Quantum associative memory with single driven-dissipative oscillator

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Abstract

Algorithms for associative memory typically need a network of many connected systems. The prototypical example is the Hopfield model [1], whose generalisations to the quantum realm are mainly based on multipartite open quantum systems [2]. We propose a model of associative memory with a *single* driven-dissipative quantum system exploiting its infinite degrees of freedom in phase space [3]. We prove that the model is able to distinguish among *n* coherent states, which represent the stored patterns of the system. These can be tuned continuously by modifying the driving and dissipation strength, constituting a modified learning rule. We show that the associative-memory capacity is inherently related to the existence of a spectral gap in the Liouvillian superoperator, which results in a large time-scale separation in the dynamics corresponding to a metastable phase. There, a near-unit success probability is achieved, even for a single trajectory.

References

[1] Hopfield, J. J. (1982). Neural networks and physical systems with emergent collective computational abilities. *Proceedings of the national academy of sciences*, ***79***(8), 2554-2558.

[2] Fiorelli, E., Marcuzzi, M., Rotondo, P., Carollo, F., & Lesanovsky, I. (2020). Signatures of associative memory behavior in a multimode Dicke model. *Physical Review Letters*, ***125***(7), 070604.

[3] A. Labay Mora, R. Zambrini, and G. L. Giorgi. *In preparation.*

Figures

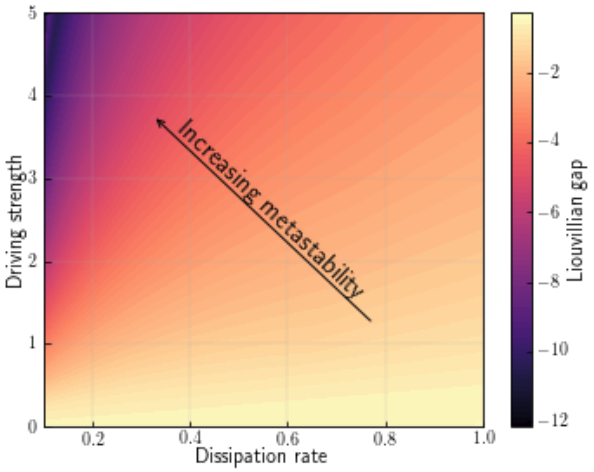

Figure 1: Liouvillian gap (logarithmic scale).

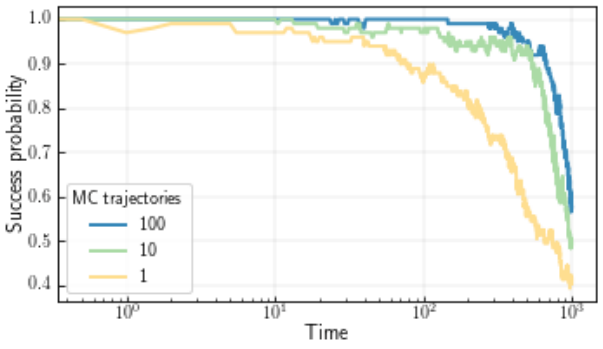

Figure 2: Probability of finding the correct pattern in time. Averaged over 100 randomly chosen initial coherent states for a different number of Monte-Carlo trajectories.