CEWQO 2019
Invited

Unconventional quantum optics in structured photonic environments

A. González-Tudela[1],
[1] Instituto de Física Fundamental-CSIC, C/ Serrano 113bis, C.P. 28006, Spain

Abstract

Recent experimental advances provide us with platforms where natural or artificial quantum emitters interact with structured photons or matter waves confined to reduced dimensionalities. In this talk, we will show several examples how the interplay between the reduced dimensionality and non-trivial energy dispersion gives rise to phenomena very different from conventional platforms such as novel collective atomic interactions or non-trivial relaxation dynamics.

The interaction of (natural or artificial) emitters with the structured propagating photons (or matter-waves) which appear in nanophotonics structures [1, 2], circuits [3], or state-dependent optical lattices [4] challenge standard quantum optical wisdom. These unconventional photonic reservoirs can be engineered to display non-trivial energy dispersions and propagation, e.g., with band-gaps or saddle-points, where conventional quantum optical approximation fail. In this talk, we will present several cases where these structured photonic reservoirs leads to unconventional phenomena, such as non-exponential decays [5, 6, 7], anisotropic collective decays leading to novel super/subradiant states [5, 7], or purely long-range dipole-dipole interactions [6], which can be harnessed to simulate long-range interacting spin models.

References

[1] Peter Lodahl, Sahand Mahmoodian, and Søren Stobbe. Interfacing single photons and single quantum dots with photonic nanostructures. Rev. Mod. Phys., 87:347–400, May 2015.

[2] D. E. Chang, J. S. Douglas, A. González-Tudela, C.-L. Hung, and H. J. Kimble. Colloquium: Quantum matter built from nanoscopic lattices of atoms and photons. Rev. Mod. Phys., 90:031002, Aug 2018.

[3] Yanbing Liu and Andrew A Houck. Quantum electrodynamics near a photonic bandgap. Nature Physics, 13(1):48–52, 2017.

[4] Ludwig Krinner, Michael Stewart, Arturo Pazmino, Joonhyuk Kwon, and Dominik Schneble. Spontaneous emission of matter waves from a tunable open quantum system. Nature, 559:589–592, 2018.

[5] A. González-Tudela and J. I. Cirac. Quantum emitters in two-dimensional structured reservoirs in the nonperturbative regime. Phys. Rev. Lett., 119:143602, Oct 2017.

[6] A. González-Tudela and J. I. Cirac. Exotic quantum dynamics and purely long-range coherent interactions in dirac conelike baths. Phys. Rev. A, 97:043831, Apr 2018.

[7] A. González-Tudela and J. I. Cirac. Non-Markovian Quantum Optics with Three-Dimensional State-Dependent Optical Lattices. Quantum, 2:97, October 2018.