METAMATERIAL MAGNETLESS NONRECIPROCITY

ABSTRACT

Nonreciprocity is a fundamental concept in all the branches of physics, where it underpins a myriad of phenomena and applications. It may be defined as the property according to which a system exhibits different received-to-transmit field ratios when the source and the detector are exchanged. Since World War II, electromagnetic nonreciprocal devices have been almost exclusively based on ferrimagnetic materials (ferrites) biased by permanent magnets, although this technology suffers from severe issues, such as crystallographic incompatibility with semiconductors. In this context, recent advances in metamaterial research have initiated in the past decade a real quest for "magnetless" nonreciprocity, i.e. for novel technologies requiring neither ferrimagnetic materials nor magnets and yet exhibiting the same – and hopefully even more! – properties than ferrite systems. This talk presents an overview of this emerging area and reports on the latest related developments in the group of the speaker.

The first part of the talk will introduce nonreciprocity by recalling its engineering/physics definitions, historical milestones and ferrite-technology fundamentals. Motivated by the drawbacks of that technology, the second part of the talk will establish the key conditions for nonreciprocity and deduce from them three routes for magnetless that have been recently explored, namely asymmetric nonlinearity, spacetime modulation and transistor loading. The third part will show that while most magnetless nonreciprocal systems to date have been waveguide-type or circuit-type systems, the main potential of magnetless nonreciprocity resides in media-type solutions based on metamaterial principles. The fourth part will note that metasurfaces represent the most promising embodiments of metamaterials for magnetless nonreciprocity, and subsequently describes the Generalized-Sheet Transition Condition (GSTC) synthesis allowing to design efficient bianisotropic metasurfaces. Finally, the fifth part will overview several examples of metamaterial magnetless nonreciprocity applications recently developed in the speaker's group, including nongyrotropic/gyrotropic rotators and isolators, nonreciprocal refractive and birefringent systems, nonreciprocal specular transformers, energy sinking cavities and angle-independent absorbers/amplifiers.

BIOGRAPHY

Christophe Caloz received the Diplôme d'Ingénieur en Électricité and the Ph.D. degree from École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, in 1995 and 2000, respectively. From 2001 to 2004, he was a Postdoctoral Research Fellow at the Microwave Electronics Laboratory, University of California at Los Angeles (UCLA). In 2004, he joined Polytechnique Montréal, where he was a Full Professor and the holder of a Canada Research Chair (Tier-II and Tier-I) in Metamaterials until 2020. In 2020, he joined KU Leuven as a BOFZAP Research Professor and as the head of the META Research Group.

Dr. Caloz has authored and co-authored over 750 technical conference, letter and journal papers, 17 books and book chapters, and he holds a dozen of patents. His works have generated over 27,000 citations (h-index=67), and he is a Thomson Reuters Highly Cited Researcher. He received a number of awards, including the UCLA Chancellor's Award for Post-doctoral Research in 2004, the MTT-S Outstanding Young Engineer Award in 2007, the E.W.R. Steacie Memorial Fellowship in 2013, the Prix Urgel-Archambault in 2013, the Killam Fellowship in 2016, and many best paper awards with his students at international conferences. He has been Fellow of the Institute of Electrical and Electronics Engineers (IEEE) since 2010, a Distinguished Lecturer of the Antennas and Propagation Society (AP-S) from 2014 to 2016, a Fellow of the Canadian Academy of Engineering (CAE) since 2016, and a Fellow of the Optical Society of America (OSA) since 2019.

He was an Associate Editor of the Transactions on Antennas and Propagation of AP-S in from 2015 to 2017 and an elected as a member of the Administrative Committee of AP-S from 2014 to 2016. Moreover, he was a Distinguished Adjunct Professor at King Abdulaziz University (KAU), Saudi Arabia, from May 2014 to November 2015. He was a Member of the Microwave Theory and Techniques Society (MTT-S) Technical Committees MTT-15 (Microwave Field Theory) and MTT-25 (RF Nanotechnology), a Speaker of the MTT-15 Speaker Bureau, the Chair of the Commission D (Electronics and Photonics) of the Canadian Union de Radio Science Internationale (URSI), an MTT-S representative at the IEEE Nanotechnology Council (NTC), and the instigator of the URSI XXIInd General Assembly and Scientific Symposium (GASS) (Montréal, 2017). In 2009, he co-founded the company ScisWave (now Tembo Networks). He has also been a scientific advisor of several RF and optical companies. His research interests include all fields of theoretical, computational and technological electromagnetics, with strong emphasis on emergent and multidisciplinary topics, such as metamaterials and metasurfaces, nanoelectromagnetics, space-time electrodynamics, thermal radiation management, exotic antenna systems and real-time radio/photonic processing.

PHOTOGRAPHY