Developing a quantum description of gravity is a major conundrum in physics, compounded with the challenge of verifying models due to the vastly different measurement scales of gravity and quantum mechanics.

GQuEST (Gravity from Quantum Entanglement of Space-Time) is a collaboration seeking to verify the quantum gravity model proposed by Verlinde & Zurek.

From holographic principles, it is predicted that energy fluctuations of vacuum lead to detectable metric fluctuations, which is the pursued measurable [1].

The apparatus is a highly sensitive Michelson-Morley interferometer with both homodyne readout and superconducting nanowire single-photon detection.

A biquadratic filter is a 2nd order iterative filter whose behavior is characterized by five coefficients (b0, b1, b2, a1, a2) and the following difference equations:

\[
y_n = b_0 w_n + b_1 w_{n-1} + b_2 w_{n-2}
\]

\[
w_n = x_n - a_1 w_{n-1} - a_2 w_{n-2}
\]

Electronically, these coefficients are represented as fixed-point numbers:

\[
\begin{array}{cccccc}
2 & 2 & 2 & 1 & 2 & 2
\end{array}
\]

Digital Signal Processing & Fixed-Point

We choose to stress test the FPGA control system by tuning the fixed-point representation of the five coefficients from a biquadratic low-pass filter.

Threshold Bit Resolution

For a critical frequency near 10 Hz, being precise to within 1 dB entails that we need at least 38 bits of resolution on our fixed-point filter.

38 bits will not be enough to sufficiently minimize read and digitization noise.

For future work, we will tune the number of bits further to minimize the effects lower resolution on noise while maintaining precision.

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References


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