Modelling Leakage with Perturbation Theory in Singlet-Triplet Spin Qubits

Oliva delMoral, Javier
Rubén M.Otxoa, Josu Etxezarreta Martinez and Pedro M. Crespo

Department of Basic Sciences, Tecnun – University of Navarra, 20018 Donostia-San Sebastian, Spain. Donostia International Physics Center (DIPC), 20018 Donostia-San Sebastian, Spain

jolivam@unav.es

Quantum computers are a promising technology poised to outperform classical computers in various problem domains. Despite their theoretical potential, qubits are susceptible to decoherence caused by interactions with their environment. These interactions sometimes lead to the population of higher energy levels, resulting in computational errors known as leakage errors. Recent research [1], has shown that quantum computers can prepare an initial state,, ρ_0 , more rapidly when more than two accessible levels are present. Consequently, leakage, instead of being a hindrance, could offer an advantage for quantum computing. We have conducted a study on how leakage induces dephasing in the time evolution, comparing scenarios with only two levels to those with more than two levels using perturbation theory, which elucidates the observed speedup.

In this poster, we will study the dynamics of Singlet-Triplet spin qubits (ST_0), which are qubits encoded in two electrons in two different quantum dots. These qubits are easier to control and suffer less dephasing due to interactions with the nuclei spins in their environment compared to single spin qubits. Spin qubits in quantum dots represent a promising technology for quantum computing. However, since these qubits have more than two accessible levels, they could populate levels outside of the computational basis ($|0\rangle$ and $|1\rangle$), making them a favourable scenario for experimental observation of this acceleration. We anticipate observing a trade-off between the acceleration caused by leakage and an increase in the decoherence experienced by the qubit.

References

[1] Asthana, Ayush et al., Phys. Rev. Appl., Vol. 19, issue 6, 2023.