Hyperuniform Disordered Metasurfaces

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In the past, in order to effectively reduce the backward scattering of a metasurface most of the focus was directed towards optimizing the geometry of the unit cells so that minimum reflection can be achieved when the metasurface is illuminated by a plane wave. In many cases, in order to generate diffusion, the concept of coding metamaterials is employed where unit cells with different frequency responses are employed, each corresponding to a different bit in the coding metasurface scheme [1, 2, 3]. In the vast majority of the published work on coding metasurfaces the coding bits (unit cells) are placed on a fixed periodic lattice. In order to generate further diffusion and thus effectively reduce the RCS of the metasurface, we make use of the extraordinary scattering properties of hyper-uniform disordered systems and generate disordered patterns for the distribution of the unit cells in a controlled manner, thus further reducing backward scattering when compared to the case of the periodic arrangement of the coding bits.

Disordered hyperuniform systems have the ability to suppress large scale density fluctuations and are characterized by an exclusion region in reciprocal space, where the structure factor completely vanishes. The structure factor is a physical quantity that describes how a particular point configuration scatters incident radiation. These aperiodic element distributions have been previously used in the design of metasurfaces with a single type of meta-atom [4]. Here, we design 1-bit coding metasurfaces where each species of meta-atoms is distributed according to a hyperuniform disordered distribution. Furthermore, we rotate each meta-atom by 90 degrees in order to account for both types of linear polarization for the incoming wave (x-pol and y-pol). In this way the metasurface is comprised by four different species, each following a hyperuniform disordered distribution.



Figure 1. Far-field back-scattering pattern when the metasurfaces are illuminated by a plane wave incoming for the top of the structures at 14.6 GHz: (a) Metasurface with hyperuniform disorder for x-polarized incident wave, (b) periodic metasurface for x-polarized incident wave, (c) metasurface with hyperuniform disorder for y-polarized incident wave and (d) periodic metasurface for y-polarized incident wave.

References

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