# Comparing Classical Boson Sampling and Stabilised Quantum Circuits for Interferometry

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***Abstract*—Interferometers are devices which use light, or more generally superimposing waves, using interference to extract information. We propose a method by which quantum information can be obtained and used as a benchmark for quantum circuits, as well as modelling non-linear interferometers. We simulate these with traditional classical methods, then show quantum circuit variants, finally showing how these circuits can be used as benchmarks for qubit coherence.**

## I. Introduction

## II. Mach-Zehnder Interferometer

The Mach-Zehnder interferometer determines a relative phase shift variation between two collimated beams of light. It also has the property that each light path is only traversed once. It consists of two beam splitters, and a mirror.

In our classically computed photonic model, an MZI is a 2-mode interferometer. We use a matrix representation of the beam splitter [1, i, i, 1]/root(2)

To encode this as a quantum circuit REF HERE, we use Hadamard gates to represent the 50/50 beam splitters, a single qubit as the initial single photon input, and a unitary operation U(phi) to represent some phase shift.

## III. Michelson Interferometer

## IV. Ramsey Interferometer and Benchmarking

Measuring phase decoherence using a Ramsey interferometer quantum circuit.

## V. Beating Ramsey limits with deterministic qubit control

SNR per shot (Rv): Compare phase contrast (vary amplitude) between protocols.

SNR per √time (Rs): Compare sensitivity improvement when including longer stabilized evolution windows.

Breakdown Time (tb): Quantify how long stabilization lasts before vx coherence collapses.

Robustness: Test sensitivity to miscalibrated T1/T2 (simulate with noise models).

This level of quantum information abstraction has applications in quantum sensing, quantum communication,

## VI. Application of stablising operators to Galton Board

Implementation Steps

Start with the standard Galton circuit:

Initialize ball qubit in center peg.

Use CSWAP-CNOT-CSWAP controlled by the control qubit.

Insert stabilization between layers:

After each layer, extract/estimate Bloch components of control qubit (or infer from expected evolution).

Compute hy(t)∝γ2·vx/vzhy(t)∝γ2·vx/vz - use eq in paper 2

Apply Trotterized slices: Ustab≈∏ke−iδt [Δσz/2+hy(tk)σy/2] Ustab≈k∏e−iδt[Δσz/2+hy(tk)σy/2]

which in gates is CLOSE ENOUGH TO small Rz(Δδt)Rz (Δδt) + Ry(hyδt)Ry(hyδt).

Repeat for each Galton layer:

CSWAP scattering

Trotterized stabilization pulses

Move to next layer.

demonstrate with fewer shots