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Quantum Optics near Photonic Flat Bands

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Flat Bands (FBs) are dispersionless energy bands, feature that makes such systems extremely sensitive to small perturbations and non-linearities. Here, we examine the case in which the non-linearity is introduced through the coupling of two-level emitters (almost) resonant to the FB energy.
Surprisingly, we find that a FB seeds a new type of *detuning independent* exponentially localized dressed bound state, never discussed before in literature, whose appearance is tightly linked to the **non-orthogonality** of the Flat Band basis made by *Compact Localized States* (CLSs). Indeed, we prove that the localization length λ_{BS} of such states is analytical related to the overlap between neighbouring CLSs in both 1D- and 2D-systems, effectively representing a measure of non-orthogonality. Furthermore, if the FB is **symmetry-protected**, the shape of such states is robust against all kind of disorder, being exactly invariant under non-symmetry breaking disorder. This robustness is naturally inherited by the ensuing photon-mediated interactions, induced between the emitters in the dispersive regime.
Finally, we also investigate this class of systems when the emitter is made by a *giant atom*, which couples to the photonic bath at several distinct locations. We show that the high degeneracy of the FB subspace permits the tuning of the photonic wavefunction through an appropriate choice of the coupling points and their strength. Indeed, the photonic wavefunction *mirrors* the structure of the coupling points, allowing to virtually engineer any possible BS shape as, for instance, a single CLS by using a finite number of coupling points. In this case, the resulting mediated-interactions will be strictly finite-ranged.

Abstract category

Quantum Optics

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