Predictions for Near-Future Experiments in MNT

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Abstract

This document outlines the near-future experimental predictions of the Refined Unified Matrix Node Theory (MNT), focusing on gravitational wave detections by LISA and the Einstein Telescope, as well as dark matter searches by LUX-ZEPLIN and XENONnT. By providing specific, falsifiable forecasts, MNT aims to engage the community and guide future observational efforts to confirm or challenge its deviations from General Relativity and standard WIMP-based dark matter models.

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1 Gravitational Wave Predictions

1.1 Specific Events Detectable by LISA or Einstein Telescope

MNT predicts measurable phase shifts in gravitational wave signals due to quantum effects at small scales. These effects manifest as deviations from General Relativity (GR), particularly in the ringdown phase after a black hole merger and in the high-frequency tail of the waveform.

LISA: LISA operates at low frequencies ($\sim 10^{-4}$ Hz to 10^{-1} Hz), making it ideal for observing supermassive black hole mergers. MNT predicts a phase shift on the order of 10^{-2} radians at frequencies above 10^{-3} Hz. Supermassive black hole binaries in the mass range $10^5 - 10^6 M_\odot$ could exhibit these detectable shifts.

Einstein Telescope (ET): ET covers higher frequencies (from 10 Hz to 10^3 Hz), focusing on stellar-mass binary mergers and neutron star mergers. While the predicted phase shifts are smaller in this band, ET's high sensitivity can still detect them in the ringdown phase. A binary black hole merger with masses around $10 - 50M_\odot$ (similar to GW150914) could reveal a measurable phase shift in the high-frequency tail of the waveform.

1.2 Measurable Phase Shifts

The phase shift between MNT and GR can be approximated as:

$$\Delta\phi(f) = \epsilon \cdot f^{-\beta},$$

where:

- $\epsilon \sim 10^{-4} - 10^{-2}$ is the quantum correction parameter.
- f is the gravitational wave frequency.
- $\beta \approx 2/3$ governs the scaling of the correction at high frequencies.

Both LISA and ET will be capable of detecting such phase shifts during the merger and ringdown phases of black hole coalescences.

2 Dark Matter Predictions

2.1 Forecasting Signals in Dark Matter Detectors

MNT predicts deviations from standard WIMP models. Quantum node interactions at the Planck scale modify interaction rates and cross-sections, potentially producing detectable anomalies in dark matter searches.

XENONnT and LUX-ZEPLIN: These experiments target WIMP-like dark matter candidates in the 10 GeV to 10 TeV mass range. MNT's modifications to the dark matter-nucleus scattering cross-section can be expressed as:

$$\sigma_{dm}(E) = \rho_{dm} G^2 m_{WIMP}^2 f(E)(1 + \delta),$$

where $\delta \sim 0.1 - 1$ represents the quantum correction factor. Unlike simple power-law dependencies ($\sigma \sim 1/m_{WIMP}^2$), MNT's quantum corrections introduce a different scaling behavior.

With improved sensitivity (1 ton-year exposure), XENONnT and LUX-ZEPLIN can probe deeper into parameter space. MNT's predicted signals could appear as subtle excesses in the low-energy nuclear recoil spectrum, especially for WIMP masses between 10 GeV and 1000 GeV.

3 Summary of Near-Future Predictions and Testability

Gravitational Wave Experiments:

- LISA: Measurable phase shifts in the high-frequency tail for supermassive black hole mergers ($10^5 - 10^6 M_\odot$).

- Einstein Telescope: Detectable phase shifts in binary black hole mergers $(10 - 50M_{\odot})$ during the ringdown phase.

Dark Matter Detectors:

- XENONnT and LUX-ZEPLIN: Test dark matter scattering cross-sections in the 10 GeV to 10 TeV range. MNT predicts deviations from standard WIMP models, potentially observable in the form of anomalous signals at certain cross-section vs. mass values.

4 Conclusion

By making concrete, falsifiable predictions for near-future experiments such as LISA, the Einstein Telescope, LUX-ZEPLIN, and XENONnT, MNT provides a clear pathway for experimental verification. Detectable phase shifts in gravitational waves and modified dark matter cross-sections offer tangible signatures that either confirm or refute the theory's quantum node-based corrections to standard physics. These predictions not only enhance MNT's empirical relevance but also guide the design of future observational campaigns, fostering a productive dialogue between theory and experiment.