
Hypothesis in Contemporary Astrophysics—Could Galactic Interactions Occur Sooner? Relativistic Temporal Effects in Milky Way–Andromeda Encounters

[Theodor-Nicolae Carp](#) *

Posted Date: 9 March 2026

doi: 10.20944/preprints202504.2030.v4

Keywords: earth; solar system; Milky Way; Sagittarius Dwarf; Andromeda; time; space; matter; multi-galactic interaction; UV light; acceleration; time; dilation; contraction; Albert Einstein; Stephen Hawkins; Isaac Newton; general relativity; special relativity; Thermodynamics; compound interest; amplification; mathematical model; coarse-graining; quadrupolar anisotropy; pulsar timing arrays; tidal curvature; electromagnetic influence; gravity; interconnection; correlation; implication; causation; Gutenberg; Richter; equation; earthquake; magnitude; frequency; NASA; planetary; stellar; alignment; evidence; ethics; GDPR; astrophysics; Philosophy of Science



Preprints.org is a free multidisciplinary platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This open access article is published under a [Creative Commons CC BY 4.0 license](#), which permit the free download, distribution, and reuse, provided that the author and preprint are cited in any reuse.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Review

Hypothesis in Contemporary Astrophysics – Could Galactic Interactions Occur Sooner? Relativistic Temporal Effects in Milky Way–Andromeda Encounters

Theodor-Nicolae Carp

Master's in Science Student, University of Westminster, Independent Academic Researcher, London, UK;
theodore.nicholas100@gmail.com:

Abstract

Throughout the second part of the Modern Era, leading researchers in astronomy, physics and applied statistics into astrophysics have brought a novel hypothesis, in which it was speculated that the Milky Way will experience a clash with another galaxy as a result of an intersection in their motion. Currently, such a statement is purely speculative in nature, although specific signs that such a hypothesis reflects real-world phenomena have started appearing, which cover seemingly increased frequencies and extents of planetary and stellar alignments within the Milky Way. Any occurrence of such a phenomenon may be probable due to increased electromagnetic and gravitational influences from outside the galaxy, which may hint at an existing approach of a different galaxy towards the Milky Way. It may be important to mention that potential effects of a multi-galactic crash would involve a general polarisation of natural and spatial phenomena, given that a multi-galactic interaction and clash would involve a sharp, unprecedented increase in the extent of electromagnetic and gravitational fluctuations of influences toward the Earth, which would affect all natural phenomena upon it, including the climate, the weather, human and animal psychology and wellbeing, as well as the effects of seas and oceans upon nearby shores. Furthermore, if the hypothesis in which major electromagnetic and gravitational influences toward specific, earthquake-prone geographical areas of the Earth would increase the probability of the occurrence of novel earthquakes and aftershocks in such areas is proven to be evidence-based, then a multi-galactic clash involving the Milky Way could also result in a sharp increase in both the frequency and extent of earthquakes throughout the Earth. Furthermore, it could be that the increasing number of people “bumping” into numerical and geometrical coincidences of symmetry at random (i.e. an increasing number of people bumping into “angel numbers”) is a sign of existing increases in electromagnetic and gravitational influences from the cosmos, which may very well reflect a scenario of an approaching multi-galactic interaction that may in a lower probability scenario even implicate the Milky Way (i.e. perhaps with Andromeda in approximately 4.5 billion years). According to Albert Einstein's Theory of Relativity, time is not an absolute entity, but a relative measure that can be contracted or dilated depending on the observer's perspective. Nonetheless, such relativistic effects are technically imperceptible on Earth, just as passengers aboard a high-speed train experience stability and consistency within the train, regardless of its external speed. Similarly, the inhabitants of the Milky Way could remain unaware of significant relativistic changes in galactic motion, whilst natural and cosmic phenomena within the galaxy would paradoxically accelerate in a manner reflective to the acceleration of time, thereby “transforming” the 4.5 billion years potentially into a much shorter time frame. If the Multiverse is real, then the same analogy applies for the inhabitants of the Universe. Furthermore, it may be important to observe whether any double-exponential growth in the speed of the approaching galaxies has been taken into consideration, which would broadly shorten the duration of 4.5 billion years and also change the relativistic states of time within the implicated galaxies - whilst keeping the internal measurements of time intact. Any real-world application of such an analogy may bring

implications that deeply intersect scientific and philosophical research, perhaps even offering a hypothesis in which traditional cosmological models that suggest an 11-billion year process of evolution of physical matter, may not be mutually exclusive with theological narratives, such as a “Seven-Day Creation”. Some hypotheses have even proposed a paradoxical existence of a relative state of the speed of light, although empirical scientific evidence states that it is an absolute value, which constitutes the foundation of Albert Einstein’s research. Such hypotheses could nonetheless operate according to the Philosophical model of “destroy the Temple and rebuild It afterward”, potentially resulting in the creation of the most foundational type of a paradox in which the speed of light would be deemed as both relative and absolute, which could constitute “the paradox of all paradoxes”. Effects of any multi-galactic interaction implicating the Milky Way may accelerate the production of more stars and planetary systems, and preserve existing forms of life, given that a clash between Sagittarius Dwarf and the Milky Way may have resulted in the creation of the Solar System. Or, such an interaction deemed to probably occur, and in the distant future, could describe religious passages in which a phenomenon of “star falling” is mentioned, which could also involve an increasing number of asteroids falling upon Earth, given that fluctuations in gravitational influences could cause asteroids from the great belt nearby Jupiter to change their direction, leading to increased statistical probabilities that more asteroids will change their direction and be headed toward the Earth. Such a phenomenon could be deemed as “beyond monumental” in nature and even impact the state of time within the interacting galaxies, given its relative nature - potentially accelerating it considerably as the galaxies approach one another, in proportion with the level of fluctuations in electromagnetic influences toward the Solar System. Overall, the effects of a multi-galactic clash could either create more life or be catastrophic for human and animal life, potentially resulting in a phenomenon of unprecedented population loss in all life forms. Likewise, it may be important for research efforts to continue in order to determine whether the Milky Way is indeed in the course of experiencing an unprecedented intersection with a different galaxy, as well as for scientists, local and international authorities to devise plans of preparation for the purpose of precaution and ensuring that all guidelines of Health & Safety are met in case of any increased frequency and extent of natural disasters throughout the Earth, whilst keeping academic and scientific perspectives in an optimistic realm, based on the available evidence. This preprint also develops a speculative but explicitly testable applied mathematics-related hypothesis concerning large-scale galactic interactions and their possible influence on coarse-grained temporal observables for extended gravitational systems. While General Relativity uniquely defines proper time along individual worldlines, it does not uniquely prescribe how clock rates should be aggregated across spatially extended, self-gravitating domains such as galaxies when these systems are embedded in non-uniform external gravitational fields. Building on this conceptual gap, we introduce a phenomenological “structural time” for a bound system G , defined through a coarse-grained lapse factor χ_G , and propose a minimal extension in which χ_G acquires a weak dependence on external tidal curvature invariants. The model is constructed covariantly using the electric part of the Weyl tensor and a dimensionless tidal-strength parameter $\Lambda_G \equiv T_G / (\Omega_G^2)$, where $T_G = \text{sqrt}(E_{ab} * E^{ab})$ measures the external tidal field and Ω_G is a characteristic internal dynamical frequency. The modified lapse takes the form $\chi_G = \chi_{G,GR} * [1 + \varepsilon * \Lambda_G^p]^{-1/2}$, recovering the standard GR coarse-grained result when $\varepsilon=0$. Applied to the Milky Way – Andromeda system, the present-day tidal strength is strongly suppressed ($\Lambda_G \sim 10^{-5}$ for fiducial parameters), implying that any effect on coarse-grained timekeeping is expected to be extremely small at current separations unless the coupling ε is unexpectedly large. A distinctive observational consequence is a fixed-axis quadrupolar anisotropy in timing or frequency measurements aligned with the dominant external mass distribution, providing a falsifiable template for pulsar timing arrays and high-precision optical-clock networks. The broader conceptual motivation of the paper is to explore whether system-level temporal observables, when defined through coarse-graining, could carry weak environmental dependence in galactic settings without modifying local tests of General Relativity. More broadly, the framework suggests that certain aspects of relativistic time may require refined interpretation when applied to

spatially extended, self-gravitating systems rather than idealised point observers. In this sense, the present work does not modify the field equations of General Relativity, but instead proposes an operational extension in how relativistic time may be defined after coarse-graining across large astrophysical domains subject to external tidal curvature. Such a perspective may help in thoroughly expanding the application of relativistic concepts to galactic-scale dynamics while remaining fully consistent with the extensive body of experimental tests confirming General Relativity in local and weak-field regimes.

Keywords: earth; solar system; Milky Way; Sagittarius Dwarf; Andromeda; time; space; matter; multi-galactic interaction; UV light; acceleration; time; dilation; contraction; Albert Einstein; Stephen Hawkins; Isaac Newton; general relativity; special relativity; Thermodynamics; compound interest; amplification; mathematical model; coarse-graining; quadrupolar anisotropy; pulsar timing arrays; tidal curvature; electromagnetic influence; gravity; interconnection; correlation; implication; causation; Gutenberg; Richter; equation; earthquake; magnitude; frequency; NASA; planetary; stellar; alignment; evidence; ethics; GDPR; astrophysics; Philosophy of Science

Introduction

A concept of galaxy clashes has emerged and been distributed by the scientific communities worldwide, in which it was proposed that galaxies throughout the Universe occasionally interact and even clash with one another, leading to the production of various types of phenomena that are often catastrophic in nature for the movement and integrity of various celestial bodies that include planets, satellites, asteroids, and also whole stars from time to time. Such a theory would logically make sense, as any interaction between distinct galaxies would severely change the patterns of electromagnetic and gravitational influences upon such celestial bodies, causing significant change in the direction of trajectories, polarisation of their movements, resulting in a serious increase of fluctuations in various subordinate phenomena, and consequently, in rising levels of instability and movement between extreme states of matter, whose extremities would continuously rise in the process.

Any interaction and clashing between various galaxies would result in a subsequent loss of material stability within the areas of influence between the two intersecting galaxies. Henceforth, stars within such areas would undergo increased rates of explosions, planets would have their trajectories influenced, their tectonic plates would become less stable with time, extreme natural phenomena would gradually become the norm, the thermal states of the planetary atmospheres and surfaces would become more polarised, any belts of asteroids would experience changed gravitational influences that would result in a significant number of asteroids having their trajectories altered and several of such bodies headed for a planetary or stellar clash as a result. Intergalactic clashes would result in severely disrupted electromagnetic and even gravitational influences within the space of their interaction, ultimately making any form of life either highly difficult or impossible, mainly due to the exponential increase in the frequency and extent of natural disasters that would be resulted from a “chain reaction of phenomenal causations”. Such a set of phenomena would be explained by the fact that physics and metaphysics represent the foundational layers of material sciences, which means that any visible changes in their patterns could substantially change the quality of life thereof. An involvement of the Milky Way in any such intergalactic clashes would not spare the Earth from such consequences, as the rates of natural disasters covered by all areas of material, human, social and economical sciences would be affected by a “chain reaction of causal events”.

Furthermore, multi galactic clashes may also influence the trajectory of various planets and stars toward black holes, potentially increasing statistical probabilities that various celestial bodies would unexpectedly become swallowed by such points of spatial void. Recently, astrophysicists have been exposed to a novel hypothesis in which planetary and stellar alignments toward the Earth and specifically toward its earthquake-prone areas would increase the statistical probability that

moderate or major forms of seismic events will occur in rather proximal points of the future, and the examples of the Sun and the Moon influencing the sea levels may have influenced the development of such hypotheses. Furthermore, it may be that the increasing number of people coincidentally “bumping” into numerical and geometrical forms of symmetry for an increasing number of times per given weeks worldwide constitutes a sign of increasing frequencies of planetary and stellar alignments toward the Earth and overall, another sign of an approaching multi galactic intersection that could even involve the Milky Way, if not at least a galaxy neighbouring it.

Whilst scientists ought to base their research on available evidence, it may be important for novel hypotheses to be tested with utmost consideration and with an open intellectual approach. It may also be that increasing rates of planetary and stellar alignments toward the Earth represent a sign of an approaching multi galactic interaction, given the rise of frequency in such multi-celestial body alignment phenomena, which may be due to increased polarisation in rates of electromagnetic and gravitational influences throughout numerous planetary systems. The manuscript explores the speculative hypothesis that the Milky Way may be on a collision course with another galaxy, potentially leading to significant astrophysical and terrestrial effects. Concentrating upon the effects on time and perception, the study proposes that multi-galactic interactions could significantly impact the state of time within the affected galaxies, accelerating the perception and flow of time due to electromagnetic and gravitational fluctuations - pointing to the example of passengers of a commercial flight needing to adjust to changes of air pressure as the airplane is in a very high speed that would not be as tolerated by the human organism alone. The manuscript references Albert Einstein’s Theory of Relativity, suggesting that as galaxies approach each other, these fluctuations could alter celestial processes and human perception, potentially aligning with biblical references to time being “shortened” in the last days. The document also speculates on a deeper philosophical level, suggesting that human perception and real-world phenomena might be interconnected in a spatio-temporal plane, making it challenging to pinpoint the beginning of physical existence or the “edge” of the universe. Furthermore, mobiles, planets, satellites, stars, planetary systems, galaxies and even the Universe itself (if the Multiverse is proven to be real) may display their individual Relative autonomy. Could such structures be part of a hierarchy that include dimensions at its top-end? Mobiles, planets, satellites, stars, planetary systems, galaxies and even the Universe itself (if the Multiverse is proven to be real) may display their individual Relative autonomy. Could such structures be part of a hierarchy that include dimensions at its top-end?

Galactic interactions are a fundamental component of cosmic structure formation. Observational surveys and numerical simulations show that galaxies frequently undergo gravitational encounters, tidal interactions, and mergers throughout their evolutionary histories. These processes play a key role in shaping galactic morphology, redistributing angular momentum, triggering star formation, and altering large-scale gravitational potentials. One of the most prominent examples within the local universe is the gravitational interaction between the Milky Way and the Andromeda galaxy (M31), which are predicted to merge on a timescale of several billion years. Although the large-scale dynamical consequences of galactic interactions have been extensively studied, their potential influence on relativistic temporal observables has received comparatively little attention. In general relativity, proper time is defined locally along individual worldlines through the spacetime metric. However, the theory does not uniquely prescribe how temporal rates should be aggregated across spatially extended, self-gravitating systems embedded in non-uniform external gravitational fields. When entire galaxies experience tidal curvature from neighboring massive structures, it remains an open question whether such curvature gradients could induce extremely small but coherent modulations in coarse-grained temporal observables.

This paper explores a speculative but explicitly testable hypothesis that external tidal curvature may weakly influence the effective macroscopic time rate of extended gravitational systems. Building on relativistic tidal theory and the electric component of the Weyl tensor, we introduce a phenomenological description in which the coarse-grained lapse factor of a galaxy depends on a dimensionless tidal-strength parameter determined by the external gravitational environment.

Within this framework, interactions between massive galaxies could generate a directionally dependent perturbation in effective clock rates across the sky. The Milky Way – Andromeda system provides a natural testbed for exploring this possibility. Because the external tidal field generated by Andromeda is well constrained observationally, it allows quantitative estimates of the magnitude and spatial structure of any resulting temporal anisotropy. The model predicts a fixed-axis quadrupolar modulation in fractional clock rates aligned with the direction of M31. Although the magnitude of the effect is expected to be extremely small under present conditions, modern precision timing infrastructures – such as pulsar timing arrays and optical-lattice clock networks – now provide the sensitivity required to test such predictions empirically.

The objective of this work is therefore not to modify the fundamental equations of general relativity, but to investigate whether coarse-grained temporal observables defined across extended gravitational systems could carry weak environmental dependence while remaining fully consistent with all existing local tests of relativity. By translating this conceptual possibility into a quantitative and falsifiable observational framework, the study aims to open a new experimental window on the relationship between large-scale gravitational structure and the measurement of time.

Compact Mathematical Summary of the Framework

To formalize the hypothesis, we introduce a coarse-grained temporal parameter associated with a gravitationally bound system G , representing the effective macroscopic clock rate of the system when averaged across its spatial domain. Let t denote a coordinate time defined in a suitable inertial reference frame, such as the Local Group barycentric frame. The structural proper time of the system is then defined through a coarse-grained lapse factor

$$dT_G / dt = \chi_G,$$

where χ_G represents the effective rate at which time evolves within the extended system relative to the chosen coordinate time.

In the weak-field regime relevant for galactic dynamics, the domain-averaged relativistic prediction for the lapse factor can be approximated as

$$\chi_{G,GR} \approx 1 - \langle v^2 \rangle_G / c^2 + 2\langle \Phi_{int} \rangle_G / c^2,$$

where $\langle v^2 \rangle_G$ is the domain-averaged velocity dispersion of the system and $\langle \Phi_{int} \rangle_G$ is the averaged internal gravitational potential.

To parameterize the influence of external gravitational structure, we introduce a dimensionless tidal-strength parameter

$$\Lambda_G = T_G / \Omega_G^2,$$

where $T_G = E_{ab} * E^{ab}$ is the scalar magnitude of the external tidal curvature derived from the electric part of the Weyl tensor, and

$$\Omega_G = v_c / R_0$$

represents a characteristic internal dynamical frequency of the galaxy.

Within this phenomenological framework, the effective macroscopic lapse factor becomes

$$\chi_G = \chi_{G,GR} * [1 + \varepsilon (\Lambda_G)^p]^{-1/2},$$

where ε is a dimensionless coupling parameter and p determines the response order of the system to external tidal curvature.

A key observable consequence of this formulation is a directional perturbation in the effective clock rate across the sky, which can be expressed as

$$\delta(\chi_G) * (\hat{n}^\wedge) = A * P_2 * (\cos(\hat{n}^\wedge \cdot \hat{\theta})),$$

where P_2 is the second Legendre polynomial and θ is the angle between the line of sight and the direction of the dominant external mass distribution (e.g., the Andromeda galaxy). This quadrupolar

signature provides a falsifiable observational template for pulsar timing arrays and precision optical-clock networks.

Methodology

To assess any novel hypothesis in astrophysics, it may be important to first perform in-depth scientific literature review, to ensure that any process of data collection is performed accurately. Throughout the initial process of literature review, all important points of statistical data applied into astrophysics are collected and various forms of probability calculation are performed again to observe the manner the data was determined. Afterward, more practical steps may be taken, which would involve the utilisation of spatial scopes, rockets and satellites, with the purpose of investigating real-world data, under real-world conditions. Any detection of changes in patterns of astronomical phenomena, which could involve a rise in the statistical occurrence of sudden discoveries, as well as a rise in the development of significant Earthly and spatial phenomena, within all areas of material sciences, could become markers of such developments within the Milky Way. Furthermore, it may be important to investigate any novel polarisations of patterns observed behind human and animal psychology and social evolutionary processes, as it has been observed that large-scale spatial events considerably impact levels of psychology via unexpected and sudden changes in electromagnetic influences toward the brains of living organisms. Throughout such investigations, Chi-Squared tests, T-tests and ANOVA are routinely used when applicable, with the purpose of clearly distinguishing between random events with no causal relationships, and correlational events that visibly display a relationship of causation. It may be important to emphasise upon the fact that numerical sciences that include mathematics and statistics constitute the foundation of all material sciences. All the rules, guidelines and regulations of GDPR, informed consent and accurate data reporting should be respected in any process of testing hypotheses against available forms of scientific scrutiny and existent evidence if any human subject will need to be included in any subsequent experimental procedure, in accordance with the Health and Safety rules and guidelines enforced for any scientific testing procedure.

This study adopts a theoretical and phenomenological approach to investigate the possible influence of external tidal curvature on coarse-grained temporal observables in extended gravitational systems. The analysis proceeds through three primary steps. First, established results from relativistic astrophysics and galactic dynamics are reviewed in order to identify the conceptual gap between locally defined proper time and the effective temporal behaviour of spatially extended gravitational systems. Second, a mathematical framework is constructed in which the domain-averaged lapse rate of a galaxy is expressed in terms of internal dynamical quantities and external tidal curvature invariants derived from the Weyl tensor. Third, order-of-magnitude estimates are performed for the present Milky Way – Andromeda system in order to evaluate the expected amplitude of the predicted effect. To assess observational feasibility, the predicted signal is compared with the sensitivity ranges of current and future high-precision timing infrastructures, including pulsar timing arrays and optical lattice clock networks. This approach allows the phenomenological coupling parameter introduced in the model to be constrained using realistic experimental limits while maintaining full consistency with established predictions of General Relativity.

Mathematical Framework for Tidal Effects on Coarse-Grained Time in Galactic Systems

1. Conceptual Foundations

In standard formulations of General Relativity, time is defined locally through the proper time measured along individual timelike worldlines. The elapsed proper time between two events along a trajectory is uniquely determined by the spacetime metric $g_{\mu\nu}$, and this prescription has been verified experimentally in a wide range of contexts, including laboratory clock comparisons, satellite

navigation systems, and astrophysical timing observations. However, many astrophysical systems of interest – particularly galaxies and galaxy clusters – cannot be treated as pointlike observers following single worldlines. Instead, they are extended gravitational systems composed of enormous numbers of interacting components whose collective behaviour must be described through spatial averaging or coarse-graining procedures.

In such contexts, quantities such as velocity dispersion, mass density, luminosity distribution, and dynamical timescales are typically defined only after averaging across large spatial domains that encompass the system. While General Relativity provides exact prescriptions for local quantities, it does not uniquely determine how proper time should be averaged across extended domains subject to non-uniform gravitational fields. Consequently, when attempting to describe the effective or “system-level” temporal behaviour of a galaxy embedded within a larger gravitational environment, an additional operational definition must be introduced.

To address this conceptual gap, we adopt a phenomenological framework in which a gravitationally bound system is treated as possessing a coarse-grained temporal parameter that reflects the collective behaviour of the worldlines composing the system. Let G denote a gravitationally bound structure such as a galaxy, and let D_G represent the spatial domain encompassing its baryonic and dark-matter components. We define a structural proper time τ_G associated with the system through a coarse-grained lapse factor χ_G such that

$$d\tau_G / dt = \chi_G.$$

Here t denotes a barycentric coordinate time defined in a suitable inertial frame, such as the Local Group rest frame. The function χ_G therefore represents the effective rate at which structural time within the system advances relative to the chosen coordinate time. In the limit where the system experiences no external tidal influences and behaves as an isolated gravitational structure, this lapse factor reduces to the domain-averaged prediction of standard General Relativity. The aim of the present formulation is not to alter the local laws of relativistic physics, but rather to explore whether the coarse-grained temporal behaviour of an extended system may acquire a small dependence on external gravitational curvature invariants arising from neighbouring structures.

2. Coarse-Grained Proper Time in the Weak-Field Regime

In the weak-field and slow-motion regime appropriate for galactic dynamics, the spacetime metric may be written in the standard post-Newtonian approximation as

$$g_{00} = -(1 + 2\Phi/c^2) + O(c^{-4}),$$

$$g_{ij} = \delta_{ij}(1 - 2\Phi/c^2) + O(c^{-4}),$$

where Φ is the Newtonian gravitational potential and c is the speed of light. For a particle moving with coordinate velocity v , the local proper time increment is given by

$$d\tau = dt \sqrt{1 - v^2/c^2 + 2\Phi/c^2}.$$

When this expression is averaged across the spatial domain D_G containing the system, one obtains a coarse-grained lapse factor describing the average clock rate of the system as a whole. Denoting domain-averaged quantities by angle brackets, the relativistic prediction for the coarse-grained lapse becomes

$$\chi_{G,GR} = \sqrt{1 - \langle v^2 \rangle_G / c^2 + 2\langle \Phi \rangle_G / c^2}.$$

This expression reflects the combined influence of the internal kinetic energy and gravitational potential of the system. Importantly, within standard General Relativity a constant external gravitational potential may be removed locally through an appropriate coordinate transformation, meaning that only local gradients influence the proper time of individual worldlines. As a result, traditional treatments predict no direct dependence of the system-level clock rate on the large-scale gravitational environment.

However, when dealing with extended systems embedded within non-uniform gravitational fields – such as galaxies interacting within a cluster or group – external tidal curvature cannot be eliminated across the entire domain. Curvature gradients across the spatial extent of the system therefore provide a natural channel through which external gravitational structure might influence coarse-grained temporal observables. This motivates consideration of an additional phenomenological term that couples the system's effective lapse to external tidal curvature invariants.

3. External Tidal Curvature and Dimensionless Tidal Strength

The tidal curvature experienced by an extended system can be characterized using the electric part of the Weyl tensor. Let u_a denote the four-velocity of the system's mass-weighted centroid. The electric part of the Weyl tensor with respect to this velocity field is defined as

$$E_{ab} = C_{acbd} * u^c * u^d,$$

where C_{abcd} is the Weyl curvature tensor. Physically, E_{ab} describes tidal gravitational forces that act to stretch or compress neighbouring geodesics in directions determined by the local curvature of spacetime.

From this tensor we construct a scalar invariant representing the magnitude of the external tidal field,

$$T_G = \text{sqrt}(E_{ab} * E^{ab}).$$

To compare the strength of this tidal curvature with the internal dynamical scale of the system, we introduce a characteristic angular frequency

$$\Omega_G = v_c / R_0,$$

where v_c is a representative circular velocity within the galaxy and R_0 is a fiducial radius. The ratio of the external tidal scalar to the square of this internal dynamical frequency defines a dimensionless tidal strength parameter

$$\Lambda_G = T_G / (\Omega_G * \Omega_G).$$

This quantity provides a natural measure of the relative importance of external gravitational curvature compared with the internal gravitational dynamics of the system. When $\Lambda_G \ll 1$, the external tidal field is dynamically insignificant and the system behaves approximately as an isolated structure. Conversely, when $\Lambda_G \sim 1$, the tidal field becomes comparable in strength to the system's internal gravitational dynamics and significant distortions or dynamical restructuring may occur.

4. Phenomenological Extension of the Coarse-Grained Lapse

To parameterize the possible influence of external tidal curvature on the coarse-grained temporal behaviour of the system, we introduce a phenomenological extension of the lapse factor of the form

$$\chi_G = \chi_{G,GR} * [1 + \varepsilon * \Lambda_G^p]^{-1/2},$$

where $\varepsilon > 0$ is a dimensionless coupling parameter and $p \geq 1$ determines the order of the response to the tidal field. By construction, this expression reduces exactly to the standard General Relativistic result in the limit $\varepsilon = 0$. The proposed modification therefore does not alter local proper time measurements or the Einstein field equations themselves; it only introduces a potential dependence of the coarse-grained system-level clock rate on external tidal curvature.

For weak tidal fields satisfying $\varepsilon * \Lambda_G^p \ll 1$, the expression may be expanded as

$$\chi_G \approx \chi_{G,GR} [1 - 1/2 * \varepsilon * \Lambda_G^p + O(\Lambda_G^{2p})].$$

The leading correction therefore scales linearly with the tidal invariant and remains extremely small whenever the external tidal strength is much smaller than the internal dynamical scale of the

system. This ensures that the phenomenological extension remains compatible with the extensive body of experimental tests confirming the predictions of General Relativity in weak-field regimes.

5. Scaling Relations for Interacting Galaxies

For two gravitationally bound galaxies interacting within a common gravitational environment, the dominant external tidal field experienced by one system arises from the gravitational potential of the other. To leading order, the tidal scalar associated with a companion galaxy of mass M_c at separation d scales as

$$T_G \sim G * M_c / d^3.$$

Consequently, the dimensionless tidal strength behaves as:

$$\Lambda_G \propto d^{-3}.$$

This cubic dependence implies that tidal effects grow rapidly as the separation between galaxies decreases. During the early stages of an interaction when the separation remains large, tidal influences remain weak and the internal dynamics of each galaxy are largely unaffected. However, as the separation decreases during the later stages of a merger, the tidal strength may approach unity, signalling the onset of strong dynamical coupling between the two systems.

6. Order-of-Magnitude Estimate for the Milky Way – Andromeda System

To illustrate the scale of the proposed effect, we consider present-day parameters for the Milky Way–Andromeda system. Observational estimates place the mass of Andromeda at approximately

$$M_c \approx 1.5 * 10^{12} M_\odot$$

with a current separation of roughly

$$d \approx 780 \text{ kpc.}$$

For the Milky Way, adopting a characteristic circular velocity

$$v_c \approx 220 \text{ km s}^{-1}$$

at a fiducial radius

$$R_0 \approx 8 \text{ kpc,}$$

yields an internal dynamical frequency

$$\Omega_G \approx 8.9 * 10^{-16} \text{ s}^{-1}.$$

Using these parameters, the tidal scalar and dimensionless tidal strength become approximately

$$T_G \approx 1.4 * 10^{-35} \text{ s}^{-2}, \Lambda_G \approx 1.8 * 10^{-5}.$$

Substituting this value into the weak-tidal expansion shows that the present-epoch correction to the coarse-grained lapse is

$$\delta(\chi_G) \approx -1/2 * \varepsilon * \Lambda_G.$$

Thus, even for moderately large coupling parameters, the present-day effect is extremely small. This result confirms that any tidal modification of coarse-grained timekeeping must be strongly suppressed at the current separation between the two galaxies and would only become dynamically significant during the late stages of the merger when the separation decreases to tens of kiloparsecs.

7. Observable Signatures

An important consequence of the tidal formulation arises from the trace-free nature of the Weyl tensor. Because the tidal curvature tensor E_{ab} possesses no trace component, the resulting

modification to the coarse-grained lapse introduces a quadrupolar angular pattern aligned with the direction of the external mass distribution.

The leading fractional variation in clock rate may therefore be written as

$$\delta(\chi_G) * (n^\wedge) = A * P_2 * (\cos[\tilde{f}_0]\theta),$$

where n^\wedge is a direction on the sky, θ is the angle between n^\wedge and the direction toward the companion galaxy, and P_2 is the second Legendre polynomial

$$P_2(\cos[\tilde{f}_0]\theta) = 1/2 * (3 \cos^2[\tilde{f}_0]\theta - 1).$$

The amplitude A scales as

$$A \sim \varepsilon * \Lambda_G^p.$$

This quadrupolar signature provides a direct observational handle through which the phenomenological coupling parameter may be constrained. Importantly, the predicted angular pattern differs from the correlation pattern associated with an isotropic stochastic gravitational-wave background, making it possible to search for both effects simultaneously in high-precision timing datasets.

8. Experimental Constraints

Current pulsar timing array experiments and high-precision optical clock networks provide the most promising observational tools for testing this hypothesis. If no quadrupolar anisotropy in clock rates is detected at a fractional sensitivity level δ^* , the coupling parameter is constrained by

$$\varepsilon \lesssim 2\delta^* / \Lambda_G^p.$$

For present-day Milky Way – Andromeda parameters and linear response $p=1$, pulsar timing arrays sensitive to fractional timing variations of order 10^{-15} imply

$$\varepsilon \lesssim 10^{-10}.$$

Future optical clock networks capable of reaching sensitivities near 10^{-18} may improve this bound by several orders of magnitude, providing an increasingly stringent test of the proposed phenomenological extension.

Limitations of the Present Model

The RTC framework presented here is intentionally phenomenological. Several simplifying assumptions have been adopted in order to isolate the potential influence of external tidal curvature on coarse-grained temporal observables. First, the model treats the Milky Way as a single effective dynamical system characterized by a representative internal frequency Ω_G , neglecting internal structural complexity such as halo anisotropy, non-axisymmetric mass distributions, and local gravitational perturbations. Second, the analysis assumes that the external tidal field generated by Andromeda remains quasi-static over the observational baseline relevant for pulsar timing and optical clock measurements. Third, the proposed coupling parameter ε is introduced phenomenologically rather than derived from a fundamental field-theoretic extension of general relativity. As a result, the framework should be interpreted primarily as a testable parameterization of possible curvature-dependent temporal effects rather than a complete alternative gravitational theory.

Data and Code Availability

All calculations presented in this work can be reproduced using publicly available astrophysical parameters and pulsar timing datasets. PTA datasets referenced include the NANOGrav 15-year release, EPTA DR2, and IPTA DR2. Numerical calculations and figure-generation scripts are available upon request from the author.

Importantly, the proposed framework preserves the local predictions of general relativity and introduces no modification to Einstein's field equations; the effect arises only at the level of coarse-grained temporal observables defined across extended gravitational systems.

AI Assistance Disclosure

The author utilised OpenAI's ChatGPT – 5.2 language model as an editorial support tool during the development of this manuscript. The system was used to assist with language refinement, structural organization and clarification of mathematical presentation. The underlying scientific ideas, hypotheses, mathematical framework and interpretations presented in this work originate from the author's own intellectual contributions. The AI system did not generate original scientific concepts or independently perform analysis, and all content produced with its assistance was reviewed, verified and approved by the author.

Results

This section summarizes the principal observational implications of the Relativistic Temporal Compression (RTC) framework developed in this study. Because the present work is theoretical in nature, the results reported here do not represent direct experimental measurements but rather quantitative predictions derived from the model and their expected detectability with current and future observational infrastructure. In particular, the framework predicts that external tidal curvature generated by neighbouring massive galaxies may introduce a small anisotropic perturbation in coarse-grained temporal observables at galactic scales.

The most distinctive signature of this effect is a quadrupolar angular modulation in effective clock rates aligned with the dominant external mass distribution. For the Milky Way, this axis is expected to be approximately oriented toward the Andromeda galaxy. The following subsections examine the expected magnitude of this signal and evaluate the sensitivity of present and future timing experiments – such as pulsar timing arrays and precision atomic clock networks – to detecting or constraining the predicted anisotropy.

For present-day Milky Way – Andromeda parameters, the predicted fractional temporal anisotropy scales approximately as

$$A \sim \varepsilon * \Lambda_G$$

which yields amplitudes on the order of 10^{-15} – 10^{-16} for coupling parameters near current observational bounds. This magnitude places the signal near the sensitivity threshold of next-generation pulsar timing experiments.

Predictions for SKA-Era Pulsar Timing Arrays

The next generation of pulsar timing arrays will dramatically improve sensitivity to low-frequency temporal anisotropies. The upcoming **Square Kilometre Array (SKA)** is expected to increase the number of precisely timed millisecond pulsars by an order of magnitude while extending timing baselines beyond two decades. Forecasts suggest that SKA-era PTAs may monitor between 200 and 500 stable pulsars with sub-100 ns timing precision.

Within the Relativistic Temporal Compression (RTC) framework, such improvements directly enhance sensitivity to the quadrupolar timing residual pattern predicted by the model. Because the signal amplitude scales with the number of pulsars and observation duration, SKA datasets could probe fractional frequency deviations approaching the 10^{-16} regime. This would allow constraints on the curvature–time coupling parameter ε an order of magnitude tighter than current PTA limits, potentially reaching $\varepsilon \lesssim 10^{-11}$ for $p = 1$. If the predicted quadrupolar anisotropy aligned with the Andromeda axis exists at amplitudes near current upper bounds, SKA-era timing arrays should be capable of detecting the signal through harmonic decomposition of pulsar timing residuals.

More broadly, the increased sky coverage provided by SKA will enable a cleaner separation between isotropic stochastic gravitational-wave backgrounds and deterministic anisotropic signals such as the RTC quadrupole. The large pulsar sample will reduce geometric biases in sky sampling and allow robust Bayesian model selection between competing hypotheses.

Table 1. Future Observational Timeline.

Instrument / Infrastructure	Typical Sensitivity	Impact for RTC Tests
Current Pulsar Timing Arrays (NANOGrav, EPTA, IPTA)	$\sim 10^{-15}$ fractional frequency	Constrain the coupling parameter ϵ and search for quadrupolar timing residuals aligned with M31
SKA-era Pulsar Timing Arrays	$\sim 10^{-16}$ fractional frequency	Potential detection of RTC quadrupole or strong exclusion limits
Global Optical-Lattice Clock Networks	$\sim 10^{-18} - 10^{-19}$ fractional frequency	Provide the most stringent constraints on ϵ and test anisotropy using terrestrial chronometric baselines
Space-based Optical Clocks / Deep-space Timing	$< 10^{-19}$ (projected)	Extend tests beyond Earth-based baselines and probe galactic-scale temporal anisotropy directly

Together, these observational pathways define a clear experimental trajectory: present datasets already constrain macroscopic curvature–time coupling, while upcoming SKA pulsar timing arrays and ultra-precise optical-clock networks will be capable of either detecting or decisively ruling out the predicted anisotropy within the next decade.

Discussion

Astrophysical events have continuously displayed various degrees of influence upon natural phenomena upon various planets, and even having displayed various forms of impact upon the quality of life. Albert Einstein has explained the existence of a mysterious “principle of the interest”, in which any phenomenon leads to a various form of amplification that is proportional with its intensity, with an example representing the relationship between the magnitudes of earthquakes that were originally scaled by Richter, and the statistical probability that a number of aftershocks will occur afterward, with both the number and the magnitude values of the aftershocks being proportional with the magnitude of the original earthquake, which altogether have originally been scaled by Gutenberg. The principle of the interest seems to cover all areas of science (knowledge of patterns observed in the entire existence) - from meta-physical philosophy and psychology, to organic chemistry, geology and astrophysics. In other words, any changes within the environment are statistically probable to be met with proportional, further changes within it, and their amplitude are also proportional with the number and amplitudes of any “responses” to such changes, as mentioned also by Isaac Newton’s Third Law of Thermodynamics. The entire physical existence lies in the continuous and proportional exchange of energy that does not have any physical point of beginning to be ever discovered. Albert Einstein’s Theory of Relativity and “Principle of Interest” explain the impossibility of the human, logical mind to ever discover the point of zero of all physical existence, just as it explains the impossibility of the logical mind to “calculate” the position of the “edge” of the Universe. Furthermore, the $e = m \cdot c^2$ formula, in which e stands for energy, m for mass and c for the speed of light, also explains that the “edge” of the Universe is actually the light, as “reaching” the speed of light is equivalent to “reaching” the state of atemporality. It has been stated that light cannot escape a black hole, but what if a layer of immaterial philosophy is reached, in which the black hole unsuccessfully “attempts” to absorb the very element it lacks - light, without ever reaching a point of “satisfaction”, given that the Universe lacks a physical edge? Or, what if a black hole actually does not constitute a “point of void”, but a “window” to a distant point of physical existence, since light constitutes the “edge” of the entire physical existence? Ultimately, it may even be that Albert

Einstein's unofficial "Principle of Interest" is in fact a "portal" to a different dimensionality of continuous change of the state of matter.

Einsteinian physics revolutionised perceptions into the entire domain of scientific research, as it determined that the flow of time is not absolute, but dependent upon relative motion and gravitational fields. Such an insight allows for the development of a speculative, but potentially meaningful hypothesis in which it is proposed that large-scale galactic dynamics modify the experience and measurement of time within a galaxy, while leaving its internal planetary systems unaffected in their relative perception. According to Special Relativity, the dilation of time is deduced when an object moves at various speeds proximal to the speed of light or is located within powerful gravitational spheres. Nonetheless, from the perspective of an object within a system undergoing relativistic motion, like an airplane passenger or a planet within a galaxy), time flows normally. Such a principle underlies the key analogy: just as passengers of a flying airplane are unaffected by their velocity relative to an external observer, so Earth- and Solar System-bound observers might experience "normal" time, in spite of the Milky Way's acceleration or gravitational interactions with other galaxies. Furthermore, it has been initially indicated that a probable clash between the Milky Way and Andromeda would only occur in 4.5 billion years, but has a double-exponential increase in the speed of approach between the two galaxies "gravitating" towards one another been considered. Also, has an alleged existence of a Multiverse with plural Universe macrosystems moving in different directions been taken into hypothetical consideration, as an aspect as such would give further, tremendous room for application of Special Relativity. As the Milky Way interacted with the Sagittarius Dwarf Galaxy, it likely underwent gravitational and potentially velocity-related changes. A similar outcome may occur with regards to the probable interaction of the Milky Way with Andromeda, as any approaching collision between the two galaxies could result in substantial accelerative forces, on a galactic scale. Such changes may not alter the perception of time for internal forms of chronological measurement, whilst the relativistic frame of the galaxy as a whole unit might substantially differ from the one of an external cosmic observer. Such a difference may introduce the possibility of a mismatch between internally-measured "galactic" time and cosmologically measured time and, if a Multiverse is ever proven to exist, then a similar analogy may apply to the different "Universes" within the Multiversal space.

It may be important to mention that, whilst relativistic time contraction originating from outside of the Solar System would not be perceptible to human observers within the planetary system, it may nevertheless contribute to the acceleration of Earthly phenomena and cosmic events within the entire Milky Way. As an increase in both gravitational and electromagnetic influences occurs, the fundamental temporal dynamics covering natural phenomena that include tectonic activity, atmospheric cycles and biological rhythms (i.e. circadian rhythms) may also shift in a manner that reflects such a pattern of change. Such a subtle acceleration, combined with an increased frequency of planetary and stellar alignments, as well as of astronomical disruptions, could explain an increase in the frequency and intensity of natural and cosmic disasters that would be independent of any direct human perception of such a change in the state of time, and a potentially existent principle of the paradox could make such an aspect possible for interdependent acceleration of temporal dynamics and cosmic phenomena involving the Earth. In other words, under scenarios of accelerated motion and relativistic temporal contraction, the traditionally projected timespan of approximately 4.5 billion years could, in theory, become significantly shorter for a multi-galactic clash involving the Milky Way. Just like in algebra, prime numbers or independent vectors maintain distinct identities within a larger structure, astronomical macrosystems (i.e. galaxies) could display independent manners of operation until strong external factors (such as gravitational interaction) lead them to either merge with or influence each other, resulting in novel, emergent cosmic events. It may be important to scientifically reiterate the manner time, space and matter constitute three interdependent, "hypostases" of the same physical realm. Furthermore, it may be beneficial to note that the mentioned and described cumulative effects that include risen frequencies of seismic activities, climatic disruptions, mysterious and suddenly-emerging biological events, as well as

increasing shifts in human emotional and social behaviours, will echo depictions and descriptions from ancient prophetic texts. Namely, there are references to “wars and rumours of wars”, “famines”, “earthquakes in diverse places”, “mountains moving and collapsing”, “the sudden emergence of mysterious diseases” and “hearts growing cold” may not be only symbolic in nature, but actually could also constitute observational records of astronomical, environmental and psychological events triggered by large-scale cosmic influences that would originate from a multi galactic clash implicating the Milky Way - potentially implicating increased energetic fluctuations and pressures upon the stability of life and the environment on Earth. The present manuscript opens interdisciplinary pathways proposing that major cosmic interactions that include a potential multi-galactic approach, may underscore both scientific observations and historical records of profound terrestrial transformations - whilst remaining firmly grounded in astrophysical and geophysical empirical studies.

Physical Interpretation of the RTC Framework

The phenomenological framework developed in this study suggests that external tidal curvature may introduce extremely small corrections to the effective macroscopic clock rate of extended gravitational systems. Importantly, the proposed mechanism does not modify the local predictions of General Relativity. Instead, it arises from the operational definition of time when proper time is averaged across a spatially extended domain embedded within a non-uniform gravitational environment. In other words, the framework does not alter the fundamental spacetime geometry experienced by individual particles or observers; rather, it examines how time may be interpreted when the behaviour of many worldlines within a large gravitational structure – such as a galaxy – is considered collectively. Within this interpretation, the tidal field generated by neighbouring massive structures introduces a curvature gradient across the spatial extent of the galaxy. While the proper time measured along individual worldlines remains governed by the spacetime metric, the domain-averaged temporal behaviour of the system may acquire a weak dependence on external curvature invariants. Physically, this reflects the fact that different regions of a galaxy may experience slightly different gravitational environments due to the presence of nearby massive bodies. Although such variations are extremely small, they are not strictly uniform across an extended domain. When averaged over galactic scales, these variations may introduce a small correction to the effective macroscopic lapse rate associated with the system as a whole.

This effect can therefore be interpreted as a subtle anisotropic perturbation in the effective clock rate of the galaxy when considered as a macroscopic dynamical entity. Rather than implying that time itself flows differently for individual observers, the framework suggests that the collective dynamical state of a galaxy embedded in an external tidal field may exhibit a weak directional dependence when temporal observables are defined through coarse-grained averaging procedures. In this sense, the RTC model represents an extension of relativistic reasoning to situations in which gravitational systems are treated as spatially extended structures rather than pointlike observers. An important conceptual aspect of this interpretation is that external gravitational potentials can often be removed locally through coordinate transformations, whereas tidal curvature gradients cannot be eliminated across extended spatial domains. This distinction provides a natural mechanism through which large-scale gravitational environments may influence macroscopic observables without altering the fundamental local laws of physics. The Weyl curvature tensor, which characterizes the tidal component of spacetime curvature, therefore provides a natural mathematical object for describing such environmental influences. In the present framework, the magnitude of this tidal curvature – normalized by the internal dynamical frequency of the galaxy – defines a dimensionless parameter that determines the strength of the potential correction to the system’s coarse-grained temporal behaviour.

For the present-day configuration of the Milky Way and the Andromeda galaxy, order-of-magnitude estimates indicate that the corresponding tidal parameter is extremely small. Consequently, any resulting modification to the effective lapse rate of the Milky Way would be far

below the threshold of current observational sensitivity. This result is fully consistent with the absence of any detected temporal anisotropy in existing astrophysical measurements and ensures compatibility with the extensive experimental verification of relativistic physics in weak gravitational fields. Nevertheless, the conceptual value of the RTC framework lies in providing a quantitative mechanism through which such effects could, in principle, arise. As observational techniques continue to improve – particularly in the fields of pulsar timing arrays, precision spectroscopy, and optical lattice clock networks – the sensitivity to extremely small deviations in temporal observables may increase significantly. If macroscopic curvature–time coupling exists at any measurable level, future instruments could potentially detect or constrain such effects. In this way, the framework offers a pathway for connecting large-scale gravitational structure with precision measurements of time, opening a new avenue for testing the interplay between relativistic physics and galactic-scale dynamics.

Consistency with General Relativity

It is important to emphasize that the framework proposed in this work does not introduce any modification to Einstein’s field equations. All local predictions of General Relativity remain unchanged, and the fundamental relationship between spacetime curvature and energy – momentum remains governed by the standard Einstein tensor formulation. The effects described in this study arise only when temporal observables are defined through coarse-graining across extended astrophysical systems rather than along individual worldlines. In classical relativistic theory, proper time is defined along the trajectory of a single observer moving through spacetime. However, galaxies and other large gravitational systems cannot be represented by a single worldline; they are extended structures composed of vast numbers of particles and stellar systems whose behaviour must be described statistically across large spatial domains.

Within this context, the RTC framework explores the operational meaning of time when such extended systems are treated as collective dynamical entities. The central idea is that when proper time measurements are averaged across a spatial domain that spans a galaxy, the resulting effective clock rate may incorporate small contributions arising from spatial variations in the surrounding gravitational environment. These variations do not alter the fundamental laws of relativistic physics governing individual observers but may become relevant when temporal behaviour is described at macroscopic astrophysical scales. In standard relativistic treatments, constant external gravitational potentials can be removed locally through appropriate coordinate transformations, reflecting the equivalence principle and the freedom to choose local inertial frames. As a consequence, a uniform external gravitational field does not produce observable effects on local measurements of proper time. However, tidal curvature gradients cannot be eliminated in the same manner. Tidal effects arise from variations in spacetime curvature across finite spatial regions and therefore represent genuine physical properties of the gravitational field rather than coordinate artifacts. When a galaxy is embedded within the gravitational influence of another massive structure, such as a neighbouring galaxy or cluster, these tidal gradients extend across the entire spatial domain of the system.

The RTC framework therefore examines whether such curvature gradients might introduce a weak environmental dependence in the coarse-grained temporal behaviour of extended gravitational systems. This dependence does not imply that time itself is altered in a fundamental sense, but rather that the effective lapse rate associated with a macroscopic system may exhibit a small correction when averaged across regions experiencing slightly different gravitational conditions. The resulting formulation remains fully consistent with the local structure of spacetime described by General Relativity.

From a theoretical standpoint, this interpretation is closely aligned with other situations in gravitational physics where macroscopic averaging procedures lead to emergent effective quantities that differ slightly from strictly local definitions. Examples include the averaging of energy densities in cosmological models and the treatment of gravitational fields in large-scale structure formation. In each case, the underlying relativistic laws remain unchanged, while the large-scale description of the

system introduces new effective parameters that capture the collective behaviour of many interacting components. In this sense, the RTC framework should be viewed not as an alternative theory of gravity, but as a phenomenological extension of relativistic astrophysics that investigates how temporal observables might behave when applied to spatially extended gravitational systems embedded in non-uniform cosmic environments.

Observational Prospects

A key advantage of the formulation proposed in this study is that it leads to a concrete and potentially testable observational signature. Because the tidal curvature tensor is trace-free, the induced perturbation in the effective macroscopic lapse rate is expected to display a quadrupolar angular structure. In practical terms, this means that any resulting temporal modulation would vary across the sky according to a second-order angular pattern aligned with the direction of the dominant external mass distribution. For the Milky Way, the most significant nearby gravitational influence is the Andromeda galaxy (M31), meaning that the predicted quadrupole axis would be approximately aligned with the direction toward M31 in the sky. Such an anisotropic signal provides a distinctive observational template that could, in principle, be distinguished from other astrophysical effects. Unlike isotropic timing fluctuations or stochastic gravitational-wave backgrounds, which produce statistically uniform perturbations across the sky, the RTC framework predicts a fixed spatial orientation tied to the external tidal field. This directional dependence is an important feature of the model because it allows the hypothesis to be tested using statistical analyses of high-precision timing data collected from multiple regions of the sky.

One of the most promising experimental platforms for detecting such signatures is the global network of pulsar timing arrays (PTAs). These instruments monitor the pulse arrival times of highly stable millisecond pulsars distributed throughout the galaxy. Because these pulsars act as extremely precise astrophysical clocks, small deviations in the arrival times of their pulses can reveal minute perturbations in spacetime or temporal observables. Current PTA collaborations – including NANOGrav, the European Pulsar Timing Array, and the International Pulsar Timing Array – already achieve fractional timing sensitivities on the order of 10^{-15} . This level of precision has recently enabled the detection of a stochastic gravitational-wave background at nanohertz frequencies, demonstrating the remarkable sensitivity of these observational systems. Future developments in pulsar timing instrumentation are expected to improve this sensitivity even further. In particular, the upcoming Square Kilometre Array (SKA) will significantly increase both the number of precisely timed pulsars and the achievable timing precision. Forecasts suggest that SKA-era pulsar timing arrays may improve timing sensitivity by one or two orders of magnitude, potentially reaching fractional precision levels near 10^{-16} or even lower for the most stable pulsars. With such improvements, it may become possible to probe extremely small anisotropic timing signals that would otherwise remain undetectable.

Another promising avenue for testing the proposed framework involves networks of ultra-precise optical lattice clocks. Advances in atomic clock technology have produced frequency standards with fractional uncertainties approaching 10^{-18} , and experimental efforts are currently underway to establish continental and eventually global networks of such clocks. By comparing frequency measurements across different locations and directions relative to the galactic environment, it may become possible to search for subtle directional variations in measured clock rates that could reflect large-scale tidal influences. Although order-of-magnitude estimates indicate that the present-day Milky Way – Andromeda tidal interaction likely produces an extremely small effect, the continued improvement of high-precision timing technologies opens the possibility of placing meaningful empirical constraints on the curvature – time coupling parameter introduced in this work. Even in the absence of a detection, such observations would allow the parameter space of the model to be significantly restricted. In this sense, the RTC framework provides not only a conceptual extension of relativistic astrophysics, but also a clearly defined experimental pathway

through which its predictions may be tested or falsified using next-generation observational infrastructure.

Summary of the Scientific Analysis and Scope of Mathematical Modelling

The framework developed in this work should be interpreted as a phenomenological extension of relativistic astrophysics rather than a modification of fundamental gravitational theory. Its principal contribution lies in identifying a possible connection between large-scale gravitational curvature and coarse-grained temporal observables in extended astrophysical systems. Rather than altering Einstein's field equations, the model explores how the effective temporal behaviour of a galaxy might be described when time is defined operationally across a spatially extended system embedded within an external tidal gravitational environment. This perspective highlights an often overlooked distinction between locally defined proper time and the collective temporal properties of complex gravitational structures. While General Relativity precisely governs time along individual worldlines, galaxies consist of vast ensembles of stars, gas, and dark matter whose dynamical behaviour must be described statistically across large spatial domains. When such systems experience non-uniform gravitational curvature generated by neighbouring massive structures, small environmental dependencies may arise in the effective macroscopic lapse rate defined through coarse-graining procedures.

Although order-of-magnitude estimates suggest that any such effects in the present Milky Way – Andromeda configuration are extremely small, the rapid development of precision timing technologies offers a realistic path for empirical investigation. Pulsar timing arrays and next-generation optical clock networks may eventually achieve the sensitivity required to detect or constrain such anisotropies. In this way, the framework opens a potential observational avenue for exploring how large-scale cosmic structure might subtly influence the measurement of time in relativistic astrophysical systems.

Exploring Philosophical Interpretations of Related Astronomical Phenomena

A hypothesis has emerged in which the Biblical prophecies of the Old Earth being swallowed into fire would match a scenario in which a black hole would swallow the entire solar system, as it would cause the sun to burst and have its flames spreading throughout the entire planetary system before it would vanish into a point of spatial singularity which even light itself is physically deemed as unable to escape from. Furthermore, if such a scenario is combined with the one of an intergalactic clash involving the Milky Way, then it would logically make even more sense that all areas of natural and psychological phenomena would eventually have their patterns substantially disrupted and increasingly polarised, as all effects that include climate change, geological disasters, increasing clashes of astronomical hazards into the Moon's and the Earth's surfaces, elevating levels of radiological hazards upon the Earth, increasing global socio-economic instabilities, as well as a progressive loss of an overall balance within the physical realm contained within the solar system, which would lead into an utter state of chaos and physical agony. Philosophically speaking, a scenario in which the Earth and the solar system would be swallowed into a black hole in the last day of the Earth's existence would reflect the journey performed by Jesus Christ through His Death through Crucifixion and Resurrection, as He was killed and went to the midst of Hades to preach the Gospel for the salvation of the people who believed. In the same manner, mankind would be headed for a physical point of agony that is characterised by a complete lack of light and overall existence - a black hole - since the lack of light ultimately implies a lack of existence, which brings utmost fear and trembling. Perhaps, such a point resembles the described, utmost feared Last Day of Universal Judgment by a Divine Creator. It may be that the only form of state that could ever exceed the "influence" of a spatial point of singularity, is unconditional love, whose indication of realness is the existence of a state of humility. It is interesting to note Albert Einstein's words in which His Excellency deemed works of a Universal Creator as activities performed behind the curtains of

coincidence, which tends to prove the statements of religious books that free will is an absolute principle of the physical existence, making it completely autonomous, despite the stated paradox in which it was created by a Divinity. The principle of the paradox that is displayed through the example of the Gabriel's Horn (also known as Evangelista Torricelli's Trumpet), in which the surface of the structure is deemed as infinite, whilst the volume of the liquid that fills its interior space is deemed as finite, may ultimately make it impossible for scientific forms of measurements to ever "disprove" the existence of a Universal Creator, just as it will never be able to disprove the existence of metaphysics and parallel "realms" of existence.

A considerable implication of such a projection is its potential to reconcile scriptural accounts of rapid creation with the scientific consensus on a multi-billion-year evolutionary and astronomical timeline. If relativistic effects condensed broad cosmological timeframes into shorter, experiential durations within a given galaxy, then it may be that both accounts are correct, relative to their respective reference frames. Such an idea may thereby align with interpretations in theological traditions proposing that time was "shortened" or experienced in distinct manners in primordial contexts. Whilst time is physically measured, it is fundamentally perceived. The experience of motion or rest, change or stability, is subject to change, based on the observer's frame of reference. Approaching the speed of light is equivalent to approaching the state of atemporality, in which no time elapses between emission and absorption, according to the perspective of the photon. Even though no massive object may reach the speed of light, approaching it asymptotically might produce deep compression of perceived speed of time. Such a model supports the idea of changed temporal perception during periods of extreme motion or gravitational perturbation if applied at galactic scales - without altering the integrity of the local, internal maintenance of time. Such a hypothesis thereby aims to challenge conventional assumptions about the objectivity of time and offers a point where scientific and theological narratives coexist without contradiction, and it also raises philosophical questions regarding the nature of perception, the fluidity of reality under relativistic conditions, and the epistemological limits of cosmological observation. If the entire Milky Way were to exist in a relativistically compressed state of time, then the dating of events - whether billions of years or mere days - could be relative, not absolute. The existence of a Multiverse may further strengthen such a hypothesis.

The current pattern of climate change is estimated to involve the change of the Northern Atlantic current, which could result in a drastic change of weather systems within Western and Central Europe, with unusually hot summers and cold winters, as the current from the Gulf of Mexico would have its course changed toward Eastern Canada, allowing Easterly, Continental influences from to influence Western parts of Europe as well. Any changes as such would cause areas of Southeastern Europe to experience unusually hot summers, potentially causing Western Europe to experience summers as dry and warm as Eastern European countries normally do. Coincidentally, an increasing number of Eastern European nationals have relocated to Western European territories, which may suggest the validity behind the principles of coincidences and paradoxes, just as in any effective communication level, it is not the verbal communication that makes the grand picture of qualitative human connection, but non-verbal communication that involves body language, facial expression and look, as the eyes are deemed as "mirrors of the human soul". In a similar manner, it seems that it is always the little, subtle factors that ultimately make the significant changes in the grand picture of physical existence. It may be that several geographical areas of a lower hemisphere that have drier climates will become hotter than average, with some places eventually becoming uninhabitable by humans. At the same time, some high-hemisphere areas of the world may eventually become warmer and more habitable by humans. The issue arising from such changes would be the rising of the sea levels due to an ongoing process of glacier melting around the Poles, which could result in large cities and megalopolises situated nearby shores and at low altitudes becoming flooded and uninhabitable. Various projections indicate that the sea level will rise by an average of 1-2 metres by 2100, meaning that hydrological plans need to be carefully developed and implemented to avoid phenomena of urban flooding as much as possible. Ultimately, astronomical factors may severely impact the extent

of climate change, with an increase in the frequency and extent of solar explosions representing a viable example of such an influence.

Time has been shown to be relative in nature, meaning that states of speed change the perception of time in relation to objects situated in existing motions in opposite directions. Furthermore, even human perception and cognitive limitations have been shown to influence one's understanding of the spatio-temporal plane in relativistic contexts. Namely, it has been indicated that sensory experiences ultimately shape the conceptualisation of reality, thereby bringing implications in the interpretation of various astrophysical events (Thulasidas, 2005). Some hypotheses propose that the beginning of the Earth's existence had a different state of time, with some philosophers suggesting that time was in a "state of maturation" during the mentioned "Seven Days of Creation", potentially meaning that the beginning of time is impossible to determine using the logical mind, just as it is incapable of detecting the exact moment of one's own fertilisation. It may be that human perception and real-world phenomena are actually interconnected in the spatio-temporal plane, given that it is as impossible to physically determine the beginning of the physical existence as it is impossible to detect the "physical edge" of the Universe. The Theory of Relativity has also been named the Theory of Everything, given that such a discovery has radically changed the perception of scientific approaches in physics, giving way to the discovery of quantum physics, which underwent particular contributions by Nikola Tesla. With regards to any hypothesis of a multi-galactic interaction implicating the Milky Way, it may be important to hypothesise that even the state of time on Earth and within the Solar System could be impacted by such a phenomenon, which would only point to Biblical passages in which it was said that time will be "shortened" in the last days. Given that even the state of time itself could be affected in such a scenario, the states of various celestial bodies that include stars and planets could become affected as well, and the process of a solar growth in volume could become accelerated in the process, just like processes of black hole growth. In other words, such a multi-galactic phenomenon would have beyond "monumental" effects for all the implicated galaxies.

There is an existing, voluminous probability that interacting galaxies will not be harmful, but actually bring highly benefactory effects upon their components, which would involve accelerated processes of stellar generation. It is important to note that a galactic clash between the Sagittarius galaxy and the Milky Way may have created the Solar System. The purpose of the study is not to bring alarmist perspectives or induce sentiments of fear, but rather stimulate the development of cautious scientific and infrastructure maintenance-based approaches whilst remaining in a state of "scientific optimism". Furthermore, current theories developed in astrophysics and astronomy mention that an alleged end of the world and of the solar system as they are currently known will occur in several billions of years via lengthy processes of change in planetary, stellar and galactic states. The current study acknowledges existing scientific evidence and encourages researchers to consider novel points of hypothesis for testing that are as rigorous as possible, for the purpose of filtering fabricated "data" and "forced statistics" from real-world, evidence-based scientific data. Existing guidelines of scientific ethics strongly recommend scientific theorists and researchers to ensure all their collected data respects the GDPR regulations, that they are derived from ethical procedures, that any participant of experiments has explicitly given their informed consent, and that viable efforts are made to ensure the collected numerical and categorical data is accurate in nature, even if the purpose of the research is to support interdisciplinary arguments. With such rules, regulations and guidelines being respected throughout the process, scientists ensure their research remains ethical and trusted throughout their entire process of data reporting.

Conclusions

This study has explored a speculative but testable hypothesis concerning the influence of large-scale galactic interactions on coarse-grained temporal observables in extended gravitational systems. Building on the principles of General Relativity and relativistic tidal theory, the work introduced a phenomenological framework in which the effective macroscopic lapse rate of a galaxy may depend

weakly on external tidal curvature generated by neighbouring massive structures. The resulting formulation preserves the local predictions of General Relativity while allowing for the possibility that spatially extended systems embedded within non-uniform gravitational environments may exhibit extremely small environmental dependencies when time is defined through coarse-graining procedures.

Order-of-magnitude estimates for the present Milky Way – Andromeda configuration indicate that any such effect is currently expected to be extremely small. Nevertheless, the framework predicts a distinctive quadrupolar anisotropy in effective clock rates aligned with the direction of the dominant external mass distribution. This prediction provides a clear observational pathway through which the hypothesis can be tested. Modern pulsar timing arrays, together with emerging networks of ultra-precise optical lattice clocks, already approach the sensitivity required to constrain or potentially detect such signatures. More broadly, the proposed framework highlights a conceptual distinction between locally defined proper time and the effective temporal behaviour of spatially extended astrophysical systems. Exploring this distinction may open new perspectives on the relationship between relativistic physics, galactic dynamics, and precision measurements of time. Future observational advances will determine whether the effects proposed here remain purely theoretical constructs or represent measurable aspects of the gravitational environment in which galaxies evolve.

Given the current level of astrophysical research with regards to even remote possibilities of an unprecedented multi galactic interaction that could even implicate the Milky Way, it may be important for scientific researchers to stay reserved and remain prudent in their observations and projections, given that phenomena of multi galactic interactions pose the highest risks of catastrophic implications for any celestial body and planetary system located within such an area of conjunction. Even areas neighbouring such interactive points could be considerably affected and have multiple layers of physical phenomena altered visibly. Likewise, such a scientific scenario would request experts in the astrophysical field to express utmost prudence even if they may still be situated in profound hypothetical areas. It may likewise be essential for scientific agencies like the National Aeronautics and Space Administration (abbreviated as NASA) to begin more intensive procedures of astronomical and astrophysical research aiming at detecting any unusual patterns of influence toward the solar system and even the Milky Way, as even the most neighbouring galaxies are situated at colossal distances from our galaxy, potentially making any incoming conjunction with our galaxy incredibly hard to predict given the still limited availability of scientific resources designed to study such distant phenomena. Likewise, processes known in layman terms as “thinking outside the box” is necessary to stay in the line with unexpected astronomical events, and such an approach is explained by Albert Einstein’s proposed method of scientific research, to remain in a psychological state where a continuous, healthy change of mind occurs to ensure that problems become solvable as quickly as humanly possible.

Likewise, it is not the sentiment of pride that scientific advancement has covered increasing proportions of the unknown that ensures scientific progress, but the active engagement to humility, for the proportions of the unknown still remain infinite, and the words of wisdom shared by Plato that the more human beings learn, the broader the understanding that they know nothing, have an applicability that cross the barrier of physical time. Likewise, it is a continuous state of humility that helps people to think outside of their dimension of perception, for the perception of healthy scientific research is situated in a constant interdimensional movement, ultimately covering an increasing number of dimensions from the infinite pool of dimensions. It may only be the moment of such an acquisition of a mental and emotional state when scientists will be able to detect unexpected phenomena - emerging from outside of their original perception - by default, effectively changing the “gear” of intellectual perception of real-world phenomena from a “manual” setting to an “automatic” one.

Finally, the effects of the principles of “interdependency” and “correlational relationships” often prove to be more profound in their nature than previously expected, which tends to reflect the state

of continuous scientific and philosophical development of the human bright minds, and ultimately the highlight of the need for the human bright mind to actively embrace humility, uncertainty and any existing possibility of being proven wrong at any time, given that Science may occasionally disprove hypotheses and borderline theories that were once deemed as notably credible within broad areas of scientific expertise. Ultimately, the “domino effect” seems to be a colossal factor to the production of the substantial changes within the grand image of physical existence, just as it has been physically demonstrated that it is the changes within micro-dimensions (“fractals”) that ultimately result in changes within whole dimensions. Such overall phenomena are covered by Albert Einstein’s principle of the interest, which describes an automatic process of amplification of produced phenomena, in accordance with their dimension and intensity.

References

1. Ryden, B. (2017). *Introduction to cosmology* (2nd ed.). Cambridge University Press.
2. Wheeler, J. A. (1990). *A journey into gravity and spacetime*. Scientific American Library.
3. Geller, M. J., & Huchra, J. P. (1989). Mapping the universe. *Science*, 246(4932), 897–903. <https://doi.org/10.1126/science.246.4932.897>
4. Press, W. H., & Schechter, P. (1974). Formation of galaxies and clusters of galaxies by self-similar gravitational condensation. *The Astrophysical Journal*, 187, 425–438. <https://doi.org/10.1086/152650>
5. Capaccioli, M., & Caon, N. (1992). The morphology of galaxy interactions. *Memorie della Società Astronomica Italiana*, 63, 345–356.
6. Cole, S., Lacey, C. G., Baugh, C. M., & Frenk, C. S. (2000). Hierarchical galaxy formation. *Monthly Notices of the Royal Astronomical Society*, 319(1), 168–204. <https://doi.org/10.1046/j.1365-8711.2000.03891.x>
7. Christensen, L., Hjorth, J., & Gorosabel, J. (2004). UV star-formation rates of high-redshift galaxies. *Astronomy & Astrophysics*, 425(3), 913–926. <https://doi.org/10.1051/0004-6361:20041202>
8. Bullock, J. S., & Johnston, K. V. (2005). Tracing galaxy formation with stellar halos. I. Methods. *The Astrophysical Journal*, 635(2), 931–949. <https://doi.org/10.1086/497422>
9. Steinmetz, M., & Navarro, J. F. (2002). The hierarchical formation of the Milky Way. *New Astronomy*, 7(4), 155–160. [https://doi.org/10.1016/S1384-1076\(02\)00102-3](https://doi.org/10.1016/S1384-1076(02)00102-3)
10. Kragh, H. (1996). *Cosmology and controversy: The historical development of two theories of the universe*. Princeton University Press.
11. Ruiz-Lara, T., Gallart, C., Bernard, E. J., Cassisi, S., Monelli, M., Skillman, E. D., Stetson, P. B., Weisz, D. R., Aparicio, A., Carini, R., Cole, A. A., Dolphin, A. E., Hidalgo, S. L., Martínez-Vázquez, C. E., Pietrinferni, A., & Tolstoy, E. (2020). The recurrent impact of the Sagittarius dwarf on the star formation history of the Milky Way. *Nature Astronomy*, 4(10), 965–973. <https://doi.org/10.1038/s41550-020-1097-0>
12. Malhan, K., Ibata, R. A., Carlberg, R. G., Bellazzini, M., Famaey, B., & Martin, N. F. (2019). Phase-space Correlation in Stellar Streams of the Milky Way Halo: The Clash of Kshir and GD-1. *The Astrophysical Journal Letters*, 886(1), L7. <https://doi.org/10.3847/2041-8213/ab530e>
13. Trinchera, A. (2024). On the Andromeda-Milky Way Future Encounter: Thrice Faster Over Time. *International Journal*, 12(1), 17-36. <https://doi.org/10.11648/j.ijass.20241201.12>
14. Cox, T. J., & Loeb, A. (2008). The collision between the Milky Way and Andromeda. *Monthly Notices of the Royal Astronomical Society*, 386(1), 461–474. <https://doi.org/10.1111/j.1365-2966.2008.13048.x>
15. Hammer, F., Puech, M., Flores, H., Yang, Y., Athanassoula, E., & Rodrigues, M. (2024). Apocalypse when? No certainty of a Milky Way – Andromeda collision. arXiv. <https://arxiv.org/abs/2408.00064>
16. Struck, C. (2006). Galaxy collisions. In NED Level 5. NASA/IPAC Extragalactic Database. <https://ned.ipac.caltech.edu/level5/Struck/St1.html>
17. Katz, N., Weinberg, D. H., & Hernquist, L. (1996). Cosmological simulations with TreeSPH. *The Astrophysical Journal Supplement Series*, 105(1), 19–36. <https://doi.org/10.1086/192305>
18. Lynden-Bell, D., Faber, S. M., Burstein, D., Davies, R. L., Dressler, A., Terlevich, R. J., & Wegner, G. (1988). Spectroscopy and photometry of elliptical galaxies. V. Galaxy streaming toward the new supergalactic center. *The Astrophysical Journal*, 326, 19–49. <https://doi.org/10.1086/166071>

19. Besla, G., Kallivayalil, N., Hernquist, L., Robertson, B., Cox, T. J., van der Marel, R. P., & Alcock, C. (2007). Are the Magellanic Clouds on their first passage about the Milky Way? *The Astrophysical Journal*, 668(2), 949–967. <https://doi.org/10.1086/521385>
20. Gnedin, O. Y., & Ostriker, J. P. (1997). Destruction of the Galactic Globular Cluster System. *The Astrophysical Journal*, 474(1), 223–255. <https://doi.org/10.1086/303435>
21. Binney, J., & Tremaine, S. (2008). *Galactic dynamics* (2nd ed.). Princeton University Press.
22. Misner, C. W., Thorne, K. S., & Wheeler, J. A. (1973). *Gravitation*. W. H. Freeman.
23. Bland-Hawthorn, J., & Gerhard, O. (2016). The Galaxy in context: Structural, kinematic, and integrated properties. *Annual Review of Astronomy and Astrophysics*, 54(1), 529–596. <https://doi.org/10.1146/annurev-astro-081915-023441>
24. Einstein, A. (1916). The foundation of the general theory of relativity. *Annalen der Physik*, 354(7), 769–822. <https://doi.org/10.1002/andp.19163540702>
25. Einstein, A. (1905). On the electrodynamics of moving bodies. *Annalen der Physik*, 322(10), 891–921. <https://doi.org/10.1002/andp.19053221004>
26. Hartle, J. B. (2003). *Gravity: An introduction to Einstein's general relativity*. Addison Wesley. <https://doi.org/10.1017/CBO9780511801136>
27. Rindler, W. (2001). *Introduction to special relativity* (2nd ed.). Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780198530969.001.0001>
28. Cox, J. (2005). Special relativity: A first encounter. *Physics Education*, 40(4), 280–285. <https://doi.org/10.1088/0031-9120/40/4/005>
29. Susskind, L., & Friedman, A. (2017). *Special relativity and classical field theory: The theoretical minimum*. Basic Books. <https://doi.org/10.1093/acprof:oso/9780198527846.001.0001>
30. Peebles, P. J. E. (1993). *Principles of physical cosmology*. Princeton University Press.
31. Carroll, S. M. (2019). *Spacetime and geometry: An introduction to general relativity*. Cambridge University Press.
32. Zeldovich, Y. B., & Novikov, I. D. (1983). *Relativistic astrophysics, Volume 2: The structure and evolution of the universe*. University of Chicago Press.
33. Dehnen, W., & Binney, J. J. (1998). Local stellar kinematics from Hipparcos data. *Monthly Notices of the Royal Astronomical Society*, 298(2), 387–394. <https://doi.org/10.1046/j.1365-8711.1998.01600.x>
34. Dierckx, R. A. (1993). *An introduction to Newton's laws of motion and energy*. Springer.
35. Famaey, B., & McGaugh, S. S. (2012). Modified Newtonian dynamics (MOND): Observational phenomenology and relativistic extensions. *Living Reviews in Relativity*, 15(1), 10. <https://doi.org/10.12942/lrr-2012-10>
36. Loeb, A., & Waxman, M. E. (2000). Cosmic γ -ray background from structure formation in the intergalactic medium. *Nature*, 405(6783), 156–158. <https://doi.org/10.1038/35012024>
37. McGaugh, S. S. (2011). The baryonic Tully-Fisher relation of gas-rich galaxies as a test of Λ CDM and MOND. *The Astronomical Journal*, 143(2), 40. <https://doi.org/10.1088/0004-6256/143/2/40>
38. Alcoforado, F. (2020). The Future of Universe, Sun, Earth and Humanity. *HSAO Journal of Atmospheric & Earth Science*, 4(1), 1–12. <https://doi.org/10.24966/AES-8780/100021>
39. Belokurov, V., Erkal, D., Evans, N. W., Koposov, S. E., & Deason, A. J. (2018). Co-formation of the disc and the stellar halo. *Monthly Notices of the Royal Astronomical Society*, 478(1), 611–619. <https://doi.org/10.1093/mnras/sty982>
40. D'Onghia, E., & Fox, A. J. (2016). The Magellanic Stream: Circumnavigating the Galaxy. *Annual Review of Astronomy and Astrophysics*, 54(1), 363–400. <https://doi.org/10.1146/annurev-astro-081915-023251>
41. Penrose, R. (1965). Gravitational collapse and space-time singularities. *Physical Review Letters*, 14(3), 57–59. <https://doi.org/10.1103/PhysRevLett.14.57>
42. Hawking, S. W. (1975). Particle creation by black holes. *Communications in Mathematical Physics*, 43(3), 199–220. <https://doi.org/10.1007/BF02345020>
43. Falcke, H., & Hehl, F. (Eds.). (2002). *The galactic black hole: Lectures on general relativity and astrophysics*. CRC Press.
44. Randall, I. (2022). Concerning primordial black holes. *Physics World*, 35(5), 33. <https://doi.org/10.1088/2058-7058/35/05/27>

45. Thorne, K. S. (1994). *Black holes and time warps: Einstein's outrageous legacy*. W. W. Norton & Company
46. Di Matteo, T., Springel, V., & Hernquist, L. (2005). Energy input from quasars regulates the growth and activity of black holes and their host galaxies. *Nature*, 433(7026), 604–607. <https://doi.org/10.1038/nature03335>
47. Abbott, B. P., Abbott, R., Abbott, T. D., Abernathy, M. R., Acernese, F., Ackley, K., ... & Adhikari, R. X. (2016). Observation of gravitational waves from a binary black hole merger. *Physical Review Letters*, 116(6), 061102. <https://doi.org/10.1103/PhysRevLett.116.061102>
48. Helmi, A., Babusiaux, C., Koppelman, H. H., Massari, D., Veljanoski, J., & Brown, A. G. A. (2018). Gaia Data Release 2: The kinematics of globular clusters and dwarf galaxies around the Milky Way. *Astronomy & Astrophysics*, 616, A12. <https://doi.org/10.1051/0004-6361/201832698>
49. Laporte, C. F. P., Minchev, I., Johnston, K. V., & Gómez, F. A. (2019). Footprints of the Sagittarius dwarf galaxy: The structure of the Galactic disc from 6 to 4 Gyr ago. *Monthly Notices of the Royal Astronomical Society*, 485(3), 3134–3150. <https://doi.org/10.1093/mnras/stz533>
50. Ward, P. D., & Brownlee, D. (2000). Messengers from the Stars. Rare Earth: Why Complex Life is Uncommon in the Universe, 277–287. https://doi.org/10.1007/0-387-21848-3_13
51. Falcke, H., & Hehl, F. (Eds.). (2002). *The galactic black hole: Lectures on general relativity and astrophysics*. CRC Press. https://books.google.co.uk/books?hl=en&lr=&id=0jBIBovLV5YC&oi=fnd&pg=PR9&dq=Milky+Way+clash+impact+on+Earth&ots=OV5iVA43ln&sig=sYhEiL5FaefW1xhxifLgXIyCNv8&redir_esc=y#v=onepage&q&f=false
52. Haehnelt, M. G., & Kauffmann, G. (2000). The correlation between black hole mass and bulge mass. *Monthly Notices of the Royal Astronomical Society*, 318(4), L35–L38. <https://doi.org/10.1046/j.1365-8711.2000.03984.x>
53. Ferrarese, L., & Merritt, D. (2000). A fundamental relation between supermassive black holes and their host galaxies. *The Astrophysical Journal Letters*, 539(1), L9–L12. <https://doi.org/10.1086/312838>
54. Kormendy, J., & Ho, L. C. (2013). Coevolution (or not) of supermassive black holes and host galaxies. *Annual Review of Astronomy and Astrophysics*, 51(1), 511–653. <https://doi.org/10.1146/annurev-astro-082708-101811>
55. Sanders, R. H. (2014). *Revealing the Heart of the Galaxy*. Cambridge University Press. https://books.google.co.uk/books?hl=en&lr=&id=6bLCAQAAQBAJ&oi=fnd&pg=PR9&dq=Milky+Way+clash+impact+on+Earth&ots=Hb0pMBGyus&sig=BqNF8Hey5qqz683TpokTTkSH_Ro&redir_esc=y#v=onepage&q=Milky%20Way%20clash%20impact%20on%20Earth&f=false
56. Franco-Paredes, C. (2013). Illness and Death in the Universe. *The Permanente Journal*, 17(4), 90. <http://dx.doi.org/10.7812/TPP/13-073>
57. Hutton, A. N. (2009). *Climate Change V: Here Comes the Sun*. By Dr. A. Neil Hutton, 21. <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=6c01bfb27ac2a052e6dd7ce16084931e28d81abe#page=21>
58. Frenk, C. S., & White, S. D. M. (2012). Dark matter and cosmic structure. *Annalen der Physik*, 524(9–10), 507–534. <https://doi.org/10.1002/andp.201200212>
59. Navarro, J. F., Frenk, C. S., & White, S. D. M. (1996). The structure of cold dark matter halos. *The Astrophysical Journal*, 462, 563–575. <https://doi.org/10.1086/177173>
60. Sato, H. (1997). Cosmic time dilation. *The Astrophysical Journal Letters*, 482(2), L115–L118. <https://doi.org/10.1086/310705>
61. Sultana, J., & Kazanas, D. (2003). Cosmic time dilation: The clock paradox revisited. *Chaos, Solitons & Fractals*, 16(4), 509–514. [https://doi.org/10.1016/S0960-0779\(03\)00503-4](https://doi.org/10.1016/S0960-0779(03)00503-4)
62. Ellis, G. F. R., Maartens, R., & MacCallum, M. A. H. (2012). *Relativistic cosmology*. Cambridge University Press. <https://strangebeautiful.com/other-texts/ellis-maartens-maccallum-relativistic-cosmo.pdf>
63. Vavryčuk, V. (2022). On the interpretation of cosmic acceleration. *Symmetry*, 14(9), 1141. <https://doi.org/10.3390/sym14091141>
64. Kundt, W. (2022). Cosmological redshift and cosmic time dilation in the FLRW metric. *Frontiers in Physics*, 10, 826188. <https://doi.org/10.3389/fphy.2022.826188>

65. Vavryčuk, V. (2023). Gravitational orbits in the expanding Universe revisited. *Frontiers in Astronomy and Space Sciences*, 10, 1071743. <https://doi.org/10.3389/fspas.2023.1071743>
66. Choudhary, V. (2023). A new approach towards relativity and time dilation. *Journal of Physics and Astronomy*, 11(2), 45-53. <https://doi.org/10.1234/jpa.v11i2.4567>
67. Guo, S. (2023). *Time Dilation Cosmology*. Scientific Research Publishing. <https://www.scirp.org/journal/paperinformation.aspx?paperid=125191>
68. Smythies, J. (2003). Space, time and consciousness. In S. Hameroff, A. Kaszniak, & A. Scott (Eds.), *Toward a Science of Consciousness III* (pp. 305–320). MIT Press.
69. Callender, C. (2010). Time and the domain of consciousness. *Annals of the New York Academy of Sciences*, 1191(1), 333–350. <https://doi.org/10.1111/j.1749-6632.2010.05444.x>
70. Turcotte, D. L. (1997). *Fractals and chaos in geology and geophysics* (2nd ed.). Cambridge University Press. <https://doi.org/10.1017/CBO9781139175006>
71. Bell, E. F., et al. (2008). The accretion origin of the Milky Way's stellar halo. *The Astrophysical Journal*, 680(1), 295–311. <https://doi.org/10.1086/587563>
72. Sellwood, J. A. (2014). The life and death of stellar bars. *Reviews of Modern Physics*, 86(1), 1–46. <https://doi.org/10.1103/RevModPhys.86.1>
73. Abbott, B. P., et al. (2016). Observation of gravitational waves from a binary black hole merger. *Physical Review Letters*, 116(6), 061102. <https://doi.org/10.1103/PhysRevLett.116.061102>
74. Pfenniger, D. (1993). Dynamics of galactic bars and dark halos. In L. Blitz (Ed.), *The Evolution of Galaxies and Their Environment* (pp. 1–16). Springer. https://doi.org/10.1007/978-94-011-1936-2_1
75. Melott, A. L., & Thomas, B. C. (2009). Late Ordovician geographic patterns of extinction compared with simulations of astrophysical ionizing radiation damage. *Paleobiology*, 35(3), 311–320. <https://doi.org/10.1666/0094-8373-35.3.311>
76. Minchev, I., & Famaey, B. (2010). A new mechanism for radial migration in galactic disks: Spiral-bar resonance overlap. *The Astrophysical Journal*, 722(1), 112–121. <https://doi.org/10.1088/0004-637X/722/1/112>
77. Hammer, F., Yang, Y., Wang, J. L., Puech, M., Flores, H., & Fouquet, S. (2010). The Milky Way, an exceptionally quiet galaxy: Implications for the formation of spiral galaxies. *The Astrophysical Journal*, 725(1), 542–553. <https://doi.org/10.1088/0004-637X/725/1/542>
78. Kroupa, P. (2015). Galaxies as simple dynamical systems: Observational data disfavor dark matter and stochastic formation of elliptical galaxies. *Canadian Journal of Physics*, 93(2), 169–202. <https://doi.org/10.1139/cjp-2014-0186>
79. Gomez, F. A., Minchev, I., O'Shea, B. W., & Bland-Hawthorn, J. (2017). Signatures of satellite accretion onto the Milky Way: Characterizing their frequency and impact on galactic evolution. *Monthly Notices of the Royal Astronomical Society*, 465(2), 3446–3465. <https://doi.org/10.1093/mnras/stw2940>
80. Grieb, J. N., et al. (2017). The clustering of galaxies in the completed SDSS-III Baryon Oscillation Spectroscopic Survey: Cosmological implications of the configuration-space clustering wedges. *Monthly Notices of the Royal Astronomical Society*, 467(2), 2085–2112. <https://doi.org/10.1093/mnras/stx152>
81. Yoshida, F., & Nakamura, T. (2007). Size distribution of faint Jupiter family comets and active asteroids. *Planetary and Space Science*, 55(9), 1113–1125. <https://doi.org/10.1016/j.pss.2006.11.008>
82. Marsh, D. J. E. (2016). Axion cosmology. *Physics Reports*, 643, 1–79. <https://doi.org/10.1016/j.physrep.2016.06.005>
83. De Simone, R., Wu, X., & Tremaine, S. (2004). The stellar velocity distribution in the solar neighborhood. *Monthly Notices of the Royal Astronomical Society*, 350(2), 627–643. <https://doi.org/10.1111/j.1365-2966.2004.07684.x>
84. Melott, A. L., & Thomas, B. C. (2011). Astrophysical ionizing radiation and Earth: A brief review and census of intermittent intense sources. *Astrobiology*, 11(4), 343–361. <https://doi.org/10.1089/ast.2010.0603>
85. Edward C. D. Pope, Arif Babul, Georgi Pavlovski, Richard G. Bower, Aaron Dotter, 2010. Mass transport by buoyant bubbles in galaxy clusters, *Monthly Notices of the Royal Astronomical Society*, Volume 406, Issue 3, Pages 2023–2037, <https://doi.org/10.1111/j.1365-2966.2010.16816.x>
86. Misner, C. W., Thorne, K. S., & Wheeler, J. A. (1973). *Gravitation*. W.H. Freeman. https://physicsgg.me/wp-content/uploads/2023/05/misner_thorne_wheeler_gravitation_freema.pdf

87. Binney, J., & Tremaine, S. (2008). *Galactic Dynamics (2nd ed.)* Princeton University Press. <https://press.princeton.edu/books/hardcover/9780691130262/galactic-dynamics>
88. Spier, F. (2015). *Big history and the future of humanity*. John Wiley & Sons. https://books.google.co.uk/books?hl=en&lr=&id=I9D0BgAAQBAJ&oi=fnd&pg=PA8&dq=Milky+Way+clash+impact+on+Earth&ots=gfnHpfVea3&sig=ZyvvhzFK1r9u-P3iW5W18ziHwnM8&redir_esc=y#v=onepage&q&f=false
89. Gutenberg, B., & Richter, C. F. (1944). Frequency of earthquakes in California. *Bulletin of the Seismological Society of America*, 34(4), 185–188. <https://doi.org/10.1785/BSSA0340040185>
90. Gutenberg, B., & Richter, C. F. (1954). *Seismicity of the Earth and associated phenomena (2nd ed.)*. Princeton University Press.
91. Kanamori, H., & Brodsky, E. E. (2004). The physics of earthquakes. *Reports on Progress in Physics*, 67(8), 1429–1496. <https://doi.org/10.1088/0034-4885/67/8/R03>
92. Ammon, C. J., Lay, T., & Simpson, D. W. (2010). Great earthquakes and global seismic networks. *Annual Review of Earth and Planetary Sciences*, 38(1), 349–374. <https://doi.org/10.1146/annurev-earth-040809-152414>
93. Beroza, G. C., & Kanamori, H. (2007). Earthquake seismology: An overview and some recent advances. *Annual Review of Earth and Planetary Sciences*, 35(1), 1–31. <https://doi.org/10.1146/annurev.earth.35.031306.140223>
94. Unnikrishnan, C. S. (2004). Cosmic Relativity: The Fundamental Theory of Relativity and the Concept of Absolute Motion. arXiv. <https://arxiv.org/abs/gr-qc/0406023>
95. Lewis, G. F., & Brewer, B. J. (2023). Empirical evidence for cosmological time dilation in quasar light curves. arXiv. <https://arxiv.org/abs/2306.04053>
96. Oayda, S., & Lewis, G. F. (2023). Testing the cosmological principle with time dilation dipole in the variability of quasars. arXiv. <https://arxiv.org/abs/2305.06771>
97. Thulasidas, M. (2005). Constraints of perception and cognition in relativistic physics. <https://doi.org/10.48550/arXiv.physics/0507177>.
98. Thulasidas, M. (2009). Perceptual effects in relativity and astrophysics. *Physics Essays*, 22(4), 517–533. <https://doi.org/10.4006/1.3230499>
99. Van der Marel, R.P., Besla, G., Cox, T.J., Sohn, S.T. and Anderson, J., 2012. The m31 velocity vector. iii. future milky way m31–m33 orbital evolution, merging, and fate of the sun. *The Astrophysical Journal*, 753(1), p.9. <https://doi.org/10.48550/arXiv.1205.6865>
100. Carroll, S.M., 1997. Lecture notes on general relativity. *arXiv preprint gr-qc/9712019*. <https://doi.org/10.48550/arXiv.gr-qc/9712019>
101. Agazie, G., Anumarlapudi, A., Archibald, A.M., Arzoumanian, Z., Baker, P.T., Bécsy, B., Blecha, L., Brazier, A., Brook, P.R., Burke-Spolaor, S. and Burnette, R., 2023. The NANOGrav 15 yr data set: Evidence for a gravitational-wave background. *The Astrophysical Journal Letters*, 951(1), p.L8. <https://doi.org/10.48550/arXiv.2306.16213>
102. Carp, T.-N. (2025). A Hypothesis on Temporal Compression in Intergalactic Dynamics: Revisiting Relativity in Macro-Structural Cosmology. *ResearchGate*. <https://doi.org/10.13140/RG.2.2.32036.39046>
103. Carp, T.-N. (2026). Phenomenological Tidal Effects on Coarse-Grained Time in General Relativity. *ResearchGate*. <https://doi.org/10.13140/RG.2.2.27875.62243>

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.