

Reflectionless modes in hyperfine levels of molecular spins coupled to a superconducting resonator

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Abstract: We show that, by tuning spin-photon detuning in molecular spins coupled to a microwave resonator, it is possible to observe reflectionless scattering modes. They can be described by a non-Hermitian effective Hamiltonian with Hermitian subspaces.

We investigate reflectionless scattering modes (in which the incoming energy is entirely absorbed [1]) in a system consisting of molecular spin centers coherently coupled to a planar microwave resonator operating at milliKelvin temperature and in the single photon regime. In particular, we examine a prototypical two-level system (BDPA) and a multi-level hyperfine system (VOTPP) with electronic spin $S=1/2$ and nuclear spin $I=7/2$ [2].

This platform allows us to fine tune the spin-photon coupling and to control the effective dissipation of the two subsystems towards the environment, thus offering the opportunity to span over a wide space of parameters. This system can be effectively described by a non-Hermitian Hamiltonian exhibiting distinct Hermitian subspaces.

We experimentally show that these subspaces, linked to the presence of reflectionless scattering modes, can be engineered through the resonator-spin detuning, which controls the composition of the polariton modes in terms of their photon and spin content. In such a way, the required balance between the feeding and the loss rates can be effectively recovered even in the absence of PT-symmetry [3]. We show that Hermitian subspaces influence the overall aspect of coherent spectra of cavity QED systems (see Fig. 1). These findings broaden the possibilities for exploring non-Hermitian effects in open quantum systems and may find applications in single-photon switches and modulators.

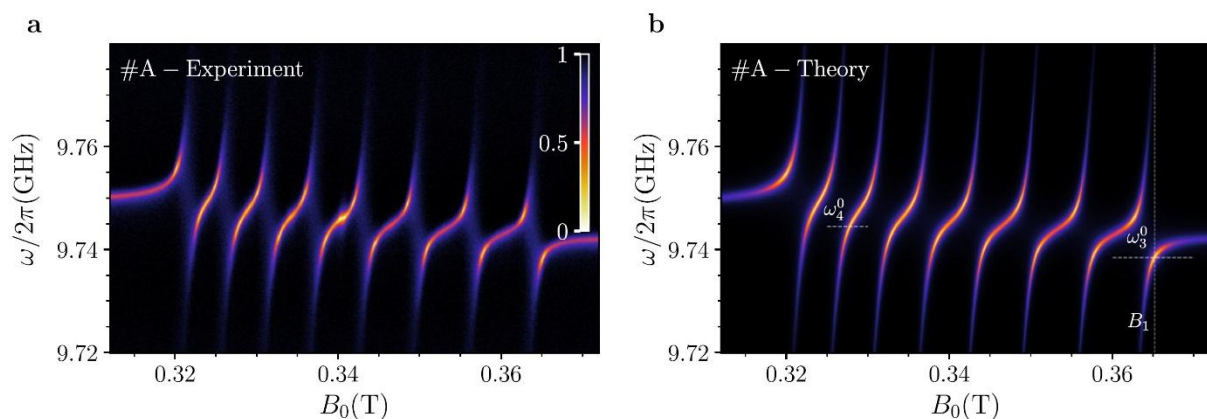


Fig. 1 Reflectionless scattering modes for the multiple spin case. **a** Normalized reflection maps measured as a function of the static magnetic field B_0 at 30mK for the VOTPP crystal. Reflectionless scattering modes (zero reflection values) are observed in the proximity of multiple hyperfine levels. **b** Simulated reflection maps obtained by fitting the maps in **a**, see Ref. [2].

References

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