Quantum Sensing from Gravity as Universal Dephasing Channel for Qubits

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Abstract

We investigate the interaction of a transmon qubit with a classical gravitational field [1]. Exploiting the generic phenomena of the gravitational redshift and Aharonov-Bohm phase, we show that entangled quantum states dephase with a universal rate. The gravitational phase shift is expressed in terms of a quantum computing noise channel. We give a measurement protocol based on a modified phase estimation algorithm which is linear in the phase drift, which is optimal for measuring the small phase that is acquired from the gravitation channel. Additionally, we propose qubit-based platforms as quantum sensors for precision gravitometers and mechanical strain gauges as an example of this phenomenon's utility. We estimate a sensitivity for measuring the local gravitational acceleration to be $\delta g/g \sim 10^{-7}$. This paper demonstrates that classical gravitation has a non-trivial influence on quantum computing hardware and provides an illustration of how quantum computing hardware may be utilized for purposes other than computation. While we focus on superconducting qubits, we point the universal nature of gravitational phase effects for all quantum platforms.

References

[1] A. V. Balatsky, P. Roushan, J. Schaltegger and P. J. Wong, Phys. Rev. A **111** (2025) 012411

Figures

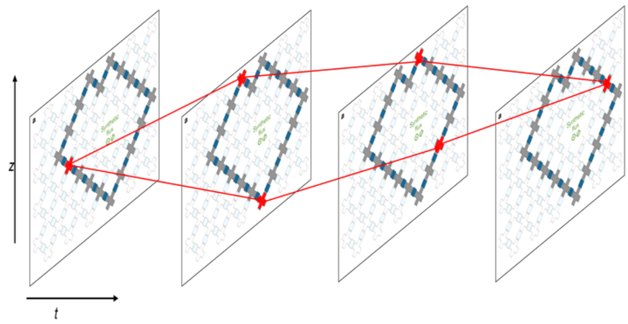

Figure 1: Aharonov-Bohm flux through (x,t) loop measured with entangled pair will reveal the gravitational phase shift. The effect is largest with entangled states, e.g. a GHZ state [1].