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First-order photon condensation in magnetic cavities: A two-leg ladder model

Recently, the existence of Dicke-like equilibrium superradiant phase transitions in cavity QED many-body system has been put into question —resulting in no-go theorems on spontaneous photon condensation. Specifically, the no-go theorems tells us that the superradiant phase transition is prohibited as long as a single-mode purely electrical vector potential is considered, with the transition being analogous to a magnetostatic instability. In this work [1] we consider a minimal setting beyond 1D –i.e., a two-leg ladder –where the orbital motion of spinless fermions is coupled through Peierls substitution to a non-uniform cavity mode which generates a fluctuating magnetic field. Thanks to the quasi-one dimensional geometry we are able to scrutinize the accuracy of (mean field) cavity-matter decoupling against large scale density-matrix renormalization group simulations and study light-matter entanglement properties as well as the exact cavity state. Our results show that ladder geometries can indeed photon condensation and in particular they serve as a first simple example of first-order photon condensation in a gauge-invariant scenario; highlighting how, in the quest for photon condensed phases, looking for only second order instabilities might be limiting.

[1] arXiv:2302.09901v2

Abstract category

Quantum Optics

Primary author: BACCICONI, Zeno (SISSA - Scuola Internazionale di Studi Superiori)

Co-authors: ANDOLINA, Gian Marcello (College de France, Paris.); Mr CHIRIACÒ, Giuliano (ICTP, Trieste); Mr DALMONTE, Marcello (ICTP, Trieste); Mr SCHIRÒ, Marco (College de France, Paris); Mr CHANDA, Titas (ICTP, Trieste)

Presenter: BACCICONI, Zeno (SISSA - Scuola Internazionale di Studi Superiori)