The Wonderful World of Flat Bands

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Certain lattice wave systems in translationally invariant settings have one or more spectral bands that are strictly flat or independent of momentum in the tight binding approximation, arising from either internal symmetries or fine-tuned coupling. These flat bands display remarkable strongly interacting phases of matter. Originally considered as a theoretical convenience useful for obtaining exact analytical solutions of ferromagnetism, flat bands have now been observed in a variety of settings, ranging from electronic systems to ultracold atomic gases and photonic devices. I will review the design and implementation of flat bands and chart future directions of this exciting field. In particular I will focus on the field of photonic lattices. Flatband photonic lattices consist of arrays of coupled waveguides or resonators where the peculiar lattice geometry results in at least one completely flat or dispersionless band in its photonic band structure. Although bearing a strong resemblance to structural slow light, this independent research direction is instead inspired by analogies with "frustrated" condensed matter systems. In this talk, I will critically analyze the research carried out to date, discuss how this exotic physics may lead to novel photonic device applications, and chart promising future directions in theory and experiment.