Quantum Control Technique

VTIP 20-013: “Method to Generate Error-resistant Quantum Control Pulses from Geometrical Curves”

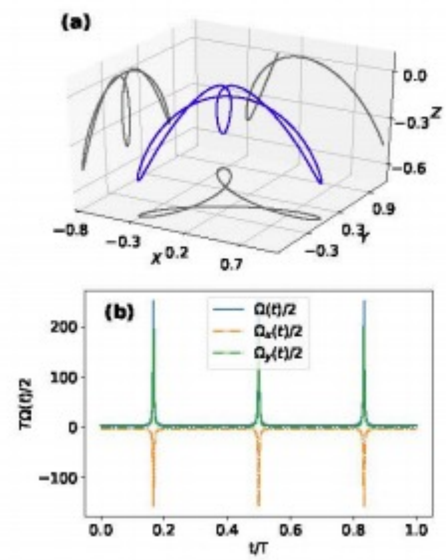
THE CHALLENGE

A quantum computer could enable us to tackle problems exponentially faster than an ordinary classical computer. For decades, people have been striving to overcome one of the main obstacles to realizing this and other proposed quantum technologies, namely the decoherence caused by the coupling between a qubit and its noisy environment. Implementing high-fidelity quantum control and reducing the effect of the coupling between a quantum system and its environment is a major challenge in developing quantum information technologies

OUR SOLUTION

This technology shows that there exists a geometrical structure hidden within the time-dependent Schrödinger equation that facilitates the design of control pulses that perform target operations on quantum systems while suppressing errors dynamically. In this framework, any single-qubit gate that is robust against quasistatic noise to first order corresponds to a closed three-dimensional space curve where the driving fields that implement the robust gate can be read off from the curvature and torsion of the space curve. Gates that are robust to second order are in one-to-one correspondence with closed curves whose projections onto three mutually orthogonal planes each enclose a vanishing net area.

Sycamore - Google’s quantum computer.



Single-qubit identity gate robust against errors up to second order. (a) The curve (blue) and its projections onto the xy, yz, and xz planes (gray). All three projected areas have zero enclosed area. (b) The pulses obtained from the curvature and torsion of curve.

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