Women's Contributions in Electromagnetic Inverse Problems

Martina T. Bevacqua, Maria Antonia Maisto, and Rosa Scapaticci

EDITOR'S NOTE

Francesca Vipiana

In this issue, the "Women in Engineering" column presents the special session "Women's Contributions in Electromagnetic Inverse Problems," organized by Martina Teresa Bevacqua (University Mediterranea of Reggio Calabria, Italy), Maria Antonia Maisto (University of Campania, Aversa, Italy), and Rosa Scapaticci (Institute of Electromagnetic Sensing of the Environment, National Research Council of Italy, Napoli, Italy) at the 2021 URSI General Assembly and Scientific Symposium (GASS 2021) in Rome, Italy, from 28 August to 4 September 2021. GASS 2021 was one of the first hybrid international conferences during the pandemic where a significant number of researchers were present in Rome, again allowing interactions in person (and not only online) among all of the participants.

Science is often considered a male-dominated field. Today, women are still discouraged from entering the fields of technology, engineering, and math and, in the last two years, the COVID-19 pandemic has worsened this situation. Nevertheless, despite challenges of gender discrimination and lack of recognition in the scientific community, countless inspiring women in these fields have made historic contributions to science and helped develop a better understanding of the world around us. Many women were not recognized in their own lifetimes, but their achievements have helped generations of female scientists to come.

These considerations, combined with the occurrence in this year of the centenary of the foundation of the International Union of Radio Science, encouraged us to organize something different from the classical session at the 2021 URSI General Assembly and Scientific Symposium (GASS). URSI-GASS takes place every three years to review current research trends, present new discoveries, and make plans for future research and special projects in all areas of radio science (for more details, visit https://www.ursi.org/homepage.php). Moreover, URSI-GASS 2021 was one of the first hybrid in-person/virtual synchronous meetings due to the COVID-19 nightmare, thus giving the possibility to partially go back to old-style conferences, meet friends and colleagues again, and have inspiring talks and ideas with them, exchanging about electromagnetics.

Then, also incited by the special occasion, we had an idea! Why not organize a *pink* session? And why not on a topic that is very close to our hearts, that is, inverse problems in electromagnetics? We suddenly decided that a session called "Women's Contributions in Electromagnetic Inverse Problems" would be a really interesting topic to promote and valorize women's efforts and results in such a specific field. This topic is in line with the aim of the IEEE Women in Engineering organization and of the URSI-GASS conference, which this year also included a more general workshop on women in radio science.

Pushed by excitement and proud at the same time, we started detailed research on Scopus over the last 40 years by using the keywords "electromagnetic inverse problem." We also considered personal knowledge of brilliant women who had contributed to the topic. We discovered, interestingly, that several research works exist, involving different applications, which are mainly led by women.

The invitation responses were positive, although there were uncertainties about the actual acceptance of the session as well as the organization of the conference in hybrid form due to the COVID-19 pandemic. Finally, the special session, "Women's Contributions in Electromagnetic Inverse Problems," took its final shape, including the following papers:

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1) (*Invited*) Natalia Nikolova (speaker), Daniel Tajik, Romina Kazemivala, and Michael Noseworthy, "Quantitative Microwave Imaging of Flattened Breast Phantoms With Direct Inversion Algorithms"
2) Marija Nikolic Stevanovic (speaker), Tushar Singh, Branislav Ninkovic, and Branko Kolundzija, "Microwave Sparse Imaging Applied to Stroke Monitoring"
3) Miguel Moscoso, Alexei Novikov, George Papanicolaou, and Chrysoula Tsogka (speaker), "3D Imaging With Single Element Intensity Measurements"
4) Sebastian Acuña and Krishna Agarwal (speaker), "Autothresholding in MUSICAL Using Non-Orthogonal Signal-Noise Separation"
5) Ilaria Catapano (speaker), "From Microwave to TeraHerz: Electromagnetic Imaging for Cultural Heritage"
6) Flora Zidane (speaker), Vanna-Lisa Coli, Jérôme Lanteri, Didier Binder, Julien Marot, and Claire Migliaccio, "Classification of Archeological Pottery Samples"
7) Adriana Brancaccio (speaker), "Localization of Bars in Reinforced Concrete by Microwaves: A Quasi-Quadratic Inverse Scattering Approach"
8) Francesca Vipiana (speaker), "Microwave Sensing and Imaging in Health and Food Industry."

The session was divided into three slots: two slots contained three presentations and the first one contained two presentations, to provide more time to the invited speaker. The technical contributions were high and touched different methodologies and applications within the framework of inverse electromagnetic problems. They showed very interesting results in different fields, such as microwave imaging problems, fluorescence optical microscopy, and X-ray crystallography wherein a phase retrieval problem must be faced. We had a good balance between applications and theoretical contributions. In particular, in the framework of microwave imaging problems, many new approaches were proposed in a very large number of applicative contexts, ranging from biomedical imaging (breast cancer detection and brain imaging), noninvasive inspection of archaeological pottery samples, or, more generally, the frame of cultural heritage, to the nondestructive testing of reinforced concrete structures in civil engineering. Industrial applications, such as the detection of foreign bodies in food manufacturing, were also considered. More experienced women researchers were not the only ones who contributed to the session; a young Ph.D. student also talked about her research activity. It was extremely interesting to appreciate how women of such different ages and from such different countries and experiences could share the same enthusiasm and passion toward research and professional life. The speeches confirmed the importance of the electromagnetic inverse problem in many applications and many efforts were made so far by women researchers to improve the imaging capabilities of existing technologies and to introduce novel ones.

Our only regret is that, because of the pandemic, not all of the speakers were on site, so we could not meet all of them in person.

The session was noteworthy and inspiring. It included many attendees, both male and female, and many interesting technical questions were posed. At the end of the day, some male colleagues agreed that despite their many difficulties and their reduced number, women's contributions to electromagnetic inverse problems are comparable and sometimes also higher than that of male colleagues. Our only regret is that, because of the pandemic, not all of the speakers were on site, so we could not meet all of them in person. The speakers present at the conference can be seen (wearing masks) in Figure 1, together with two of the organizers.

As we stated at the end the first edition of this special session, we conclude this "Women in Engineering" column with the hope that in the near future, by overcoming the travel restrictions due to the pandemic, we can meet a large number of enthusiastic women who want to share with us the results of their brilliant research in person.

FIGURE 1. The panelists and organizers of the "Women's Contributions in Electromagnetic Inverse Problems" session at GASS 2021. From left: Martina T. Bevacqua, Marija Nikolic Stevanovic, Francesca Vipiana, Maria Antonia Maisto, Andriana Brancaccio, and Natalia Nikolova.

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derivations of Ampere's law in (22) and (23) as well as Faraday's law in (33) and (34). The derivations, in principle, are theoretically complete. The results may be extended to any material medium by using suitable permittivity and permeability parameters to represent different induced effects in the internal charge structure of the material.

A NEW FORM OF GAUSS'S LAW AND CHARGE INVARIANCE

Conventional Gauss's laws are independently valid in the primed [(14) and (24)] and unprimed [(15) and (25)] frames. Experiments to implement them are simultaneously conducted at a given time in the respective frames. In addition, a new form of Gauss's laws is introduced, implemented in experiments (17) and (28). Here, a Gauss's law experiment originally conducted in the primed frame at a given time $t', \Delta t' = 0$ is invariant as observed from the unprimed frame with different timing ($\Delta t \neq 0$) for the individual measurements. These Gauss's law experiments, definitively timed in a particular frame (primed frame), unambiguously measure the same amount of charge (electric and equivalent magnetic), assuming the charge is invariant to any relative motion.

On the other hand, the conventional form of the Gauss's law experiments is not guaranteed to measure the same amount of charge in two frames because a part of the charge may be moving and might escape the measurement box during the different independent timings of measurements in the two frames. In other words, the new form of Gauss's laws is the only unambiguous way to ensure the invariance of charge (electric and equivalent magnetic) across reference frames, and therefore it is more fundamental. Enforcing this form of Gauss's laws naturally enables a direct "derivation" of Ampere's and Faraday's laws (22) and (33) as additional required conditions. This is a significant development.

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