
Gyromorphs: a new class of functional correlated disordered materials

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Abstract

Periodic and quasiperiodic systems are characterized by extensive peaks in their structure factors. In finite two dimensional systems, the strongest of these peaks populate the vertices of a polygon - a square in a square lattice, a triangle in a triangular lattice, and higher order polygons in quasicrystals. In contrast, disordered structures commonly only exhibit broad, smooth features in their structure factors. However, I show that it is indeed possible to create disordered structures that exhibit a ring of regularly-spaced extensive peaks in the structure factor, unifying the two seemingly contradictory qualities. These "gyromorphs" exhibit higher and better-resolved peaks than quasicrystals of the same rotational order. This specific feature of a ring of high peaks on the structure factor make gyromorphs ideal candidates for isotropic bandgap materials. Using a coupled dipoles approximation, I show that gyromorphs indeed exhibit complete, isotropic photonic bandgaps that are deeper and wider than those formed by stealthy hyperuniformity, high-order quasicrystals, and Vogel spirals for both scalar and vector waves in 2d and 3d. Extending the concept further, I also create "polygyromorphs" - disordered structures with multiple rings of peaks exhibiting multiple isotropic bandgaps in a single structure.

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