CERN QTI Community Workshop

Michele Grossi, CERN QTI
Dario Ferraro, University of Genova

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Abstract

Aim of this project is to **characterize the functioning of a quantum battery made by one or more qubits**. In this kind of devices the charging phase can be achieved by means of a classical time dependent drive [1].

By using the tools provided for the pulse engineering [2] the optimal profile of the drive able to minimize the charging time, still leading to a full charge of the quantum battery (arbitrary initial state to excited state transition), will be determined.

The energy fluctuation associated to this charging process will be considered in order to determine the stability and the efficiency of the device [3]. The typical discharging time of the battery towards the ground state once the drive is switched off will be also estimated. In the case of a quantum battery made by more than one qubit the role of mutual interaction among these subunits in the performance of the device will be also investigated [4].

[1] A. Crescente, M, Carrega, M. Sassetti, D. Ferraro, New J. Phys. 22, 063057 (2020).
[2] T. Alexander et al., Quantum Sci. Technol. 5, 044006 (2020).
[3] S. Gherardini, A. Belechia, M. Paternostro, A. Trombettoni, Phys. Rev. A 104, L050203 (2021).
[4] Y.-Y. Zhang, T.-R. Yang, L. Fu, X. Wang, Phys. Rev. E 99, 052106 (2019).

General Overview

We consider the charge of a single two-level system with Hamiltonian

$$\hat{\mathcal{H}}(t) = \hat{\mathcal{H}}_0 + \hat{\mathcal{H}}_1(t) = \frac{\Delta}{2}\hat{\sigma}_z + \frac{A}{2}\Theta(t)f(t)\hat{\sigma}_x$$

With:

- $\Delta = E_e - E_g$
- $f(t)$ funzione periodica di periodo T
- $f(t)$ a media nulla, $\frac{1}{T}\int_0^T dt' f(t') = 0$
- $f(t)$ normalizzata, $\frac{1}{T}\int_0^T dt' |f(t')|^2 = 1$

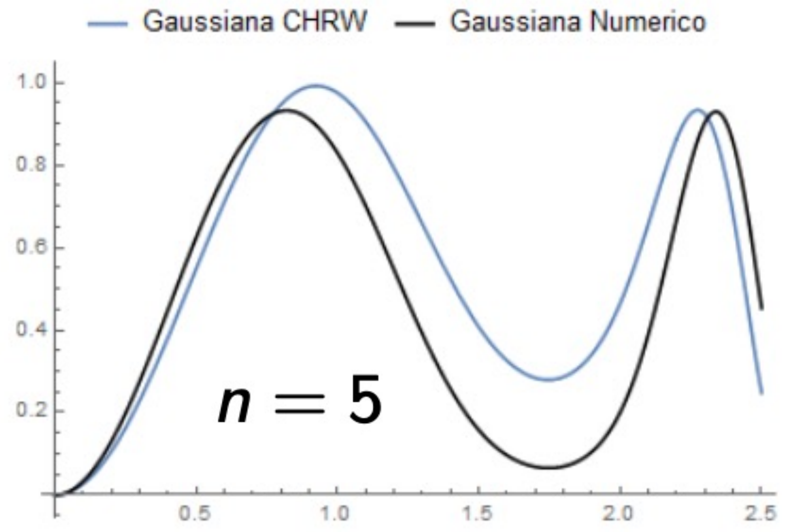
General Overview

We are interested in evaluating the time evolution of the energy of the system and we can compare it to numerical (analytical) solution.

$$E_\nu(t) = \langle\psi_\nu(t)|\,\hat{\mathcal{H}}_0\,|\psi_\nu(t)\rangle - \langle\psi_\nu(0)|\,\hat{\mathcal{H}}_0\,|\psi_\nu(0)\rangle$$
$$= \frac{\Delta}{2}(\sigma_{z,\nu}(t) - \sigma_{z,\nu}(0))$$

We want to optimize the driver choice and maximum energy stored. Example: Gaussian Driver

$$f^{(g)}(t) = Amp\left(\frac{1}{\sqrt{2\pi\sigma^2}}\sum_{k=-\infty}^{+\infty} e^{-\frac{(t-(2k+1)n\sigma)^2}{2\sigma^2}} - \frac{1}{T}\right)$$



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