The Fascinating World of Flat Bands: From Toy Models to Experiments

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Simple tight-binding lattice models often give rise to nondispersive, completely flat-band states in their band spectrum. Due to quenching of the kinetic energy, particles living in such flat bands become completely immobile, forming clusters of compact localized states. Flat bands are interesting as they offer highly degenerate manifold of single-particle states, which can act as an ideal platform to study various intriguing strongly correlated phenomena. In this talk, I will present a variety of interesting two-dimensional lattice geometries which show the appearance of multiple flat band states in their band structure. I will demonstrate how one can tune the parameters of the underlying tight-binding Hamiltonian of the system to engineer these flat-band states with interesting properties. With the application of an external magnetic field or an intrinsic spin-orbit interaction, such flat bands often show interesting topological properties and provide an ideal setup to study the quantum Hall physics in a lattice model. Finally, I will demonstrate how these theoretical flat-band toy models are realized in real-life experiments in the field of photonics using single-mode photonic waveguide networks.