Analog computation using a single array of polarizable particles

Younes Ra'di and Andrea Alù
Department of Electrical and Computer Engineering, The University of Texas at Austin, Austin, TX 78712, USA

Although, the potentials of light-based analog computation on real-time signal processing have been known for a long time, the progress in this field has been slowed down with the emergence of digital computation. However, the slow response and lossy nature of the digital computation make analog light-based computation a tempting candidate to substitute these systems.

After the emergence of metamaterials, light-based analog computation has received a renewed interest. Performing different light-based mathematical operations using metamaterials has recently attracted a great deal of attention. In comparison to the conventional lens-based computational devices, metamaterial-based structures enable low-power-consumption analog signal processing in much thinner structures. Notably, light-based computation in spatial domain enables parallel computation, resulting in faster operations in comparison to digital-based systems. Despite extensive research in this field, most of the proposed structure either require specific material properties that may be difficult to synthesize in practice (A. Silva et al., Science 343, 160−163, 2014) or have limited functionalities (T. Zhu et al., Nature Communications 8, 15391, 2017).

In our presentation, we propose a basic platform to realize differentiation and integration of the impinging spatial wavefront using a simple array of electric/magnetic dipoles, and we will extend the discussion to the case of arrays of bianisotropic inclusions. It will be shown that bianisotropic metasurfaces can enable interesting degrees of freedom to realize light-based analog computation using metasurfaces.