Level Attraction And Exceptional Points In Open Cavity Magnonic Systems

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Level attraction has recently attracted attention in open systems. It describes a dynamic regime in an interacting system where instead of usual hybridization, two modes coalesce in some region of the parameter space. This region indicates a development of an instability in the energy spectrum of the system, and it is bounded by two exceptional points [1]. The exceptional points can be potentially useful in applications that require fine control of energy gain and loss [2, 3]. Mode attraction regime has been recently reported in a number of experiments with driven dissipative cavity magnonic systems, (see Ref. [4] and references therein).

In this work, we develop a new approach to the problem of level attraction in cavity magnonic systems, which is based on a quantum description of non-linear relaxation phenomena in weakly interacting open systems. In this approach, the interaction between cavity photons and magnons is described in terms of "system-bath" formalism with memory effects. We show that the memory function for the photon mode can be expressed through a generalized non-equilibrium susceptibility of the magnonic bath. This allows us to consider a situation in which the bath is driven out of the equilibrium necessary to describe the attraction regime. The advantage of our approach is that the generalized susceptibility of the bath can be now calculated separately using various methods depending on what regime of bath dynamics we would like to take into account. We demonstrate that for the semi-classical dynamics of the magnonic subsystem, one can use micromagnetic simulations to find the generalized susceptibilities, which describe systems properties in a driven stationary state away from equilibrium. This allows us to consider "real world" materials and experiments. Using this framework, we discuss realization of mode attraction and exceptional points in driven cavity magnonic systems for certain geometries and experimental setups. The role non-linear and non-local interactions in the energy balance between cavity photon and magnon modes is emphasized.

[1] N. R. Bernier et al, Phys. Rev. A 98, 023841 (2018).
[2] A. Cerjan, Physics 12, 138 (2019)
[3] W. Chen et al, Nature 548, 192-196 (2017)
[4] Y.-P. Wang and C.-M. Hu, J. Appl. Phys. 127, 130901 (2020)