Hyperuniformity and Local Self-Uniformity in Photonic Systems

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The connection between geometrical and topological characteristics of structured photonic materials and the advanced functionalities they enable is central to the design of novel photonic materials. We explore two new order metrics, hyperuniformity and local self-uniformity to characterise the structural order in photonic networks. The hyperuniformity concept is directly connected to the properties of the structure in the reciprocal space, whereas local self-uniformity is related to the connection between uniformity on local and global length scales. Hyperuniformity is associated with a constrained randomness such that density fluctuations on large scales behave more like those of ordered solids, crystals or quasicrystals, rather than those of conventional amorphous materials. In contrast, local self-uniformity is a measure of a random network's internal structural similarity and can be used to rank networks on a continuous scale from crystalline, through glassy intermediate states, to chaotic configurations. Despite their distinct characteristics, both metrics provide novel design strategies for achieving advanced photonic functionalities in non-periodic materials.