

Coherence in critically driven resonators

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Creating quantum networks requires coherently linking distant systems through remote strong coupling. Long-distance coherence in cavity magnonics operating in the linear regime was recently demonstrated [1]. By locally tuning the cavity to near-critical coupling with traveling electromagnetic waves, non-local magnon-photon coherence can be established. A similar phenomenon can be observed in a system of two electromagnetic resonators coupled through a waveguide. In this case, the coupling between the photons and the resonators is determined by the size of the connectors linking the resonators to the waveguide.

In this work, we analyze the coupling between distant electromagnetic resonators through a waveguide. Results of numerical simulation show that near the critical coupling, in the transmission spectrum of the fundamental waveguide mode, two sharp dips occur at certain connector sizes (see Fig. 1(a)). This behavior corresponds to a loaded oscillator, for which the effective intrinsic damping rate approaches zero and the rate of extrinsic damping reaches its local maximum. Remarkably, such a loaded oscillator is highly sensitive to detecting anomalies in photon-mediated coupling. Moreover, the transmission spectra exhibit coupled double minima in the regime of critical coupling. A system of identical resonators coupled critically can undergo various modifications. For instance, we can change the size of one of the resonators. Another option is to fill one of the resonators with a dielectric, while the other remains filled with air. Such modifications lead to a change in the transmission spectrum, affecting the double minima. It is rather surprising that the dependence of the minimum positions on the detuning, caused by the system's asymmetry, may exhibit an anti-crossing, see Fig. 1(b). This system serves as a model for the study of hybrid modes in coupled magnonic and dielectric resonators.

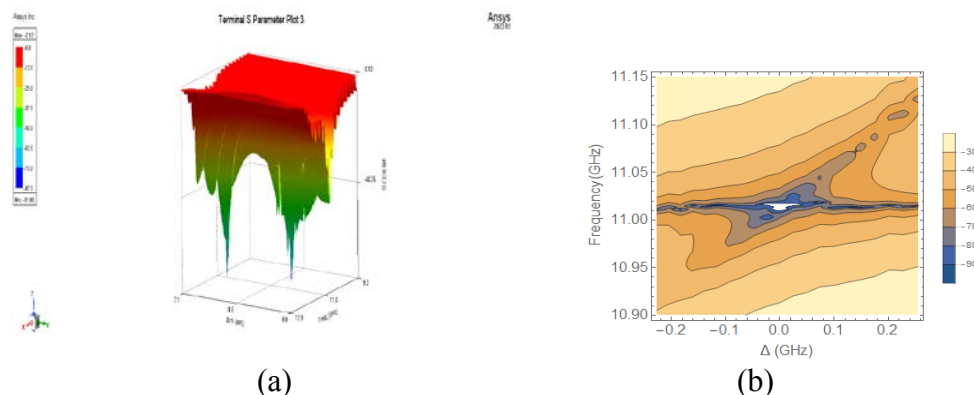


Fig. 1. (a) Two sharp dips; (b) anti-crossing of transmission spectrum as function of frequency and detuning.

[1] Ying Yang et al., “Anomalous Long-Distance Coherence in Critically Driven Cavity Magnonics,” *Phys. Rev. Lett.*, vol. 132, p. 206902, 2024.