Time-Domain Dynamics of Level Attraction in Remotely Coupled Cavity-Magnon Systems

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Hybrid quantum systems combining magnons (quanta of spin waves) with microwave photons offer promising routes toward quantum information processing and transduction. While coherent magnon-photon coupling has been extensively studied, dissipative coupling remains largely unexplored in the time domain. This study introduces the first experimental observation of time-domain dynamics in dissipatively coupled photon-magnon systems, where coupling is mediated by a heavily damped auxiliary mode [1].

In our work, we implemented a remote coupling architecture between a microwave cavity and a YIG sphere, with a transmission line acting as a heavily damped intermediary enabling magnon-photon interactions over macroscopic distances. By controlling only the phase of the input signal, we demonstrate continuous in situ tunability of the effective coupling strength – from strong level attraction to complete decoupling – without mechanical repositioning [Fig. 1(a,b)]. We resolve the associated temporal evolution, capturing Ramsey-like interference patterns and characteristic signatures of mode coalescence near exceptional points [Fig. 1(c,d)].

The understanding presented here is particularly relevant for technological applications in quantum information processing and spintronic technologies [2, 3]. By enabling precise control over the coupling strength between photons and magnons, our findings open new avenues for integrating magnonic elements into quantum networks. This capability allows for the creation of hybrid systems where information exchange between magnons and other systems such as qubits can be dynamically controlled [4, 5, 6].

References

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Figures

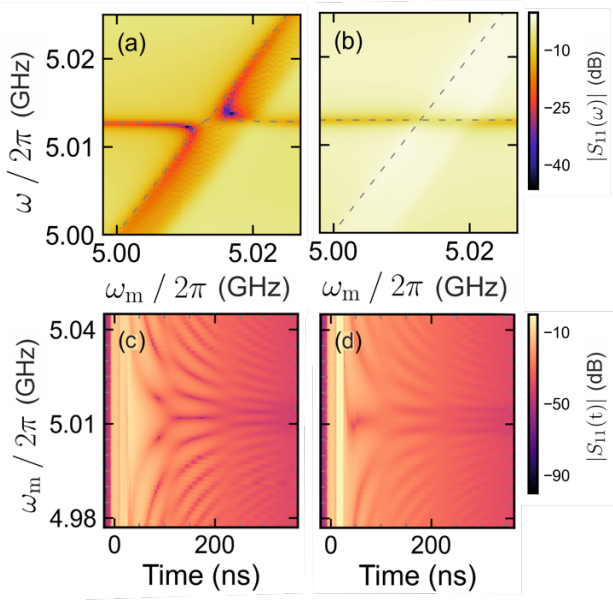

Figure 1: (a,b) Frequency-domain spectra showing tunable level attraction. Phase control enables continuous modulation from strong dissipative coupling (level attraction) to complete decoupling. (c,d) Corresponding time-domain dynamics.