Associative Memories in the Quantum Regime

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Attractor neural networks are brain-inspired computational systems that can solve and model numerous kinds of tasks, ranging from pattern and speech recognition to big data analysis. Associative memories (AMs) are a prominent example of attractor neural networks whose temporal evolution settles on stable solutions. In an AM task, a system stores a set of memory states. Then, it is interrogated using a clue state similar but not necessarily identical to one of the memories; a system equipped with AM can identify the stored pattern most similar to the clue according to a properly defined distance.

To this purpose, we deviate from standard Hopfield network techniques [1] and explore the use of non-linear bosonic oscillators. Our findings show the possibility of storing patterns in the form of coherent [2] or squeezed states [3] that span the metastable phase of the system. In the former work, we study the storage capacity of such oscillators and show that they can overcome the Hebbian limit in a large regime by toggling the oscillator parameters. In the latter, we introduce the possibility of storing patterns as purely quantum states, with no classical analogue. A novelty that had not been pursued in previously studied generalizations of quantum Hopfield networks [4]. We compare the storage capacity between squeezed and coherent states. Being the former more sensible to errors as the states are harder to discriminate.

Concerning AMs, metastability allows systems that converge towards a unique steady state to span a manifold of relevant addressable memories. Yet, there are other possibilities for building an AM. In [5] we investigate the general form of quantum channels that pursue such tasks.

References

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Figures

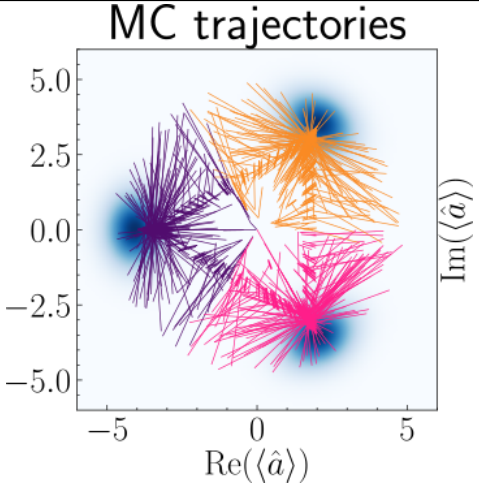

Figure 1: Association of states towards its closest pattern encoded in squeezed states.