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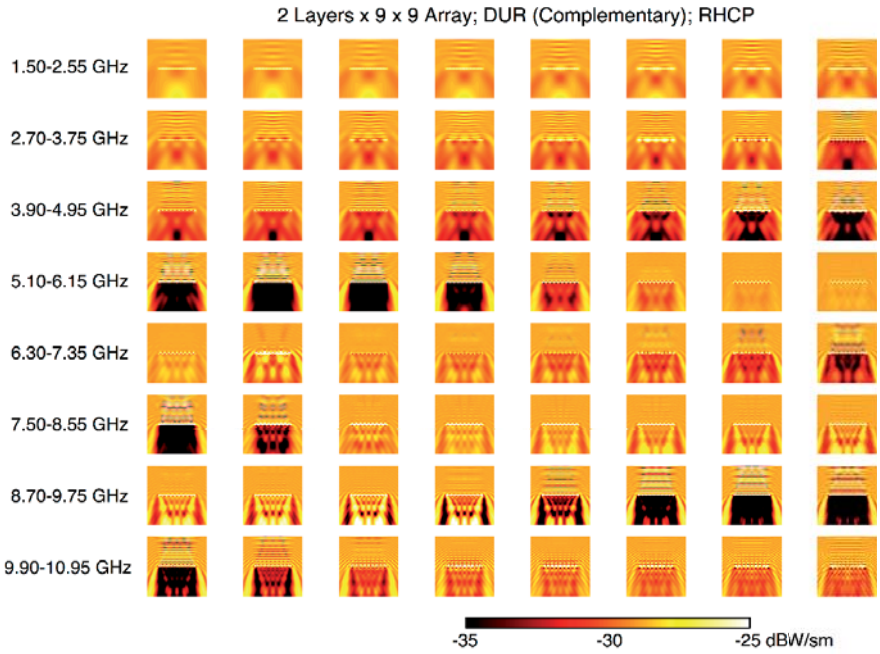

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Contents

Cover: The near-zone electromagnetic-field power density in the vicinity of a double-layer frequency-selective surface made from unit cells using double U-shaped resonators arranged in a complementary alignment at different frequencies when it was excited by plane waves with right-hand circular polarization. Each column represents an increment of 150 MHz in frequency. See the paper by Özgür Eriş, Hande İbili, and Özgür Ergül in the Solution Box column. (pp. 20 -25)

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The cover figure for this issue shows the near-zone electromagnetic field power density in the vicinity of a two-layer frequency-selective surface made from unit cells that have U-shaped elements. Frequency-selective surfaces are interesting both because of their physical (electromagnetic scattering) properties and because of their computational modeling properties. They depend on resonant structures to operate, and those very resonances produce fascinating electromagnetic and computational properties. These are explored in Özgür Ergül's Solution Box contribution by Özgür Eriş, Hande İbili, and Özgür Ergül. They considered three such structures, having three different arrangements of U-shaped unit cells. As an example of their results from an electromagnetic scattering standpoint, they showed that two different structures made from layers with identical unit cells but arranged in different orientations had significantly different scattering properties. In particular, one version of the structure had very similar responses to both left-hand and right-hand circularly polarized waves, whereas the other did not. From a computational standpoint, the most challenging frequencies for analysis in terms of number of iterations required for convergence of the solution were not the same as the frequencies at which element resonances occurred. All of this makes for quite interesting reading.

Our Other Contributions

Giuseppe Pelosi has brought us a beautiful and intriguing Historical Corner. The article, by Giuseppe Pelosi and Stefano Selleri, traces some introductory steps to the Finite-Element Method. These involved a problem know as the Brachistochrone, which was a deceptively simple shortest-path problem proposed in 1696. There were several other related problems that also played a role. What makes this article so enjoyable to read is not just the history of computational science it tells: it is the accompanying original figures and photos, and the stories of the people involved, all carefully researched and referenced. You will enjoy this.

Tayfun Akgul has brought us his usual wry perspective on a couple of aspects of radio science in his Et Cetera column. It appears that our erstwhile professor is very rapidly gaining a new perspective on one of the hottest new areas of research.

Do you know where the phrase "to show your true colors" came from? Amy Shockley and Randy Haupt explain this and explore the associated ethical implications in their Ethically Speaking column.

In her Women in Radio Science column, Asta Pellinen-Wannberg brings us the story of Tuija Pulkkinen, Professor and Chair of the Department of Climate and Space Sciences and Engineering at the University of Michigan. This is a very intriguing story of a career in space research, with valuable insights into what led to the career and life choices made.

This issue also contains the audited URSI accounts for 2018.

AP-RASC Was a Great Success: Here Comes the GASS!

As this is written, the URSI Asia-Pacific Radio Science Conference in New Delhi, India, has just been completed. It was an outstanding success! There were about 700 attendees, and the feedback I heard was uniformly strongly positive. Particular congratulations and thanks must go to Profs. Subramanian Ananthakrishnan (General Chair) and Kazuya Kobayashi (General Co-Chair), to Prof. Rajamani Paulraj (Convener and Treasurer), and to Prof. Amitava Sen Gupta (Chair of the Local Organizing Committee). They all did an outstanding job, and their organization and hospitality were excellent. On a personal note, I particularly appreciated the great kindness, hospitality, and assistance I was shown by the organizers.

URSI has three flagship meetings, one per year, in sequence: the AP-RASC is followed by the URSI General Assembly and Scientific Symposium (GASS), which is followed by the URSI Atlantic Radio Science Conference (AT-RASC). The GASS will be held August 29-September 5, 2020, in Rome, Italy. The planning for the technical program of the GASS was begun in detail at the AP-RASC. Most URSI Commissions are planning to have more sessions and papers in 2020 than they did in 2017 at the GASS in Montreal, so the 2020 GASS will be a great event. You should start planning now to organize a session and/or to submit one or more papers, and certainly to attend. If you want to organize a session, contact the Chair of the appropriate URSI Commission. Contact information can be found on the URSI Web site at www.ursi.org, or in the December issue of the Radio Science Bulletin. The call for papers will be out soon.

James Clerk Maxwell Foundation Newsletter

The 12th edition of the newsletter of the James Clerk Maxwell Foundation is now available. It can be downloaded at http://www.clerkmaxwellfoundation.org/Newsletter_2019_Spring.pdf. It contains an article by Sheldon Glashow (1979 Nobel Prize for Physics), tracing his experiences trying to unify the weak and electromagnetic forces. There is also a story recounting a visit to CERN.

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A Prelude to Finite Elements: The Fruitful Problem of the Brachistochrone

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When did finite elements begin? It is difficult to trace the origins of finite-element methods because of a basic problem in defining precisely what constitutes a "finite-element method." To most mathematicians, it is a method of piecewise polynomial approximation. Its origins are therefore frequently traced to the appendix of a paper by Courant [1], in which piecewise-linear approximations of the Dirichlet problem over a network of triangles was discussed. The "Interpretation of Finite Differences" by Polya [2] is regarded as embodying piecewise-polynomial approximation aspects of finite elements.

On the other hand, the approximation of variational problems on a mesh of triangles goes back much further: 92 years. In 1851, Schellbach [3] proposed a finite-element-like solution to Plateau's problem of determining the surface, S, of minimum area enclosed by a given closed curve. Schellbach used an approximation, S_h, of S by a mesh of triangles over which the surface was represented by piecewise-linear functions. He then obtained an approximation of the solution to Plateau's problem by minimizing S_h with respect to the coordinates of hexagons formed by six elements (see [4]). This was not quite the conventional finite-element approach, but certainly as much a finite-element technique as that of Courant.

Some say that there is even an earlier work that uses some of the ideas underlying finite-element methods: Leibniz himself employed a piecewise-linear approximation of the Brachistochrone problem, proposed by Bernoulli in 1696 (see the historical volume [5]). With the help of his newly developed calculus tools, Leibnitz derived the governing differential equation for the problem, the solution of which is a cycloid. However, most would agree that to credit this work as a finite-element approximation is somewhat stretching the point. Leibniz had no intention of approximating a differential equation; rather, his purpose was to derive one. Two and one-half centuries later, it was realized that useful approximations of differential equations could be determined by not necessarily taking infinitesimal elements, as in the calculus, but by keeping the elements finite in size. This idea is, in fact, the basis of the term "finite elements" [6, p. 153].

Figure 1a. The façade of the *Basilica di Santa Croce* in Florence.

Figure 1b. The tomb of Vittorio Fossombroni [Arezzo, Italy, September 15, 1754 – Florence, Italy, April 15, 1844] in *Santa Croce*.

This long text is an excerpt from a historical contribution on finite elements by J. T. Oden [6] with which many of the specialists in Finite Elements might be familiar. It traced the history of Finite Elements up to its maturity in the 1980s, and was mostly concerned with structural and mechanic engineering. Other details can be found in [7] and, more specifically on electromagnetics, in a recently reprinted historical paper by P. P. Silvester [8].

These paragraphs come back to us in the *Basilica di Santa Croce*, in Florence (Figure 1a), where there are the tombs, cenotaphs, or commemorative plaques of the greatest Italians. The most known at an international level might be Dante Alighieri, Michelangelo Bonarroti, Leonardo da Vinci, Lorenzo Ghiberti, Niccolò Machiavelli, and Gioacchino Rossini. Among the scientists, there are Eugenio Barsanti, Galileo Galilei, Enrico Fermi, Guglielmo Marconi, and Girolamo Segato.


SAGGIO
DI UN DILETTANTE DI MATEMATICA
SULLE
EQUAZIONI DI CONDIZIONE
E SOPRA
L' INVENZIONE
DELLA BRACHISTOCRONA

1791

Figure 1c. The first page of Fossombroni's essay on the brachistochrone [9].

There is also the tomb of Vittorio Fossombroni [Arezzo, Italy, September 15, 1754 – Florence, Italy, April 15, 1844], a statesman, mathematician, economist, and engineer (Figure 1b). In 1794, he directed the work for the drainage of the marshy valley of the Arno River. In 1814, he was made President of the legislative commission, and was appointed Prime Minister of the Great Duchy of Tuscany.

Among Fossombroni's writings was a booklet dated 1791 on the problem of the Brachistochrone [9], a copy of which is in the personal library of one of the authors (Figure 1c). This problem is fundamental, since it contributed to the birth to the calculus of variations, and eventually to modern numerical techniques such as the Finite Element Method, as Oden said [6]. A step back by a full century since Fossombroni's essay, and more than three centuries since Oden's paper, is now necessary if we want to remember this landmark in mathematics.

1. The Brachistochrone Problem

In the June, 1696, issue of the *Acta Eruditorum*, the young mathematician Johann Bernoulli [Basel, Switzerland, July 27, 1667 – Basel, Switzerland, January 1, 1748] (Figure 2a) posed a challenge to all mathematicians ([10] and Figures 3 and 4):

> Given in a vertical plane two points A and B, assign to the moving body M, the path AMB, by means of which, descending by its own weight from point A, it would arrive at the other point B in the shortest time.

Seldom in the history of science did a challenge lead to so fruitful results.

*The challenge was aimed mainly at Isaac Newton [*Woolsthorpe, England, January 4, 1643 – Kensington, England, March 31, 1727*] (Figure 2b). This was because*

Figure 2a. The protagonists of the Brachistochrone challenge: Johann Bernoulli [Basel, Switzerland, July 27, 1667 – Basel, Switzerland, January 1, 1748].

Figure 2b. Isaac Newton [Woolsthorpe, England, January 4, 1643 – Kensington, England, March 31, 1727].

Figure 2c. Jakob Bernoulli [Basel, Switzerland, December 27, 1654 - Basel, Switzerland, August 16, 1705].

Figure 2d. Gottfried Wilhelm Leibniz [Leipzig, Saxony July 1, 1646 – Hanover, November 14, 1716].

Figure 2e. Ehrenfried Walther von Tschirnhaus [Kieslingswalde, Saxony, April 10, 1651 – Dresden, Saxony, October, 11, 1708].

Figure 2f. Guillaume de l'Hôpital [Paris, France, 1661 – Paris, France, February 2, 1704].

Bernoulli was a follower of Gottfried Wilhelm Leibniz [Leipzig, Germany, July 1, 1646 – Hanover, Germany, November 14, 1716] (Figure 2d), and sided with him in the famous Newton-Leibniz controversy about the invention of the calculus.

Bernoulli initially allowed six months for the solutions, but none was received during this period. He then allowed an extension. Isaac Newton become aware of the challenge on January 29, 1697. According to records, Newton solved the problem that same night, and mailed the solution anonymously by the next post. Upon reading the solution, Bernoulli immediately recognized its author, stating that *tanquam ex ungue leone* [one recognizes a lion from his claws].

In the end, five mathematicians responded with solutions: Newton, Jakob Bernoulli (Johann's brother, Figure 2c), the already mentioned Leibniz, Ehrenfried Walther von Tschirnhaus (Figure 2e), and Guillaume de l'Hôpital (Figure 2f).

2. Other Contemporary Problems

The Brachistochrone was not an isolated case. Several similar problems were proposed in those years. In his own reply to [10], Jakob Bernoulli posed a second challenge: a complex problem of surface maximization given the boundary perimeter, which was even harder than the brachistochrone challenge (Figure 5):

> Of all isoperimetric curves on a given axis BN, we seek the one that, like BFN, does not contain the greatest surface, but which maximizes another one contained by the curve BZN, after having extended FP in such a way that PZ is any ratio multiplied or divided by PF or the arc BF, that is to say that PZ is any proportion of a given A and of the distance PF or the arc BF [11, p. 214].

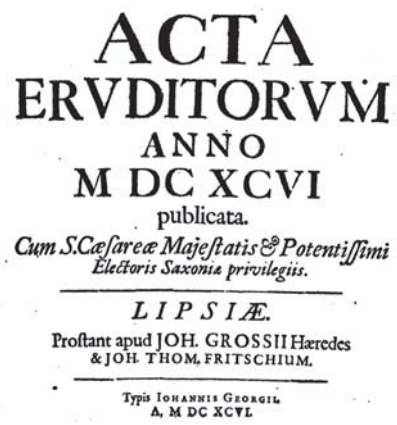
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Figure 3. The first page of the *Acta Eroditorum* year 1696 [10], hosting Bernoulli's challenge.

The excitement was not limited to these two problems. Immediately afterwards, a third arose (Figure 6). In a letter to Leibniz, Johann Bernoulli wrote:

> I haven't seen what my brother gave you about the shortest line between two points of the same surface, yet; I doubt that it might hold in general. Your method,

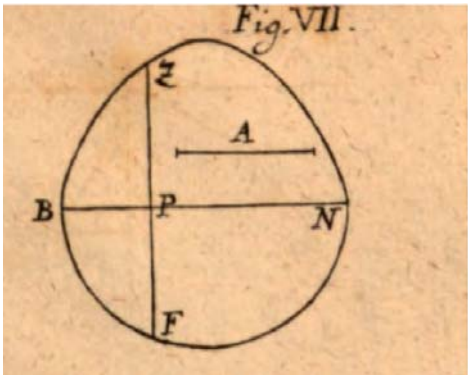

Figure 5. The accompanying figure to Jakob Bernoulli's counter-challenge in [11].

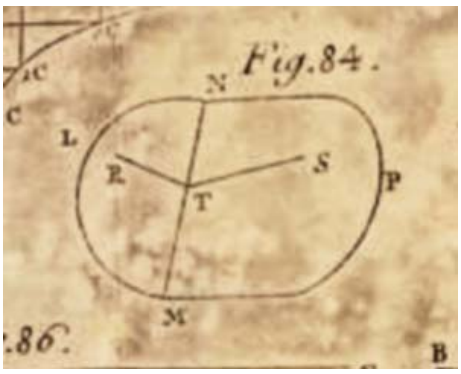

Figure 6. The figure associated with Johann Bernoulli's geodetic problem to Leibnitz [12].

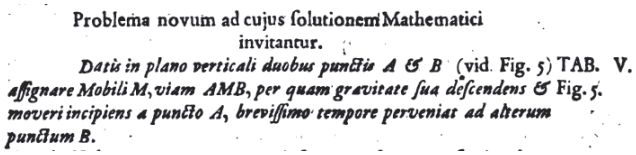
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Figure 4a. Bernoulli's challenge in [10] (in Latin).

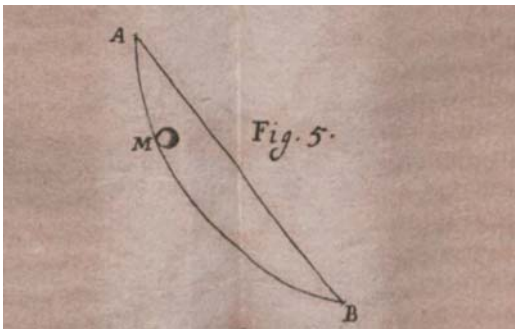

Figure 4b. The figure accompanying Bernoulli's challenge.

> which is actually a basis for some method, is legitimate and first came to my mind when the problem arose for me and noticed with ease (see Figure 4) that the shortest line, relatively to two intersecting planes, from the point R to point S is the one that makes with the common intersection NM of the dihedron two equal angles, so to say opposite, RTM, STN. But, up to now it seems not useful to the construction of the requested lines on the curved surface. Hence, I found another method, which is very general and founded on it, in order to solve the question, according to which a plane through three close generic points on the requested line must be perpendicular to the tangent plane to the curved surface in any of those points. From this, I realized an equation for any surface that can be easily constructed for any conoid or spheroid of any degree [12, Vol. I, Epist. LXXVI, p. 393].

This was to become one of the hottest topics in mathematics, the problem of the geodesic: the shortest line between two points on a surface.

It is indeed true that Newton worked on a problem, which we would now call variational, about one decade earlier, in 1685, publishing it in his 1687 book [13, Book 2, prop XXXIV]. This was about the shape of a body of revolution with minimal resistance in a fluid. However, it was only with Bernoulli's challenge that the topic became one of the hottest in mathematics.

3. Conclusions

What really matters is not the problem itself and indeed not the relative, particular, solution proposed, but how the problem was solved. The new method was to be elaborated by Lenard Euler [Basel, Switzerland, April 15, 1707 – Saint Petersburg, Russia, September 18, 1783].

He worked on the geodesic problem in 1732 [14], and significantly improved it by an intuition by Joseph-Louis Lagrange [Turin, Italy, January 25, 1736 – Paris, France, April 10, 1813], communicated to Euler in a letter dated August 12, 1755 [15]. Finally, in 1756, Euler himself gave it its current name: *Calculus of Variations* [16].

Of course, a full history of the Calculus of Variations is out of the scope of a paper, but a matter for a whole book. The interested reader can refer to [17], but it is interesting for our community to remember how far in the past stretch the roots of our modern numerical methods, such as those of Finite Elements.

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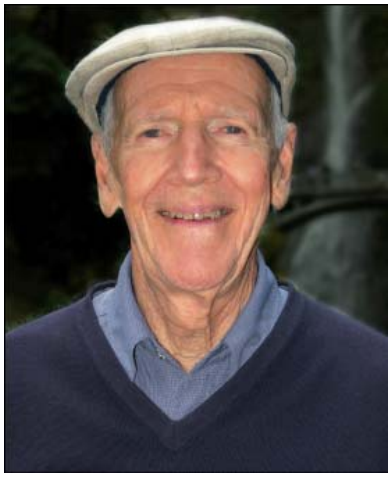
In Memoriam: Donald Leland Carpenter



Donald Leland Carpenter, 91, a pioneer space scientist, passed away peacefully on February 5, 2019, in Santa Cruz, California. Don Carpenter, as he was generally known, is best known as the discoverer of what is now called the "plasmapause" (affectionately also known as "Carpenter's Knee"), the sharp drop in the density of plasma that co-rotates with the Earth and plays a fundamental role in the physics of the upper atmosphere.

Born on January 3, 1928, in Spokane, Washington, Don graduated from Grant High School in Portland, Oregon, and served in the US Navy from 1946 to 1948. He then studied international politics and language at Willamette University. In 1951, he moved to New York City to pursue his Master's in Political Science at Columbia University. Ultimately discovering his true calling, as described in his contribution to the 1997 AGU publication *Discovery of the Magnetosphere*, Don settled in the San Francisco Bay area, attending Stanford University for his MS and PhD in Electrical Engineering. He was a research professor for over 40 years at the Space Telecommunications & Radio Science Laboratory (STAR Lab) at Stanford University, a career he truly enjoyed.

Using naturally-occurring and manmade very-low-frequency (VLF) waves as a tool to probe the upper atmosphere, Don made significant contributions to many areas of magnetospheric physics until he was well into his eighties. At age 87, Don authored a book on the history of radio research at Stanford entitled *Very Low Frequency Space Radio Research at Stanford 1950-1990*. In 2002, he was nominated by Belgium and awarded the John Howard Dellinger Medal by the International Union of Radio Science (URSI) "For his discovery of the plasmapause, for pioneering studies of the plasmasphere structure and dynamics and for development and use of whistler-mode waves as diagnostic probes of the magnetosphere." In the same year, he was elected a Fellow of the American Geophysical Union. Collaborators and close friends of Don included scientists from all parts of the world. A man of impeccable integrity and great personal humility and generosity, Don was truly loved by his colleagues, students, friends, and family alike.

Don helped to form a running group at Stanford called the Angell Field Ancients, where he made many life-long friends. Later in life, when Don could no longer run, he and his beloved wife of more than 50 years, Betty Carpenter, spent many hours hiking trails near their home in Palo Alto, California. In addition to running and scientific discovery, Don had a passion for languages, speaking several fluently. Two years ago, Don moved to Aptos, California, to be closer to family, including his granddaughter, who brought him much joy.

Don is survived by his son, Frederic P. Carpenter and his wife, Rose, of Philadelphia, Pennsylvania; by his son, Jesse V. Carpenter and his wife, Erika, and granddaughter, Megan, of Aptos, California; and by his brother, Richard Carpenter, of Portland, Oregon.

Vikas Sonwalkar
Antony Fraser-Smith
Umran S. Inan
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In Memoriam: Bengt Hultqvist

It is with great sorrow that we report that Professor Emeritus Bengt Hultqvist (Figure 1), the founder of the Swedish Institute of Space Physics, has passed away at the age of 91.

It is largely thanks to Bengt Hultqvist that space activities in Sweden, and in particular in Kiruna, had such a dramatic development. During Bengt Hultqvist's 37 years as Director of the Swedish Institute of Space Physics (IRF), space activities in Kiruna in the far north of Sweden developed from six people in 1957 to some 450 (including about 100 students) in 1994.

Figure 1. Bengt Hultqvist at the Kiruna Space Campus (photo by Torbjörn Lövgren, IRF).

Bengt Hultqvist (who was born in 1927) studied science at Stockholm University, where he completed a doctorate in Physics in April 1956.

A committee of the Swedish Academy of Sciences was planning a new geophysical observatory in Kiruna, and Bengt Hultqvist was appointed its first Director. The Kiruna Geophysical Observatory (KGO) was established in 1957, and Hultqvist was Director of KGO (later renamed Kiruna Geophysical Institute, and then the Swedish Institute of Space Physics) until he retired in 1994.

"Bengt is the father of IRF. He created not only a world-leading space research institute, he created IRF's unique atmosphere and working relationships, he created a family called IRF," said Stas Barabash, IRF's Director.

Bengt Hultqvist took an active role in planning collaborations within European space research, and was chair of the committee that first suggested a European program of space science. As a result, he was able to recommend that the European sounding rocket base Esrange should be situated in Kiruna, and KGO got the opportunity to participate with an instrument on the first European satellite, ESRO 1, launched in 1968. This opened the way for the large number of satellite instruments that IRF has had the chance to fly to many parts of the solar system.

For two decades, Bengt Hultqvist was chair of the Swedish space research committee, and established an important collaboration with the equivalent committee within the Soviet academy of sciences. This collaboration led to opportunities for several Swedish satellite instruments to fly on Soviet satellites, including IRF's first instrument to another planet, Mars, in 1988.

He took the initiative in establishing EISCAT (the European Incoherent Scatter scientific association) with radar facilities in northern Norway, Sweden, and Finland, and on Svalbard, one of the most advanced radars of its type. EISCAT has its head office in Kiruna, Sweden.

After retirement, Bengt Hultqvist was Director of the newly-formed International Space Science Institute in Bern, Switzerland, for four years. He was also the Secretary General of the International Association of Geomagnetism and Aeronomy.

"Without Bengt Hultqvist, Sweden would not have reached the peaks in space that it has done. Bengt also played a very important role in the establishment of the European Space Research Organization ESRO – that later became ESA – and many other European and international space research organizations. Bengt made an outstanding contribution in paving the way to space for many generations of space scientists," said Stas Barabash.

Bengt Hultqvist was appointed Professor of Space Physics at Umeå University in 1967. He became a member of the Royal Swedish Academy of Science and the Royal Swedish Academy of Engineering Sciences during the 1980s. He received an honorary doctorate from LTU in 1993. Over the years, he gathered an impressive number of awards, including Knight of the Northern Star, 1965; The Grand Gold Medal of the Royal Swedish Academy of Engineering Sciences, 1988; COSPAR Prize for International Cooperation, 1990; King's Medal 8th size, 1991; Berzelius Medal in gold from the Royal Swedish Academy of Sciences, 1994; and the Julius Bartels Medal from the European Geophysical Society, l996.

During his active years, Bengt Hultqvist was also a productive scientist, with over 180 publications in international journals. He was the Chair of URSI Commission G from 1978-1980. The successes also came for IRF, which is the main research environment in the field of space physics in Sweden, and one of the foremost of its kind in the world.

Prizes to space engineering students at the Space Campus in Kiruna are named after Bengt Hultqvist, as is the Bengt Hultqvist Observatory in Kiruna.

[This was taken from a message from the Swedish Institute of Space Physics, Prof. Stas Barabash, Director (e-mail: stas@irf.se), with additional information from Asta Pellinen Wannberg (e-mail: asta.pellinen-wannberg@umu.se).]

In Memoriam: Keith G. Balmain

Keith G. Balmain, a world-leading scholar in electromagnetics, antennas, electromagnetic compatibility, and antennas in plasmas, passed away on January 2, 2019. at the age of 85. Keith had a sharp and clear mind, and could simplify and explain complex concepts with ease. He was a scholar of high integrity and a great mentor. Keith Balmain's intellect, integrity, humor, professionalism, and humanity will be greatly missed.

Keith Balmain received the BASc in Engineering Physics from the University of Toronto, Toronto, Ontario, Canada, in 1957. He received the MS and PhD in Electrical Engineering from the University of Illinois, Urbana, in 1959 and 1963, with theses on printed-circuit dipole antennas and spacecraft-borne dipole antennas in anisotropic plasma. He was an Assistant Professor of Electrical Engineering at the University of Illinois until 1966. He then joined what is now the Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto, holding the positions of Professor and, later on, of Professor Emeritus. From 1991 to 2001, he was the Senior Chair holder of the NSERC/Bell Canada/Nortel Industrial Research Chair in Electromagnetics. He chaired the Division of Engineering Science for two and one-half years until 1987, after which, for a three-year term, he chaired the University of Toronto's Research Board. His research included antennas in plasma, broadband antennas, electromagnetic compatibility, human electrostatic discharge, radio wave scattering from power lines and buildings, Space Shuttle EMC prediction, electrostatic charging and discharging in spacecraft dielectrics, and microwave metamaterials.

He coauthored (with E. C. Jordan) the second edition of *Electromagnetic Waves and Radiating Systems* (Prentice-Hall, 1968), which is a highly regarded textbook in electromagnetics and antennas. He also co-edited (with G. V. Eleftheriades) one of the first books in metamaterials, *Negative-Refraction Metamaterials: Fundamental Principles and Applications* (John Wiley & Sons and IEEE Press, 2005). Prof. Balmain was a Life Fellow of the IEEE "for contributions to the understanding of log-periodic antennas and antennas in plasmas." He was the co-recipient of the IEEE Antennas and Propagation Society (AP-S) 1970 Best Paper Award, and was a co-recipient of a 1992 NASA Group Achievement Award for an "exceptional engineering assessment of plasma effects from electrical grounding for the Space Station Freedom program." Keith Balmain's scientific papers exuded the ingenuity, precision, and clarity that were the characteristics of the high-caliber researcher that he was. He was a member of the AP-S AdCom (1974-77), an Associate Editor of *Radio Science* (1978-1980), Chair of the Technical Program Committee for the Quebec City 1980 IEEE AP-S/USNC-CNC-URSI International Symposium, and Chair of the Local Organizing Committee for the Toronto 1999 General Assembly of the International Union of Radio Science (URSI).

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IEEE RADIO 2019

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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
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5. Smart antennas and arrays
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7. Wireless communication systems
8. Biological effects
9. Wireless power transfer
10. Devices and circuits
11. Nanotechnology
12. Radio astronomy
13. Remote sensing
14. High-power devices and techniques
15. Instrumentation and measurement techniques
16. Medical and industrial applications of electromagnetic fields
17. Modeling, simulation, computer aided design
18. Electronic packaging and integration
19. Metamaterials and other novel materials
20. Any other relevant topic

Language and Venue

The **working language** will be **English**.
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Et Cetera

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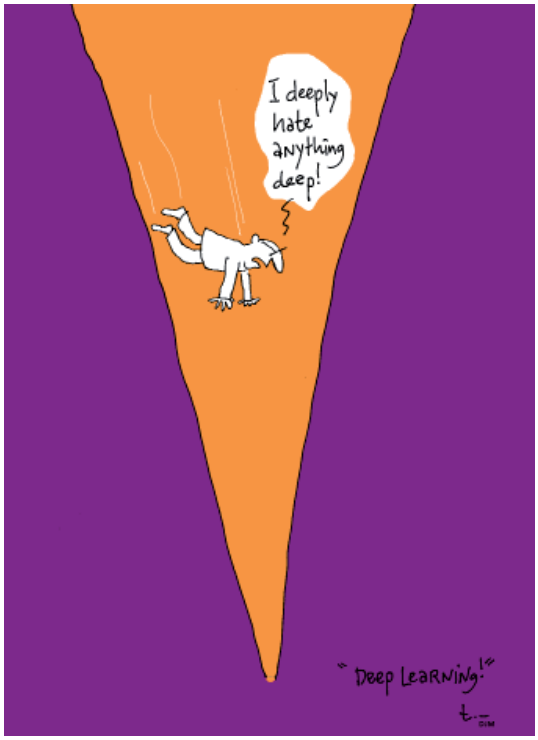

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SOLBOX-*15*

Özgür Eriş, Hande İbili, and Özgür Ergül

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1. Introduction

From computational point of view, frequency-selective structures are challenging to analyze since they involve resonating elements. In fact, resonances are essential for the operation of these structures, i.e., they generally provide the required responses (shadowing, focusing, full transmission, etc.) when their elements resonate. These resonances can be studied well via analytical approaches, e.g., by using circuit representations to model unit cells. However, as for other structures, numerical simulations – particularly those based on three-dimensional models – can be extremely useful for complete analyses of electromagnetic characteristics of complex frequency-selective structures before their realizations. The challenge is that when there are resonating elements, linear systems constructed in numerical simulations tend to become very ill-conditioned. For example, when using iterative solvers, iteration counts can be extremely large, while a convergence to a given error threshold may not guarantee an accurate result.

In this issue of Solution Box, three different frequency-selective structures are considered. The structures involve U-resonators that resonate at different frequencies, making the structures become opaque to block the transmission of electromagnetic waves. Sample solutions were obtained by using a frequency-domain integral-equation solver. In order to perform fast iterative solutions, the Multilevel Fast Multipole algorithm (MLFMA) was used, not only as an acceleration algorithm for the required matrix-vector multiplications, but also as a preconditioning tool to speed up iterative convergence. The solver used provided fast and accurate solutions of the three-dimensional models of the given frequency-selective structures, while it had drawbacks that may be mitigated by using other types of solvers. For example, using a frequency-domain approach, sampling frequency at discrete points may lead to loss of information, especially if resonances are sharp. Other types of solvers may also be helpful to explain why numerical resonances (at which iterative solutions become difficult to convergence) do not exactly coincide with physical resonances (at which electromagnetic responses abruptly change). As usual, we are looking forward to receiving alternative solutions to problems considered in this issue, as well as to all other problems presented in previous issues (SOLBOX-01 to SOLBOX-14).

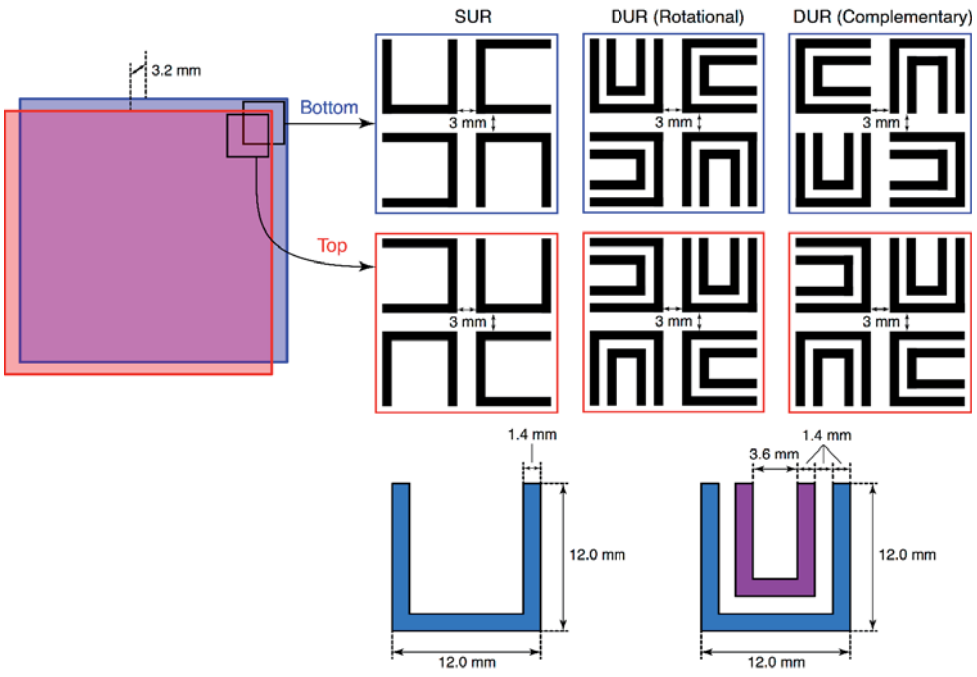

Figure 1. The three frequency-selective structures of SOLBOX-15. Each structure involved two layers with 3.2 mm distance between them, while each layer involved 9 × 9 unit cells. In the SUR design, each unit cell included four U-resonators. In the DUR designs, smaller U-resonators were added. In the rotational DUR design, the unit cell of the bottom layer was obtained from the unit cell of the top layer via three-dimensional rotation. In the complementary DUR design, resonators at the top and bottom layers complemented each other. All surfaces were assumed to have zero thicknesses.

2. Problems

2.1 Problem SOLBOX-15 (by

Özgür Eriş, Hande İbili, and Özgür Ergül)

The problem SOLBOX-15 includes three different frequency-selective structures, each having two layers, as depicted in Figure 1. The layers consist of 9 × 9 unit cells, which are also detailed in the same figure. The design for the single-U-resonator (SUR) case is taken from [1]; each unit cell involves four U-resonators arranged differently at the bottom and top layers. Despite that there is a single type of resonator, the SUR design provides resonances at multiple frequencies (other than doubled frequencies). This design is upgraded by adding smaller U-resonators, leading to double-U-resonator (DUR) designs. While one may expect that the number of resonance frequencies directly increases by simply adding a new type of resonator [2], interactions between resonators lead to complex responses that may not be straightforwardly predicted. For example, using the template of the SUR design (leading to the rotational DUR design), the smaller resonators mostly act as parasitic elements, and indeed, they reduce the strength of the original resonances. In addition, their own resonances are extremely sharp, such that they are not easy to observe,

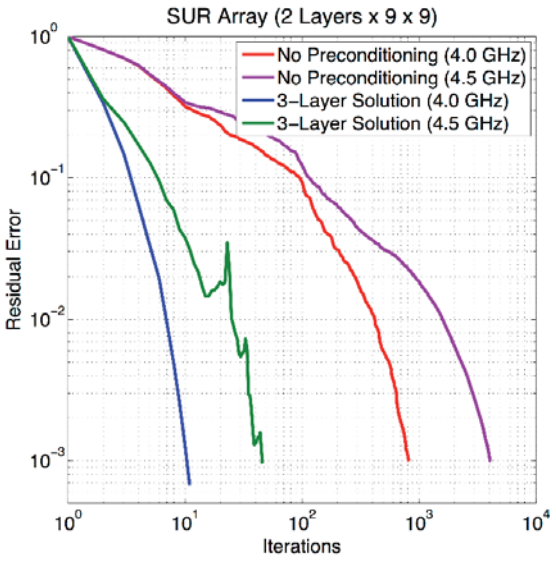

Figure 2. The iterative solutions of the SUR structure at two different frequencies. The structure was excited via a Hertzian dipole. Without preconditioning, the residual error was plotted with respect to GMRES iterations. However, in three-layer solutions the *x* axis represents the main iterations of the flexible variant of GMRES.

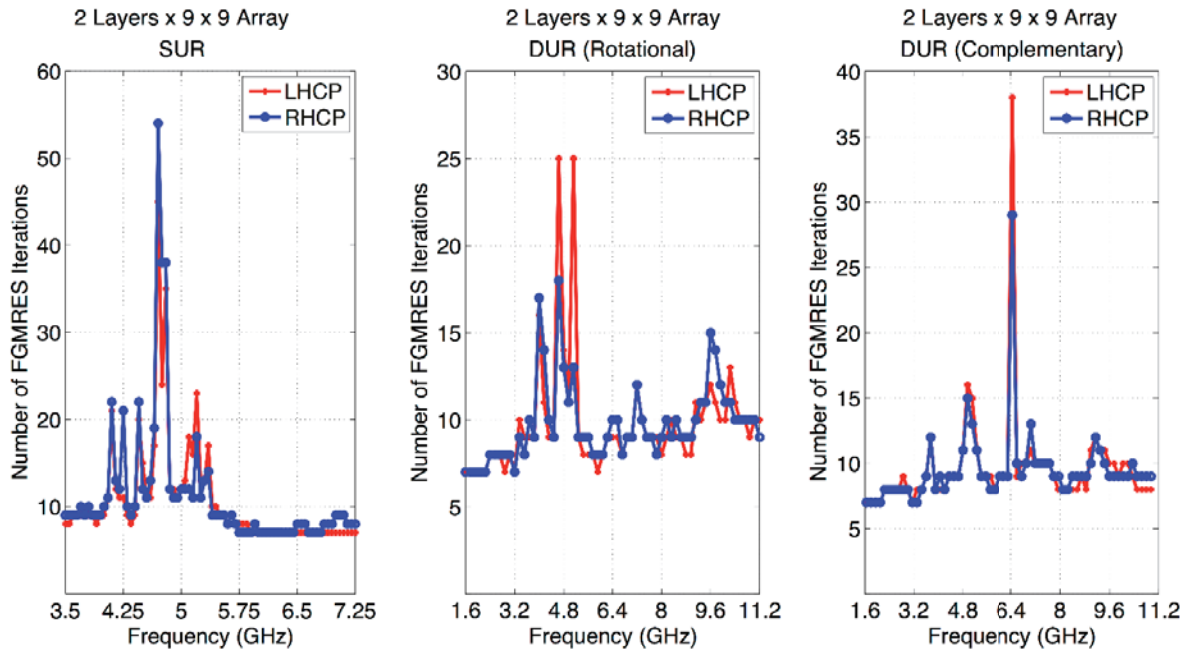

Figure 3. The iterative solutions of the frequency-selective structures, when they were illuminated by plane waves with LHCP and RHCP.

especially in frequency-domain numerical simulations. On the other hand, it is possible to design an effective structure by changing the arrangement of resonators at the bottom layer, leading to the complementary DUR design shown in Figure 1. As presented in the sample results, the resulting frequency-selective structure demonstrated strong resonances corresponding to both larger and smaller resonators.

Given the frequency-selective structures described above, the purpose was to find their electromagnetic responses at microwave frequencies, particularly from 1 GHz to 11 GHz when they were located in free space. In the sample solutions, only normal incidence was assumed, while both right-hand and left-hand circular polarizations were considered. We noted that the structures were expected to block transmission at resonances, while they were typically transparent at other microwave frequencies.

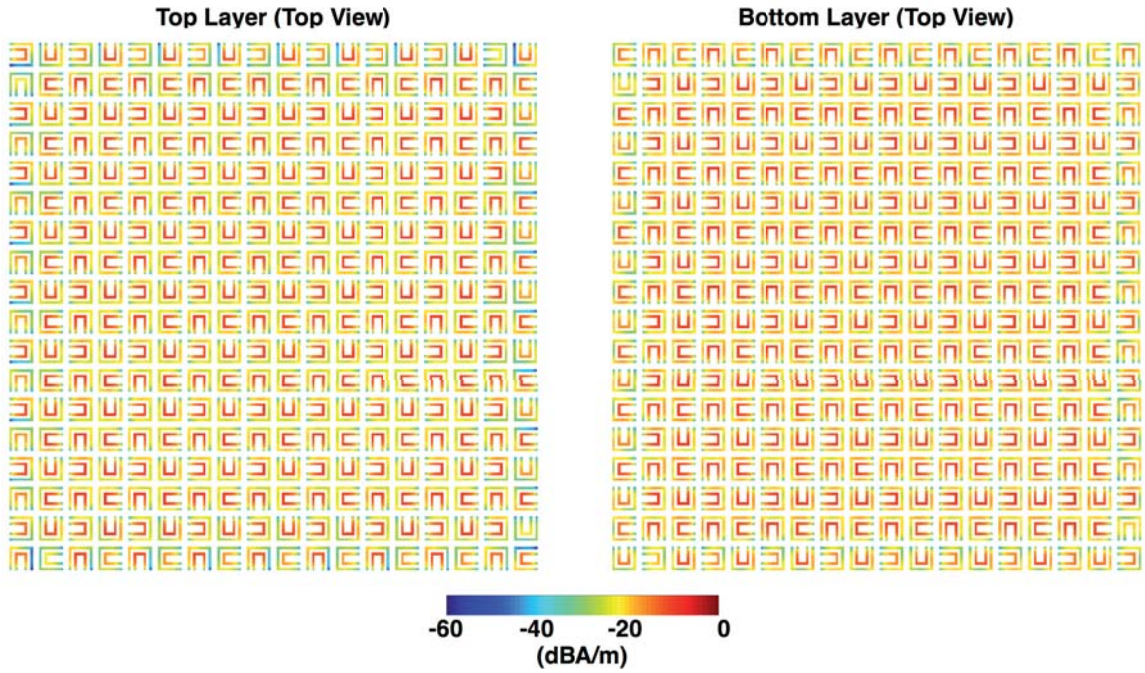

Figure 4. The electric-current density induced on the complementary DUR structure at 7.65 GHz when it was illuminated by a plane wave with LHCP. Smaller resonators were active at this frequency.

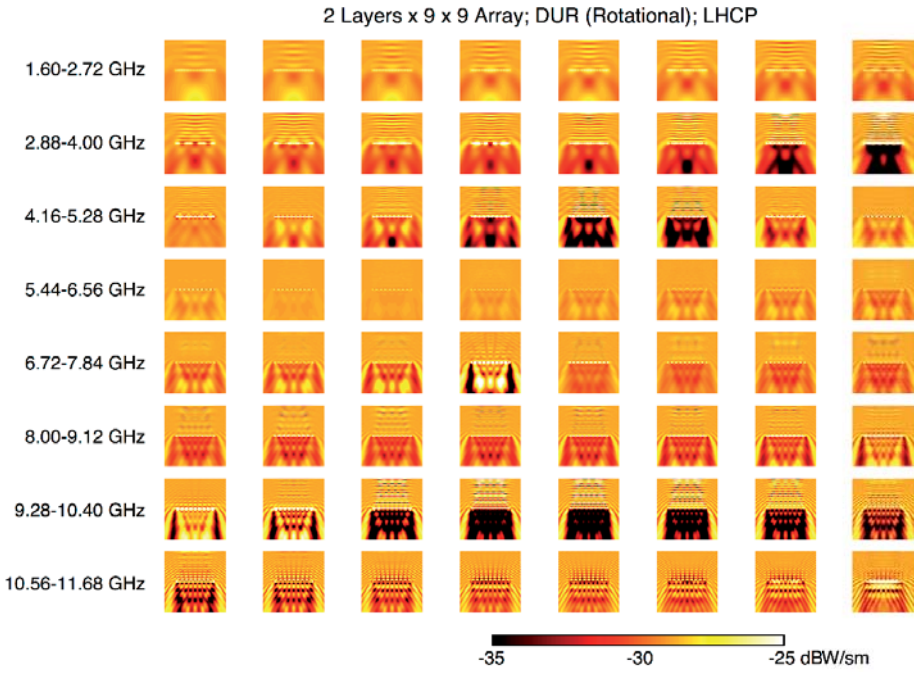

Figure 5. The near-zone power density in the vicinity of the rotational DUR structure at different frequencies when it was excited by plane waves with LHCP.

3. Solution to Problem SOLBOX-15

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 resources used: 2.5 GHz Intel Xeon E5-2680v3 processors (using 1 core)
Total time required to produce the results shown (categories: < 1 sec, < 10 sec, < 1 min, < 10 min, < 1 hour, < 10 hours, < 1 day, < 10 days, > 10 days) <1 hour for each solution (per frequency)

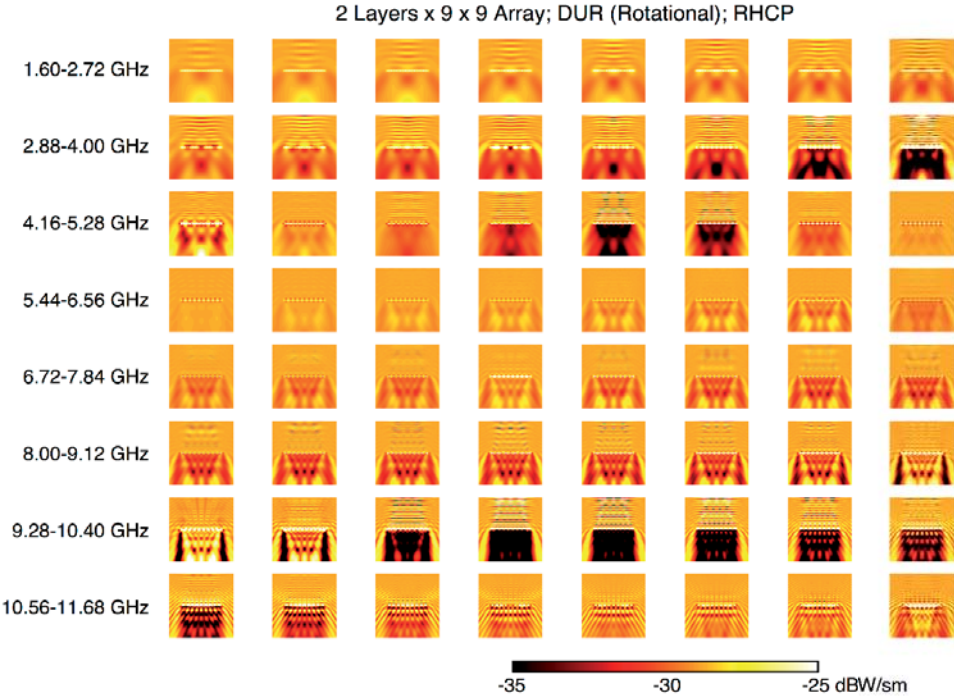

Figure 6. The near-zone power density in the vicinity of the rotational DUR structure at different frequencies when it was excited by plane waves with RHCP.

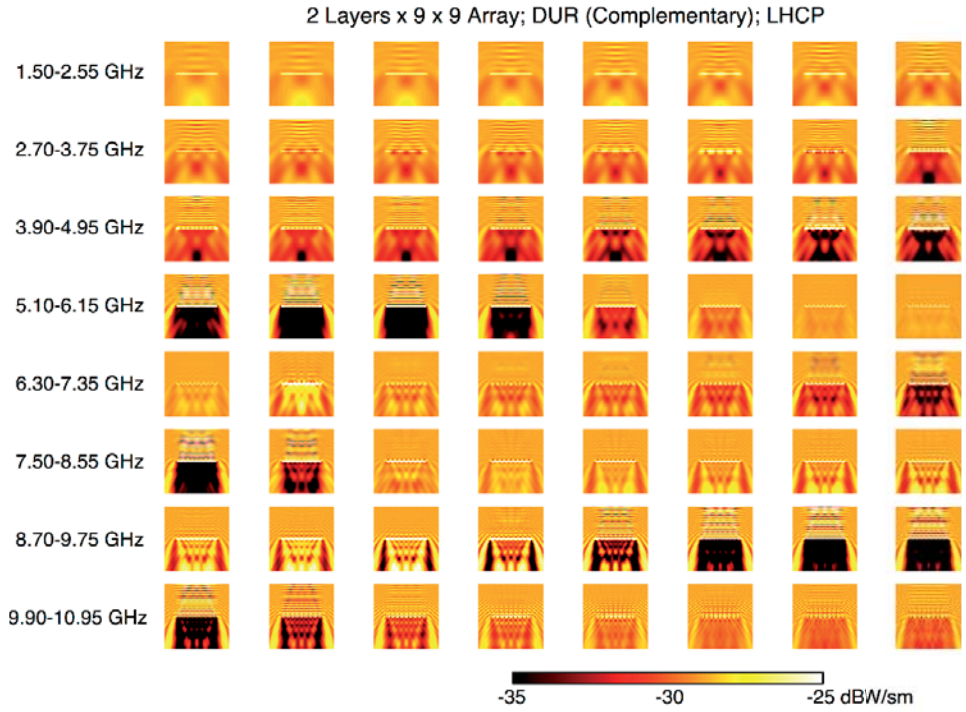

Figure 7. The near-zone power density in the vicinity of the complementary DUR structure at different frequencies when it was excited by plane waves with LHCP.

3.2 Short Description of the Numerical Solutions

The frequency-selective structures described in SOLBOX-15 were solved by using a frequency-domain solver based on the conventional MLFMA [3]. Assuming perfectly conducting surfaces with zero thicknesses, the well-known electric-field integral equation was employed as the formulation. Each structure was discretized with nearly 30,000 triangles, while Rao-Wilton-Glisson functions were used to expand the electric-current density induced on surfaces. The frequency was sampled with 150 MHz or 160 MHz intervals. Iterative solutions were performed by using the Generalized Minimal

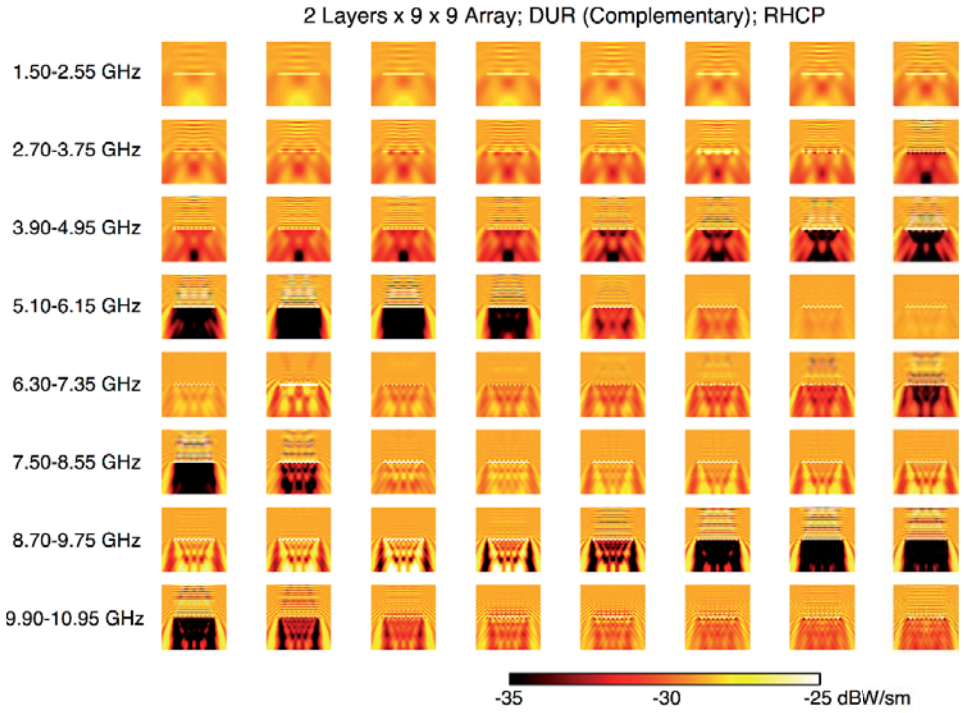

Figure 8. The near-zone power density in the vicinity of the complementary DUR structure at different frequencies when it was excited by plane waves with RHCP.

Residual (GMRES) algorithm. However, even when using no-restart GMRES, solutions are quite challenging without preconditioning (or with simple preconditioners). Therefore, multilayer solutions involving recursive application of MLFMA and its approximate forms [4] were carried out to reach results in reasonable processing times. For example, Figure 2 presents iterative solutions of the SUR design at 4.0 GHz and 4.5 GHz. The residual error was plotted with respect to iterations of the flexible GMRES (that allowed for multilayer solutions) when three-layer solutions were performed, in addition to those without preconditioning. At 4.0 GHz, the number of iterations to reach 0.001 error was 818 without preconditioning, while it could be reduced to only 11 via three-layer solutions. At the more challenging frequency of 4.5 GHz, the reduction in the number of iterations was from 4086 to 41. We noted that these numbers did not directly correspond to processing times. However, it was clear that a complete analysis of the frequency-selective structures of SOLBOX-15 required rigorous acceleration techniques if iterative methods were to be used. In the following results, all solutions were performed via the three-layer mechanism.

3.3 Results

Figure 3 presents iterative solutions of the three frequency-selective structures of SOLBOX-15 when they were illuminated by plane waves with left-hand-circular polarization (LHCP) and right-hand-circular polarization (RHCP). For each structure, the number of flexible GMRES iterations was plotted with respect to frequency when three-layer solutions were performed. We observed relatively small numbers of iterations, except at specific frequencies. However, even at these frequencies iteration counts did not exceed 60. It was remarkable that challenging frequencies in terms of iterative solutions did not exactly coincide with frequencies at which element resonances were observed. These types of shifts (numerical versus physical resonances) have occasionally been observed in the literature of metamaterials and frequency-selective structures [5]. As an example, Figure 4 depicts the electric-current density induced on the complementary DUR design at 7.65 GHz when it was illuminated by a plane wave with LHCP. At this frequency, smaller U-resonators became active and made the structure opaque. On the other hand, this frequency was not among the most challenging frequencies in terms of iterative solutions, as depicted in Figure 3. Similarly, at the numerically challenging frequency of 6.4 GHz for the same structure, the electromagnetic response was not very strong, i.e., no shadowing occurred (see Figure 7).

Figures 5 and 6 present the power density (in dBW/sm) in the vicinity of the frequency-selective structure with the rotational DUR design from 1.6 GHz to 11.68 GHz. Power density values were plotted on the *z*-*x* plane, assuming that the structure was located on the *x*-*y* plane (side view). Plane waves with LHCP (Figure 5) and RHCP (Figure 6) illuminated the structure from the top, while the transmission region was located at the bottom of the plots. In the frequency range considered, we observed three important resonance effects: one located at around 4.0 GHz, another at around 4.8 GHz, and the third one centered at approximately 9.8 GHz. Although not shown here, a close examination revealed that all these three resonances were related to the larger resonators, while resonances of the smaller resonators were not visible, at least with the sampling of the frequency used. As a related observation, a rapid change in the near-zone characteristics at 7.2 GHz for the LHCP excitation, which might be caused by small resonators, was remarkable.

Near-zone characteristics of the complementary DUR structure are shown in Figures 7 and 8, where we again considered excitations with LHCP and RHCP, respectively. In this case, the frequency was sampled at 150 MHz intervals from 1.5 GHz to 10.95 GHz. In this frequency range, there were three main resonance regions. The first region became strong at around 5.25 GHz, while it started to be visible even at 3.75 GHz. This resonance was caused by the larger resonators. The second resonance, which was related to the smaller resonators, occurred at approximately 7.5 GHz. Finally, the third resonance that was also induced by the larger resonators was centered at around 9.6 GHz. It was remarkable that as opposed to the rotational DUR design, this frequency-selective structure provided very similar responses to LHCP and RHCP excitations, which may be preferred in real-life applications.

4. References

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European School of Antennas 2019

ESoA Board

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www.esoa-web.org

http://www.facebook.com/europeanschoolofantennas

COMPRESSIVE SENSING AS APPLIED TO ELECTROMAGNETICS
UNITN, Riva del Garda, March 18-22
Coordinators: A. Massa, G. Oliveri

ANTENNA MEASUREMENTS FOR MILLIMETER AND SUBMILLIMETER WAVELENGTHS
AALTO, Espoo, May 6-10
Coordinator: A. Räisänen

INDUSTRIAL ANTENNA DESIGN
IMST, Kamp-Lintfort, May 13- 17
Coordinators: W. Simon, D. Manteuffel

ANTENNA SYSTEM FOR 5G COMMUNICATION
CHALMERS, Gothenburg, May 20-24
Coordinators: J.Yang, R. Sauleau

ADVANCED MATERIALS FOR ANTENNA AND MICROWAVE DEVICES
LBORO, Loughborough, June 10-14
Coordinator: Y. Vardaxoglou, A. Alexandridis

MOBILE RADIO PROPAGATION FOR 5G AND BEYOND
UNIBO, Cesenatico, June 10-14
Coordinators: , V. Degli Esposti, C. Oestges,T. Kürner

ADVANCED SPHERICAL NEAR-FIELD ANTENNA MEASUREMENT TECHNIQUES
DTU, Copenaghen, June 17-21
Coordinator: O. Breinbjerg

ANTENNA IMAGING TECHNOLOGIES
TUDelft, Delft, June 24-28
Coordinator: A. Neto

FREQUENCY DOMAIN TECHNIQUES:FROM INHOUSE TO COMMERCIAL EM SOLVERS
UNIFI, Florence, September 2-6
Coordinators: A. Freni, J. Mosig

DIAGNOSTIC AND THERAPEUTIC ELECTROMAGNETIC APPLICATIONS
UNINA, Naples, September 9-13
Coordinators: L.Crocco, G. Vecchi

METASURFACES FOR ANTENNAS
UNIZG, Zagreb, September 23-27
Coordinators: S. Maci, Z. Sipus

FUNDAMENTALS ON ANTENNAS
UC3M, Madrid, October 14-18
Coordinator: D. Segovia

BODY AREA NETWORK
QMUL, London, October 21–25
Coordinator: Y. Hao

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

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

ESOA off-shore

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

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True Colors

I have two- and four-year-old granddaughters who love holidays and celebrations. This past holiday season, my daughter got both girls their own miniature Christmas trees to decorate. This allowed my daughter to decorate the large tree while the young girls decorated their own trees. The girls eagerly snagged up ornaments and garland and made their trees glitter and sparkle. Later that day, my daughter noticed ornaments missing from around the bottom of the big tree. The two-year-old's little tree seemed to have a lot more ornaments than before. Suspicious, but with no concrete evidence that a crime was committed, my daughter ignored the problem and let the littlest girl have some fun. Very early the next morning, the two-year-old awoke and took all of the low-hanging ornaments from the big tree and placed them on her tree. In addition, she snagged all of the ornaments from her sister's tree, also adorning them onto hers. She had created a large, Las-Vegas-style structure (you could no longer see the tree) that glimmered with holiday cheer. How could this innocent-looking child wake up before the rest of the family and conduct such an unexpected raid? Where was her family loyalty?

In the 17th century, pirates began flying the flag of the ship that they planned to attack [1]. The unknowing victims allowed the pirates to approach. While boarding the ship, the pirates would then raise their real flag and attack. Battle ships in the 18th century also used this ploy in order to easily overtake their opponent's vessels [2]. This increasingly common maneuver led to the idiom, "to show your true colors," which is used when someone reveals their true character or opinions.

Some people build impressive facades that hide their unethical behavior. Behavioral patterns rather than words assess someone's "true colors." Many people have high standards for others, but not for themselves. These same people lack any awareness of their limits and moral deficiencies. Seeking to understand the motivation and actions of others helps identify a person's true colors.

In an article titled "How to Work With Coworkers You Distrust," published by *Fast Company*, Steve Errey outlined how to evaluate and react to seemingly unethical behavior with three suggestions [3]:

1. *Own Your Story*: Many times, people misinterpret a situation and jump to conclusions that create a story of ill will in others. Strip away the narrative in order to objectively assess a person's behavior and character. Reframe the scenario from someone else's point of view in order to determine their true intentions.

2. *Plant Your Feet*: Understand your own personal values and act accordingly. You must maintain your ethical code when faced with someone else's unethical behavior.

3. *Professionalism Doesn't Preclude Honesty*: Inaction in order to maintain professional relationships or to avoid "rocking the boat" is unacceptable. Modern definitions of acting "professional" require people to act with integrity and courage when faced with ethical dilemmas.

Everyone forgives an innocent-looking two-year-old for acting selfishly. However, you need to protect yourself from individuals who act solely in their self-interests. Analyzing behavioral patterns for intent will help you identify peoples' true colors. Defining your personal ethics and living by them equips you to deal with those who lack good character.

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3. https://www.fastcompany.com/3062590/how-to-work-with-coworkers-you-distrust, accessed 2/16/2019.

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Introduction by the Associate Editor

In this issue I present Tuija Pulkkinen, Professor and Chair of the Department of Climate and Space Sciences and Engineering at the University of Michigan. My intention was to present Tuija of Finland, but during the process she surprised the world by appearing in the US.

When I left the University of Helsinki for the Swedish Institute of Space Physics in the early 1980s, I heard quite soon that there are several very talented women on their way into space physics inspired by the approaching Finnish European Space Agency – ESA membership. Tuija was one of the first, and became very successful, indeed. She did her PhD at the Finnish Meteorological Institute – FMI, and advanced there to Research Professor and Head of the Space Research Program. She was recruited to the new multidisciplinary science, business, art, and design Aalto University – a merger of three former universities, the University of Technology, the School of Economics, and the University of Art and Design, all in Helsinki – first as Dean for the School of Electrical Engineering, and then as Vice President for Research and Innovation.

Tuija's success has, of course, been carried by a lot of publications and acquired research funding, many advised students, international awards and honors, key positions of trust, reviewing, memberships and offices held at AGU, COSPAR, EGU, IAGA, URSI, etc. The past eight years, I have been a member of the Space Research Programme Committee at the Norwegian Research Council, which Tuija was chairing, and I witnessed her firm leadership. Tuija gives here a very nice and humble view into her career, and answers the important and challenging question, "Why not?"

To Boldly Go Where Only Men Have Gone Before

Yesterday, I gave a presentation to a group of female high-school seniors, newly admitted to the University of Michigan College of Engineering. As a starter, I asked what was the most important thing they had learned during their weekend on campus. The most popular answer was, "There are more people like me." I, too, remember that feeling. The friendships created during those first years of studies (in the early 1980s) have endured time, children, and career moves until today.

Looking back at my career, it can be written as a sequence of logical steps: Enter graduate school to study space following Finland joining the European Space Agency; climb upward the management ladder from scientist to group leader to research professor and program chief at the Finnish Meteorological Institute; international experience through extended stays at UC Boulder and Los Alamos National Laboratory; moving on to become a Dean and then Vice President at Aalto (an ambitious merger university in Finland); and ending up in my current position as a department Chair at the University of Michigan in a top space research department. Meanwhile, networking in multiple professional societies, research organizations, and funding agencies. However, is that how it all happened? Not really.

I don't want to say that I don't have a will or interest of my own, but chance and other people have played a big role in my life. When I was a graduate student, Finland was building its space research community. We graduate students were sent to visit international research institutions in lieu of formal graduate education, which was nonexistent in Finland at the time. I was sent to NASA Goddard Space Flight Center (GSFC), which proved to be great on multiple accounts: I got mentorship, research results, and an opportunity to follow seminars given by a continuous flow of visitors from all over the world, covering everything from here and now to the fringes and formation of the universe. What I brought back were good connections, which led to a continuing sequence of future graduate students and postdocs to visit GSFC, equally enjoying the top science and engineering environment.

It seems that about every seven years, I start feeling restless, and that is when something usually happens, whether I actively plan it or not. The 16-month trip to Boulder in the mid-1990s was motivated by the mountains, and facilitated by my former mentor who had moved there. The one-year visit to Los Alamos 10 years later was initiated by invitation from their end, as they were seeking a modeling expert. However, what is ever so critical about going from initial planning to actual realization of moving a family across the Atlantic is the readiness of the family to be part of a nomadic scientist's life. I have the fortune of having a wonderful husband and son, who are always eager to try something new. These long trips involve a lot of work, cost a lot of money, and include many stressful moments, but that said, they have made us a very close family that always keeps together.

Then came Finnish university reform, and I got an opportunity to join Aalto, first as a Dean and then as Vice President. Never having worked as a professor, I was challenged to develop, together with other deans, a tenure-track career system for professors, which was nonexistent in Finland and rare in Europe. Later in my role as Vice President, I, who could not sell even Girl Scout cookies as a kid, was tasked with developing entrepreneurship and industrial collaborations at the university. Those years were intense, fun, and challenging, but science finally called me back in my next move to Michigan.

Many people ask why I moved to Michigan from a good position at Aalto. There are logical (and true) answers: I wanted to get back to doing science; it was about time to make the last big career move; I moved to a leading research university, top department and resources.... However, that's not really it. I moved because I had an opportunity. The question that has shaped my life and my career over and over again is not "Why?" but "Why not?" If I cannot convince myself of "Why not," I'm too curious not to try.

Last year, I was asked in an interview what I considered my most important contribution to the field. Undoubtedly, by far the most significant are the young scientists whose careers I have had the opportunity to support as an advisor or mentor. I consider these people my "children," and I am as proud (or even more) of their successes than I am of my own. It is one of the things that has not changed in the thousand years of existence of universities: Science advances through new minds that learn, challenge what they have learned, and come up with new solutions.

Figure 1. Tuija Pulkkinen

URSI Accounts 2018

Over the past few years, URSI has increased its efforts to stimulate and encourage interaction, collaboration and networking across different disciplines in the field of radio science. The creation of a yearly URSI Flagship meeting in 3-year cycle between the URSI General Assembly and Scientific Symposium (GASS), the Atlantic Radio Science Conference (AT-RASC) and the Asia-Pacific Radio Science Conference (AP-RASC) is one of these initiatives and cornerstones of the current operation of URSI. In order to enhance the visibility of URSI and increase the awareness, URSI has also established now Individual Membership with different levels (Corresponding members, Members and Fellows). URSI has also launched, towards the end of 2018, a new publication: the URSI Radio Science Letters which will add a possibility for radio scientists to quickly publish their work.

Although URSI has substantial reserves that allow us to invest in new initiatives, all of the investments related to this transformation and new initiatives are taken in a very careful and exploratory way without compromising the long-term future of URSI. The tremendous amount of voluntary work done by all the URSI officers, Commission representatives and individuals within the URSI community to support URSI is not always valued to the extent it should be. The commitment of our scientific community to URSI is crucial in the success of URSI and cannot be underestimated. It is obvious this involvement contributes to the financial health of URSI.

Also thanks to the financial success of both the GASS 2017 (Montreal) as well as the AT-RASC 2018 (Gran Canaria), the financial situation of URSI is positive as can be seen from the audited accounts. The growth of these Flagship meetings, thanks to the efforts of many, is offering the possibility to URSI to continue its support to Young Scientists attending these Flagship meetings as well as to Student Paper Competitions at regional or national meetings organized by the URSI Member Committees.

On a personal note, I would like to express my special thanks to my predecessor, Prof. Paul Lagasse, who has been serving URSI for over 25 years as Secretary General and has always been able to let URSI grow and to increase the added value for scientists being involved in URSI while maintaining URSI's financial health and financial stable situation during all those years, despite the many economic downturns that we have seen. I share Prof. Lagasse's view that, attracting young people to careers in radio science, helping them launch their career successfully, giving them the opportunity to present their work and facilitating their participation in a free exchange of scientific results in a worldwide community of radio scientists, is a very important, if not the most important aspect of the URSI mission.

Prof. Peter Van Daele
Secretary General of URSI

BALANCE SHEET: 31 DECEMBER 2018

	EURO	EURO
ASSETS		
Installations, Machines & Equipment		2,633.83
Dollars		
BNP Paribas (USD)	137.46	
BNP paribas (CAD)	64,622.60	
		64,760.06
Euros		
Banque Degroof	0.00	
BNP Paribas zichtrekening	46,871.42	
BNP Paribas spaarrekening	692.87	
BNP Paribas portefeuillerekening	32,049.25	
Paypal	0.00	
		79,613.54
Investments		
DPAM Bonds EMU (formerly Demeter Sicav Shares)	22,681.79	
Rorento Units	111,995.67	
DPAM MML MON (formerly Aqua Sicav)	63,785.56	
Bonds	381,000.00	
	579,463.02	
673 Rorento units on behalf of van der Pol Fund	11,833.55	
		591,296.57
Petty Cash		126.49

Total Assets		738,430.49
Less Creditors		
IUCAF	34,750.50	
ISES	5,053.53	
		(39,804.03)
Balthasar van der Pol Medal Fund		(11,833.55)
Basu Medal Fund		(4,216.35)
Paid Remuneration		6,752.90
NET TOTAL OF URSI ASSETS		**689,329.46**

The net URSI Assets are represented by:	EURO	EURO
Closure of Secretariat		
Provision for Closure of Secretariat		115,000.00
Scientific Activities Fund		
Scientific Activities in 2018	60,000.00	
Routine Meetings in 2018	20,000.00	
Publications/Website in 2018	40,000.00	
Young Scientists in 2018	0.00	
Administration Fund in 2018	105,000.00	
I.C.S.U./I.S.C. Dues in 2018	6,000.00	
		231,000.00
Flagship Meetings		
GASS 2017 - Montreal		0.00
GASS 2020 - Rome		120,000.00
AT-RASC - Gran Canaria (2018)		30,000.00
AP-RASC - New Delhi (2019)		30,000.00
Total allocated URSI Assets		526,000.00
Unallocated Reserve Fund		163,329.46
		689,329.46

Statement of Income and expenditure for the year ended 31 December 2018

I. INCOME

Contributions from National Members (year -1)	35,918.00	
Contributions from National Members (year)	177,890.00	
Contributions from National Members (year +1)	8,510.00	
Income General Assembly 2017	168,100.25	
Income AT-RASC 2015/2018	254,405.98	
Income AP-RASC 2019	0.00	
Sales of Publications, Royalties	0.00	
Bank Interest	0.00	
Other Income	7,432.40	
Total Income		**652,256.93**

II. EXPENDITURE

A1) Scientific Activities		391,797.22
General Assembly 2014/2017	16,789.02	
Mid Term Meetings 2015	0.00	
AT-RASC	339,052.60	
AP-RASC	28,806.01	
Scientific Meetings: Symposia/Colloquia	5,239.93	
Representation at Scientific Meetings	1,909.66	
Other	0.00	

A2) Routine Meetings			285.20
Bureau/Executive committee		285.20	
Other		0.00	
A3) Publications			34,105.06
B) Other Activities			5,821.00
Contribution to ICSU/I.S.C. (2018)		3,821.00	
Contribution to other ICSU bodies/I.S.C. bodies		2,000.00	
C) Administrative Expenses			128,537.62
Salaries, Related Charges		99,535.91	
General Office Expenses		1,693.71	
Travel and representation		5,918.34	
Insurances/Communication/Gifts		8,013.33	
Office Equipment		0.00	
Accountancy/Audit Fees		6,170.42	
Bank Charges/Taxes		5,888.99	
Depreciation		1,316.92	
Loss on Investments (realised/unrealised)			
Total Expenditure:			**560,546.10**
Excess of Expenditure over Income			91,710.83
Currency translation diff. (USD => EURO) - Bank Accounts			(2,793.34)
Currency translation diff. (USD => EURO) - Investments			0.00
Currency translation diff. (USD => EURO) - Others			0.00
Accumulated Balance at 1 January 2018			600,411.97
			689,329.46
Rates of exchange			
January 1, 2018	1 USD = 0.8347 EUR		
December 31, 2018	1 USD = 0.8737 EUR		1 CAD = 0.6409 EUR
Balthasar van der Pol Fund			
652 Robeco Global (formerly Rorento Shares) : market value on December 31			
(Aquisition Value: USD 14,175.00/EUR 11,833,55)			37,457.40
Book Value on December 31, 2018/2017/2016/2015/2014			11,833.55
Market Value of investments on December 31, 2018-2014			
DPAM EMU (formerly Demeter Sicav Shares)			94,832.10
Robeco Global (formerly Rorento Units) (1)			720,720.00
DPAM MML MON (formerly Aqua-Sicav)			89,156.20
Bonds			381,000.00
			1,285,708.30
Book Value on December 31, 2018/2017/2016/2015/2014			591,296.57

(1) Including the 652 Rorento Shares of v d Pol Fund

APPENDIX : Detail of Income and Expenditure

I. INCOME

Other Income		
Young scientist support (Japan)	0.00	
Income bonds	4,639.40	
Other	2,793.00	
		7,432.40

II . EXPENDITURE

General Assembly 2014		
Organisation	0.00	
Vanderpol Medal	0.00	
Young scientists	0.00	
Expenses officials	0.00	
Support Commissions	0.00	
General Assembly 2017		
Organisation	15,025.34	
Vanderpol Medal	0.00	
Basu Award	0.00	
President's Award	0.00	
Young Scientists	0.00	
Expenses officials	0.00	
Support Commissions	1,763.68	
		16,789.02
AT-RASC		
Organisation	228,957.77	
Young Scientists	25,930.98	
Expenses Officials	41,744.55	
Support Commissions	42,419.30	
		339,052.60
AP-RASC		
Organisation	28,806.01	
Young Scientists	0.00	
Expenses Officials	0.00	
Support Commissions	0.00	
		28,806.01
Routine Meetings		
Board Meeting	285.20	
		285.20
Symposia/Colloquia/Working Groups		
Commission A	0.00	
Commission B	0.00	
Commission C	0.00	
Commission D	0.00	
Commission E	0.00	
Commission F	0.00	
Commission G	0.00	
Commission H	1,700.00	
Commission J	0.00	
Commission K	0.00	
Central Fund	0.00	
Central Fund (Student Award MC)	3,539.93	
		5,239.93
Contribution to other ICSU bodies		
IUCAF	2,000.00	
		2,000.00
Publications		
Publications/Website	34,105.06	
		34,105.06

URSI Conference Calendar

March 2019

SPIN 2019
6th International Conference on Signal Processing and Integrated Networks
Noida, Uttar Pradesh, India, 7-8 March 2019
Contact: Dr. Pradeep Kumar, Department of Electronics and Communication Engineering, Amity School of Engineering and Technology, Sector-125, Block E1, II Floor, Amity University Uttar Pradesh Noida, Delhi-NCR- 201313, (U.P.) Tel: +91-1204392517, Email: spin@amity.edu, http://www.amity.edu/spin2019/default.asp

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

EuCAP 2019
13th European Conference on Antennas and Propagation
Krakow, Poland, 31 March – 5 April 2019
Contact: Please e-mail all enquiries to eucap2019@mazurkas.pl, https://www.eucap2019.org

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/

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

IEEE RFID-TA 2019
10th IEEE International Conference on RFID Technology and Applications
Pisa, Italy, 25-27 September 2019
Contact: http://www.elettromagnetismo.it/10th-ieee-international-conference-on-rfid-call-for-papers/

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

COSPAR 2020
43rd Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events
Sydney, Australia, 15-23 August 2020
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.cospar2020.org

URSI GASS 2020
Rome, Italy, 29 August - 5 September 2020
Contact: URSI Secretariat, c/o INTEC, Tech Lane Ghent Science Park - Campus A, Technologiepark-Zwijnaarde 15, B-9052 Gent, Belgium, E-mail gass@ursi.org, http://www.ursi2020.org

May 2021

AT-RASC 2021
Third URSI Atlantic Radio Science Conference
Gran Canaria, Spain, 23-28 May 2021
Contact: Prof. Peter Van Daele, URSI Secretariat, Ghent University – INTEC, Technologiepark-Zwijnaarde 15, B-9052 Gent, Belgium, Fax: +32 9-264 4288, E-mail: peter.vandaele@ugent.be, http://www.at-rasc.com

August 2022

AP-RASC 2022
Asia-Pacific Radio Science Conference 2022
Sydney, Australia, 21-25 August 2022
Contact: URSI Secretariat, Ghent University – INTEC, Technologiepark-Zwijnaarde 126, B-9052 Gent, Belgium, E-mail: info@ursi.org

A detailed list of meetings is available on the URSI website at http://www.ursi.org/events.php

Information for Authors

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