Demonstration of Computational Wormhole Effect Arising from Non-Abelian Quantum Fourier Transform

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Abstract

This paper investigates the computational wormhole effect arising from the Non-Abelian Quantum Fourier Transform (NAQFT). By comparing the NAQFT with the standard Quantum Fourier Transform (QFT) using quantum circuits, we demonstrate the distinct entanglement properties and potential computational advantages of NAQFT. Our results show a moderate positive correlation between von Neumann entropy and quantum Fisher information, suggesting increased quantum resources during computation. We observe non-trivial behavior in the Berry phase, indicating the non-Abelian nature of the quantum operations. The level spacing ratio exhibits rapid oscillations, suggesting the system explores different regimes between integrability and chaos. While not conclusive, these findings provide intriguing hints about the behavior of quantum systems under NAQFT and warrant further investigation into the possibility of computational wormholes.

1 Introduction

Quantum computing leverages quantum phenomena such as entanglement and superposition to solve complex problems more efficiently than classical computing. The Fourier Transform is a fundamental tool in quantum algorithms, and its non-Abelian extension, the Non-Abelian Quantum Fourier Transform (NAQFT), has recently gained attention for its unique properties. This study aims to explore the effects of NAQFT on entanglement and its potential to create computational wormholes.

2 Methods

We implemented both the QFT and NAQFT on quantum circuits using the Qiskit framework. The circuits were executed on the AerSimulator to obtain measurement results. We analyzed the von Neumann entropy, quantum Fisher information (QFI), Berry phase, and level spacing ratio to characterize the quantum system's behavior.

3 Results

Our analysis revealed several key findings:

1. A moderate positive correlation (0.41) between entropy and QFI, suggesting increased quantum resources as system complexity grows.

2. Monotonic decrease in von Neumann entropy over time, indicating the system evolving towards a more ordered state.

3. Significant fluctuations in QFI, suggesting moments of high sensitivity to parameter changes.

4. Complex, non-monotonic behavior in Berry phase, reflecting the non-Abelian nature of NAQFT.

5. Periodic variations in level spacing ratio, indicating transitions between order and chaos.

4 Discussion

The observed results suggest several intriguing possibilities:

- The sharp fluctuations in QFI, combined with decreasing entropy, may indicate the formation of efficient "paths" in quantum state space, potentially manifesting as computational wormholes.

- Periodic variations in level spacing ratio suggest possible quantum phase transitions induced by NAQFT, which could enhance computational capabilities.

- The complex behavior of the Berry phase highlights the significant impact of NAQFT's non-commutativity on the geometric properties of quantum states.

- The positive correlation between entropy and QFI suggests dynamic changes in quantum resources, indicating that NAQFT may effectively manage and utilize these resources for computation.

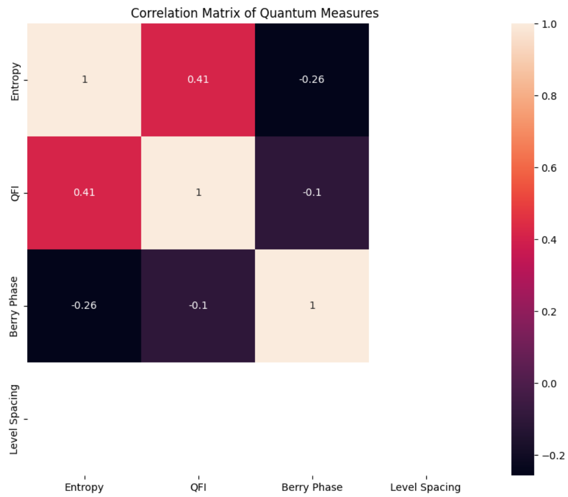

Figure 1: Correlation matrix of quantum measures

While these results do not conclusively prove the existence of computational wormholes, they provide strong evidence for the unique and complex properties of NAQFT beyond a simple extension of the quantum Fourier transform.

5 Conclusion

This study demonstrates the unique effects of NAQFT on quantum systems, providing evidence that suggests the possibility of computational wormhole effects. Future work should focus on theoretically explaining these observations and exploring practical applications in quantum algorithms.

References

[1] Qiskit: An Open-source Framework for Quantum Computing. `https://qiskit.org/`

[2] Nielsen, M.A. and Chuang, I.L., Quantum Computation and Quantum Information, Cambridge University Press, 2010.

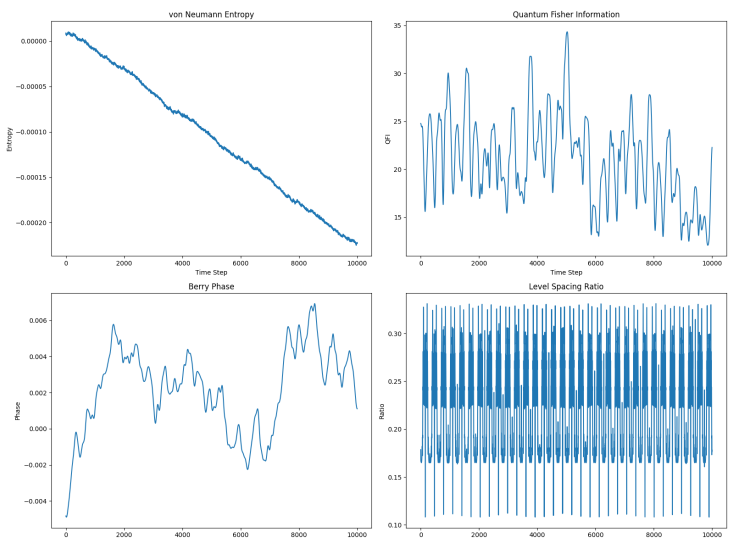

Figure 2: Time evolution of quantum measures