One shot approach in the quantum-to-classical emergence of objectivity

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Decoherence, despite its success at explaining some questions of the quantum-to-classical transition, ignores the question of an emergent and objective classical picture of a system seen by the spread of information in degrees of freedom of the environment. The paradigm shift proposed by the Quantum Darwinism [1-3] framework solves this issue by shifting the perspective toward the multipartite entanglement between the system and many observers within the environment, seen as a communication channel. Hence, the mutual information, was identified as a relevant quantity to study the build up of correlations between the system and parts of the environment defining the observer. However, Shannon quantum theory being an asymptotic theory, it requires some form of tomography to measure entropies, and so ideally an infinite amount of copies of the states. To remedy these experimental obstacles, one-shot quantum information could offer new tools to characterized multipartite correlations with finite resources.

The present work develops a one-shot quantum information approach to Quantum Darwinism in the context of cavity and circuit QED: the model is a qubit coupled to an environment of bosonic modes in the dispersive regime. We compare the usual mutual information characterization of classicality with two one-shot information concepts: first the error probability, given by Helstrom's bound , obtained in the quantum binary hypothesis testing task [4] which is linked to the min-entropy [5]. Then the Chernoff bound [6], which tests the ability of the environment to contain many copies of the state of the system. These results open the way to a full one-shot characterization of classical objectivity in quantum theory which can be measured in many experimental plateformes.

References

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