# Surface Wave Control by Transformation Optics

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Transformation Optics (TO) establishes a rigorous analytical rule for controlling wave propagation within inhomogeneous anisotropic materials, which are implemented by means of metamaterials (MTMs). This control is achieved by designing the equivalent macroscopic constitutive tensors of the metamaterial on the basis of the differential parameters of a spatial coordinate transformation. The most famous use of TO concerns invisibility cloaks. However, the technological difficulties in controlling the constitutive parameters in a volume complicate the application of TO to practical devices. A significant technological simplification can be obtained by using metasurfaces (MTSs) instead of volumetric MTMs. Similarly to the case of 3-D materials, the phase velocity, wavefront, and energy flow direction of surface waves (SWs) can be controlled by tailoring the properties of impenetrable MTSs (S. Maci et al., "Metasurfing: addressing waves on impenetrable metasurfaces," IEEE Antennas Wireless Propag. Lett., vol. 10, pp. 1499–1502, 2011).

This work proposes a systematic approach to metasurface design able to control SW propagation, based on an extension of the Transformation Optics concept. The proposed formulation relies on a modulation of the surface impedance describing the MTS's electromagnetic properties, designed according to a coordinate transformation. This leads to the design of devices consisting in isotropic or anisotropic modulated MTSs, depending on whether the coordinate transformation is conformal or not. At microwave frequencies, a modulated surface impedance can be synthesized by gradually changing the sizes of metallic patches printed on grounded slab. This allows one to control the phase velocity, the wave-front, and the energy flow direction of the supported SW.

The proposed approach can be applied to design devices with novel functionalities, characterized by low losses, reduced thickness, low cost, and potentially increased operational bandwidth. Examples of such devices at microwave frequencies, including a generalized Maxwell-fish eye, a beam shifter, a beam splitter, and a beam bender will be presented at the conference. The basic relations between ray-paths, ray velocity and transport of energy for both isotropic and anisotropic boundary conditions will be also discussed.