Extreme Electromagnetics

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Abstract

Materials are often the means to control and manipulate electromagnetic fields and waves. With the recent development in materials science and engineering, nanoscience and nanotechnology, and atomic- and molecular-level structuring of matters, ample opportunities have become available to construct structures with unprecedented attributes and characteristics in tailoring and sculpting waves and fields at various length scales. We have been exploring a series of phenomena related to the wave-matter interaction in platforms with "extreme" features, such as one-atom-thick structures capable of guiding EM waves (i.e., thinnest possible waveguides), composite structures with near-zero effective refractive index, geometry-independent resonant structures (i.e., cavity resonators whose resonance frequency is independent of the shape of their external boundaries), photonic doping of zero-index media (i.e., electromagnetic analogue of electronic doping), materials with effective permittivity and/or permeability near zero, optical lumped nanocircuitry ("optical metatronics") which is a circuit paradigm with light at the nanoscale, slow energy velocity, nonreciprocal vortices at subwavelength scales, materials that can perform analog computing with waves, large anisotropy and nonlinearity, and more. The "extreme electromagnetics" is an exciting platform with unconventional features and functionalities in wave dynamics. I will discuss some of our current work in these areas, will present some of the exciting opportunities and challenges, and will speculate some future directions and possibilities.

Biography

Nader Engheta is the H. Nedwill Ramsey Professor at the University of Pennsylvania in Philadelphia, with affiliations in the Departments of Electrical and Systems Engineering, Bioengineering, Materials Science and Engineering, and Physics and Astronomy. He received his B.S. degree from the University of Tehran and his M.S and Ph.D. degrees from Caltech. His current research activities span a broad range of areas including electromagnetics, photonics, metamaterials, nano-optics, graphene electromagnetics, imaging and sensing inspired by eyes of animal species, microwave and optical antennas, and physics and engineering of fields and waves.

He has received several awards for his research including the 2018 *Pioneer Award in Nanotechnology* from the IEEE Nanotechnology Council, the *2017 William Streifer Scientific Achievement Award* from the IEEE Photonics Society, *the 2014 Balthasar van*

der Pol Gold Medal from URSI, the *2015 Gold Medal from SPIE, the 2015 Fellow of US National Academy of Inventors (NAI),* the *2012 IEEE Electromagnetics Award, the 2015 IEEE Antennas and Propagation Society Distinguished Achievement Award,* the *2017 Beacon of Photonics Industry Award* from the Photonics Media, *the 2015 Vannevar Bush Faculty Fellowship Award* from US Department of Defense, *the 2015 Wheatstone Lecture in King's College London,* the *2013 Inaugural SINA Award in Engineering, 2006 Scientific American Magazine 50 Leaders in Science and Technology*, the *Guggenheim Fellowship*, and the *IEEE Third Millennium Medal.* He is a Fellow of seven international scientific and technical organizations, i.e., IEEE, OSA (Optical Society of America), APS (American Physical Society), MRS (Materials Research Society), SPIE (International Society for Optics and Photonics), URSI, and American Association for the Advancement of Science (AAAS). He has received the honorary doctoral degrees from the Aalto University in Finland in 2016, the University of Stuttgart, Germany in 2016, and Ukraine's National Technical University Kharkov Polytechnic Institute in 2017.