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Detection of virtual photons in superconducting architectures

Micro/nano-fabrication techniques have recently allowed producing quantum devices displaying ultra-strong coupling (USC) of radiation and matter. In this non-perturbative regime, distinctive phenomena emerge, as the highly entangled ground state involving many-photon states of the field. These ground-state virtual photons (VPs) cannot be revealed by standard photodetection since the ground-state does not decay. Several works [1-6] have proposed that VPs in USC solid-state devices can be converted to real photons using architectures with three-level artificial atoms (AAs). In this enlarged Hilbert space, appropriate classical control drives may induce leakage from the Rabi subspace which marks the presence of VPs. The works [1-6] consider different control protocols, namely, AC continuous pumping of photons with dynamical Casimir effect(DCE) [1], spontaneous emission pumping in Lambda scheme [2], Raman oscillations with two-tone pulses [3] and STIRAP in Lambda [4,5] and Vee [5] scheme, and stimulated emission, also implemented by a two-tone control field in Lambda scheme[6]. Notwithstanding having been subject of many investigations, such a population of virtual excitations remains still unobserved. The aim is of this work is to understand if experimental progress can be made in the detection of ground state photons with controlled three-level atom structures. To this end, we study a model integrating the various conversion protocols as mentioned above[1-6] and the detection steps, and with optimal control theory(OCT) to find optimal conditions for the efficient detection of VPs. Further, open systems effects have to be accounted for, since they may impact in particular on the fully coherent protocols [3,4,5].

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Presenter: RAJENDRAN, Jishnu (Università degli Studi di Catania)

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