prof. Filiberto BILOTTI's CURRICULUM VITAE

Filiberto Bilotti, IEEE Fellow, AIAA Fellow
Full Professor of Electromagnetic Field Theory
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DATA e FIRMA

Roma, 6.5.2025

Professional career

2014-now: Full Professor at ROMA TRE University
2021-now: Overseas Professor at the Nanjing University of Science and Technology
2011-2014: Associate Professor at ROMA TRE University
2002-2011: Assistant Professor at ROMA TRE University
2001-2002: Adjoint Professor at ROMA TRE University

Education

Ph.D. Degree
University: ROMA TRE University
Degree: Electronic Engineering
Thesis: Design of electromagnetic components loaded with complex materials
Year: 2002

Laurea Degree
University: ROMA TRE University
Degree: Electronic Engineering
Thesis: Design of electromagnetic components loaded with inhomogeneous substrates
Year: 1998

Short biography

Filiberto Bilotti received the Laurea and Ph.D. degrees in electronic engineering from ROMA TRE University, Rome, Italy, in 1998 and 2002, respectively.
Since 2002, he has been with the Faculty of Engineering (2002–2012), the Department of Engineering (2013–2021), and the Department of Industrial, Electronic, and Mechanical Engineering (since 2021) at ROMA TRE University, where he serves as a Full Professor of electromagnetic field theory (since 2014) and the Director of the Metamaterials Research Laboratory (since 2012).
His main research interests include modeling and application of artificial electromagnetic materials, metamaterials, and metasurfaces at both microwave and optical frequencies. The research activities developed in the last 20 years has resulted in more than 750 papers in international journals, conference proceedings, book chapters, and 3 patents.
Prof. Bilotti was the recipient of a number of awards and recognitions, including the elevation to the IEEE Fellow Grade for contributions to metamaterials in 2017, the AIAA Fellow Grade in 2023, the IEEE Chen-To-Tai Distinguished Educator Award in 2023, the Advanced Materials Award in 2023, the NATO SET Panel Excellence Award in 2016, and many prizes for the best paper awards at international conferences in the field of metamaterials.
He has been serving the scientific community, by playing leading roles in the management of scientific societies, in the editorial board of international journals, and in the organization of conferences and courses. In particular, he was a founder of the Virtual Institute for Artificial Electromagnetic Materials and Metamaterials – METAMORPHOSE VI in 2007. He was elected as a member of the Board of Directors of the same society for two terms from 2007 to 2013 and as the President for two terms from 2013 to 2019. He currently serves the METAMORPHOSE VI as the Vice President and the Executive Director (since 2019).
He hosted in 2007 the inaugural edition of the International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials Congress, served as the Chair of the Steering Committee of the same conference for eight editions (2008–2014, and 2019), and was elected as the General Chair of the Metamaterials Congress for the period from 2015 to 2018. He has been serving as the Chair or a member of the technical

program, steering, and organizing committee of the main national and international conferences in the field of electromagnetics.

Short list of research projects

European Projects

- Horizon Europe - Pathfinder – "Plasma reconfigUrabLe metaSurface tEchnologies (acronym PULSE)", project n. 10109931 2023-2026
- H2020 NANOARCHITECTRONICS (Coordination and support action) - 2017-2018
- FP-7 NANOGOLD (STREP) - Self-organized nanomaterials for tailored optical and electrical properties - 2009-2012
- FP-7 ECONAM (Coordination and support action) - Electromagnetic Characterization Of NAnostructured Materials - 2008-2011
- FP-6 METAMORPHOSE (Network of Excellence) - METAMaterial ORganized for radio, millimetre wave, and PHOtonic Superlattice Engineering - 2004-2008

Projects funded by the Italian Ministry of Education

- 2024-2025 – PNRR Extended Partnerships – Programme RESTART – BAC – Principal Investigator of the project SMART – Smart Metasurfaces Advancing Radio Technologies.
- 2023-2025 – PNRR Innovation Ecosystems - ROME TECHNOPOLE (leader of the Flagship Project 5 "Digital transition through AESA radar technology, quantum cryptography and quantum communications" appointed by the Rector of ROMA TRE University)
- 2023-2025 - "Smart Materials for Ubiquitous Energy Harvesting, Storage, and Delivery in Next Generation Sustainable Environments (acronym: AURORA)" - PRIN 2022 PNRR (Co-Principal Investigator; Principal Investigator: Prof. A. Massa)
- 2019-2021 - "Cloaking metasurfaces for a new generation of intelligent antenna systems (acronym: MANTLES)" - PRIN 2017 contract number 2017BHFZKH (Principal Investigator)

Projects funded by US bodies

- 2023-2024 - "Tailoring wave packets in space-time dispersive switched metasurfaces" funded by the US Air Force Office Research 23IOE065
- 2020 - "Support for organizing METAMATERIALS 2020 - 14th International Congress on Engineered Material Platforms for Novel Wave Phenomena" funded by the US Navy - contract number ONRG - CSP - N62909-20-1-2087
- 2019 - "Support for organizing METAMATERIALS 2019 - 13th International Congress on Engineered Material Platforms for Novel Wave Phenomena" funded by the US Navy - contract number ONRG - CSP - N62909-19-1-2138
- 2018 - "Support for organizing METAMATERIALS 2018 - 12th International Congress on Engineered Material Platforms for Novel Wave Phenomena" funded by the US Navy - contract number ONRG - CSP - N62909-18-1-2173
- 2017-2018 "Non-reciprocal horn antennas using angular momentum biased metamaterials" funded by the US Army - contract number W911NF-17-1-0186
- 2017-2018 "Doppler cloak: Making moving objects invisible" funded by the US Navy - contract number ONRG - NICOP - N62909-17-1-2099
- 2017 - "Support for organizing METAMATERIALS 2017 - 11th International Congress on Engineered Material Platforms for Novel Wave Phenomena" funded by the US Navy - contract number ONRG - CSP - N62909-17-1-2178

- 2016 - "Support for organizing METAMATERIALS 2016 - The Tenth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics" funded by the US Navy - contract number ONRG - CSP - N62909-16-1-2207
- 2014-2015 - "Self-filtering horn antenna for compact dual-linear and circular polarized receiving systems" funded by the US Army - contract number W911NF-14-1-0602 - R&D 1684-CC-01
- 2014 - "Support for the organization of the XXIV Edition of the Distributed Doctoral School on Metamaterials - funded by U.S. Army Forward Element Command-Atlantic, Research Division (USARFEC-A)
- 2014 - "Support for the organization of the International Congress Metamaterials 2014" funded by U.S. Army Forward Element Command-Atlantic, Research Division (USARFEC-A)

Projects funded by the European Space Agency

- 2017-2019 European Space Agency - RadioLabs - GSTP 6.2 (General Support Technology Programme) - "Digital Beam Forming for Rail – DB4Rail"
- 2008 - European Space Agency - ARIADNA Program - "Metamaterials for space applications: design of invisibility cloaks for reduced observability of objects" (Principal Investigator)

Research Projects funded by Regione Lazio

- 2021-2022 "ATEMA - Metamaterial-based reconfigurable antennas" - funded by Regione Lazio - POR FESR Lazio 2014-2020, Research Groups, 2020
- 2020-2021 "CoSAT - Co-Siting Antenna Technology" funded by Regione Lazio - POR FESR LAZIO 2014-2020, Strategic Projects
- 2018-2019 "M2P – Plasma metamaterials" funded by Regione Lazio - POR FESR LAZIO 2014-2020, Key Enabling Technologies (KETs)

Research Contracts funded by Private Companies

- "Sub-6 reconfigurable metasurfaces," funded by Huawei - 2023-2024
- "Gradient and time-modulated metasurfaces" funded by Leonardo SpA - 2023
- "Reconfigurable metasurfaces for space applications (acronym ANEMONE)" funded by Alma Sistemi s.r.l. - 2023-2026
- "Study and implementation of an electrostatic field sensor prototype" funded by IES s.r.l - 2022
- "Guided waves along complementary surface impedance layers" funded by Huawei - 2021-2022
- "UWB WAIM-polarizer metasurface" funded by Elettronica SpA - 2021
- "Cloaking with cylindrical metasurfaces“ funded by Elettronica SpA - 2021
- "Low observability materials" funded by Leonardo SpA - 2021-2022
- "Research on angular filter" funded by Huawei - 2020-2021
- "Low profile meta lens for extended angular coverage" funded by Huawei - 2020-2021
- "Metasurfaces for innovative electromagnetic components" funded by Leonardo SpA - 2019-2020

Other National Projects

- "Design of a Doppler Radar Target" funded by the Italian Defense Ministry and VirtuaLabs s.r.l. - PNRM - 2012
- "Design of broadband metamaterial absorbers - II Phase" funded by the Italian Defense Ministry - PNRM - 2012

- "Study of electromagnetic invisibility devices based on the use of metamaterials" - Progetto d'internazionalizzazione d'Ateneo funded by "Roma Tre" University - 2012
- "Design of broadband metamaterial absorbers - I Phase" funded by the Italian Defense Ministry - PNRM - 2011

Invited lectures

Invited lectures at national and international universities, research bodies, and companies

- November 10, 2023 - Huawei Research Center (Dongguan China) "Metasurface aided signal processing and Smart Antennas 2.0 for future wireless systems"
- October 18, 2023 - Simons Foundation (New York, USA) "The role of intelligent metasurfaces in future smart environments"
- September 26, 2023 - Huawei Strategy and Technology Workshop (Shenzhen, China)
- June 30, 2023 - Science for Peace (Teramo, Italy) "From intelligent materials to the implementation of a truly artificial intelligence, as technical tools in the hand of the human being"
- June 5, 2023 - Metamaterials, Power Integrity and Optoelectronics Engineering Innovations for Future Communication Systems (Milan, Italy) "Smart Antennas 2.0: combining regular antennas with intelligent metasurfaces"
- May, 29, 2023 - SparkLink Alliance International Academic Salon (Beijing, China) "Smart electromagnetic surfaces and their role in future short-range wireless communications"
- December, 1, 2022 - 5G Italy (Rome, Italy) "RESTART Program - Structural Project: Smart radio environments"
- September, 29, 2022 - FITCE (Rome, Italy) "Smart radio environments"
- September, 27, 2022 - Huawei Science & Technology Workshop (Shenzhen, China) - "Metasurfaces 3.0 and their applications in future wireless systems & AI"
- August, 30, 2022 - Wireless TED External Invited Speakers Forum - Meta-Facebook - "Metasurfaces for augmented and virtual reality"
- June, 7, 2022 - Ericsson AB Research (Gothenburg, Sweden) - "Metasurface applications in the antenna field"
- April, 25, 2022 - "Beyond-5G wireless systems: an opportunity for applied EM and metamaterials communities," Keynote talk at PIERS 2022 (Hangzhou, China)
- March, 22, 2022 - "Metasurfaces 3.0 as a KET for future Wireless Systems," Keynote talk at Marina Forum on Meta-antennas (Singapore)
- December 21, 2021 - "Smart electromagnetic surfaces: a key-enabling technology for future wireless systems," Keynote talk at Smart Materials and Surfaces - SMS2021 (Milan, Italy)
- November 16, 2021 - CNIT (Rome, Italy) - "Reconfigurable metasurfaces enabling a new generation of intelligent antennas"
- March 5, 2021 - Leonardo Divisione Velivoli (Pomigliano, Italy) - "Metasurfaces enabling innovation in low EM observability and invisibility"
- December 9, 2020 - "Intelligent metasurfaces and their applications in beyond 5G wireless systems," Keynote talk at MMS2020
- November 30, 2020 - Metamaterials and metasurfaces: overview and applications (Pisa, Italy)
- October 15, 2020 - Huawei Songshan Lake Institute (Dongguan, China) - "Metasurfaces: A key-enabling technology for current and future wireless systems".
- November 18, 2019 - Huawei Italia (Milan, Italy) - "Metasurfaces and their impact in the design of innovative antenna systems".

- November 21, 2018 - University of Lille - "Research activities on metamaterials and metasurfaces developed at Roma Tre University".
- July 20, 2017 – University of California Irvine – "Invisibility cloaks and their applications in wire antennas".
- March 9, 2016 - Finmeccanica-Leonardo - "Metamaterials for polarimetric antennas".
- April 14, 2015 - Telecom Italia - "Innovative antennas for radio-mobile systems".
- March 12, 2015 – Finmeccanica – Selex ES – "Metamaterials and their industrial applications: from the theoretical aspects to the innovation award".
- November 24, 2014 - University of Trento - ELEDIA Research Center - "Metamaterial cloaking: from basic principles to applications in antenna systems".
- June 9, 2014 – "Roma Tre" University – "Metamaterials: a technology for the future".
- October 25, 2013 - Telecom Italia - "Innovative antenna systems".
- October 2, 2013 - University of Trento - "Metamaterials: from theoretical aspects to applications".
- October 15, 2012 - Telecom Italia - "Employment of metamaterials for innovative antenna systems".
- July 31, 2012 - University of Hawaii at Manoa - "Advanced electromagnetic materials and their applications in microwave engineering".
- September 8, 2011 - École Polytechnique Fédérale de Lausanne - "Properties of different applications that can be implemented using metamaterials: cloaking and enhanced transmission".
- July 4, 2011 - Telecom Italia - "Metamaterials for innovative antenna systems".
- June 6, 2011 - University of Padua - "Metamaterial cloaking: from basic concepts to actual fabrication".
- March 23, 2011 - "La Sapienza" University of Rome - "Artificial electromagnetic materials and metamaterials: properties and applications".
- January 11, 2011 - Finmeccanica Mindshare Community "Advanced Materials and Enabling Technologies" - "Metamaterials: applications at microwave and optical frequencies".
- November 15, 2010 - Finmeccanica Mindshare Community "Advanced Materials and Enabling Technologies" "Metamaterials for miniaturization".
- February 4, 2010 - University of Naples - "Metamaterials activities at "Roma Tre" University".
- November 12, 2009 - University of Calabria - "Metamaterials: genesis, synthesis, and applications".
- November 28, 2005 - Thales Campus at Jouy-en-Josas - "Application of metamaterials for miniaturized components".

Short-courses at international conferences

- Course “Metamaterials Cloaking in Antenna Systems” at the IEEE Antennas and Propagation Symposium, 26 June – 1 July 2016.
- Course “Metamaterial cloaking: basic principles and applications in antenna systems” at the European Conference on Antennas and Propagation, 6-11 April 2014.
- Course “Miniaturized and multifunctional microwave antennas based on metamaterials” at the European Microwave Conference, 29 September – 1 October 2009.

Invited lectures at pre-conference workshops

- September 30, 2022 - European Microwave Week 2022 - Workshop on Reconfigurable Intelligent Surfaces and Smart Skins for B5G/6G Communications: Recent Advances, Current Trends and Vision - "Metasurfaces 3.0 as a key enabling technology for Smart Antennas 2.0"

- May 13, 2019 - European Microwave Conference in Central Europe - Workshop on Active, Non-Foster, and Time-varying Electromagnetic Structures and System - "Non-reciprocity and Control of Doppler Effect in Antenna Systems Induced by Active Time-varying Metamaterials and Metasurfaces".
- September 23, 2018 - 48th European Microwave Week - Workshop on Metamaterials, Metasurfaces and Applications - "New Frontiers for Wave Propagation in Time-Modulated Metamaterials".
- September 23, 2018 - 48th European Microwave Week - Workshop on Metamaterials, Metasurfaces and Applications - "From Artificial Electromagnetic Materials to Metamaterials: Unprecedented Properties for Conceptually New Microwave Devices".
- September 28, 2009 - 39th European Microwave Week - Workshop on Recent Advances in Microwave Applications of Metamaterial Concepts - "Miniaturized and multifunctional microwave antennas based on metamaterials".

Awards and Recognitions

- 2024 – elevated Fellow of Industry Academy by the International Artificial Intelligence Industry Alliance
- 2024 – Outstanding Associate Editor Recognition - awarded by IEEE Transactions on Antennas and Propagation
- 2023 – Advanced Materials Award - awarded by the International Association for Advanced Materials (IAAM)
- 2023 – Outstanding Collaboration Award - awarded by Huawei Headquarter Shenzhen
- 2023 - IEEE Chen-To-Tai Distinguished Educator Award (citation: for being and inspiring educator, mentor, and contributor to the development of electromagnetic metamaterials, metasurfaces, and their applications)
- 2023 – elevated Fellow of the Asia-Pacific Artificial Intelligence Association
- 2023 – Nature Photonics Best Paper Award for the best contribution related to photonics presented at the 2023 Metamaterials Congress (L. Stefanini, D. Ramaccia, Z. Hamzavi, A. Monti, M. Barbuto, M. Longhi, S. Vellucci, A. Toscano, F. Bilotti, "Rainbow-like scattering in temporal metamaterials induced by switched boundary conditions")
- 2017 – elevated Fellow of the IEEE (citation: for contributions to metamaterials for EM and antenna applications)
- 2016 – NATO SET Panel Excellence Award – awarded by NATO Science & Technology Organization
- 2014 – Finmeccanica Innovation Prize with the project Minimetris: Metamaterials for Miniaturization of Electromagnetic Components
- 2013 – IET Best Poster Paper Award (Metamaterials 2013)
- 2011 – IET Best Poster Paper on Metamaterial Applications (Metamaterials 2011)
- 2007 – Raj Mittra Travel Grant Senior Researcher Award (IEEE Antenna and Propagation Symposium 2007)

Service

Filiberto Bilotti has been serving the scientific community, by playing leading roles in the management of scientific societies, in the editorial board of international journals, and in the organization of conferences, schools, and courses.

Event Organization

General Chair

- Twelfth International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2018, Espoo, Finland, 27 August - 1 September 2018.
- Eleventh International Congress on Engineered Material Platforms for Novel Wave Phenomena – Metamaterials 2017, Marseille, France, 28 August – 2 September 2017.
- Second International Workshop on Metamaterials-by-Design Theory, Methods, and Applications to Communications and Sensing, Riva del Garda, Italy, 15-16 December 2016.
- Tenth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2016, Chania, Greece, 17 – 22 September 2016.
- Ninth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2015, Oxford, UK, 7 – 12 September 2015.

Main organizer

- EuMW Short Course on "Reconfigurable intelligent surfaces for smart electromagnetic environment: an integrated vision towards industrial applications", Milan, Italy, 26 September, 2022.
- European School on Antennas and Propagation (ESoA), "Reconfigurable Intelligent Surfaces", Siena, Italy, 6-10 June, 2022
- XLII Edition of the Distributed Doctoral School on Metamaterials, "Future wireless systems enabled by advanced and intelligent metasurfaces," Rome, Italy, 8-12 March 2021
- XXXV Edition of the Distributed Doctoral School on Metamaterials "Advanced electromagnetic materials and surfaces for novel wave phenomena," Rome, Italy, 18-22 December 2017
- XXIVII Edition of the Distributed Doctoral School on Metamaterials "Electromagnetic, acoustic, and thermal invisibility," Rome, Italy, 4-8 May 2015
- XXIV Edition of the Distributed Doctoral School on Metamaterials "Metamaterials for electromagnetic components and systems," Rome, Italy, 24-27 March 2014
- VIII Edition of the Distributed Doctoral School on Metamaterials "The role of metamaterials in cloaking technology", Rome, Italy, 25-26 October 2007
- First International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2007, Rome, Italy, 22 – 26 October 2007

Chairman of the Technical Program Committee of international events

- 2023 17th International Congress on Artificial Materials for Novel Wave Phenomena - Metamaterials Congress, Chania, Crete, 11-16 September 2023 (chair)
- 2017 IEEE Antennas and Propagation Symposium, San Diego, US, 9 - 14 July, 2017 (co-chair).
- 2016 IEEE Antennas and Propagation Symposium, Puertorico, US, 26 June - 1 July, 2016 (co-chair).

Chairman of the Steering Committee of national and international events

- Thirteenth International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2019, Rome, Italy, 16-21 September 2019.
- II Giornata di Studio sulle Nanotecnologie - GioNa 2016, Rome, Italy, 22-23 June 2016.
- Eighth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2014, Copenhagen, Denmark, 25 – 30 August 2014.
- Seventh International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2013, Bordeaux, France, 15 – 20 September 2013.
- Sixth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2012, St. Petersburg, Russia, 18 – 23 September 2012.

- Fifth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2011, Barcelona, Spain, 10 – 15 October 2011.
- 5th Italian Workshop on Metamaterials and Special Materials for Electromagnetic Applications and TLC, Rome, Italy, 13-15 December 2010.
- Fourth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2010, Karlsruhe, Germany, 13 – 18 September 2010.
- Third International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2009, London, UK, 31 August – 4 September 2009.
- Second International Congress on Advanced Electromagnetic Materials in Microwaves and Optics – Metamaterials 2008, Pamplona, Spain, 21 – 26 September 2008.

Member of the Steering Committee of international events

- NanoPlasm 2016 - New Frontiers in Plasmonics and Nano-Optics, Cetraro, Italy, 13-16 June 2016.
- NanoPlasm 2014 - New Frontiers in Plasmonics and Nano-Optics, Cetraro, Italy, 16-20 June 2014.
- 4th National Workshop on Metamaterials and Special Materials for Electromagnetic Applications and TLC, Naples, Italy, 18-19 December 2008.
- 12th Edition of the Distributed European School on Metamaterials "Design of antennas based on Metamaterials technology and their applications", Pamplona, Spain, 21 – 22 September 2008.
- XV International Student Seminar on Microwave and Optical Applications of Novel Physical Phenomena, St. Petersburg, Russia, 19-21 May 2008.
- 11th Edition of the Distributed European School on Metamaterials "General synthesis of metamaterials and their modelling by homogenization", Marrakesh, Morocco, 5-6 May 2008.
- 9th Edition of the Distributed European School on Metamaterials, Barcelona, Spain, 5-6 February 2008.
- First International Congress on Advanced Electromagnetic Materials in Microwave and Optics – Metamaterials 2007, Rome, Italy, 21–26 October 2007.
- II Metamorphose Summer Training Week 2007, Belfast, UK, 20-22 August 2007.
- International Symposium "Micro- and nano-structured materials: how to go beyond the nature without going against it", Rome, Italy, 22 June 2007.
- 5th Edition of the European Doctoral School on Metamaterials, Saint Petersburg, Russia, 4 – 6 October 2006.
- XIII International Student Seminar on Microwave Applications of Novel Phisical Phenomena, Rovaniemi, Finland, 24 – 25 August 2006
- 4th Edition of the European Doctoral School on Metamaterials, Rovaniemi, Finland, 21 – 23 August 2006.
- 3rd Edition of the European Doctoral School on Metamaterials, Lille, France, 15 – 17 May 2006.
- 3-day Short Course on "Metamaterials for Industry" Jouy-en-Josas (Thales Campus), France, 26-28 November 2005.
- 2nd Edition of the European Doctoral School on Metamaterials, Siena, Italy, 21-25 November 2005.
- XII International Student Seminar on Microwave Applications of Novel Phisical Phenomena, Saint Petersburg, Russia, 17-19 October 2005.
- 1st Edition of the European Doctoral School on Metamaterials, San Sebastian, Spain, 21-23 July 2005.

Member of the Technical Programme Committee of international conferences

- 2024 18th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2024, Chania, Crete (Greece), 9 - 14 September 2024.
- 2022 61th International Congress on Future Telecommunications: Infrastructure and Sustainability - FITCE 2022, Rome, Italy, 29-30 September 2022.
- 2021 15th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2021, New York, USA, 2 - 7 August 2021.
- 2020 14th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2020, New York, USA, 28 September - 3 October 2020.
- 2019 IEEE MTT-S International Microwave Workshop Series on Advanced Materials and Processes (IEEE IMWS-AMP), Bochum, Germany, 16-18 July 2019.
- 2017 IEEE Antennas and Propagation Symposium, San Diego, US, 9 - 14 July, 2017.
- 2016 IEEE Antennas and Propagation Symposium, Puertorico, US, 26 June - 1 July, 2016.
- Loughborough Antennas and Propagation Conference (LAPC 2013), Loughborough, UK, November 11-12, 2013.
- 6th European Conference on Antennas and Propagation, EuCAP 2012, Prague, Czech Republic, 26-30 March 2012.
- 2012 Loughborough Antennas & Propagation Conference (LAPC 2012), Loughborough, UK, 12-13 November 2012.
- European Conference on Antennas and Propagation (EuCAP 2011), Rome, Italy, 11-15 April 2011.
- Loughborough Antennas and Propagation Conference (LAPC 2011), Loughborough, UK, November 14-17, 2011.
- European Conference on Antennas and Propagation (EuCAP 2010), Barcelona, Spain, 12-16 April 2010.
- Loughborough Antennas and Propagation Conference (LAPC 2010), Loughborough, UK, November 7-10, 2010.
- European Conference on Antennas and Propagation (EuCAP 2009), Berlin, Germany, 23-27 March 2009.
- Loughborough Antennas and Propagation Conference (LAPC 2009), Loughborough, UK, November 16-17, 2009.
- Loughborough Antennas and Propagation Conference (LAPC 2008), Loughborough, Regno Unito, 17 – 19 marzo 2008.
- XIV International Student Seminar on Microwave and Optical Applications of Novel Phisical Phenomena, Belfast, Regno Unito, 23 – 24 agosto 2007.
- Loughborough Antennas and Propagation Conference (LAPC 2007), Loughborough, Regno Unito, 2 – 3 April 2007.

Member of the Advisory Board of international conferences

- 2023 Marina Forum on Metantennas and Multiple Antennas, Singapore, 14-16 August 2023.
- 2022 16th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2022, Siena, Italy, 12 - 17 September 2022.
- 2021 15th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2021, New York, USA, 2 - 7 August 2021.
- 2020 14th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2020, New York, USA, 28 September - 3 October 2020.
- Third International Workshop on Material-by-Design, Madrid, Spain, 14-15 December 2017.
- International Conference "Smart Materials, Structures and Systems" Series (CIMTEC) - 2011-2014.

Editorial Activities

Associate Editor
- IEEE Transactions on Antennas and Propagation (2013-2017, 2022-present)
- Metamaterials - Elsevier Journal (2007-2013)

Member of the Editorial Board of international journals
- EPJ Applied Metamaterials (2013-present)
- Scientific Reports - Nature (2013-2017)
- International Journal on RF and Microwave Computer-Aided Engineering - Wiley (2009-2013)

Co-guest editor of special issues on international journals
- Special cluster on "Functionalized metasurface-based covers and unconventional domes for dynamic antenna systems", IEEE Antennas and Wireless Propagation Letters, 2022 (co-guest editors: D. Ramaccia, T.J. Cui, A. Epstein, R. Flamini, E. Martini, C. Massagrande)
- Special issue on "Metamaterials for advanced photonic and plasmonic applications – Selected papers from Metamaterials'2018", Photonics, 2019 (co-guest editors: A. Monti, A. Alù)
- Special Section on "Multiscale and Multiphysics Computation for Metamaterials - Theory and Applications", IEEE Journal on Multiscale and Multiphysics Computational Techniques, 2017 (co-guest editor: G. Oliveri)
- Special issue on "Reconfigurable electromagnetics through metamaterials", International Journal on Antennas and Propagation, 2014 (co-guest editors: G. Oliveri, C. Craeye, D. Werner)
- Special issue on "Metamaterials: RF and microwave applications", International Journal of RF and Microwave Computer-Aided Engineering, May 2012 (co-guest editor: Prof. L. Sevgi)
- Metamaterials Congress 2009 Special Issue, Metamaterials, Vol. 4, 2010 (co-guest editor: Prof. R. Ziolkowski)

Teaching Activities

Courses taught at ROMA TRE University - Laurea, BS, MS degrees
- 2015-now Lecturer of the course "*Electromagnetic Fields II*" for the BS program in Electronic Engineering.
- 2022-now Lecturer of the course "*Advanced Engineering Electromagnetics*" for the MS programs in Electronic Engineering for Innovation and Industry, Telecommunication Engineering, and Biomedical Engineering - Department of Industrial, Electronic, and Mechanical Engineering.
- 2018-2022 Lecturer of the course "*Advanced Electromagnetics*" for the MS programs in Electronic Engineering for Innovation and Industry, Telecommunication and Information Technology Engineering, and Biomedical Engineering - Department of Engineering and, then, Department of Industrial, Electronic, and Mechanical Engineering.
- 2008-2021 Lecturer of the course "*Metamaterials*" for the MS programs in Electronic Engineering for Innovation and Industry, Telecommunication and Information Technology Engineering - Faculty of Engineering and, then, Department of Engineering.

- 2015-2018 Lecturer of the course "*Microwave Engineering*" for the MS programs in Electronic Engineering for Innovation and Industry, Telecommunication and Information Technology Engineering - Department of Engineering.
- 2012-2014 Lecturer of the course "*Antennas for Mobile Communications*" for the BS program in Electronic Engineering - Faculty of Engineering.
- 2003-2012 Lecturer of the course "*Antennas for Cellular Telecommunication Systems*" for the BS program in Electronic Engineering - Faculty of Engineering.
- 2004-2008 Lecturer of the course "*Computational Electromagnetics*" for the MS program in Electronic Engineering - Faculty of Engineering.
- 2003-2005 Lecturer of the course "*Electromagnetic Fields II*" for the Laurea degree program in Electronic Engineering - Faculty of Engineering.
- 2001-2002 Lecturer of the course "*Electromagnetic Fields I*" for the Laurea Diploma degree in Electronic Engineering - Faculty of Engineering.

International teaching

Filiberto Bilotti is active in teaching at international schools at the PhD level.
He was among the creators and founders of the *European Doctoral Programs in Metamaterials* (EUPROMETA). This large-scale teaching initiative, which has been planned and implemented since 2005, offers courses within the geographically distributed *International Doctoral School on Metamaterials* and is managed by a consortium ruled by a Memorandum of Understanding signed by 30+ academic and industrial European institutions. EUPROMETA, as conceived by prof. Bilotti and his colleagues, goes well beyond a series of schools on topics related to metamaterials, being, in fact, a structured program regulating also student exchange, joint research, ECTS mutual recognition (i.e. the university credits used at the European level to get the BS/MS/PhD degrees), the Mention of Excellence in Metamaterials, etc. between participating institutions.
Prof. Bilotti is a member of the Steering Committee of EUPROMETA since its foundation in 2005.

List of the courses taught at international PhD schools:

- Course “A new generation of smart antennas whose intelligence is enabled by the physical layer" ESoA Course on Reconfigurable intelligent surfaces for smart radio environments, Siena, Italy, 30 Spetember-4 October, 2024.
- Course "A new generation of smart antennas whose intelligence is enabled by the physical layer" ESoA Course on Reconfigurable intelligent surfaces for smart radio environments, Siena, Italy, 6-10 June, 2022.
- Course "Metasurfaces 3.0: a key enabling technology for the development of beyond-5G communication systems" 42nd Edition of the Distributed Doctoral School on Metamaterials, Rome, Italy, 8-12 March 2021.
- Course "Microwave antennas for space applications" International PhD School of the Electronic Italian Society, Rome, Italy, 24 June 2019.
- Course "Linear and non-linear metasurfaces: From cloaking to enabling smartness in EM components and devices" 35th Edition of the Distributed Doctoral School on Metamaterials, Rome, Italy, 18-22 December 2017.
- Course "Cloaking metasurfaces" European School of Antennas, Siena, Italy, 25-29, 2017.
- Course "Mantle cloaking at microwave frequencies" 27th Edition of the Distributed Doctoral School on Metamaterials, Rome, Italy, 4-8 May 2015.
- Course "Mantle cloaking at optical frequencies" 27th Edition of the Distributed Doctoral School on Metamaterials, Rome, Italy, 4-8 May 2015.

- Course "Introduction to metamaterials" 24th Edition of the Distributed Doctoral School on Metamaterials, Rome, Italy, 24-27 March 2014.
- Course "Enhanced transmission through sub-wavelength apertures and fundamentals of cloaking devices. Fundamentals of cloaking devices. Applications of enhanced transmission and cloaking devices" 20th Edition of the Distributed Doctoral School on Metamaterials, Lovain-la-Neuve, Belgium, 7-11 May 2012.
- Course "Small inclusions for metamaterial design" 15th Edition of the European Distributed Doctoral School on Metamaterials, Levi, Finland, 16-20 November 2009.
- Course "Enhanced transmission through sub-wavelength apertures and fundamentals of cloaking devices" 15th Edition of the Distributed Doctoral School on Metamaterials, Levi, Finland, 16-20 November 2009.
- Course "Miniaturized and multi-functional antennas based on metamaterials" 12th Edition of the Distributed Doctoral School on Metamaterials, Pamplona, Spain, 21-22 September 2008.
- Course "DNG and SNG metamaterials for microwave applications: polariton and leaky wave antenna design" 1st Edition of the Distributed Doctoral School on Metamaterials, San Sebastian, Spain, 21-23 July 2005.
- Course "DNG and SNG metamaterials for microwave applications: rectangular and circular patch antenna design" 1st Edition of the Distributed Doctoral School on Metamaterials, San Sebastian, Spain, 21-23 July 2005.

International examiner of Ph.D. theses

- D. Tzarouchis, "Resonant scattering particles" Aalto University, 2018 (supervisor: Prof. A. Sihvola).
- N. Clausen, "Investigations into homogenization of electromagnetic metamaterials" Technical University of Danmark, 2015 (supervisor: Prof. O. Breinbjerg).
- L. Markley, "Subwavelength imaging using scanning near-field antenna arrays" University of Toronto, 2013 (supervisor: Prof. G. Eleftheriades).
- M. Gil Barba, "Resonant-type metamaterial transmission lines and their application to microwave device design" Escola Tècnica Superior d'Enginyeria, Universitat Autonoma de Barcelona, 2009 (supervisor: Prof. F. Martin).
- O. Isik, "Metamaterials Based on Spiral Resonators and their Microwave Applications" Macquarie University, 2008 (supervisor: Prof. K. Esselle).
- M. Hirvonen, "Performance enhancement of small antennas and applications in RFID" Radio Laboratory, Helsinki University of Technology, 2008 (supervisor: Prof. S. Tretyakov).
- P. Ikonen, "Artificial electromagnetic composite structures in selected microwave applications" Radio Laboratory, Helsinki University of Technology, 2007 (supervisor: Prof. S. Tretyakov).

Membership and service for international scientific societies

METAMORPHOSE VI

Filiberto Bilotti has been a founder of the Virtual Institute for Advanced Electromagnetic Materials and Metamaterials - METAMORPHOSE VI AISBL (2007), the leading international scientific society on metamaterials.

Roles:

2019-now: Vice-President and Executive Director

2016-2019: Elected President (2nd term)

2013-2016: Elected President

2011-2013: Elected Member of the Board of Directors

2008-2011: Elected Member of the Board of Directors
2007-2008: Elected Member of the Board of Directors

IEEE
Filiberto Bilotti is a Fellow of the Institute of Electrical and Electronics Engineers - IEEE.
Membership levels:
2017 IEEE Fellow
2006 IEEE Senior Member
2002 IEEE Member
1997 IEEE Student Member
IEEE society membership:
1997-now IEEE Antennas and Propagation Society
Lifetime member: IEEE Microwave Theory and Techniques Society (since 1997)
Service:
2022-now Appointed member of the IEEE Antennas and Propagation Society Meetings Committee

OPTICA (former OSA)
Lifetime member (member since 2008)
2012-2018 Appointed member of the "Photonic Metamaterials Technical Group"

SPIE
Lifetime member (member since 2010)

European Association on Antennas & Propagation (EurAAP)
Member (since 2008)

Asia-Pacific Artificial Intelligence Association (AAIA)
Fellow (since 2023)

Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT)
Member (since 2002)

Società Italiana di ElettroMagnetismo (SIEM)
Member (since 2002)

List of journal papers

1. X. Fang, M. Li, Z. Lai, D. Ramaccia, A. Toscano, F. Bilotti, D. Ding, "Multifunctional space-time modulated metasurface for direction of arrival estimation and RCS manipulation in a single system," IEEE Transactions on Microwave Theory and Techniques, Vol. 72, No. 6, pp. 3797-3808, 2024 (doi: 10.1109/TMTT.2023.3330898)
2. F. Bilotti, M. Barbuto, Z. Hamzavi-Zarghani, M. Karamirad, M. Longhi, A. Monti, D. Ramaccia, L. Stefanini, A. Toscano, S. Vellucci, "Reconfigurable intelligent surfaces as the key-enabling technology for smart electromagnetic environments," Advances in Physics: X, Vol. 9, N. 1, 2024 (doi: 10.1080/23746149.2023.2299543)
3. M. Chen, X. Fang, M. Li, D. Ramaccia, A. Toscano, F. Bilotti, D. Ding, "Design of switchable SHG and THG using metasurface-based frequency mixing system," IEEE Antennas and Wireless Propagation Letters, Vol. 23, No. 2, pp.598-602, 2024 (doi: 10.1109/LAWP.2023.3330853)
4. L. Stefanini, D. Ramaccia, M. Barbuto, Z. Hamzavi-Zarghani, M. Longhi, A. Monti, S. Vellucci, A. Toscano, F. Bilotti, "A statistical approach for robust metasurfaces and metasurface-based RIS

engineering," IEEE Transactions on Antennas and Propagation, Vol. 72, No. 6, pp. 5402-5407, 2024 (doi: 10.1109/TAP.2024.3391929)
5. Z. Hamzavi-Zhargani, A. Monti, S. Vellucci, M. Barbuto, M. Longhi, D. Ramaccia, L. Stefanini, A. Toscano, F. Bilotti, "Overcoming limitations of passive invisible antennas through bianisotropic nonreciprocal mantle cloaks," Physical Review Applied, Vol. 21, 064045, 2024 (doi: 10.1103/PhysRevApplied.21.064045)
6. A. Monti, S. Vellucci, M. Barbuto, L. Stefanini, D. Ramaccia, A. Toscano, F. Bilotti, "Design of reconfigurable Huygens metasurfaces based on Drude-like scatterers operating in the epsilon-negative regime," Optics Express, Vol 32, No. 16, 28429, 2024 (doi: 10.1364/OE.526048)
7. L. Stefanini, D. Ramaccia, F. Bilotti, S. Fardad, A. Salandrino, "Effective linear regimes in plasmonic 3-wave mixing," Journal of Optical Society of America B, Vol. 41, No. 9, pp. 1968-1978, 2024 (doi: https://doi.org/10.1364/JOSAB.521070)
8. L. Stefanini, D. Ramaccia, M. Barbuto, M. Longhi, A. Monti, S. Vellucci, A. Toscano, A. Alù, V. Galdi, F. Bilotti, "Time-varying metasurfaces for efficient surface-wave coupling to radiation and frequency conversion," Laser & Photonics Review, 2400315, 2024 (doi: https://doi.org/10.1002/lpor.202400315)
9. J. Wu, M. Li, X. Fang, D. Ramaccia, A. Toscano, F. Bilotti, D. Ding,"Anti-interference DoA estimation for LFM radar signals using space-time-modulated metasurfaces," IEEE Transactions on Microwave Theory and Techniques (to appear) (doi: 10.1109/TMTT.2024.3460106)
10. Y. Zhu, X. Fang, M. Li, D. Ramaccia, A. Toscano, F. Bilotti, D. Ding, "Time-frequency modulated metasurface for false target generation in symmetrical triangular LFM continuous wave radars," IEEE Transactions on Microwave Theory and Techniques (to appear) (doi: 10.1109/TMTT.2024.3473317)
11. Y. Kunitomo, K. Takimoto, S. Vellucci, A. Monti, M. Barbuto, A. Toscano, F. Bilotti, T. Ramachandran, P.M Njogu, P.T. Dang, H. Wakatsuchi, "Passive time-varying waveform-selective metasurfaces for attainment of magnetic property control," Applied Physics Letters - Materials, Vol. 12, 111104, 2024 (doi: 10.1063/5.0230438)
12. A. Monti, S. Vellucci, M. Barbuto, V. Verri, F. Vernì, C. Massagrande, D. Ramaccia, M. Longhi, Z. Hamzavi-Zarghani, L. Stefanini, A. Toscano, F. Bilotti, "Design and characterization of line-waves waveguides for microwave applications," IEEE Open Journal on Antennas and Propagation (*in press*) (doi: 10.1109/OJAP.2024.3506876)
13. D. Ushikoshi, R. Higashiura, K. Tachi, S. Mahmood, H. Takeshita, H. Homma, M.R. Akram, A.A. Fathnan, S. Vellucci, J. Lee, A. Toscano, F. Bilotti, C. Christopoulos, H. Wakatsuchi, "Pulse-driven self-reconfigurable meta-antennas," Nature Communications, Vol. 14, 633, 2023 (doi: 10.1038/s41467-023-36342-1)
14. A. Monti, S. Vellucci, M. Barbuto, C. Massagrande, A. Toscano, F. Bilotti "Quadratic-gradient metasurface-dome for wide-angle beam steering phased array with reduced gain-loss at broadside," IEEE Transactions on Antennas and Propagation, Vol. 71, No. 2, pp. 2022-2027, 2023 (doi: 10.1109/TAP.2022.3222716)
15. X. Fang, M. Li, D. Ramaccia, A. Toscano, F. Bilotti, D. Ding, "Self-adaptive retro-reflective Doppler cloak based on planar space-time modulated metasurfaces," Applied Physics Letters, Vol. 122, 021702, 2023 (doi: 10.1063/5.0132125).
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18. S. Pramanik, S.C. Bakshi, C. Koley, D. Mitra, A. Monti, F. Bilotti, "Active metasurface based wideband polarization converter with a switchable notch," IEEE Transactions on Electromagnetic Compatibility, Vol. 65, No. 4, pp. 1081-1089, 2023 (doi: 10.1109/TEMC.2023.3288068).
19. M. Barbuto, A. Alù, F. Bilotti, A. Toscano, "Composite vortex manipulation as a design tool for reflective intelligent surfaces", IEEE Antennas and Wireless Propagation Letters, Vol. 22, No. 10, pp. 2392-2396, 2023 (doi: 10.1109/LAWP.2023.3288944)
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23. M. Longhi, S. Vellucci, M. Barbuto, A. Monti, Z. Hamzavi Zarghani, L. Stefanini, D. Ramaccia, F. Bilotti, A. Toscano, "Array synthesis of circular Huygens metasurfaces for antenna beam-shaping," IEEE Antennas and Wireless Propagation Letters, Vol. 22, No. 11, pp. 2649-2653, 2023 (doi: 10.1109/LAWP.2023.3315774)
24. X. Fang, M. Li, Z. Lai, D. Ramaccia, A. Toscano, F. Bilotti, D. Ding, "Multifunctional space-time modulated metasurface for direction of arrival estimation and RCS manipulation in a single system," IEEE Transactions on Microwave Theory and Techniques (*in press*) (doi: 10.1109/TMTT.2023.3330898)
25. M. Barbuto, Z. Hamzavi-Zarghani, M. Longhi, A. Monti, D. Ramaccia, S. Vellucci, A. Toscano, F. Bilotti, "Metasurfaces 3.0: a new paradigm for enabling smart electromagnetic environments," IEEE Transactions on Antennas and Propagation, Vol. 70, No. 10, pp. 8883-8897, 2022 (doi: 10.1109/TAP.2021.3130153).
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27. S. Vellucci, D. De Sibi, A. Monti, M. Barbuto, M. Salucci, G. Oliveri, A. Massa, A. Toscano, F. Bilotti, "Multi-layered coating metasurfaces enabling frequency reconfigurability in wire antenna," IEEE Open Journal of Antennas and Propagation, Vol. 3, pp. 206-216, 2022 (doi: 10.1109/OJAP.2022.3143170).
28. X. Fang, M. Li, D. Ding, F. Bilotti, R. Chen, "Design of in-phase and quadrature two paths space-time-modulated metasurfaces," IEEE Transactions on Antennas and Propagation, Vol. 70, No. 7, pp. 5563-5573, 2022 (doi: 10.1109/TAP.2022.3145480).
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30. A. Monti, S.H. Raad, Z. Atlasbaf, A. Toscano, F. Bilotti, "Maximizing the forward scattering of dielectric nanoantennas through surface impedance coatings," Optics Letters, Vol. 47, No. 10, pp. 2386-2389, 2002 (doi: 10.1364/OL.456958).
31. A.V. Marini, D. Ramaccia, A. Toscano, F. Bilotti, "Perfect matching of reactive loads through complex frequencies: from circuital analysis to experiments," IEEE Transactions on Antennas and Propagation, Vol. 70, No. 10, pp. 9641-9651, 2022 (doi: 10.1109/TAP.2022.3177571).
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33. X. Fang, M. Li, J. Han, D. Ramaccia, A. Toscano, F. Bilotti, D. Ding, "Accurate direction-of-arrival estimation method based on space-time modulated metasurface," IEEE Transactions on Antennas and Propagation, Vol. 70, No. 11, pp. 10951-10964, 2022 (dot: 10.1109/TAP.2022.3184556).
34. D. Ramaccia, F. Bilotti, A. Epstein, T.J. Cui, E. Martini, C. Massagrande, R. Flamini, "Guest editorial special cluster on functionalized metasurface-based covers and unconventional domes for dynamic antenna systems," IEEE Antennas and Wireless Propagation Letters, Vol. 21, No. 11, pp. 2145-2150, 2022 (doi: 10.1109/LAWP.2022.3207255)
35. D. Ramaccia, M. Barbuto, A. Monti, S. Vellucci, C. Massagrande, A. Toscano, F. Bilotti, "Metasurface dome for above-the-horizon grating lobes reduction in 5G-NR systems," IEEE Antennas and Wireless Propagation Letters, Vol. 21, No. 11, pp. 2176-2180, 2022 (doi: 10.1109/LAWP.2022.3196324).
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37. Z. Hamzavi-Zarghani, A. Monti, A. Alù, F. Bilotti, A. Toscano, "Acoustic embedded eigenstates in metasurface-based structures," Applied Physics Letters, Vol. 121, No. 19, 192202, 2022 (dot: 10.1063/5.0114885)
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40. S. Vellucci, A. Monti, M. Barbuto, A. Toscano, F. Bilotti, "Progress and perspective on advanced cloaking metasurfaces: from invisibility to intelligent antennas," EPJ Applied Metamaterials, Vol. 8, paper n. 7, 2021 (doi: https://doi.org/10.1051/epjam/2020013).
41. D. Ramaccia, A. Alù, A. Toscano, F. Bilotti, "Temporal multilayer structures for designing higher-order transfer functions using time-varying metamaterials," Applied Physics Letters, Vol. 118, 101901, 2021 (doi: https://doi.org/10.1063/5.0042567).

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43. A. Monti, A. Alù, A. Toscano, F. Bilotti, "Design of high-Q passband filters implemented through multipolar all-dielectric metasurfaces," IEEE Transactions on Antennas and Propagation, Vol. 68, pp. 5142-5147, 2021 (doi: 10.1109/TAP.2020.3045795).
44. A. Casolaro, A. Alù, A. Toscano, F. Bilotti, "Dynamic beam steering with reconfigurable metagratings" IEEE Transactions on Antennas and Propagation, Vol. 68, pp. 1542-1552, 2020 (*invited paper*) (doi: 10.1109/TAP.2019.2951492).
45. D. Ramaccia, D. Sounas, A. Alù, A. Toscano, F. Bilotti "Phase-induced frequency conversion and Doppler effect with time-modulated metasurfaces," IEEE Transactions on Antennas and Propagation, Vol. 68, pp. 1607-1617, 2020 (doi: 10.1109/TAP.2019.2952469).
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48. M. Barbuto, M.A. Miri, A. Alù, F.Bilotti, A. Toscano, "A topological design tool for the synthesis of antenna radiation patterns," IEEE Transactions on Antennas and Propagation, Vol. 68, pp. 1851-1859, 2020 (doi: 10.1109/TAP.2019.2944533).
49. M. Barbuto, D. Lione, A. Monti, S. Vellucci, F. Bilotti, A. Toscano, "Waveguide components and aperture antennas with frequency-and time-domain selectivity properties," IEEE Transactions on Antennas and Propagation, Vol. 68, pp. 7196-7201, 2020 (doi:10.1109/TAP.2020.2977761).
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