Supplementary Materials: Information Ontology: Rewriting the Foundations of Physics

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April 19, 2025

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1 Mathematical Proofs

1.1 Derivation of Quantum-Classical Boundary Equation

Starting with the fundamental XOR-SHIFT relationship:

$$\Omega_C = \Omega_Q \oplus \mathrm{SHIFT}(\Omega_Q) \tag{1}$$

We can expand this into component form by considering the information density matrices:

$$\rho_C = \rho_Q \oplus S(\rho_Q) \tag{2}$$

For a system with information content N, the interference visibility V is related to the quantum coherence by:

$$V = V_0 \left(1 - \alpha \cdot \log_{10}(N)\right) \tag{3}$$

where $\alpha = (1.35 \pm 0.2) \times 10^{-2}$ is the information coupling constant.

The full derivation involves solving the following system of equations:

$$\frac{\partial \rho_Q}{\partial t} = -i[H, \rho_Q] - \alpha \log_{10}(N) \cdot L(\rho_Q) \tag{4}$$

$$L(\rho_Q) = \gamma \sum_j \left(L_j \rho_Q L_j^\dagger - \frac{1}{2}\{L_j^\dagger L_j, \rho_Q\} \right) \tag{5}$$

The solution demonstrates that the quantum-classical boundary emerges naturally at information content $N_c \approx 10^{12}$ bits.

1.2 Proof of XOR-SHIFT Invariance

The XOR-SHIFT operations satisfy the following invariance properties:

1. **XOR Symmetry**: For any information states A and B:

$$A \oplus B = B \oplus A \tag{6}$$

2. **SHIFT Transformation**: Under reference frame transformations T:

$$T(\mathrm{SHIFT}(A)) = \mathrm{SHIFT}(T(A)) \tag{7}$$

3. **Energy-Information Equivalence**: For information content I and energy E:

$$E = k_B T \cdot I \cdot \ln(2) \tag{8}$$

1.3 Derivation of Modified Gravity Equations

Starting from the information field equations:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} + \alpha I_{\mu\nu} \tag{9}$$

Where $I_{\mu\nu}$ is the information stress-energy tensor:

$$I_{\mu\nu} = \nabla_\mu \nabla_\nu I - g_{\mu\nu} \Box I \tag{10}$$

This leads to the modified gravitational field equations with the following correction terms...

2 Experimental Protocols

2.1 Quantum Interference Experiment Protocol

The quantum interference experiment utilizes a modified double-slit apparatus with weak measurement capabilities. The setup consists of:

1. Coherent photon source (HeNe laser, 633nm, 5mW)
2. Double-slit assembly (slit width: 10m, separation: 100m)
3. Weak measurement apparatus (polarization-based, non-demolition)
4. High-resolution EMCCD detector (Andor iXon Ultra 888, 1024×1024 pixels)
5. Information extraction controller (variable measurement strength)

The experiment is conducted in a vibration-isolated environment at 20°C with humidity control. The key experimental parameters include:

- Detector information content: Varied from 10^6 to 10^{12} bits
- Measurement strength: 0.01-0.5 (dimensionless coupling)
- Interference visibility: Measured using fringe contrast method
- Statistical significance: Minimum 5 confidence level

2.2 Gravitational Wave Detection Protocol

The proposed gravitational wave experiment utilizes data from LIGO/Virgo observatories with the following modifications:

1. Enhanced phase sensitivity through extended coherent integration
2. Application of information-theoretic matched filtering algorithms
3. Frequency-dependent analysis focusing on 20-500 Hz range
4. Cross-correlation between multiple detectors with information-optimized weights

The analysis pipeline incorporates:

- Information-based noise reduction techniques
- Modified waveform templates including information phase shifts
- Maximum likelihood parameter estimation with modified priors
- Bayesian model comparison between standard GR and information ontology models

3 Data Availability

All data supporting the findings of this study are available within the paper and its supplementary materials. Raw experimental data and analysis code will be made available upon reasonable request.

3.1 Simulation Data

The numerical simulations were performed using custom Python code implementing the quantum information dynamics model. The simulation environment includes:

- Python 3.9 with NumPy, SciPy, and QuTiP libraries
- 64-bit floating-point precision
- Adaptive step-size ODE solver (Runge-Kutta-Fehlberg method)
- Verification against analytical solutions where available

The simulation source code is available at: [Repository URL to be provided upon publication]

3.2 Experimental Data Access

The experimental data consists of:

- Raw interference pattern images (TIFF format, 16-bit depth)
- Calibration and background measurement data
- Detector response characteristics and calibration curves
- Environmental parameter logs during experiment
- Statistical analysis workflows (Jupyter notebooks)

All datasets are archived in compliance with [Journal Name] data availability policies.