QUANTUM METROLOGY THROUGH SPECTRAL MEASUREMENTS IN QUANTUM OPTICS

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Quantum optical systems can emit light with very complex spectral properties. For instance, the emergence of dressed states from coherently driven quantum emitters, hybridized excitonic states or hybrid light-matter states (polaritons) in cavity QED translate into rich fluorescence spectra with multiple peaks that reflect the complex structure of eigenstates. These spectra exhibit equally complex dependences with the parameters that govern the dynamics of the system [see Fig 1. (a)], and therefore offer the opportunity to improve the inference of unknown parameters by frequency-filtering the emitted signal.

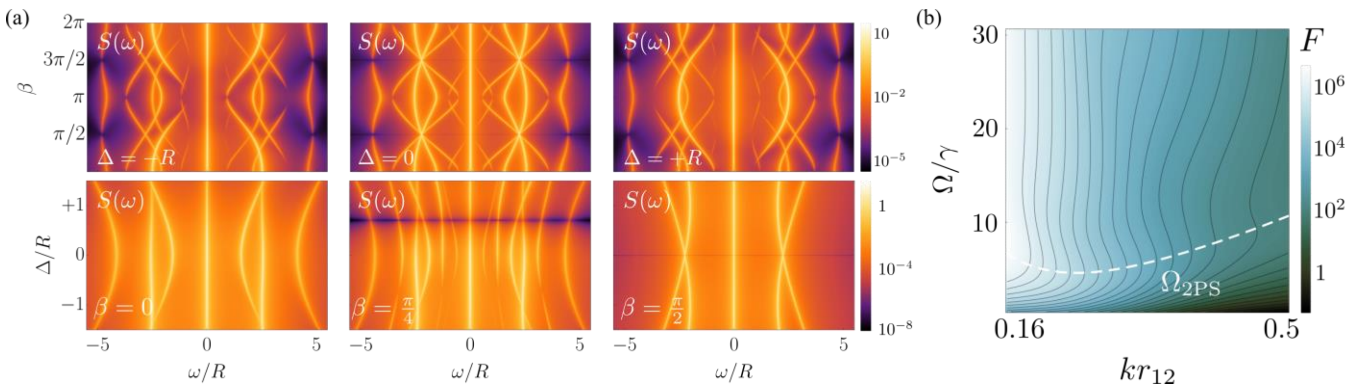

Fig. 1. (a) Resonance fluorescence spectrum in terms of the mixing angle β=ArcTan(J/δ) (upper panels), and the qubit-laser detuning Δ (lower panels). (b) Fisher information in terms of the driving intensity Ω and the normalized inter-emitter distance kr_{12} at the two-photon resonance, Δ=0.

Here, we explore this idea in quantum optical systems consisting of coherently driven quantum emitters in dissipative scenarios. Specifically, in Ref. [1], we focus on the estimation of the inter-emitter distance between two nonidentical interacting quantum emitters driven by a coherent field by measuring the fluorescence spectrum. We identify, by means of the Fisher information [2], that the two-photon resonance (i.e., when the laser frequency is at half of the energy of the doubly excited state) and the onset of the two-photon saturation regime (i.e., when the two-photon dressing effects begin to be resolved in the spectrum) are the most sensitive points for distance estimation [see Fig 1. (b)].

It is known that hybridized light-matter systems, e.g., a strongly driven two-level system [3], give complex correlations in frequency space. Following this idea, we discuss the role of quantum correlations and quantify their impact on the precision by which unknown atomic parameters can be estimated, assessing the potential of frequency-resolved correlation measurements for the task of parameter estimation in driven-dissipative quantum optical systems.

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