

# Quantum Nonlinear Response of Emitter Lattices

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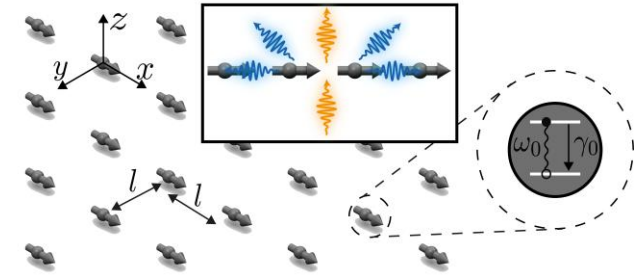
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In this work [1], we theoretically investigate the optical response of a periodic lattice of quantum emitters coherently driven by a plane wave. For subwavelength lattice periods, where the system behaves as a quantum metasurface, and contrary to the case of a lattice formed by bosonic (classical) resonators, we find that a resonant incident plane wave can populate excitonic Bloch states with parallel wavevectors different from the incident field, including those lying outside the light cone. Consequently, in close relationship with the phenomenon of resonance fluorescence, the lattice emission into the far-field is dominated by a background of photons at any frequency and wavevector for strong driving. Moreover, we show that, for periods approaching the driving wavelength, the emitter lattice enters in a bistable regime due to the renormalization of the driving rate [2], in striking contrast with its classical (bosonic) analog. This bistable behavior enables the selective activation and deactivation of the optical quantum nonlinearities of the system.

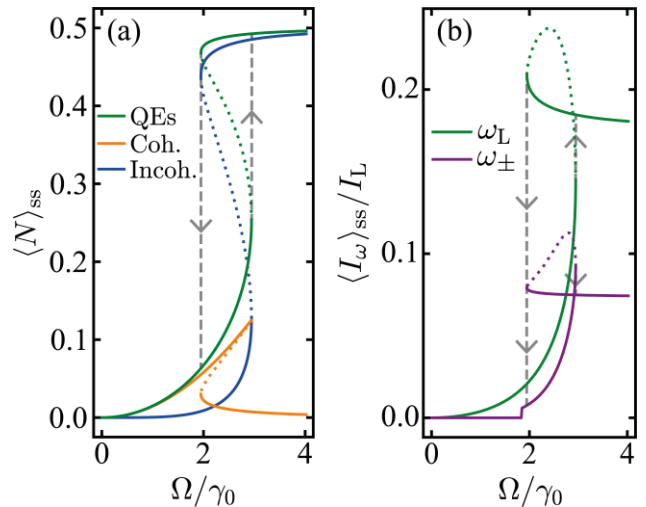
## References

- [1] Blas Durá-Azorín, Antonio I. Fernández-Domínguez, Alejandro Manjavacas, Quantum nonlinear response of emitter lattices, arXiv (2025).
- [2] C. D. Parmee, J. Ruostekoski, Bistable optical transmission through arrays of atoms in free space, Phys. Rev. A, 103 (2021).

## Figures



**Figure 1:** Schematics of a quantum emitter lattice with period  $l$  lying in the  $xy$  plane and excited with an  $x$ -polarized laser propagating in the  $z$  axis. Orange photons indicate emission at the same energy and momentum than laser photons, whereas blue photons highlight emission at other frequencies and wavevectors. The inset shows a schematic of an individual quantum emitter.



**Figure 2:** (a) Population per emitter (green), along with its coherent (orange) and incoherent (blue) contributions, as function of the driving rate. The coherent contribution corresponds to the population of the Bloch state with the same wavevector as the incident laser plane wave, while the incoherent contribution accounts for populations in states with different  $k$ . (b) Intensity emitted by the lattice at the laser frequency (green) and at the two sidepeaks of the Mollow triplet (purple). Arrows and dotted curves indicate the abrupt transitions and metastable states of the system, respectively.