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Toward Computational Design of a Light Steering Device

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What if you could bend light in any direction you wished? This seemingly innocent question holds a key to many important areas in optics research, including cloaking, ultracompact light guides, and nanometer resolution imaging. To address this question, optics researchers have created a host of metamaterials, materials not found in nature but made from natural components. In theory, we can tailor a metamaterial with any desired light-bending property by combining materials with different indices of refraction and dielectric permittivity. One such class of metamaterials is epsilon-near-zero (ENZ) metamaterials. These devices have their dielectric permittivity and refractive index close to zero and are shown to possess unique capabilities in steering light flow.

The objective of this research is to create a simulation tool that can aid the design and verification of an ENZ-metamaterial. The simulator implements the electromagnetic interaction of a dipole with an ENZ material. The tool computes the far-field radiation pattern of a dipole antenna at a given wavelength, and optimizes the design parameters, such as material layer thickness, the dipole antenna orientation, and its separation from the ENZ surface, for a given performance metric.

The simulator implemented on the Matlab platform was based on dyadic Green's function approach. The electromagnetic response of the multilayered metamaterial substrate was captured by effective reflection and transmission coefficients computed by transfer matrix method.

The simulator has enabled the design of an efficient ENZ metamaterial with new plasmonic materials operating in the telecommunication S band. In the future, this simulator will be employed in studying more complex metamaterial structures that can be useful in real-world applications.

Research advisor Alexandra Boltasseva and graduate mentor Gururaj Naik write, "Kitamura-McNair's research on modeling a new class of optical device, epsilon-near-zero metamaterials, provides insight in choosing the right design parameters for building an efficient device. Thus, it guides the experiment design aimed at demonstrating the light-steering ability of these devices."

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