Exceptional Antimodes in Multi-Drive Cavity Magnonics

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Cavity magnonics is a burgeoning field where strongly coupled magnons and photons are studied with applications that include quantum computation, microwave to optical transduction, and high precision sensors. Here we discuss experimental and theoretical results for a multi-port system in which multiple drive fields can be used to tune the system to exceptional points with potential applications as sensing devices. Exceptional points are spectral singularities present in non-Hermitian systems in which both the eigenvalues and the eigenvectors coalesce. These spectral features are highly sensitive to perturbations leading to their enhanced sensing abilities. Resonant exceptional points are associated with modes of a system. In a multimode system, destructive interference leads to the formation of antimodes, or antiresonances. In a multiport system, one may use multiple drive fields to tune the antimodes. We consider a four port, three mode, cavity-magnonics system, and show that multiple drive fields may be utilized to obtain antiresonant (absorbing) exceptional points for any given system parameters. This removes much of the fine tuning required to obtain more conventional resonant exceptional points. As the antiresonant exceptional points exhibit the same sensitivity to perturbations as their resonant counterparts they may prove useful for future sensing applications [1–3].

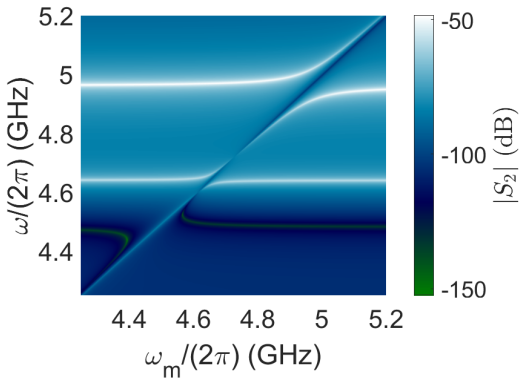

FIG. 1. Transmission through a cavity-magnonics system consisting of two cavity modes (horizontal white lines) coupled to a magnon mode (the diagonal line), as a function of the magnon-mode frequency, ω_m. The avoided level crossings indicate the presence of hybridised light-matter quasiparticles known as magnon-polaritons. The dark green lines in the lower half of the figure are antimodes stemming from interference between the modes. Exceptional points occur at the apex of these lines. The region bounded by the exceptional points is a level attraction region in which the antimodes are degenerate. Due to an increase in the linewidth of the antimodes, they do not show up clearly in the level attraction region.

[1] M. A. Smith, R. D. McKenzie, A. Joseph, R. L. Stamps, and R. Macêdo, Exceptional antimodes in multi-drive cavity magnonics, arXiv:2510.16163 (2025).

[2] R. Macêdo, M. A. Smith, A. Joseph, R. D. McKenzie, and R. L. Stamps, A map of cavity magnonics: Concepts, developments, and recent advances, Journal of Physics: Condensed Matter (DOI 10.1088/1361-648X/ae1ab9) (2025).

[3] R. D. McKenzie, M. Smith, A. Joseph, A. Eden, R. Macêdo, and R. L. Stamps, Higher order exceptional points in multi-drive cavity magnonics, In Preparation (2025).