Asmeeta Prakash Sayaji Research Portfolio

Noise, Verification, and Quantum Advantage

Asmeeta Prakash Sayaji

Independent Researcher — Quantum Information Theory

Email: asmitasayaji21@gmail.com
GitHub: github.com/asmeeta-quantum/ETH_Qiskit_Workspace
Location: Ahmedabad, India
Date: 28 December 2025

Abstract

This portfolio synthesizes my independent research in quantum information theory, focusing on how realistic noise constrains quantum computation and verification. My work connects smooth entropy methods and quantum channel divergences with simulation tools informed by ISRO hardware experience, targeting noise-adapted verification and quantum advantage boundaries.

1 Research Alignment with ETH Zürich

My research aligns with the Quantum Information Group at ETH Zürich, especially the work of Prof. Dominik Hangleiter and Prof. Renato Renner on verification complexity, quantum advantage certification, noise-adapted resource theories, and practical simulation boundaries.

2 Core Research Projects

2.1 Noise-Induced Classical Simulability Transitions

Objective: How T_1, T_2, and leakage influence classical simulability.
Methods: Lindbladian simulations using QuTiP; channel divergence measures.
Key Insight: Shallow circuits become efficiently simulable above a noise threshold.

2.2 Hardware-Informed Noise Modeling

Objective: Translate stability metrics to quantum noise parameters.
Methods: ML-based drift prediction; phase noise $\rightarrow$ dephasing models.
Key Insight: Phase noise is the dominant cause of verification failure.

2.3 Verification Complexity Under Noise

Objective: Study verification overhead under structured noise.
Methods: Sample-complexity scaling; entropy production.
Key Insight: Noise introduces phase transitions in verification cost.

2.4 Leakage-Aware Quantum Control

Objective: Suppress non-computational leakage.
Methods: DRAG pulses; Lindblad-Sim toolkit.
Achievement: >90% leakage suppression.

3 Technical Implementation

3.1 Software Tools

- **Noise-Bench QC:** Verification benchmarking under physical noise
- **Lindblad-Sim:** Leakage-aware and non-Markovian simulation toolkit
- **ZNE Toolkit:** $\sim 20\%$ fidelity boost via zero-noise extrapolation
- **DRAG Pulse Optimizer:** $>90\%$ leakage suppression

3.2 Mathematical Methods

- Smooth entropies for information leakage characterization
- Quantum channel divergences for recoverability
- Lindbladian dynamics for composite noise
- Resource-theoretic modeling of noisy advantage

4 Research Contributions and Next Steps

4.1 Key Contributions

1. Analytical bounds linking physical noise to verification scalability
2. Open-source simulation frameworks for realistic quantum noise
3. Hardware-informed noise modeling pipeline from ISRO experience
4. Identification of noise-triggered simulability transitions

4.2 PhD Research Plans at ETH Zürich

Planned work under Prof. Hangleiter:

- Noise-adapted verification protocols
- Resource thresholds for genuine quantum advantage
- Calibration-efficient verification and certification

4.3 Why ETH Zürich

ETH offers world-leading expertise in noise-aware verification grounded in both theory and experiment.

Code Availability

All simulation tools and analysis scripts: github.com/asmeeta-quantum/ETH_Qiskit_Workspace