

Flat Band Physics

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Flat bands (FB) – single-particle energy bands – in tight-binding networks (TBN) have attracted attention due to the presence of macroscopic degeneracies and compact localized states (CLS), and their extreme sensitivity to perturbations. This makes them natural candidates for emerging exotic phases and unconventional orders. The challenging part however is to construct flat band networks through TBN finetuning. In this talk we introduce CLS based FB generators of the three different FB classes and the corresponding real space FB projector properties. We then discuss how the fine-tuning constructions can be further extended, adapted or exploited in presence of perturbations, both single-particle and many-body. This strategy has lead to the discovery of non-perturbative metal-insulator transitions, fractal phases, nonlinear and quantum caging and many-body nonergodic quantum models. I will match the above by reviewing a plethora of experimental photonic applications.

Reads: Adv.Phys.:X3 1473052 (2018); APL PHOTONICS 3 070901 (2018); Nanophotonics 13 3925 (2024); Adv. Phys. DOI: 10.1080/00018732.2026.2658992 (2026).