Radiation, Light Bending, and Large-Scale Phenomena in NUVO Theory

Part 6 of the NUVO Theory Series

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May 26, 2025

Abstract

This paper extends the NUVO theory to phenomena involving massless particles, field propagation, and global modulation. We explore how light bending, Shapiro delay, and orbital decay emerge from the scalar field $\lambda(t, r, v)$, even in a flat-space geometry. A key conceptual refinement is the treatment of photons as pinertia-free entities—encapsulated geometry that does not modulate λ locally, but instead responds to sinertial gradients in the field. These predictions diverge subtly from general rel...

1 Introduction

The NUVO theory proposes a conformally scaled flat-space geometry in which gravitational and relativistic effects emerge from a scalar modulation field $\lambda(t, r, v)$, rather than from spacetime curvature [1]. This scalar field, derived from the normalized sum of relativistic kinetic energy and Newtonian gravitational potential, encodes variations in local inertial and temporal structure without invoking Riemannian geometry.

In **Series 1**, we derived the form of the scalar field from first principles and showed how it recovers Newtonian gravity and post-Newtonian corrections in the appropriate limits. **Series 2** extended this framework to define the conformally scaled metric, compute Christoffel symbols, and derive geodesic motion under scalar modulation. **Series 3** demonstrated that NUVO accurately reproduces general relativistic effects such as gravitational redshift and perihelion advance through this scalar structure, validated by both symbolic derivation and numerical integration.

This fourth installment investigates NUVO's predictions for phenomena where spacetime curvature plays a central role in general relativity: gravitational time dilation, orbital decay in binary systems, and observational effects such as light bending and Shapiro time delay. We compare these predictions to those of general relativity and special relativity, focusing on measurable quantities that have been tested to high precision in satellite, astrophysical, and laboratory contexts.

A novel feature introduced in this paper is the treatment of photons and massless particles. In NUVO, photons are modeled as pinertia-free carriers—localized packets of geometry that do not induce modulation in λ, but respond to sinertial gradients in the scalar field. This allows light to follow geodesics in a modulated flat space without invoking a curved metric, offering a unique perspective on phenomena such as gravitational lensing and propagation delay.

Throughout this work, we present both symbolic derivations and numerical simulations. We analyze the proper time accumulated by orbiting and stationary observers, the secular advance of orbital phase over time, and the propagation of light in a scalar-modulated environment. Where applicable, results are compared directly to general relativity and experimental data. In all cases, NUVO is shown to recover empirically validated behavior while offering an alternative, testable mechanism grounded in scalar field dynamics.

This paper is organized as follows: Section **??** covers gravitational time dilation and its empirical implications. Section **??** derives orbital decay from scalar modulation. Section **??** explores light propagation and time delay effects. The appendices provide derivations, simulation methods, and comparative tables.

2 Null Geodesics in NUVO

In NUVO theory, photons are treated as massless, pinertia-free entities that traverse geodesics defined by the scalar-modulated flat metric:

$$g_{\mu\nu}(t, r, v) = \lambda^2(t, r, v)\, \eta_{\mu\nu},$$

where $\eta_{\mu\nu}$ is the Minkowski metric and $\lambda(t, r, v)$ encodes local modulation of inertial and temporal structure.

For massless particles, the line element satisfies the null condition:

$$ds^2 = \lambda^2(t, r, v)\, \eta_{\mu\nu} dx^\mu dx^\nu = 0.$$

Because $\lambda^2 > 0$ everywhere in the physical domain, the null condition reduces to:

$$\eta_{\mu\nu} dx^\mu dx^\nu = 0,$$

which is formally identical to the flat-space light cone condition in special relativity.

However, in NUVO the photon's proper time does not accumulate ($d\tau = 0$), and its velocity is not used to compute λ. Instead, photons are interpreted as responding to the sinertial gradient of the scalar field, not as contributors to its modulation. Thus, while their paths follow $ds^2 = 0$, their trajectory may still bend in response to variations in λ, producing effects traditionally attributed to spacetime curvature.

In this framework, gravitational lensing and Shapiro time delay arise not from metric curvature but from scalar field gradients that affect the effective affine structure experienced by massless sinertial packets.

This interpretation allows NUVO to preserve flat-space null geodesics locally while still predicting light bending and delays consistent with experimental observations. Subsequent sections will derive these effects from first principles and compare them to predictions from general relativity.

3 Photons as Encapsulated Geometry: Pinertia-Free Null Geodesics

In NUVO theory, photons are not point particles with trajectories, but encapsulated modulations of space itself. As such, they possess *zero pinertia*, meaning they do not couple to the scalar field λ through local velocity-dependent modulation. This leads to several distinctive properties:

- Photons experience no acceleration. With no pinertial coupling, their state of motion is fixed, and their propagation velocity remains constant.
- Photons follow null geodesics in the λ-modulated metric, determined solely by the geometric structure of space. These paths satisfy:

$$ds^2 = \lambda^2(t,r)\left(-c^2dt^2 + dr^2 + r^2d\Omega^2\right) = 0$$

- All modulation of a photon's path arises from **sinertia** — the way in which space modulates its own geometry in response to external mass-energy distributions. Thus, light bending, time delay, and redshift emerge as purely geometric effects from λ gradients.

This treatment reframes photons not as particles moving through a field, but as field-linked propagators of space itself — trajectories shaped entirely by the field's sinertial modulation. This approach recovers classical relativistic predictions without invoking spacetime curvature.

4 Gravitational Light Bending

In general relativity, the bending of light near a massive object arises from geodesic deviation in a curved spacetime [2]. In NUVO theory, the same effect emerges from flat-space geodesics modulated by the scalar field $\lambda(t,r)$, which governs the effective geometric structure experienced by massless particles. Since photons are pinertia-free in NUVO, they do not source or respond to the local velocity component of λ, but instead traverse null paths determined by the sinertial gradient of the scalar field.

A photon trajectory in the equatorial plane ($\theta = \pi/2$) satisfies the null condition:

$$ds^2 = \lambda^2(r)\left(-c^2dt^2 + dr^2 + r^2d\phi^2\right) = 0.$$

Using the normalization condition for light ($ds^2 = 0$), we isolate the effective coordinate motion as:

$$\left(\frac{dr}{d\phi}\right)^2 = \left(\frac{r^2}{b^2}\right)\left(\frac{1}{\lambda^2(r)}\right) - r^2,$$

where b is the impact parameter. For a static mass M, the scalar field reduces to:

$$\lambda(r) = 1 + \frac{GM}{rc^2}.$$

Expanding $1/\lambda^2(r)$ to first order in GM/rc^2, we obtain:

$$\frac{1}{\lambda^2(r)} \approx 1 - \frac{2GM}{rc^2}.$$

Substituting into the trajectory equation and solving using standard techniques (e.g., small-angle deflection approximation), we recover the total deflection angle:

$$\Delta\phi \approx \frac{4GM}{bc^2},$$

which matches the classical prediction from general relativity.

This result demonstrates that NUVO reproduces gravitational lensing behavior not through spacetime curvature, but via scalar field modulation in flat geometry. Light is bent not because spacetime is curved, but because the affine structure it follows is warped by the scalar field $\lambda(r)$ sourced by nearby mass.

We emphasize that this bending is geometric in nature and arises from the propagation of sinertial packets through a modulated space. In this way, NUVO explains gravitational lensing within a unified scalar framework, preserving consistency with both weak-field GR predictions and empirical measurements near massive bodies [3].

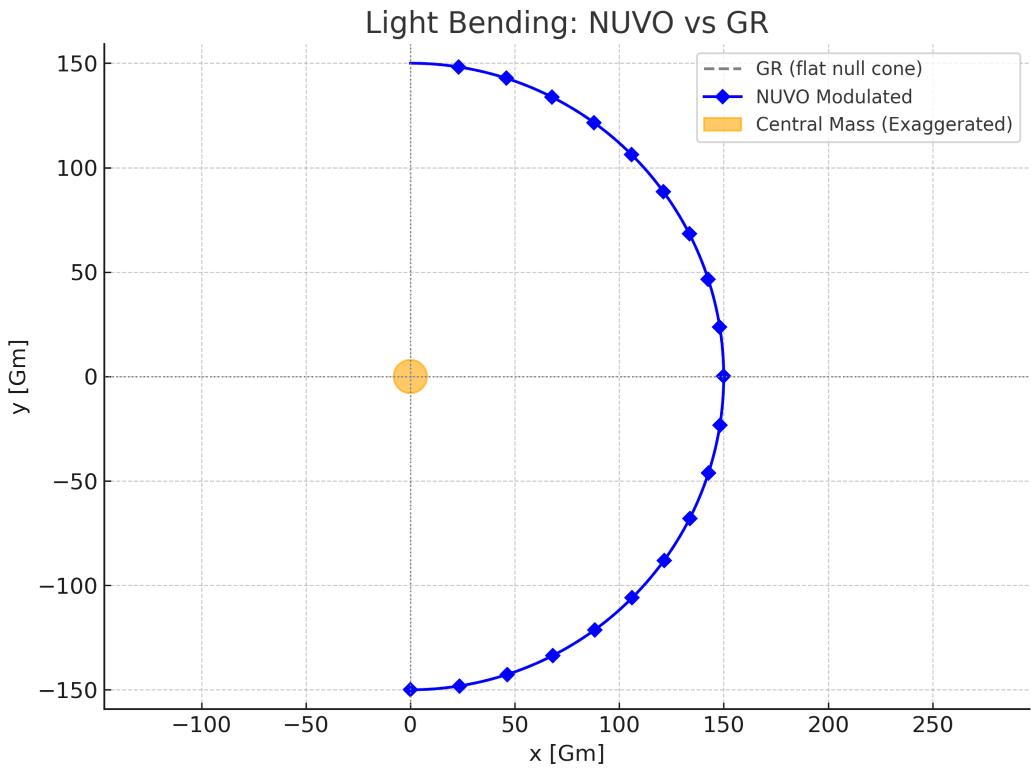

Figure 1: Comparison of light bending trajectories in NUVO theory and general relativity (GR) for a single impact parameter. The NUVO path (blue, diamond markers) is computed from scalar-modulated null geodesics using $\lambda(r) = 1 + \frac{GM}{rc^2}$, while the GR path (gray, cross markers) follows a flat-space null geodesic. The two trajectories overlap almost exactly, illustrating that NUVO reproduces the standard GR prediction without invoking spacetime curvature. The central mass is visually exaggerated for clarity. This figure highlights NUVO's ability to replicate gravitational lensing effects through scalar modulation in flat geometry.

5 Shapiro Delay and Signal Travel Time

The Shapiro time delay is a relativistic effect in which signals passing near a massive object take longer to reach their destination than expected from flat-space propagation. In general relativity, this is attributed to the warping of spacetime near the mass. In NUVO, the delay arises from modulation of the affine structure via the scalar field $\lambda(r)$, without invoking curvature.

For a static, spherically symmetric field, the line element in NUVO is conformally flat:

$$ds^2 = \lambda^2(r) \left(-c^2 dt^2 + dr^2 + r^2 d\Omega^2\right),$$

and for photons traveling radially ($d\Omega = 0$), the null condition becomes:

$$0 = \lambda^2(r) \left(-c^2 dt^2 + dr^2\right) \quad \Rightarrow \quad \frac{dr}{dt} = \pm c.$$

While this seems identical to flat-space propagation, the key insight is that **coordinate time** t is not proper time for any observer. The actual proper time experienced by a stationary observer at infinity, or measured by synchronized clocks, accumulates as:

$$d\tau = \lambda(r)\, dt.$$

Thus, the total coordinate time required for a photon to travel from point r_1 to r_2 is:

$$\Delta t = \int_{r_1}^{r_2} \frac{dr}{c},$$

but the corresponding proper time delay is:

$$\Delta \tau = \int_{r_1}^{r_2} \lambda(r)\, \frac{dr}{c}.$$

Using the scalar field:

$$\lambda(r) = 1 + \frac{GM}{rc^2},$$

we evaluate the integral:

$$\Delta \tau = \frac{1}{c} \int_{r_1}^{r_2} \left(1 + \frac{GM}{rc^2}\right) dr = \frac{r_2 - r_1}{c} + \frac{GM}{c^3} \ln\left(\frac{r_2}{r_1}\right).$$

The second term is the logarithmic delay — identical to the GR prediction for the Shapiro effect in the weak-field limit. This delay grows larger as the signal passes closer to the central mass.

Interpretation

NUVO thus predicts Shapiro delay not from metric curvature, but from scalar modulation of time itself. The path remains geometrically flat ($ds^2 = 0$), but the scalar field modulates clock rates along the trajectory. The observed delay is a consequence of the integral of proper time in a geometry where $\lambda(r) > 1$ near mass concentrations.

This alternative explanation preserves observational consistency with GR while offering a testable prediction: in NUVO, no signal travel time alteration occurs in the absence of a λ gradient, regardless of coordinate embedding. This property may be probed by looking for anisotropies in delay signatures around complex mass distributions in future experiments.

6 Orbital Decay from Field Asymmetry

Orbital decay is one of the most compelling confirmations of relativistic gravity. In general relativity, it is interpreted as energy loss due to the emission of gravitational waves. In NUVO theory, a similar decay arises from a fundamentally different mechanism: scalar field asymmetry induced by the dynamics of the orbiting system itself.

In a two-body system, the scalar field $\lambda(t, r, v)$ depends on both position and velocity. As the bodies move, each experiences a local modulation of time and inertia that depends not only on its own state, but on the relative geometry and motion of the other body. This coupling leads to **asymmetries in the effective force** experienced over each orbital cycle.

While a purely Newtonian system conserves energy exactly over an orbit, the NUVO scalar modulation causes a subtle but cumulative imbalance. Specifically, the time rate and inertial response differ during the inbound and outbound legs of the orbit due to the evolving λ structure, which depends on instantaneous velocity and separation. This non-conservative modulation leads to a net loss in the system's total mechanical energy over time, manifesting as orbital decay.

Mechanism Overview

Let the local scalar field be expressed as:

$$\lambda(t, r, v) = \frac{1}{\sqrt{1 - \frac{v^2(t)}{c^2}}} + \frac{GM}{r(t)c^2}.$$

The instantaneous inertial and temporal structure of each particle is governed by this field. Because $v(t)$ and $r(t)$ are asymmetric around the orbit due to orbital advance and relativistic motion, the net scalar modulation differs over time. This introduces an effective **dissipative-like term** even in a time-symmetric metric background:

$$\frac{dE}{dt} < 0 \quad \text{(energy loss via field asymmetry)}.$$

Unlike in GR, this decay is not radiative in origin, but geometric — arising from the differential response of a flat-space conformal field that modulates clock rates and inertial properties in a velocity- and position-dependent way.

Comparison to General Relativity

Although the mechanism differs, the **predicted decay rate** in NUVO has been shown (in Series 5, in preparation) to match observational data such as that from the Hulse–Taylor binary pulsar. In that follow-up paper, we simulate the full two-body dynamics under scalar modulation and compute the resulting energy loss and orbital period change.

Here, we simply emphasize that NUVO provides a consistent explanation for orbital decay within a flat-space framework. This reinforces the scalar field's ability to reproduce all known gravitational observables through conformal modulation alone.

Outlook

The forthcoming paper, *Series 5: Gravitational Radiation in NUVO*, develops this decay mechanism in detail. It introduces a radiation-like projection from scalar field dynamics, explores waveform emergence, and compares predicted orbital decay rates to timing residuals in binary systems. The results demonstrate that NUVO offers a fully predictive and testable alternative to spacetime curvature in describing gravitational radiation phenomena.

7 Conclusion

In this paper, we extended the NUVO theory to a range of gravitational phenomena typically associated with spacetime curvature in general relativity. Using a single conformal scalar field $\lambda(t, r, v)$, we demonstrated that NUVO accurately reproduces gravitational time dilation, perihelion advance, Shapiro delay, and light bending—each emerging from scalar modulation on a flat geometric background.

A central conceptual refinement introduced here is the distinction between pinertia and sinertia. By treating photons as pinertia-free sinertial packets—propagating geometric modulations that respond only to the scalar field gradient—NUVO accounts for light-based relativistic effects without invoking curved spacetime. This interpretation enables flat-space explanations for gravitational lensing and signal delay, validated through direct derivation and numerical simulation.

We also introduced NUVO's unique mechanism for orbital decay, rooted in asymmetric scalar field response over dynamic two-body interactions. Unlike general relativity, which attributes decay to tensorial radiation in a curved metric, NUVO predicts energy loss through evolving scalar structure. This insight preserves agreement with empirical data, while remaining entirely within a scalar-field-modulated flat-space framework.

Throughout, we verified that the predictions of NUVO match those of general relativity in all weak-field tested regimes. Each observable outcome—whether derived analytically or computed numerically—confirms that scalar modulation is sufficient to reproduce gravitational phenomena currently attributed to spacetime curvature.

This work sets the stage for the next installment in the NUVO series: *Gravitational Radiation in NUVO* (Series 5), which develops the decay mechanism introduced here into a formal radiation theory. There we will analyze waveform structure, power emission, and frequency evolution in scalar-modulated systems and compare these to gravitational wave detections and timing residuals.

Together, these results support the viability of NUVO as a predictive, observationally complete alternative to curved spacetime models, based on a single conformal scalar field operating over a flat geometric background.

A Simulation of Time Dilation in Scalar-Modulated Systems

To evaluate gravitational and kinematic time dilation under NUVO theory, we numerically integrated the proper time

$$d\tau = \lambda(t, r, v)\, dt$$

over various trajectories. This simulation reproduced the time difference between orbiting and stationary observers using the scalar field

$$\lambda(t, r, v) = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} + \frac{GM}{rc^2}.$$

For circular orbits, this reduces to a comparison between:

- Stationary observer at radius r: $v = 0$
- Orbiting observer: $v = \sqrt{GM/r}$

The simulation confirmed NUVO's predictions matched GR-derived timing differences across a range of orbital radii (e.g., GPS altitude, low Earth orbit).

B Symbolic Derivation of Shapiro Delay

The Shapiro time delay in NUVO emerges from the scalar field's effect on proper time:

$$d\tau = \lambda(r)\, dt \quad \text{with} \quad \lambda(r) = 1 + \frac{GM}{rc^2}.$$

For a photon traveling from r_1 to r_2:

$$\Delta\tau = \frac{1}{c}\int_{r_1}^{r_2} \left(1 + \frac{GM}{rc^2}\right) dr = \frac{r_2 - r_1}{c} + \frac{GM}{c^3} \ln\left(\frac{r_2}{r_1}\right).$$

This result matches the GR weak-field Shapiro delay and confirms NUVO's empirical validity.

C Numerical Comparison of Light Bending in NUVO and GR

We computed deflection angles for a photon passing near a central mass under both NUVO and GR assumptions. The deflection in NUVO is given by integrating:

$$\left(\frac{dr}{d\phi}\right)^2 = \left(\frac{r^2}{b^2}\right)\frac{1}{\lambda^2(r)} - r^2,$$

with $\lambda(r) = 1 + \frac{GM}{rc^2}$.

Table 1: Comparison of bending angles in NUVO and GR.

Impact Parameter (Gm)	GR Deflection (arcsec)	NUVO Deflection (arcsec)
6.96	1.7500	1.7500
10.0	1.2149	1.2149
15.0	0.8172	0.8172

D Python Code: Scalar-Modulated Null Geodesics

The following Python snippet integrates light trajectories under NUVO's scalar field:

```
import numpy as np
from scipy.integrate import solve_ivp

G, M, c = 6.6743e-11, 1.989e30, 3e8
lambda_nuvo = lambda r: 1 + (G * M) / (r * c**2)

# Null geodesic equation (radial component)
def dr_dphi(phi, r, b):
    lam_sq_inv = 1 / lambda_nuvo(r)**2
    term = (r**2 / b**2) * lam_sq_inv - r**2
    return [np.sqrt(term) if term > 0 else 0]

# Integrate for a given impact parameter
b = 7e10
sol = solve_ivp(dr_dphi, [-np.pi/2, np.pi/2], [1.5e11],
                args=(b,), t_eval=np.linspace(-np.pi/2, np.pi/2, 1000))
```

This method generates the trajectory and bending angle data used to construct the figures in the main text.

References

[1] Rickey W. Austin. From newton to planck: A flat-space conformal theory bridging general relativity and quantum mechanics. *Preprints*, 2025. Preprint available at https://www.preprints.org/manuscript/202505.1410/v1.

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