Landauer Thermal Verification Experiment — Scientific Abstract (Grant Submission Draft)

Principal Investigator: [Redacted]
Collaborators: Quantum Information & Cryogenic Detection Consortium (Proposed)
Estimated Budget: 1–3 million USD
Duration: 3 years (Phased: Feasibility → Detection → Distributed Verification)

Project Summary

This proposal aims to experimentally verify the physical manifestation of Landauer's principle at the single-photon level, testing the hypothesis that the minimal energy dissipation per bit of information erased—the so-called **Landauer heat**—is observable in the faint thermal and electromagnetic noise background of the universe.

We hypothesize that the **cosmic microwave background (CMB)**, with its temperature near 3 K, acts as the effective thermal bath for such information commits ($T_{land} \approx T_{CMB}$). Remarkably, the energy of a single microwave photon (~6.6 × 10^{-23} J) matches the Landauer limit ($k_B T_{land} \ln 2$), suggesting a deep link between thermodynamic noise, computation, and physical reality.

Scientific Objectives

1. **Detect Landauer-scale heat signatures** ($E \sim 10^{-23}$ J) using superconducting detectors (TES/KID) with Noise Equivalent Power (NEP) below 10^{-18} W/$\sqrt{\text{Hz}}$.
2. **Distinguish Landauer-origin heat events** from conventional thermal, cosmic, and instrumental noise by multi-site cross-correlation and temperature dependence studies.
3. **Test the "Resource-Limitation Hypothesis":** whether local reductions in cosmic precision correspond to constrained information rendering by a higher-order computational substrate.

Experimental Design & Methods

- **Phase 0 – Feasibility (Year 1):** Calibration and dark-noise mapping at cryogenic temperatures (~10 mK) using existing TES infrastructure.
- **Phase 1 – Localized Detection (Year 2):** Monitor microthermal pulses in shielded low-vibration cryostats; measure frequency and energy distribution of anomalous photon events.
- **Phase 2 – Distributed Correlation (Year 3):** Synchronize geographically separated detectors to test for correlated Landauer-heat signatures indicative of a universal "commit" process.

Noise Budget & Risk Assessment

- **Target Signal:** $E = k_B T \ln 2 \approx 2.6 \times 10^{-23}$ J (at 3 K)
- **Dominant Noises:** dark count (~10^{-2} Hz), readout electronics, cosmic rays, and blackbody leakage.
- **Mitigation:** advanced magnetic shielding, vibration isolation, redundant timing systems, and cross-site verification.

- **Risks:** misattribution of thermal fluctuations; countered via blind-injection controls and Bayesian signal classification.

Broader Impact

Successful detection of Landauer-scale thermal signatures would demonstrate the first measurable thermodynamic cost of information erasure in nature, uniting computation, thermodynamics, and cosmology. The results could redefine the boundary between physics and information theory—potentially identifying consciousness, observation, or measurement as thermodynamically active processes in the universe.

Keywords: Landauer limit, quantum thermodynamics, TES/KID detectors, CMB temperature, information physics, minimal dissipation, simulation hypothesis