighborhood Polish church; and we played within a four-block radius of our home, in an ethnic part of Boston. Although Boston was a big city, we lived in a very small part of it: a very nice small part, by my recollection, but quite limited in its view of the world.

Ours was largely a blue-collar family, and it was my generation that was deemed to be the first college graduates in the family. At the time, it seemed to be a heavy expectation, starting with *whatever will I be?* The common goals among girls I knew at that time included becoming teachers, nurses, and secretaries. All noble careers, for sure, but nothing that interested me. It wasn't until I was at the University of Massachusetts that I appreciated a strong aptitude for mathematics and statistics, and an interest in physical science. Here is where I started my career: not as a scientist, but as a statistician for the insurance industry, and later for the US Internal Revenue Service. This path seemed like a good idea at the time, and it broadened my view of the world just a little bit more – but still generally limited to New England.

Figure 1. Oh, the places you will go! A most memorable coffee making experience in Ethiopia.

Just a few years into my professional career, I married a wonderful man (also from Boston). We soon had a daughter, and then a son. With this young family, I felt that I was needed more at home, and decided to take eight years out of the workforce. Those were memorable years, and I enjoyed them immensely. It did put a gap in my career, but it also gave me more time to think about the future, as I was sure that I wanted to professionally follow a different path.

Around the time I decided to resume my career, I had a fantastic opportunity to join a research group at Emmanuel College. This came about quite unexpectedly, through a friend who knew my interests and technically capability. As it happens, she also knew the Director of the Emmanuel College Space Science group, and thought we would be a good match. I am forever grateful to this person, as it was a turning point in my career. The Emmanuel College group supported US Air Force scientists in their studies of the Earth's ionosphere and radio propagation. Although this was somewhat of a foreign topic for me, it certainly peaked my interest, and I made it my ambition to learn as much as possible on the topic.

Another lucky occurrence for me was that I had the unparalleled opportunity to work with leaders in our field, including Mr. Jack Klobuchar and Drs. Santimay and Sunanda Basu. They were quite patient with me as I learned as much as possible from them and furthered my studies. As you can see, my world was getting larger by this time, as I also had opportunities to work with radio scientists and engineers from around the world when they visited our laboratories in the Boston area.

A couple of years later, I moved to the Institute for Scientific Research at Boston College to expand my adventures in space research. It was at Boston College that

Figure 2. Oh, the places you will go! The BC/ICTP Outreach Workshop of 2017: 17 women from 14 countries.

my career really started to take shape. After several more years of study and research, I developed competence as a radio scientist, with a focus on studying the ionosphere using satellite signals of opportunity, and later with the Global Positioning System (GPS) satellites. I was also researching space weather, and its effects on GPS and GPS-based applications, such as the US Federal Aviation Administration's Wide Area Augmentation System (WAAS), a civil aviation system that would be largely dependent on GPS satellites. At Boston College, I continued to advance my career from Research Scientist to Senior Research Scientist, Principal Investigator, and finally as the Director for the Institute for Scientific Research (ISR) at Boston College. ISR is an organized research institute, supporting the research mission of Boston College to conduct national and international significant research that advances insight and understanding, enriches culture, and addresses pressing social needs. With this mission, I felt most at home in my career of choice – or, more appropriately, my career of happenstance. It was certainly not something I planned, but something that has been most rewarding and enjoyable. It has given me extraordinary opportunities to observe the scientific exploits of our highly skilled team

Figure 3. Just a few URSI friends from around the world: US, Canada, UK, and India.

of scientists in the fields of space physics, space chemistry, solar-terrestrial research, space weather, and astrophysical studies. It has further expanded my view of the world, with many chances to work and make friends from around the globe.

One of the highlights of my career has been an outreach program that has played a role in the expansion of space science education and research in developing countries (Figure 1). This program has been performed under a partnership between Boston College and the Abdus Salam International Centre for Theoretical Physics (ICTP) to host a series of workshops on the use of Global Navigation Satellite Systems (GNSS) for applications with societal benefits and for space science research. Since 2009, annual workshops have hosted approximately 50 participants from developing countries in Africa, Asia, Eastern Europe, and South America. These workshops have increased the number of young scientists studying space science in developing nations, and have dramatically increased the publication rate of scientists from these countries. In addition, we have worked to increase the number of women participating in our workshops. Our first workshop included just a few female participants from Nigeria, Kenya, and Egypt. However, over the years we have steadily increased the number of women participants (Figures 2 and 3). This success was particularly evident in our 2018 workshop, where we had participation from 29 countries, and 49% of those participants were women. This, together with many other international experiences, have certainly expanded my view of the world: from a small and sheltered beginning to having so many colleagues and friends from around the world.

I am humbled to note that along the way, I have been blessed by much recognition in the world of radio science. This has ranged from serving as the 2013-2015 President of the Institute of Navigation (ION) and as the current Chair of URSI Commission G, to being awarded fellowships in ION, the African Geophysical Society (AGS), and URSI. Finally, I am a recent recipient of the 2017 GPS World Leadership Services Award and the 2018 American Geophysical Union (AGU) Space Physics and Aeronomy Richard Carrington (SPARC) Education and Public Outreach Award.

I have many people to thank for the enjoyment of my career. I have had much support from supervisors, sponsors and colleagues, both male and female. We often hear stories where women felt they had been held back in their career due to male dominance in the workplace. I can honestly state that this has not been my personal experience. Both men and women alike have done much to support me along the way. I particularly thank my mentors, including Jack Klobuchar, Santimay Basu, and Sunanda Basu; and my colleagues, including everyone at Boston College's ISR and so many others in the US and beyond. I would like to note a special thanks to Dr. Reinhart Leitinger and Jack Klobuchar, who sparked my interest in URSI; to Dr. Sunanda Basu, for encouraging me to lead a scientific organization; to Dr. P.V.S. Rama Rao (now deceased), who supported all of my efforts in leadership of the URSI Commission G and its Beacon Satellite Study group; and especially to Prof. Sandro Radicella, who inspired me to reach out to the developing world. Together with Sandro and his team at ICTP, our organizations have performed 10 outreach workshops that have been as enjoyable as they were effective. Finally, I thank my husband, Charlie, my children, Karen and Brian, and my three beautiful grandchildren, Hailey, Liam, and Julia. Without their love and support, nothing here could have happened.

When looking back on my career, the book *Oh, the Places You'll Go* by Dr. Seuss comes to mind. After growing up in a very small and somewhat sheltered part of Boston, I have had paramount opportunities to perform space research, to work with a stellar group of national and international scientists, and to travel to distant places on the globe.

Now that I have been in this career for many years, I feel that I can offer some advice to young women entering this field: that is to have confidence in yourself to do what you may think is not possible; to not be afraid to make a mistake (everyone make mistakes); to respect your colleagues (even when they make mistakes); to reach out to other women (and men) for friendship and to provide reassurance and encouragement they may need to succeed; and, finally, to be patient, flexible and understanding when it comes to balancing work and family for yourself and for your colleagues and staff. You really can have it all!

"Today is your day. You're off to Great Places! You're off and away!"

Dr. Seuss

Patricia Doherty, Director, Institute for Scientific Research at Boston College

URSI Conference Calendar

January 2019

UK URSI Symposium 2019
Teddington, Middlesex TW11 0LW, United Kingdom, 10 January 2019
Contact: Dr Martin Robinson, E-mail: martin.robinson@york.ac.uk

USNC-URSI NRSM 2019
USNC-URSI National Radio Science Meeting
Boulder, CO, USA, 9-12 January 2019
Contact: Dr. Sembiam R. Rengarajan, Department of ECE, California State University, Northridge, CA 91330-8346, USA, Fax: 818-677-7062, E-mail: srengarajan@csun.edu; Logistics: Christina Patarino, E-mail: christina.patarino@colorado.edu, Fax: 303-492-5959, https://nrsmboulder.org/

March 2019

C&RS "Smarter World"
18th Research Colloquium on Radio Science and Communications for a Smarter World
Dublin, Ireland, 8-9 March 2019
Contact: Dr. C. Brennan (Organising Cttee Chair)
http://www.ursi2016.org/content/meetings/mc/Ireland-2017-CRS Smarter World CFP.pdf

AP-RASC 2019
2019 URSI Asia-Pacific Radio Science Conference
New Delhi, India, 9-15 March 2019
Contact: Prof. Amitava Sen Gupta, E-mail: sengupto53@yahoo.com, http://aprasc2019.com

May 2019

EMTS 2019
2019 URSI Commission B International Symposium on Electromagnetic Theory
San Diego, CA, USA, 27-31 May 2019
Contact: Prof. Sembiam R. Rengarajan, California State University, Northridge, CA, USA, Fax +1 818 677 7062, E-mail: srengarajan@csun.edu, http://www.emts2019.org

June 2019

EMC Sapporo & APEMC 2019
2019 Joint International Symposium on Electromagnetic Compatibility and Asia-Pacific International Symposium on Electromagnetic Compatibility, Sapporo
Sapporo, Japan, 3-7 June 2019
Contact: http://www.ieice.org/~emc2019/

September 2019

Metamaterials 2019
Rome, Italy, 16-19 September 2019
Contact: http://congress2019.metamorphose-vi.org/

RADIO 2019
IEEE Radio and Antenna Days of the Indian Ocean 2019
Reunion Island, 23-26 September 2019
Contact: http://www.radiosociety.org/radio2019/

November 2019

COSPAR 2019
4th Symposium of the Committee on Space Research (COSPAR): Small Satellites for Sustainable Science and Development
Herzliya, Israel, 4-8 November 2019
Contact : COSPAR Secretariat, 2 place Maurice Quentin, 75039 Paris Cedex 01, France, Tel: +33 1 44 76 75 10, Fax: +33 1 44 76 74 37, E-mail: cospar@cosparhq.cnes.fr
http://www.cospar2019.org

August 2020

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May 2021

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Third URSI Atlantic Radio Science Conference
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