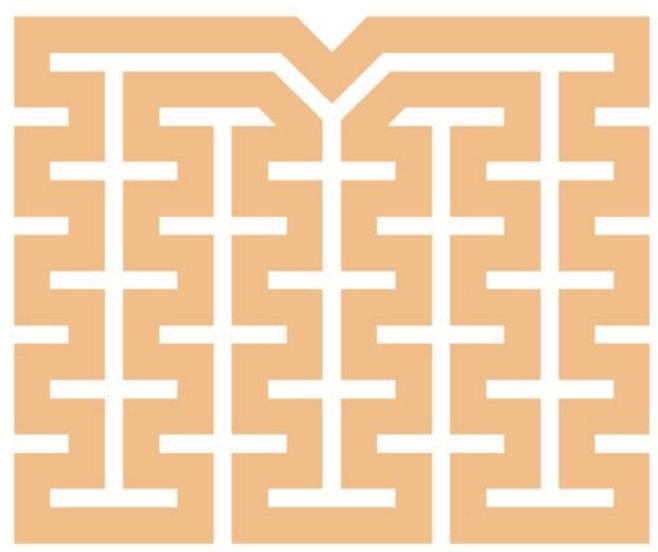


Predictive Noise-Adaptive Digital Twin for Ultra-Fast Solid-State Quantum Control

Unlocking $\mathcal{O}(N)$ Scalability and 25.4 ps Qubit Purification via Monitored Free Fermions

Awatif Allahyani – Mind Success



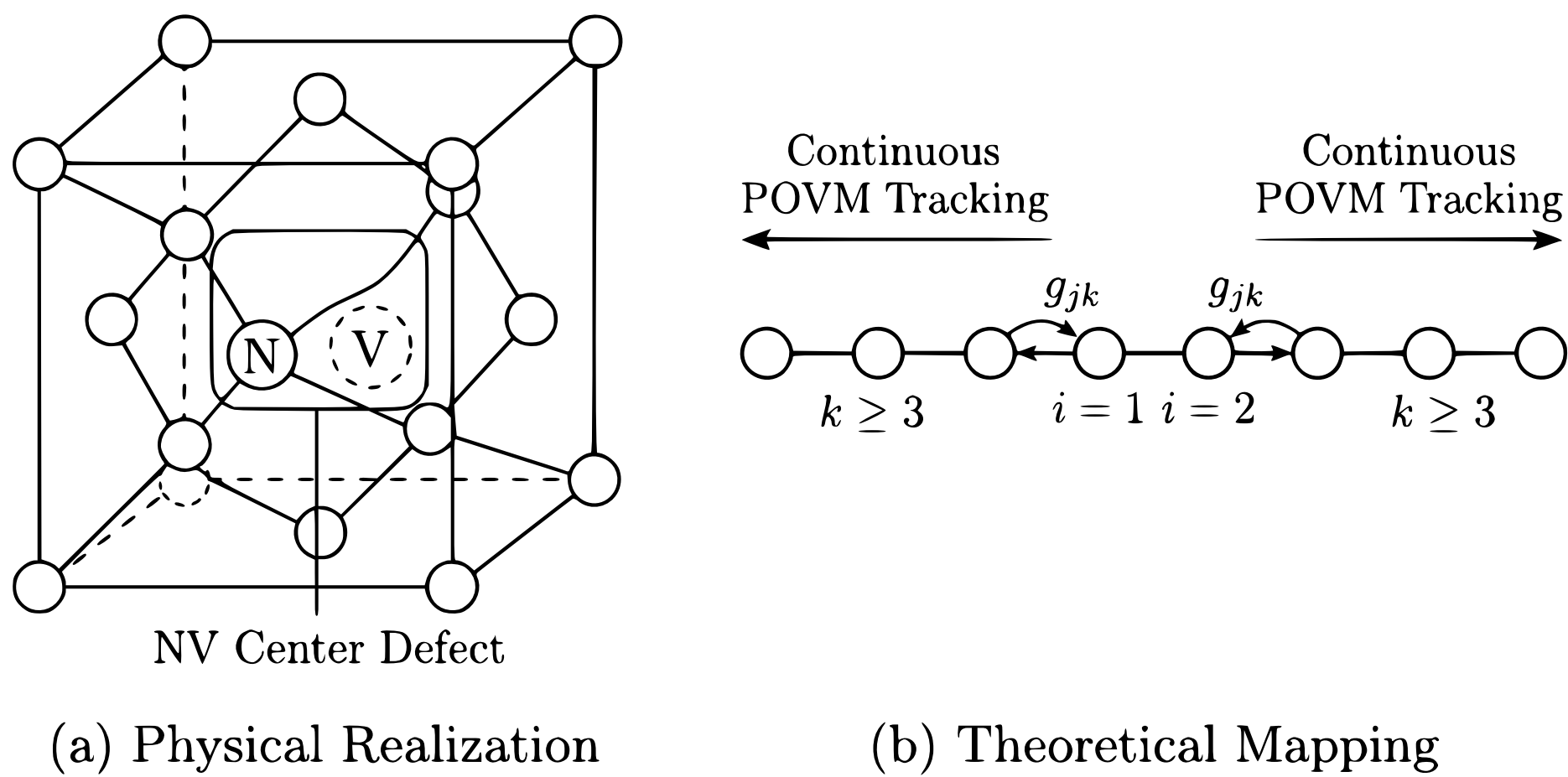
MIND SUCCESS

1. The Industrial Bottleneck

- **Environmental Decoherence:** Solid-state quantum platforms suffer severe non-Markovian noise from surrounding spin environments.
- **The Exponential Wall:** Standard simulation tools encounter an exponential complexity barrier $\mathcal{O}(2^N)$, making large-scale environmental modeling computationally impossible.
- **Prohibitive R&D Costs:** Physical hardware prototyping and wet-lab drug discovery iterations cost millions without predictive digital simulation.

2. The Quantum Digital Twin Engine

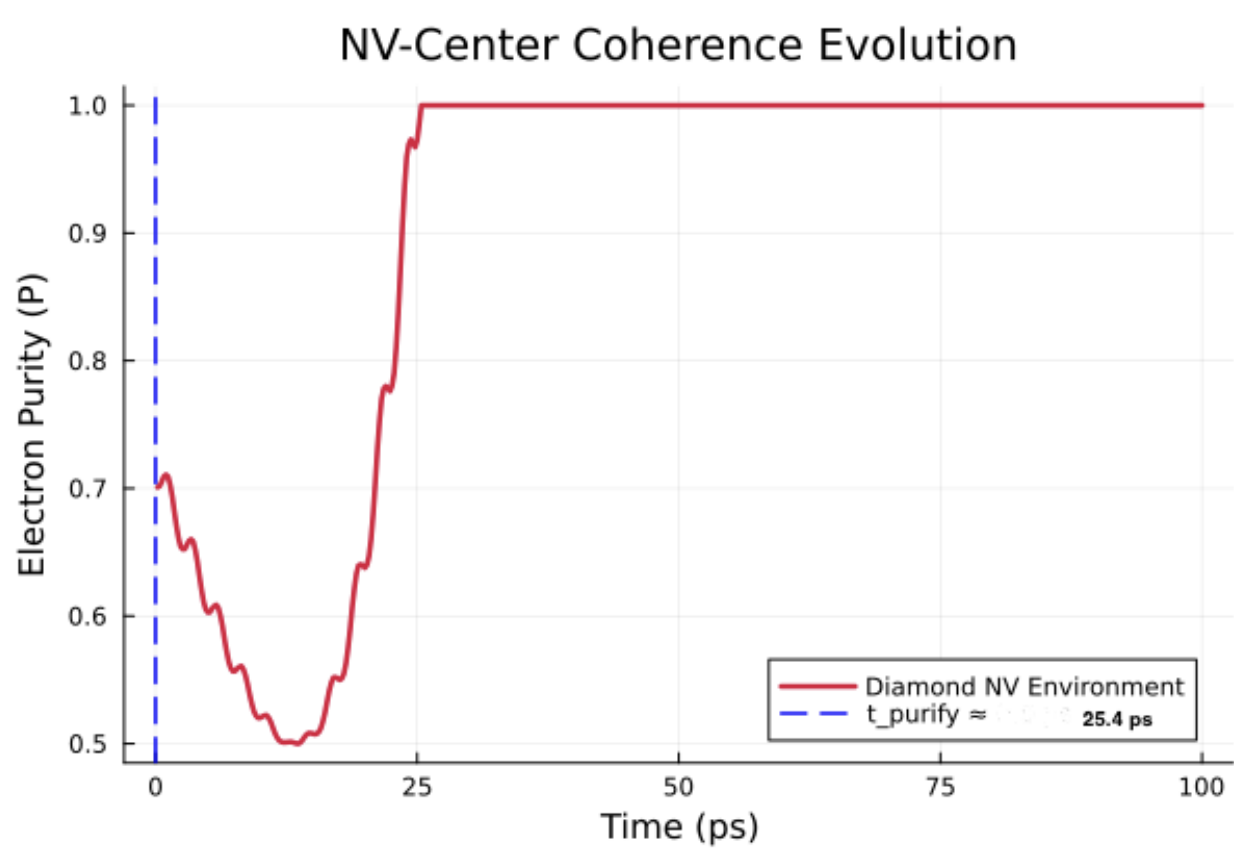
- **Linear Complexity Scaling:** Leverages free-fermion dynamics to compress memory requirements to $\mathcal{O}(N)$ and runtime to $\mathcal{O}(N^3)$, bypassing the exponential bottleneck.
- **Continuous Entropy Extraction:** Implements continuous weak measurement protocols (POVM) to continuously extract noise without destroying quantum state superposition.
- **Predictive Analytics:** Provides real-time tracking of coherence loss and deterministic recovery across large-scale open quantum systems.



Open quantum system architecture and continuous POVM tracking model.

3. Performance Proof & Key Validation

- **Ultra-Fast 25.4 ps Purification:** Achieves full state purification ($P = 1.0$) within **25.4 picoseconds** under diamond NV-center physical parameters.
- **Thermodynamic Scalability:** Successfully models up to $N = 1000$ environmental noise modes with stable convergence on standard hardware.



Deterministic electron purity evolution reaching $P = 1.0$ at 25.4 ps.

4. Industry Value & Sector-Specific Benefits

- **Quantum Hardware Manufacturers:** Pre-fabrication digital testing of quantum chips, optimizing gate fidelity and reducing fabrication iterations.
- **Pharma & Materials Science:** Accelerated in-silico molecular screening and fermionic interaction modeling, bypassing classical memory limits.
- **Quantum Sensing & Metrology:** Extends qubit operational coherence time in noisy environments, maximizing sensor accuracy.
- **Enterprise Quantum Readiness:** Fully integrated computational workflows with cloud deployment integration (e.g., Quantinuum cloud) for execution and mitigation.