Dynamic Beam Steering by Metaguides and Multilattices

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Electromagnetic beam steering and scanning have a variety of applications in wireless communication, radar, imaging, and related areas. Much attention in recent years has been devoted to reconfigurable metamaterial guides and metasurfaces. The resonating elements in these structures can be controlled electrically, optically, or thermally.

We are putting forward the idea of *multilattices* for beam steering. The simplest configuration involves waveguide-fed resonators acting as radiating micro- or nano-antennas, but the concept can be extended to metasurfaces. In contrast with e.g. [Smith et al. Phys. Rev. Applied, 8:054048, 2017] or [Urzhumov et al. Phys. Rev. B, 86:075112, 2012], we consider *two* (or possibly more) lattices with their respective spatial periods. "Meta-atoms" in lattices 1 and 2 (e.g. Mie resonators or split rings) are engineered to be "turned on" when the refractive index of the guide is $n = n_{1,2}$, respectively.

When index $n = n_1$, lattice 1 is "active," while lattice 2 is passive. For $n = n_2$, the situation is reversed. Neglecting, as an initial rough approximation, the passive lattice, one arrives at the radiation conditions

$$\sin\theta_i = \frac{\lambda_0}{\lambda_B(n_i)}$$

where $\lambda_B(n_i)$ $(i = 1, 2)$ is the Bloch wavelength for each lattice, λ_0 is the vacuum wavelength, and θ_i is the angle of outgoing radiation. The guide can be filled with a host material whose index, and consequently the radiation patterns of the multilattice, can be controlled electrically, thermally or optically, as appropriate for a given frequency range (see e.g. [Turpin et al., Int J Antennas & Prop, 429837, 2014]). Such materials could be e.g. semiconductors or GST (GeSbTe) composites (e.g. [Kaina et al., Opt. Express 22(16), 18881-–18888, 2014], [Pogrebnyakov et al., Opt. Mater. Express 8(8), 2264-–2275, 2018], [Galarreta et al., Adv Funct Mater 28(10), 1704993 2018]).

The proposed design is simple, as it relies on one single control parameter and does not require complex circuitry with numerous diodes, varactors, liquid crystals or other such components. Numerical simulations of several prototype devices will be presented at the conference.