Adiabatic protocols in Lindbladian systems

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We develop a theory for adiabatic evolution of Lindbladian systems. While adiabatic theory of closed (Hamiltonian) systems is well established, real systems are open and can be described by non-Hermitian (Lindbladian) operators. Such operators have a complex gap that may close at exceptional points (EPs) – branch points in the eigenvalue spectrum. EPs are important for adiabatic theory for several reasons: (a) Instead of following individual eigenstates, adiabatic evolution can take place inside a multi-dimensional subspace spanned by Jordan chains [1], (b) Cyclic processes that involve encircling EPs may lead to mode swapping and chiral behavior [2], (c) EPs determine diabatic errors in the asymtotic limit [3]. We classify the geometry and topology of EP surfaces in Lindbladians (Fig. 1). We propose utilizing Lindbladian EPs for robust coherent control. Furthermore, we develop an optimal control method which finds pulses that optimally adhere to adiabatic eigenstates. Finally, we present a formula for asymptotic scaling of diabatic errors in Lindbladians.

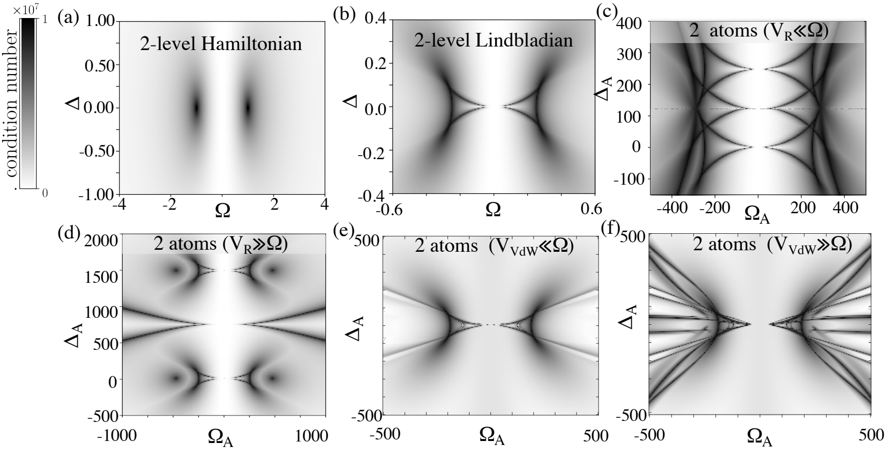

Figure 1: Condition number of the Lindbladian (diverges at EPs) when scanning Rabi frequency (Ω) and detuning (Δ) of the controls. (a) Isolated EPs (black) in the effective Hamiltonian of a dissipative driven two-level system. (b) Bow-tie of EPs [4] in the Bloch equations of a driven two-level system. (c-d) A pair of Rydberg atoms, with weak ($V_R \ll \Omega$) (c) and strong ($V_R > \Omega$) interactions. (e-f) A pair of atoms with dipole-dipole weak/strong interactions.

References

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