EXPANSION-DEFINED RELATIVITY (EDR)

A conceptual framework by David Suttle

Abstract

This paper proposes an Expansion-Defined Relativity (EDR) framework, in which a physical expansion field sets both the local rate of expansion of space and the local rate of time. Variations in this field, driven by the distribution of mass-energy, cause different regions of the universe to evolve at different time rates. When observations made from within one region are applied to others, these differential time rates generate several large-scale apparent phenomena, including the inferred presence of dark energy, dark matter, a single cosmic age, and a sudden beginning (big bang).

EDR provides a scalar-field mechanism that yields the same classical gravitational observables as General Relativity in tested regimes, while offering a distinct physical foundation. In this framework, cosmic voids evolve on faster clocks, producing the apparent acceleration of expansion; galactic outskirts experience outward expansion-field gradients that raise orbital velocities; early-time suppression yields an apparent origin without requiring a singular boundary or an inflation field; and large-scale structure emerges from expansion-driven void formation rather than matter-driven collapse.

Because late-time behaviour depends primarily on how suppression and expansion interact, many global features become insensitive to the precise initial state, allowing EDR to accommodate both an apparent Big-Bang-like beginning and an underlying evolution that may be arbitrarily old. The result is a coherent physical picture in which several longstanding cosmological puzzles - arising when comparing regions that evolve at different rates - are resolved naturally, without requiring additional components or finely tuned initial conditions.

1. Introduction

Expansion-Defined Relativity (EDR) treats the expansion field, ϕ, as a physical quantity whose local strength determines the local rate of time, $d\tau$. Rather than introducing new components or modifying existing laws, EDR focuses on how variations in the expansion field shape the behaviour of clocks, trajectories, and large-scale evolution. This perspective provides a scalar-field foundation for gravitational and cosmological phenomena, reproducing the validated predictions of General Relativity without relying on geometric curvature as the underlying mechanism.

The central idea is simple: local time runs at a rate set by the local expansion field. Where the field is suppressed by mass-energy, ρ, time slows; where it is unsuppressed, time runs faster. The consequences of this relationship become increasingly significant at large scales, where differences in suppression accumulate across cosmic structures.

Key principles:

- Expansion is an intrinsic property of space.
- Expansion and time are inseparable; they are the same physical process – two sides of the same coin.
- The passage of time is the local rate at which space expands, defining the pace of motion, light frequencies, and quantum phase evolution.
- Mass-energy suppresses expansion, slowing the local rate of time.

- Gravity is motion along gradients in suppressed expansion (and hence suppressed time).
- Expansion is not embedded in time; it is the physical process that generates time.

Think of the expansion field as a local "heartbeat" of space: where mass damps that heartbeat, clocks slow; where expansion is unhindered, clocks run faster.

Because the local rate of time is directly tied to the local expansion field, EDR provides a unified picture of gravitational time dilation, black hole horizons, cosmic acceleration, and the large-scale structure of the universe.

2. Conceptual Foundations of Expansion-Defined Relativity

2.1 The Expansion Field as a Physical Quantity

In EDR, the expansion of the universe is treated as a physical field whose local strength determines the local rate of time. Regions with higher mass-energy suppress this field, causing time to run more slowly; emptier regions experience less suppression and therefore evolve more quickly. This principle provides the physical basis for the differential time rates that underpin all later results.

2.2 Local Time Rates and Observational Asymmetry

Because each region evolves according to its own expansion-defined clock, observations made from one region and applied to another inevitably mix different evolutionary stages. This mismatch produces several apparent large-scale effects - behaviours that look like new components or dramatic events when interpreted through a single, universal time rate.

2.3 Suppression, Gradients, and the Structure of the Universe

Mass-energy suppresses the expansion field, creating gradients that shape cosmic structure. Voids, experiencing minimal suppression, evolve rapidly and expand into their surroundings. Denser regions evolve more slowly, allowing voids to grow and push matter into sheets, clusters, and filaments. This expansion-driven mechanism naturally generates the observed large-scale structure without requiring matter-dominated collapse as the primary driver.

2.4 Apparent Phenomena from Differential Evolution

When regions with different time rates are compared from a single vantage point, several longstanding cosmological puzzles emerge as apparent phenomena - perspective illusions:

- Apparent acceleration arises because fast-running voids are observed from slower-running regions (Dark Energy).
- Apparent dark matter emerges from outward expansion-field gradients that raise orbital velocities in galactic outskirts (Dark Matter).
- Apparent early-time behaviour results from strong suppression in the deep past, giving the impression of a sudden beginning (Big Bang).
- Apparent uniformity follows from the fact that regions we observe at the same cosmic distance are not at the same physical age.

These effects are not added components, but a natural consequence of comparing regions that evolve at different speeds.

2.5 Insensitivity to Initial Conditions

Many late-time behaviours depend primarily on the interaction between suppression and expansion, not on finely tuned initial states. This allows the universe to appear to have begun in a hot, dense state even if its underlying history is far older. The model therefore accommodates both an apparent Big-Bang-like origin and an arbitrarily extended underlying evolution without contradiction.

3. Physical Consequences

Preface

EDR provides a scalar-field description of gravity that reproduces the same classical observables as GR while offering a different physical origin for time, gravity, and cosmic evolution. Because regions evolve at different time rates, many large-scale features become insensitive to the precise initial state, with late-time behaviour shaped primarily by how suppression and expansion interact. Measurements made from within one region can therefore create the appearance of additional components or abrupt events.

3.1 Refractive Gravity and Light Bending

Mass-energy suppresses both the local rate of time and the local scale of space. This “double suppression” acts like a refractive index, matching Eddington’s light-bending tests (1.75 arcseconds). In EDR, this is simply the consequence of light passing through a region where the expansion “heartbeat” has been dampened by mass.

3.2 Black Holes as Gradient Horizons

In EDR, a black hole is not a singular boundary but a region where the expansion field becomes extremely small. As mass-density increases, the field is progressively suppressed, and the rate of time slows accordingly. The “event horizon” is therefore not a sharp surface but the region where the gradient of suppressed expansion becomes extremely steep.

This gradient-based horizon removes the strict one-way nature of black holes. Outward motion is not forbidden; it is simply governed by a region of extremely slow time. Escape is possible in principle, but would require an external duration so long that it is observationally irrelevant. The horizon behaves like a practical barrier, not an absolute one.

Because time never reaches zero in finite proper time, no true singularity forms. Collapse simply slows as the field decreases, producing a “frozen” interior rather than an infinite-density point.

3.3 Voids and the Apparent Acceleration of Expansion

In low-density cosmic voids, expansion is unsuppressed and time runs faster. Using “slow” clocks inside galaxies to measure “fast” void expansion creates the appearance of acceleration - the effect attributed to dark energy. This is an observational illusion arising from differential expansion-driven time rates.

3.4 Galactic Outskirts and the Apparent Need for Dark Matter

At the edges of galaxies, stars sit closer to surrounding cosmic voids where the expansion field is higher and time runs faster. This creates an outward gradient that boosts orbital velocities without requiring additional unseen mass. The apparent need for dark matter is therefore an artefact of comparing regions with different expansion-defined time rates.

3.5 Early-Time Behaviour and the Apparent Beginning

When the universe's mass was concentrated in a small volume, expansion was maximally suppressed everywhere. From within the universe, this appears as a sudden beginning and rapid early evolution (Big Bang). Because early-time evolution occurred on uniformly slow clocks, many large-scale features become insensitive to the precise initial state. No separate inflation field is required.

Void growth produces a foam-like cosmic web: under-dense regions expand more rapidly and push matter into walls and filaments, producing a structure that resembles a foam of cells separated by thin boundaries.

3.6 Large-Scale Structure from Void Growth

In EDR, the large-scale structure of the universe is driven by the growth of voids rather than the collapse of over-densities. Regions with slightly lower density in the early universe had slightly higher expansion rates, so their local time ran faster and they expanded more quickly. These regions became voids whose growth accelerates as the expansion field increases.

Matter is pushed outward by the resulting gradients and collects at void boundaries, forming the familiar network of filaments, walls, and clusters. Because voids dominate the cosmic volume and run on faster clocks, the large-scale structure, the apparent acceleration, and the Hubble tension all arise from the same underlying differential expansion.

3.8 The Arrow of Time

Because the expansion field defines the local rate of time, its global behaviour sets the direction of time itself. Expansion is intrinsically monotonic: the field increases and is never reversed. Mass-energy can locally suppress it, slowing time, but there is no mechanism to drive it backwards. The arrow of time therefore arises directly from the universe's expansion.

3.7 Quantum Time

Quantum phase evolution depends on proper time. If proper time is defined by expansion, then quantum frequencies, decay rates, and oscillations are governed by the same field that governs gravity and cosmology.

4. Mathematical Structure

4.1 The Unitary Metric

Time and space are tethered to the same expansion-sink mechanism. The metric is expressed as:

$$ds^2 = -F(\phi)^2 c^2 dt^2 + F(\phi)^2 (dr^2 + r^2 d\Omega^2)$$

This ensures correct light-bending and Shapiro delay by scaling both clocks and yardsticks through the same field.

4.3 The Sink Equation

$$\nabla^2 \phi = \alpha \rho$$

Mass acts as a sink for ϕ, creating a gradient that recovers the inverse-square law of gravity. ϕ approaches a constant background value in low-density voids, providing the boundary condition for the sink equation. In the weak-field limit, small perturbations in ϕ reproduce the Newtonian potential and the inverse-square law.

4.4 GR Recovery Condition

$F(\phi)$ is a monotonic function ensuring that suppressed expansion corresponds to slower time and reduced spatial scale. EDR is constructed so that its scalar-field dynamics reproduce all classical gravitational tests in the weak-field limit. This ensures observational continuity with GR where its predictions have been validated, while allowing the underlying physical mechanism to differ:

$$F\big(\phi(r)\big)^2 \approx 1 + \frac{2\phi(r)}{c^2}$$

ensuring consistency with:

- Mercury's perihelion shift
- gravitational redshift
- light bending
- Shapiro delay
- GPS-level time dilation

5. Falsifiable Predictions

Clocks in deep cosmic voids should tick measurably faster than clocks in galaxies, and this difference should show up both in precision timing measurements and in the way local and global methods infer different values of the Hubble constant (the Hubble tension).

EDR also predicts an environmental signature in galactic rotation curves. Galaxies located near large cosmic voids should show slightly higher outer rotation speeds than similar galaxies in denser regions, because the outward expansion-field gradient is stronger. This creates a simple, testable correlation between rotation-curve shape and proximity to voids, offering a clear observational check on the EDR framework.

6. Plain-English Summary

Imagine the universe at the largest scale as a "foam" consisting of regions that age at different rates, with the foam bubbles being cosmic voids and the boundaries between bubbles being where mass has accumulated.

The central idea of EDR is that the universe's expansion is not just something happening in time - it is something that sets the rate of time itself. Regions with more mass-energy slow the expansion field and therefore run on slower clocks; emptier regions run faster. When we observe distant parts of the universe from our own time-rate, these differences create several apparent large-scale effects that look like extra components or dramatic events, even though they arise naturally from comparing places that age at different speeds.

In this picture, fast-running voids make it look as if the universe's expansion is speeding up; slowed-down galactic outskirts make stars orbit faster than expected; early-time suppression makes the universe appear to have a sudden beginning; and the large-scale structure of the cosmos grows inevitably from the way expansion pushes matter aside, not from matter pulling itself together.

Because the behaviour we see today depends mostly on how expansion and suppression interact - not on a finely tuned starting point - the universe can appear to have begun in a hot, dense state even if its underlying history is far older. The Expansion-Defined Relativity framework therefore offers a simple and coherent physical explanation for several longstanding puzzles with a physical mechanism that is easy to visualise.

Collaboration Invitation

This paper sets out the core idea behind Expansion-Defined Relativity (EDR): that the rate of time is the rate of expansion, and that mass-energy slows both. The aim here isn't to present a finished theory, but to lay out a clear conceptual foundation that ties together gravity, time, cosmology, and several long-standing anomalies in a single, coherent way.

The next stage is to turn this framework into a full mathematical structure. That will need people with the right background in GR, scalar-field theory, cosmology, or related areas who can see the potential in the underlying idea and want to help shape it into something formal and testable.

If the core principle resonates with you - or if you can see a way to push the maths further - I'd welcome a conversation.