Supplementary Materials: Experimental Protocols

Information Ontology: Rewriting the Foundations of Physics

Authors: Auric | **Date:** April 20, 2025 | **Version:** 1.0

1. Quantum Interference Experiment with Weak Measurement

1.1 Objectives

- Detect the predicted modification to quantum interference patterns
- Measure the information coupling constant
- Provide empirical evidence for information-based quantum mechanics

1.2 Equipment Requirements

- **Electron Source**: Cold field emission gun with energy stabilization (ΔE < 0.1 eV)
- **Double-Slit Apparatus**:
  - Fabricated using focused ion beam on gold foil
  - Slit width: 50 nm
  - Slit separation: 100 nm
  - Thickness: 20 nm
- **Weak Measurement Device**:
  - Weak magnetic field gradient: 10 T/m
  - Field region length: 5 cm
  - Spin-selective detection capability
- **Detection System**:
  - Microchannel plate with phosphor screen
  - CMOS camera with 5 nm effective spatial resolution
  - Single-electron detection capability
- **Vacuum System**:
  - Ultra-high vacuum: < 10 Torr
  - Vibration isolation: < 1 nm amplitude

1.3 Experimental Setup

```
[Source] --> [Collimators] --> [Double-Slit] --> [Weak Measurement Region] --> [Detector]
                                     |                        |
                                [Position                [Magnetic
                                 Monitor]               Field Control]
```

1.4 Experimental Protocol

1. **Calibration Phase**:
   - Measure background noise and detector sensitivity
   - Characterize electron beam properties (coherence length, energy spread)
   - Establish standard double-slit interference pattern without weak measurement
   - Verify detection resolution meets requirements
2. **Data Collection Phase**:
   - Configure weak measurement field strength (5 different strengths)
   - For each configuration, collect 10 electron detection events
   - Alternate between measurement ON and OFF states to isolate effects
   - Record spatial distribution of all electron detection events
   - Maintain stable temperature (±0.1°C) and electromagnetic environment
3. **Control Experiments**:
   - Single-slit configuration to verify no intrinsic modification
   - Vary electron energy (5 values between 1-10 keV)
   - Vary slit separation (3 different values)
   - Block one slit to confirm interference elimination

1.5 Data Analysis

1. **Pattern Extraction**:
   - Convert raw detector data to spatial probability distributions
   - Apply noise reduction algorithms (wavelet denoising)
   - Normalize distributions for comparison
2. **Model Fitting**:
   - Fit standard quantum mechanics model: $P(x) = |\ (x)|^2$
   - Fit information ontology model: $P(x) = |\ (x)|^2 + \ \cdot d^2|\ (x)|^2/dx^2$
   - Extract best-fit   parameter and confidence intervals
   - Perform $\ ^2$ goodness-of-fit tests for both models
3. **Statistical Analysis**:
   - Bootstrap resampling (1000 iterations)
   - Calculate p-values for model comparison
   - Determine statistical significance of any observed deviations

1.6 Expected Results

The information ontology model predicts: - Slight shifts in interference maxima positions - Modified fringe contrast ratio - Dependence of modification on electron wavelength - Predicted   value: $(1.35 \pm 0.2) \times 10^{1}$ m^2

1.7 Error Analysis

- Accounting for position uncertainty: 2 nm

- Momentum uncertainty from weak measurement: ħ/10d
- Systematic errors from field inhomogeneities
- Statistical errors from finite sampling
- Quantum back-action estimation

2. Gravitational Wave Phase Shift Detection

2.1 Objectives

- Detect the predicted phase shift in gravitational waves
- Distinguish between general relativity and information ontology predictions
- Measure frequency-dependent modification

2.2 Equipment and Facilities

- **Gravitational Wave Observatories**:
  - LIGO/Virgo/KAGRA network (current generation)
  - Cosmic Explorer / Einstein Telescope (next generation)
  - LISA (space-based, for low-frequency observations)
- **Computational Resources**:
  - High-performance computing cluster: >100,000 CPU-hours
  - GPU acceleration for waveform generation
  - 500+ TB storage for data analysis

2.3 Observation Strategy

1. **Target Sources**:
   - Binary black hole mergers (primary targets)
   - Neutron star mergers (secondary targets)
   - Selection criteria:
     - Signal-to-noise ratio > 20
     - Total system mass: 50-100 M
     - Distance: < 1 Gpc
2. **Data Collection**:
   - Continuous monitoring from detector network
   - Trigger-based recording of candidate events
   - Minimum observation duration: 3 years

2.4 Analysis Protocol

1. **Waveform Template Generation**:
   - Standard GR templates (numerical relativity)
   - Information ontology templates incorporating phase modification
   - Template bank spanning parameter space:
     - Mass ratio: 1:1 to 1:10
     - Total mass: 10-200 M

    - Spins: 0-0.99
    - Phase shift parameter: 0-$10^{\ 2}$ rad · Hz$^{\ 1}$
2. **Match Filtering Analysis**:
    - Apply both template sets to detector data
    - Calculate Bayes factors between models
    - Parameter estimation via nested sampling
    - Combined multi-detector analysis
3. **Frequency-Dependent Testing**:
    - Split analysis into frequency bands
    - Test prediction that modification scales with frequency
    - Verify logarithmic dependence on system parameters

2.5 Verification Strategy

- Cross-validation between different detector networks
- Hardware injection tests to verify detection capability
- Null tests on control data segments
- Blind analysis protocol to prevent bias

2.6 Expected Results

- Phase shift parameter measurable to precision of $10^{\ 21}$ radians with next-gen detectors
- Frequency-dependent signature distinctive from other modified gravity theories
- Expected 3 detection possible with ~50 well-measured events

3. Black Hole Radiation Spectrum Observation

3.1 Objectives

- Detect modified Hawking radiation spectrum
- Measure deviation from standard black hole thermodynamics
- Test information conservation at black hole horizons

3.2 Observational Requirements

- **Space Telescopes**:
    - James Webb Space Telescope (near/mid-infrared)
    - Future IR/X-ray missions
- **Target Objects**:
    - Primordial black holes (if they exist, $M < 10^{1}$ kg)
    - Evaporating micro black holes

3.3 Secondary Approaches (Laboratory)

1. **Analog Black Hole Systems**:

- Bose-Einstein condensates with sonic horizons
- Optical systems with effective horizons
- Requirements:
  - Temperature: < 100 nK
  - Flow control precision: < 1 m/s
  - Detection sensitivity: single phonon/photon

2. **Experimental Setup for Optical Analogs**:

```
[Laser Source] --> [Nonlinear Medium] --> [Flow Control] --> [Horizon Region] --> [Spec
                             |                    |
                   [Temperature Control]   [Flow Velocity Monitor]
```

3.4 Measurement Protocol

1. **Observational Strategy**:
   - Deep integration of candidate sources (>100 hours per target)
   - Spectral analysis in 0.1-10 m range
   - Background subtraction using nearby fields
   - Multi-wavelength cross-correlation
2. **Analog System Measurements**:
   - Generate effective horizon in controlled environment
   - Measure radiation spectrum with spectral resolution < 0.1 nm
   - Vary system parameters to test scaling relations
   - Compare with theoretical predictions

3.5 Signature Identification

- **Spectral Features**:
  - Modified thermal spectrum with correction factor $(1 + \ \hbar/Mc^2)$
  - Enhancement at high frequencies
  - Characteristic spectral slope modification
- **Correlation Tests**:
  - Temporal correlations between emitted quanta
  - Entanglement measurements between Hawking pairs
  - Phase relationships in radiation field

3.6 Challenges and Mitigations

- **Challenge**: Extremely low signal strength
  - **Mitigation**: Long integration times, multiple targets, statistical analysis
- **Challenge**: Background radiation sources
  - **Mitigation**: Multi-wavelength analysis, spatial filtering, temporal variations
- **Challenge**: Theoretical uncertainties
  - **Mitigation**: Model-independent feature extraction, parameter marginalization

3.7 Expected Results

- Detectable deviation from standard Hawking spectrum for primordial black holes
- In analog systems, spectral modification observable at 5 significance
- Verification of information preservation mechanisms

4. Information Coupling Constant Measurement

4.1 Objectives

- Precisely measure the information coupling constant
- Verify consistency across different physical systems
- Determine if is truly constant or scale-dependent

4.2 Complementary Experimental Approaches

1. **Quantum Circuit Experiments**:
    - Superconducting qubits in circuit QED architecture
    - Ion trap quantum processors
    - Measurement of decoherence modification due to information coupling
2. **Precision Interferometry**:
    - Matter-wave interferometry with large molecules
    - Path length differences of 10 or more wavelengths
    - Detection of phase shifts due to information coupling
3. **Casimir Force Modifications**:
    - Parallel plate configuration with separation 10-100 nm
    - Precision force measurement at 10^{1} N sensitivity
    - Detection of information-induced force corrections

4.3 Universal Analysis Framework

- Common dimensionless parameters across all experiments
- Bayesian parameter estimation with hierarchical modeling
- Global fit across all datasets
- Cross-validation between different physical systems

4.4 Consistency Tests

- Verify scaling relations predicted by the theory
- Test for any environmental dependencies
- Check theoretical consistency between quantum and gravitational measurements
- Look for potential variations with energy scale

4.5 Expected Outcome

- Determination of to precision of 1% or better
- Verification of theoretical prediction: 1.35×10^{1} m^2
- Constraints on any potential running of the coupling constant
- Establishment of as a fundamental physical constant

5. Data Management and Availability

5.1 Open Science Framework

- All experimental data will be made publicly available
- Raw and processed datasets accessible via digital repository
- Analysis software published with open source licenses
- Comprehensive documentation of all experimental procedures

5.2 Data Formats

- Raw data: HDF5 format with complete metadata
- Processed results: Standard formats (fits, csv, etc.)
- Analysis scripts: Python/Julia notebooks with reproducible environments
- Statistical methods: Documented in accordance with best practices

5.3 Collaboration Structure

- International consortium of experimental groups
- Coordinated approach to ensure compatible methodologies
- Regular cross-validation exercises
- Blind analysis protocols where applicable

6. Timeline and Milestones

6.1 Phase 1: Initial Validation (1-2 years)

- Quantum interference experiments with weak measurement
- Development of analog black hole systems
- Preliminary gravitational wave data analysis

6.2 Phase 2: Precision Measurements (2-4 years)

- High-precision determination
- Advanced gravitational wave analysis
- Multiple complementary experimental approaches

6.3 Phase 3: Comprehensive Testing (4-6 years)

- Synthesis of all experimental results
- Tests of prediction universality

- Constraints on theory modifications
- Development of advanced applications

6.4 Key Milestones

- First measurement of : 18 months
- Gravitational wave signature detection: 3 years
- Black hole radiation modification constraint: 4 years
- Global consistency verification: 5 years

This experimental program will provide comprehensive testing of the information ontology framework, with multiple independent lines of evidence that can validate or falsify its key predictions. The multi-faceted approach ensures robustness against systematic errors in any single experimental modality.