Technical Limitations Encountered in the UAT/UCP Validation Programme: LIGO Data Handling, Infrastructure Constraints, and Boltzmann Code Implementation

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Abstract

This technical note documents three significant obstacles encountered during the observational validation of the Unified Applicable Time (UAT) and Unified Causal Principle (UCP) frameworks. First, repeated instances of data corruption during the local download of LIGO strain files were identified, leading to inconsistent results across different computing environments. Second, the LIGO interferometer design, while optimised for standard gravitational-wave astronomy, is not ideally suited for detecting the subtle phase-coherence signatures predicted by UAT/UCP. Third, the UAT/UCP frameworks were conceived as independent descriptive metrics of reality rather than as extensions of the ΛCDM model, making their implementation in standard Boltzmann solvers (CLASS, CAMB) impossible without fundamental modifications to the source code. This note serves as a transparent record of these technical challenges and outlines the necessary conditions for future validation efforts.

1 Introduction

The Unified Applicable Time (UAT) [1] and Unified Causal Principle (UCP) [2] frameworks propose a radical reinterpretation of cosmic dynamics, in which the flow of time is regulated by a fundamental causal coherence constant and the accelerated expansion of the universe emerges from a kinematic viscosity between Dark Matter and the temporal coordinate. Throughout the development of these frameworks, numerous observational tests have been conducted with encouraging results [3, 4]. However, three recurring technical obstacles have been identified that currently limit the precision and reproducibility of the validation programme. This note documents these obstacles in the interest of transparency and to guide future research efforts.

2 Data Corruption During Local LIGO File Downloads

A persistent and non-trivial problem was encountered when downloading LIGO strain data files from the Gravitational Wave Open Science Center (GWOSC) to local computing environments. After repeated analyses, it was determined that the downloaded HDF5 files were being corrupted during the transfer process. This corruption manifested in subtle ways: the numerical values of the strain time series were altered at the level of the least significant digits, or the file structure was partially damaged, leading to segmentation faults or silent errors during processing.

The consequences of this corruption were significant. Researchers who executed the same UAT/UPC analysis scripts on their own systems reported results that, while qualitatively similar, were not numerically identical to those obtained in the original environment. This lack of exact reproducibility undermined confidence in the quantitative predictions of the framework and highlighted the sensitivity of phase-coherence analyses to even minuscule variations in the input data.

The root cause was traced to the combination of large file sizes (typically several hundred megabytes for a 4096-second segment at 16384 Hz), network instability during long downloads, and the lack of integrated checksum verification in the standard download workflow. The problem was mitigated by switching to direct in-memory data access via the GWOSC API (using `TimeSeries.fetch_open_data` from the `gwpy` library), which bypasses the local file system and ensures data integrity. All subsequent analyses adopted this approach, and the corruption issue was resolved.

3 Inadequacy of the LIGO Design for UAT/UCP Metrics

The LIGO interferometers are extraordinary instruments designed to detect the tiny space-time distortions produced by the merger of compact binary objects. Their sensitivity is optimised for transient gravitational-wave signals with specific time-frequency characteristics, and their data analysis pipelines are calibrated under the assumption of standard general relativity.

The UAT/UCP frameworks, however, predict extremely subtle signatures: persistent phase coherence at specific frequencies (e.g., 187.37 Hz and 230.17 Hz), phase quantisation in multiples of 43.515°, and a stochastic "quantum jitter" that acts as a background phase noise. These signatures are fundamentally different from the chirp-like transients that LIGO was designed to detect. As a result:

- The standard LIGO noise subtraction pipelines may inadvertently remove or attenuate the very signals that UAT/UCP predicts, as they are designed to eliminate stationary or quasi-stationary spectral lines.
- The calibration of the strain data relies on models of the detector response that assume standard physics. Any deviation from this physics in the UAT/UCP framework could be partially absorbed by the calibration process itself.
- The UAT/UCP predictions involve phase relationships that require simultaneous analysis of both Hanford and Livingston detectors with precise time synchronisation.

Small timing errors or instrumental phase shifts can mimic or mask the predicted signatures.

It is therefore concluded that while LIGO data provide a valuable testbed for exploratory analysis, the current generation of interferometers is not optimally configured for a definitive validation or refutation of the UAT/UCP frameworks. A dedicated experiment, designed from first principles to measure the specific phase-geometric predictions of the theory, would be required for a conclusive test.

4 Impossibility of Implementing UAT/UCP in Boltzmann Codes Without Source Modification

The UAT and UCP frameworks were conceived as independent descriptive and analytical metrics of reality. They do not constitute an extension or modification of the ΛCDM model; rather, they offer a phenomenologically distinct alternative. This foundational difference has profound implications for their implementation in standard cosmological software.

Modern Boltzmann solvers such as CLASS and CAMB are designed around the assumption of a Friedmann-Lemaître-Robertson-Walker metric with a perfect-fluid stress-energy tensor. The UAT framework modifies the expansion history through mechanisms (quantum braking, temporal viscosity) that cannot be expressed as a simple equation of state for a dark energy fluid. During our attempts to implement UAT in CLASS, we encountered the following specific obstacles:

- The option to supply an external background expansion table (`background_from_file`) was not functional in the standard distributed version of CLASS. Enabling it required recompilation with a specific flag, and even then, the compiled executable produced segmentation faults when reading the UAT-generated table.
- Direct modification of the `background.c` source file to insert the UAT Friedmann equation was successful at the code level, but the Python wrapper (`classy`) could not be recompiled against the modified library due to environment management restrictions in the Python installation.
- The UAT framework involves parameters (e.g., the quantum brake k_{early}, the viscosity coefficient β, the causal coherence constant κ_{crit}) that have no counterpart in the standard cosmological parameter set. Even if the background module were successfully modified, the perturbation and thermodynamics modules would require corresponding modifications to maintain internal consistency.

In summary, a full implementation of UAT/UCP in a Boltzmann code is not a matter of parameter adjustment or plugin development; it requires a fundamental rewrite of the background, perturbation, and thermodynamics modules. This is a substantial software engineering project that exceeds the scope of the current validation programme. Until such an implementation is achieved, the cosmological predictions of UAT/UCP (CMB power spectra, BAO scale, etc.) remain limited to the analytical and semi-analytical approximations presented in the companion papers.

5 Conclusions and Outlook

The three technical obstacles documented in this note —LIGO data corruption, the sub-optimal design of current gravitational-wave detectors for UAT/UCP signatures, and the incompatibility of the framework with standard Boltzmann codes— represent genuine challenges that must be overcome for a definitive validation of the UAT/UCP frameworks.

However, it is important to stress that none of these obstacles constitutes a refutation of the theory. They are limitations of the available infrastructure, not contradictions with observational data. The numerical analyses that could be performed robustly —the fits to cosmic chronometers, the growth factor and S_8 calculations, the age of the universe test, and the MCMC analyses of Pantheon+ and BAO data— all yield results that are either competitive with or superior to ΛCDM.

Future progress will require three key developments:

1. The construction of a dedicated table-top experiment to measure the phase-geometric predictions of UAT/UCP (the $43.515°$ phase shift and the 0.2791 residual amplitude) under controlled laboratory conditions. A prototype of such an experiment has already been constructed and has yielded promising preliminary results.

2. The development of a custom Boltzmann solver, or a deep modification of an existing one, that incorporates the UAT/UCP expansion history and its associated perturbation equations. This is a long-term project that would benefit from collaboration with computational cosmologists.

3. The analysis of data from next-generation gravitational-wave detectors (Einstein Telescope, Cosmic Explorer) and large-scale structure surveys (Euclid, Roman Space Telescope), which will provide higher precision and may reveal the subtle signatures predicted by the theory.

This note is submitted as a transparent record of the challenges faced and as a roadmap for the next phase of the UAT/UCP research programme.

References

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