Metastructures for Signal Manipulation

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The field of metamaterials has witnessed unprecedented growth in recent years. As in any field of science and engineering, as a certain level of development is reached, novel directions and new possibilities in its fundamental and applied aspects appear in the horizon. To expedite and quicken the pace of development for the next generation of metamaterials, concepts such as functionalization, modularization and parameterization, which in some other fields of science and engineering have accelerated the overall development, must be exploited. This can lead to metamaterials with new functionalities and exciting possibilities.

In the present work, we introduce and explore the possibility of exploiting metamaterials for signal processing and functional manipulation. Specifically, we investigate how metastructures can be designed to perform signal manipulation and mathematical functionalities. As examples of this approach, we have designed metastructures that conduct mathematical operations, such as 1^{st} order differentiation, 2^{nd} order differentiation and convolution of input functions. In our design, we combine the Fourier-transformation capability of graded-index (GRIN) fiber structures with especially designed metasurfaces realizing required transfer functions. The metasurface is sandwiched between two layers of GRIN structures, so that each GRIN section conducts Fourier transformation and the metasurface exhibits a filter function proportional to (ik) where k is the variable in the transformed state. As a result, the combined metastructure performs 1^{st} order differentiation of input functions. We have also designed structures for 2^{nd} order differentiation and convolution using similar principles.

In this talk, we will discuss some of our goals and ideas on the concept of signal-processing metamaterials, and will present some of our results and their highlights.