Equation for OQGO

July 29, 2025

Introduction

This document presents the mathematical equations and results for the quantum circuits and analyses implemented in a Qiskit program, referred to as the Omniverse Quantum Gravitational Observatory (OQGO). The program includes quantum circuits for state preparation, measurements, entanglement entropy calculations, and correlations with physical data (LHC and gravitational wave signals). The results are integrated into the equations to reflect the output of the simulation.

1 Omniverse Theory Circuit with Measurement

This circuit prepares a 10-qubit state, applies gates, and measures qubits 6–9.

State Preparation

The initial state is:

$$|0\rangle^{\otimes 10}$$

Apply X gates to qubits 6–9:

$$|0000111100\rangle$$

Apply a Hadamard gate to qubit 0 and CNOT gates (CNOT$(0, 1)$, CNOT$(1, 2)$):

$$|\psi\rangle = \frac{1}{\sqrt{2}} \left(|00000111100\rangle + |11100111100\rangle\right)$$

Target State Probability

The probability of the target state $|1111000000\rangle$ (index 960) is:

$$P(|1111000000\rangle) = |\langle 1111000000|\psi|1111000000|\psi\rangle|^2$$

Result: The reported probability is:

$$P(|1111000000\rangle) = 0.5000$$

Measurement Outcomes

Measure qubits 6–9 into classical bits 0–3. Ideally, qubits 6–9 are in $|1111\rangle$, so:

$$P(1111) \approx 1$$

Unmitigated probabilities (shots $= 10000$):

$$
\begin{aligned}
P_{\text{raw}}(1111) &= \frac{9673}{10000} = 0.9673 \quad (96.7\%) \\
P_{\text{raw}}(1011) &= \frac{106}{10000} = 0.0106 \quad (1.1\%) \\
P_{\text{raw}}(1101) &= \frac{81}{10000} = 0.0081 \quad (0.8\%) \\
P_{\text{raw}}(1110) &= \frac{77}{10000} = 0.0077 \quad (0.8\%) \\
P_{\text{raw}}(0111) &= \frac{55}{10000} = 0.0055 \quad (0.5\%) \\
P_{\text{raw}}(1001) &= \frac{4}{10000} = 0.0004 \quad (0.0\%) \\
P_{\text{raw}}(1100) &= \frac{2}{10000} = 0.0002 \quad (0.0\%) \\
P_{\text{raw}}(0011) &= \frac{1}{10000} = 0.0001 \quad (0.0\%) \\
P_{\text{raw}}(1010) &= \frac{1}{10000} = 0.0001 \quad (0.0\%)
\end{aligned}
$$

Mitigated probabilities (using Mthree):

$$
\begin{aligned}
P_{\text{mitigated}}(1111) &= 1.0816936 \\
P_{\text{mitigated}}(1110) &= -0.024201097 \\
P_{\text{mitigated}}(1011) &= -0.019141676 \\
P_{\text{mitigated}}(1101) &= -0.008984862 \\
P_{\text{mitigated}}(0111) &= -0.031229032 \\
P_{\text{mitigated}}(1001) &= 0.00048916455 \\
P_{\text{mitigated}}(1100) &= 0.00034177073 \\
P_{\text{mitigated}}(1010) &= 0.00043788625 \\
P_{\text{mitigated}}(0011) &= 0.00059428706
\end{aligned}
$$

2 Omniverse Theory Circuit without Measurement

This circuit applies a complex sequence of gates to 10 qubits.

State Preparation

The final state is:

$$|\psi\rangle = U|0\rangle^{\otimes 10}$$

where U includes Hadamard, CNOT, CZ, rotation ($R_x(\pi/3)$, $R_y(\pi/8)$, $R_z(\pi/10)$), Toffoli, and X gates.

Entanglement Entropy

The reduced density matrix for qubits 1, 3, 5, 6 (tracing out 0, 2, 4, 7, 8, 9):

$$\rho = \mathrm{Tr}_{0,2,4,7,8,9}\left(|\psi\rangle\langle\psi|\right)$$

Von Neumann entropy:

$$S(\rho) = -\mathrm{Tr}\left(\rho \log_2 \rho\right)$$

Result:

$$S(\rho) = 3.1856 \text{ bits}$$

3 Bell States Circuit

This circuit creates five Bell pairs.

State Preparation

The state is:

$$|\psi\rangle = \left(\frac{1}{\sqrt{2}}\left(|00\rangle + |11\rangle\right)\right)^{\otimes 5}$$

Reduced density matrix for qubits 1, 3, 5, 7:

$$\rho_{\text{bell}} = \mathrm{Tr}_{0,2,4,6,8,9}\left(|\psi\rangle\langle\psi|\right)$$

Entropy:

$$S(\rho_{\text{bell}}) = 4 \text{ bits}$$

Result:

$$S(\rho_{\text{bell}}) = 4.0000 \text{ bits}$$

4 Expected Measurement Outcome

This circuit prepares and measures a specific state.

State Preparation

The state is:

$$|\psi\rangle = |1111000000\rangle$$

Ideal measurement probability:

$$P(1111000000) = 1$$

Results (with noise, shots = 10000):

$$P_{\text{raw}}(0000001111) = \frac{9586}{10000} = 0.9586 \quad (95.9\%)$$
$$P_{\text{raw}}(0000001110) = \frac{114}{10000} = 0.0114 \quad (1.1\%)$$
$$P_{\text{raw}}(0000001101) = \frac{74}{10000} = 0.0074 \quad (0.7\%)$$
$$P_{\text{raw}}(0000001011) = \frac{58}{10000} = 0.0058 \quad (0.6\%)$$
$$P_{\text{raw}}(0000101111) = \frac{14}{10000} = 0.0014 \quad (0.1\%)$$
$$P_{\text{raw}}(0100001111) = \frac{20}{10000} = 0.0020 \quad (0.2\%)$$
$$P_{\text{raw}}(1000001111) = \frac{14}{10000} = 0.0014 \quad (0.1\%)$$
$$P_{\text{raw}}(0000000111) = \frac{66}{10000} = 0.0066 \quad (0.7\%)$$
$$P_{\text{raw}}(0010001111) = \frac{19}{10000} = 0.0019 \quad (0.2\%)$$
$$P_{\text{raw}}(0000011111) = \frac{18}{10000} = 0.0018 \quad (0.2\%)$$
$$P_{\text{raw}}(0000011011) = \frac{1}{10000} = 0.0001 \quad (0.0\%)$$
$$P_{\text{raw}}(0001001111) = \frac{10}{10000} = 0.0010 \quad (0.1\%)$$
$$P_{\text{raw}}(0000001001) = \frac{2}{10000} = 0.0002 \quad (0.0\%)$$
$$P_{\text{raw}}(0000000110) = \frac{1}{10000} = 0.0001 \quad (0.0\%)$$
$$P_{\text{raw}}(0100001110) = \frac{1}{10000} = 0.0001 \quad (0.0\%)$$
$$P_{\text{raw}}(0000001010) = \frac{1}{10000} = 0.0001 \quad (0.0\%)$$
$$P_{\text{raw}}(0100001011) = \frac{1}{10000} = 0.0001 \quad (0.0\%)$$

5 Correlations

LHC Correlation

Data:

$$x = [0.013, 0.016, 0.019, 0.011, 0.018], \quad y = [0.95, 1.02, 1.18, 0.87, 1.10]$$

Pearson correlation:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Result:

$$r = 0.984, \quad p\text{-value} = 0.0023$$

Gravitational Wave (GW) Correlation

Data:

$$x = [0.013, 0.016, 0.019, 0.011, 1.0816936], \quad y = [0.0094, 0.0101, 0.0119, 0.0086, 0.0112]$$

Result:

$$r = 0.009, \quad p\text{-value} = 0.9888$$