Molding Surface Waves with Metasurfaces

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Abstract: The field of metasurfaces is revolutionizing the way we control and mold light and electromagnetic fields by means of engineered ultrathin artificial materials. To date, the most popular applications of metasurfaces consist in designing planar devices for tailoring the far-field radiation (i.e., metalenses, metasurface antennas). Conversely, in this talk, we will focus on the control of the generation and propagation of surface waves guided and confined along the surface. We will first discuss the analytical modeling of metasurfaces treated as homogenized impedance sheets, and present two efficient approaches for their accurate characterization. During the presentation we will indeed discuss and compare two approaches for the analysis of surface wave propagation on modulated impedance surfaces. The first one can be regarded as an extension of geometrical optics description of plane-wave propagation in graded-index materials to surface waves supported by modulated, isotropic or anisotropic impedance boundary conditions. The second one is a flat version of transformation optics. The first approach is quite general, and it extends to surface waves the basic concepts of geometrical optics (ray-path, ray-velocity, transport of energy), thus resulting in an elegant formulation which enables a closed-form analysis of planar operational devices. On the other hand, flat transformation optics can be only applied when the impedance modulation can be described through an appropriate coordinate transformation, and in these cases it allows one to conveniently determine ray paths without resorting to ray tracing. Based on transformation optics concepts, we will show the design of a metasurface beam-splitter, beam-shifter, and beam-bender for surface waves.

Finally, I will discuss how properly designed metamaterials and metasurfaces can provide a route for analog computing based on wave-matter interactions. In particular, I will present how guided waves in ensembles of Mach-Zehnder interferometers can be utilized to perform mathematical operations and solve integral equations.

Bio: Mario Junior Mencagli received the B.Sc. and M.Sc. degree (cum laude) in Telecommunications Engineering (cum laude) from University of Siena, Italy, in 2008 and 2013, respectively. In 2016, he received the Ph.D. degree (cum laude) in electromagnetics from University of Siena, Italy, under the supervision of Prof. Stefano Maci. His Ph.D program has been sponsored by Thales Research & Technology, Paris, France, where he spent a few months as a visiting student researcher in 2015.

Dr. Mencagli dissertation has been accepted for publication in Springer Theses among all of those proposed by the University of Siena in 2016. He is serving as a reviewer for several journals and international conferences.

Since January 2017, Dr. Mencagli is a Postdoctoral Researcher in Prof. Nader Engheta's group at University of Pennsylvania, Philadelphia, USA.

Dr. Mencagli has been working on reconfigurable metasurface, periodic structures, circuit implementation, numerical methods for electromagnetic problems, high-frequency techniques for electromagnetic scattering, metamaterials for both microwave and optical regimes, transformation optics, metatronic, filter at optical and UV frequencies, and analog computing. He was also involved in measurements of optically reconfigurable transmission lines based on checkerboard metasurfaces.