Qutrit quantum battery: sequential vs coherent charging

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In recent years, the investigation of quantum systems out of equilibrium contributed to the advancement of quantum thermodynamics. In particular, the study of quantum batteries, small quantum mechanical systems able to temporarily store energy and further release it on-demand, recently emerged as a fast-growing subject in this field.
In this framework we have characterized the performances of IBM quantum chips as quantum batteries, establishing the optimal compromise between charging time and stored energy [1].
Considering this result, and motivated by recent experimental observations [2], we have investigated the possibility of realizing charging protocols addressing two excited states of a superconducting qubit in the transmon regime, namely realizing a qutrit quantum battery. This extension allows to store a greater amount of energy in the system and opens the door to a richer variety of charging protocols. We have compared some of them both analytically and through tests on IBM quantum processors with the aim of characterizing their advantages and limitations. Moreover, we have investigated how the charging of a qutrit is affected by crosstalk among the transmons.

References

[1] G. Gemme, M. Grossi, D. Ferraro, S. Vallecorsa, M. Sassetti, Batteries, 8 (2022) 43.
[2] C.-K. Hu *et al*, Quantum Science and Tecnology, 7 (2022), 045018

Figures

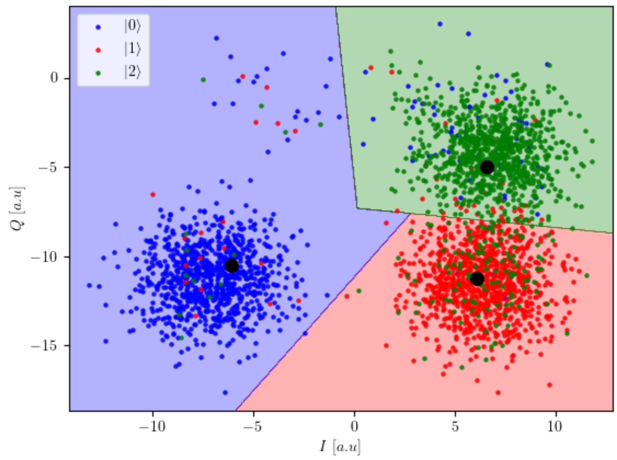

Figure 1: Data distribution associated to the measurements in the (I, Q) plane of the ground state (blue dots), first excited state (red dots) and second excited state (green dots) for one qubit of the Auckland IBM quantum device. Big black dots indicate the mean of each distribution.

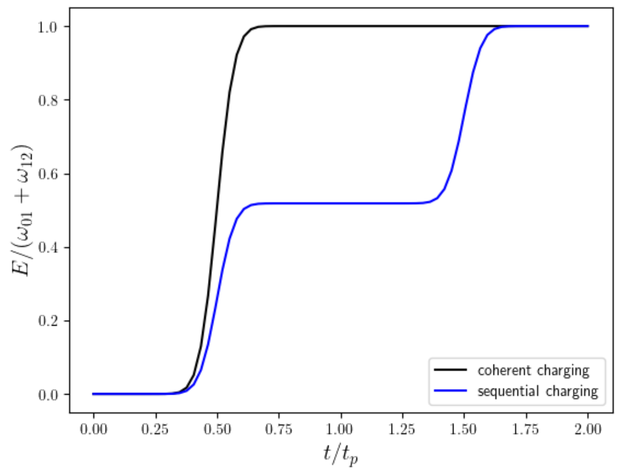

Figure 2: Energy stored in the qutrit quantum battery as a function of time for the sequential (blue) and coherent (black) charging protocol.