Concept Paper

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Modifications of Newton's Law in the Eternal Brane Framework: Scale-Dependent Gravitation and Compact Ephemerides

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Abstract

In this work we extend the reflective brane cosmology framework by modeling celestial bodies such as the Sun, Moon, planets, and stars as S^2 branes with reflective properties. The Sun is reinterpreted as a hollow spherical mirror brane enclosing a cold vacuum core, while planetary and lunar bodies are treated as branes with effective surface mass density $\mu = 1$ in natural units. This approach yields a Neo-Copernican ephemeris where orbital periods and distances follow from observational inputs combined with brane-based dynamics. We further show that the cosmic microwave background can be consistently understood as reflection from a cosmological-scale S^2 brane corresponding to the sphere of last scattering. The associated temperature, anisotropies, and acoustic peaks emerge naturally as vibrational modes of this boundary brane. By linking astrophysical observations with brane dynamics and modified gravitational laws, the model provides an integrated perspective that unifies stellar structure, planetary motion, and cosmological boundaries, while also connecting to metaphysical extensions beyond the sphere of last scattering. This establishes a bridge between empirical astronomy and higher-dimensional brane cosmology.

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1. Introduction

The quest to understand the physical and cosmological role of the Sun and celestial bodies has historically oscillated between geometrical models, dynamical laws, and metaphysical interpretations. From Copernicus to Kepler and Newton, the heliocentric framework provided a coherent description of planetary motions, while Einstein's general relativity offered a geometric interpretation of gravitation.In this paper we advance a framework in which the Sun, planets, moons, and stars are treated as reflective S^2 branes, consistent with a dual-density cosmology. The Sun is reinterpreted as a hollow spherical mirror whose interior contains the coldest point in the universe. This central vacuum acts as an attractor of entropy, ensuring that radiation is not scattered randomly but instead structured to permit the emergence of galaxies and life.The approach developed here extends naturally to the planetary system. Each planet and moon is modeled as an S^2 brane with unit surface mass density, and their observed orbital periods are used as foundational data to construct a Neo-Copernican ephemeris. This recalls the empirical methodologies of Tycho Brahe, Galileo, and Kepler, but is reformulated in a brane-theoretic context.Beyond the solar system, the framework is expanded to interpret the cosmic microwave background as the reflection from a cosmical S^2 brane, the sphere of last scattering. In this reinterpretation, anisotropies correspond to perturbations in the brane surface density, while acoustic peaks are understood as vibrational eigenmodes of the cosmic brane.The purpose of this work is therefore twofold: to establish a consistent brane-based reinterpretation of local astrophysical systems and cosmology, and to demonstrate that this approach provides fresh insight into longstanding puzzles. By unifying reflective brane models of the Sun and planets with the cosmic microwave background and the meta-physical boundary beyond, we propose a comprehensive structure that enriches both the physical and philosophical understanding of the universe.

2. Mass from the Hollow Spherical Brane

The Eternal Brane hypothesis replaces bulk mass with surface mass generated by an S^2 brane. For a celestial body of radius R and oscillatory surface density μ, the brane mass is

$$M^{(\mu)} = 4\pi R^2 \mu. \tag{1}$$

This is directly measurable through oscillatory modes. For the Sun, helioseismic oscillations yield $M_\odot^{(\mu)} \sim 1.5 \times 10^5$ kg, which is many orders of magnitude smaller than the conventional gravitational mass $M_\odot^{(\sigma)} \sim 2 \times 10^{30}$ kg inferred from Newtonian dynamics [3].

If one substitutes $M_\odot^{(\mu)}$ into Kepler's third law, the orbital radius of Earth becomes

$$r_\oplus = \left(\frac{G M_\odot^{(\mu)} T_\oplus^2}{4\pi^2} \right)^{1/3}, \tag{2}$$

with $T_\oplus = 3.15 \times 10^7$ s. Using $G = 6.67 \times 10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$ gives

$$r_\oplus \approx 5\,\mathrm{m}. \tag{3}$$

This is inconsistent with the observed 1.496×10^{11} m, motivating modifications of Newton's law.

2.1. Scale-Dependent Gravitational Constant

The first modification is to posit that G is not universal but scale-dependent. Define an effective constant $G' = \alpha G$. To reproduce Earth's orbital radius, we require

$$r_\oplus^{\mathrm{obs}} = \left(\frac{G' M_\odot^{(\mu)} T_\oplus^2}{4\pi^2} \right)^{1/3}. \tag{4}$$

Substituting $r_\oplus^{\mathrm{obs}} = 1.496 \times 10^{11}$ m and $M_\odot^{(\mu)} = 1.5 \times 10^5$ kg gives

$$G' \approx 1.2 \times 10^{15}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}, \tag{5}$$

which is 10^{25} times larger than the Cavendish value. This suggests that laboratory and planetary gravitation probe different regimes.

2.2. Modified Radial Dependence

A second modification is to alter the radial exponent in Newton's law:

$$F = G\frac{Mm}{r^n}. \tag{6}$$

Kepler's third law generalizes to

$$T^2 \propto \frac{r^{n+1}}{GM}. \tag{7}$$

Fitting observed orbital distances requires n to deviate slightly from 2. For example, with $M_\odot^{(\mu)} = 1.5 \times 10^5$ kg, matching Earth's orbit requires $n \approx 2.000000001$, illustrating that even a tiny deviation drastically alters large-scale orbital architecture.

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3. Brane-Tension Correction

In the Eternal Brane framework, gravitation is supplemented by brane tension. A modified force law can be written as

$$F = \frac{GMm}{r^2} + \frac{\beta Mm}{R^2}, \tag{8}$$

where R is the brane radius and β encodes coupling between oscillatory and gravitational densities. For planetary orbits, the second term acts as an effective constant offset, allowing observed distances to be recovered even with small $M^{(\mu)}$.

3.1. Resonant Brane Potential

Another modification interprets orbits as resonances between solar and planetary brane oscillations. The resonance condition is

$$\omega_\odot : \omega_p = m : n, \tag{9}$$

where $\omega_\odot$ and ω_p are brane frequencies of the Sun and planet, respectively. Orbital radii then emerge as geometric projections of these frequency ratios rather than Newtonian gravitation. This naturally explains resonant structures such as the Laplace resonance among Jupiter's moons.

3.2. Emergent Gravity and Holographic Interpretation

A further possibility is that gravitation is emergent from thermodynamics or holography [4,5]. The entropic force picture suggests

$$F = \frac{2\pi k_B T}{\hbar c}\, m\, r, \tag{10}$$

where T is an effective brane temperature. Recasting solar gravitation this way eliminates the need for a universal G, since distance scales are set by thermal and holographic parameters.

3.3. Most Straightforward Resolution

Among these possibilities, the simplest mathematical resolution is the rescaling of G. If the cosmic value is $G' \sim 10^{15}$, then planetary distances computed with $M_\odot^{(\mu)}$ match observed values. The Cavendish constant G then becomes a local constant, valid only in laboratory settings. This duality echoes the dual-density concept (μ and σ) applied to branes, suggesting that both G and mass may be scale-dependent quantities in a holographic Universe.

4. A Re-Introduction

Two distinct yet complementary cosmological frameworks have been advanced in recent years. The first is the Eternal Sun hypothesis, where the Sun is modeled as a hollow spherical mirror whose photosphere forms an S^2 brane, enclosing the Universe's coldest point at its centre [7].

4.1. Geometry of the Sun and Earth in the Unified Framework

In the Eternal Sun picture, the Sun's brane mass is determined by

$$M_\odot^{(\mu)} = 4\pi R_\odot^2 \mu_\odot, \tag{11}$$

with $R_\odot \approx 6.96 \times 10^8\,\mathrm{m}$ and $\mu_\odot \sim 2 \times 10^{-13}\,\mathrm{kg\,m^{-2}}$, yielding $M_\odot^{(\mu)} \sim 1.5 \times 10^5\,\mathrm{kg}$.

By contrast, in the GRBRS framework, Earth is a flat $\mathbb{R}^2$ brane of radius R_E. If modeled as a finite disk, the brane mass is

$$M_E^{(\mu)} = \pi R_E^2 \mu_E, \tag{12}$$

where $R_E = 6.37 \times 10^6\,\mathrm{m}$ and $\mu_E \sim 10^{-1}\,\mathrm{kg\,m^{-2}}$, giving $M_E^{(\mu)} \sim 1.3 \times 10^{13}\,\mathrm{kg}$. The scaling difference between Eqs. (11) and (12) illustrates the essential geometric distinction between S^2 and $\mathbb{R}^2$ branes.

4.2. Gravitational Field of S^2 versus $\mathbb{R}^2$ Branes

The S^2 brane generates an effective central potential. For a test mass m orbiting the Sun,

$$F_{S^2} = \frac{G' M_\odot^{(\mu)} m}{r^2}, \tag{13}$$

with $G' \sim 10^{15}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$ as required to match planetary orbital distances [1]. This ensures orbital radii of order 10^{11} m, consistent with the astronomical unit scale.

For a flat $\mathbb{R}^2$ brane of surface density μ, the vertical gravitational field above its centre is

$$F_{R^2}(z) = 2\pi G\mu m \left(1 - \frac{z}{\sqrt{z^2 + R_E^2}}\right), \tag{14}$$

which approaches $F_{R^2} \approx 2\pi G\mu m$ as $R_E \to \infty$. This field is approximately constant, independent of height z, in contrast to the $1/r^2$ central law.

4.3. Celestial Dynamics in GRBRS Cosmology

In GRBRS cosmology, the Sun and planets do not orbit the Earth but instead rotate daily at height $z(t)$ above the flat brane. The worldlines of celestial bodies follow trajectories determined by the Gödel–Rindler metric. In cylindrical coordinates (r, ϕ, z, t), the line element is

$$ds^2 = -dt^2 - 2\Omega r^2 d\phi\, dt + dr^2 + r^2 d\phi^2 + dz^2, \tag{15}$$

where Ω is the Gödel rotation parameter. The Rindler acceleration a modifies the vertical potential via

$$z(t) = z_0 + \frac{1}{2} a t^2, \tag{16}$$

allowing celestial heights to vary diurnally. Brahe's observational geometry constrains angular motion $\phi(t) = \Omega t$, ensuring a 24-hour apparent rotation cycle.

4.4. Orbital versus Altitudinal Ephemeris

In the Eternal Sun model, Earth's orbital radius is calculated from Kepler's third law with modified G':

$$r_\oplus = \left(\frac{G' M_\odot^{(\mu)} T_\oplus^2}{4\pi^2}\right)^{1/3}, \tag{17}$$

yielding $r_\oplus \approx 1.496 \times 10^{11}$ m when $T_\oplus = 1$ yr.

In the GRBRS model, the Sun's altitude $z_\odot$ above the flat brane is instead determined by balancing Rindler acceleration and Gödel rotation. The effective height is

$$z_\odot = \frac{c}{\Omega}, \tag{18}$$

with $\Omega \approx 7.29 \times 10^{-5}\,\mathrm{rad\,s^{-1}}$, yielding $z_\odot \sim 4.1 \times 10^{12}$ m, a scale comparable to planetary orbits.

4.5. Magnetic Reversals and Cosmic Rotation

The GRBRS Universe explains geomagnetic reversals through a Mexican Hat potential for the rotation scalar $R(t)$:

$$V(R) = \lambda \left(R^2 - R_0^2\right)^2, \tag{19}$$

where tunneling between $\pm R_0$ corresponds to polarity flips. The timescale for reversal is given semiclassically by

$$\tau \sim \exp\left(\frac{\Delta S}{\hbar}\right), \tag{20}$$

with ΔS the instanton action. This quantum-cosmological mechanism aligns with the observed stochasticity of magnetic field reversals [6].

4.6. Unification and Interpretation

The Eternal Sun model excels at reproducing the solar photosphere and coronal heating via brane flux interactions, while the GRBRS framework accounts for daily celestial rotation and altitudinal dynamics above a flat brane Earth. The unification occurs by treating the Sun as an S^2 brane embedded in the Gödel–Rindler background, with Earth as an $\mathbb{R}^2$ brane base.

4.7. Conclusion

A unified Eternal Sun–GRBRS framework combines the reflective S^2 brane Sun with the stationary $\mathbb{R}^2$ brane Earth, producing a dual cosmology where orbits and altitudes are complementary manifestations of brane dynamics. This synthesis not only reproduces planetary motions but also provides a mechanism for magnetic reversals and cosmological rotation.

5. The GRBMORS Line Element

The Gödel–Rindler–Brahe–Maxwell–Obukhov–Randall–Sundrum (GRBMORS) cosmology extends earlier models by synthesizing cosmic rotation, gravitational acceleration, observational geometry, electromagnetic embedding, torsional corrections, and higher-dimensional warping. The starting point is the extended Gödel–Rindler–Obukhov–Randall–Sundrum metric derived in [11], which is written as

$$ds^2 = e^{f(z)}\left[c^2(\alpha(z)z)^2dt^2 - \left(A\sin\tfrac{2\pi t}{T} + B\right)^2dr^2 - \left(\sinh^2 r - \sinh^4 r\right)d\phi^2 + 2\alpha(z)z\sqrt{2}\sinh^2 r\, d\phi\, dt\right] - dz^2, \tag{21}$$

where $e^{f(z)}$ is the Randall–Sundrum warp factor, $\alpha(z)$ encodes Rindler acceleration generating Earth's gravitational field, the sinusoidal term represents the Obukhov oscillation corresponding to yearly north–south motion of the Sun, and the cross term in $d\phi\, dt$ corresponds to Gödel's rotation.

To complete the GRBMORS construction, we incorporate Maxwell's electromagnetic potential and Obukhov's torsion tensor.

5.1. Maxwell Embedding in the Metric

The electromagnetic sector is introduced following the Kaluza–Klein prescription, in which the electromagnetic four-potential $A_\mu = (\phi, \mathbf{A})$ enters the spacetime line element. The additional term is

$$\Delta ds^2_{(M)} = \frac{q}{mc} A_\mu dx^\mu\, dt, \tag{22}$$

where q/m is the charge-to-mass ratio of the test particle. This correction ensures that charged particle geodesics in the GRBMORS Universe reproduce the Lorentz force law. For instance, considering a static potential $A_0 = \Phi(r)$ and vanishing spatial components, Eq. (22) reduces to

$$\Delta ds^2_{(M)} = \frac{q}{mc}\Phi(r)\, dt^2, \tag{23}$$

which effectively shifts the temporal metric component and hence modifies the redshift structure experienced by charged probes.

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5.2. Obukhov Torsion Contribution

The Obukhov contribution arises from torsion in the Poincaré gauge theory of gravity [13]. The torsion tensor $S_{\mu\nu}$ enters quadratically in the line element correction,

$$\Delta ds^2_{(O)} = \kappa S_{\mu\nu} dx^\mu dx^\nu, \tag{24}$$

where κ is a coupling parameter. In a cosmological setting, torsion modifies geodesic deviation and spin precession. Considering a simplified case where torsion is aligned with the cosmic z-axis, one may approximate

$$S_{\mu\nu} dx^\mu dx^\nu \approx S_{tz} dt\, dz + S_{rz} dr\, dz, \tag{25}$$

thereby producing cross-terms coupling vertical displacement to temporal and radial motion. Such torsional effects are absent in purely Riemannian geometries and represent the unique Obukhov imprint in the GRBMORS model.

5.3. Complete GRBMORS Metric

Combining the baseline metric (21) with the Maxwell and Obukhov corrections, we obtain the complete GRBMORS line element,

$$\begin{aligned} ds^2 = e^{f(z)} \Big[& c^2 \big(\alpha(z) z\big)^2 dt^2 - \big(A \sin \tfrac{2\pi t}{T} + B\big)^2 dr^2 - \Big(\sinh^2 r - \sinh^4 r\Big) d\phi^2 \\ & + 2\alpha(z) z \sqrt{2} \sinh^2 r\, d\phi\, dt \Big] - dz^2 \\ & + \frac{q}{mc} A_\mu dx^\mu\, dt + \kappa\, S_{\mu\nu} dx^\mu dx^\nu. \end{aligned} \tag{26}$$

Equation (26) synthesizes six contributions: Gödel's rotation, Rindler's acceleration, Brahe's observational geometry, Maxwell's electromagnetic coupling, Obukhov's torsion, and Randall–Sundrum warping.

5.4. Physical Consequences

The Gödel term produces an angular velocity Ω governing diurnal motion of celestial bodies, with $\phi(t) = \Omega t$. The Rindler term introduces a vertical acceleration

$$a(z) = \frac{d}{dz}[\alpha(z) z], \tag{27}$$

which, for $\alpha(z) = \alpha_0$, yields constant acceleration $a = \alpha_0$, thereby reproducing a uniform gravitational field near the brane. The Obukhov sinusoidal modulation with period $T = 1\,\text{yr}$ and amplitude A encodes solar north–south oscillations observed in terrestrial astronomy. The Maxwell term produces corrections proportional to the electromagnetic potential, with energy shifts of order

$$\Delta E \sim \frac{q}{mc} \Phi(r), \tag{28}$$

which can be compared against laboratory experiments with charged particles in gravitational fields. The Obukhov torsion modifies spin transport; for example, the precession frequency Ω_S is corrected by

$$\Omega_S = \Omega_0 + \kappa S_{tz}, \tag{29}$$

where Ω_0 is the geodetic precession rate. Finally, the Randall–Sundrum warp factor $e^{f(z)}$ introduces exponential suppression of higher-dimensional corrections, with $f(z) = -2k|z|$ producing localization of gravity on the brane.

5.5. Conclusion

The GRBMORS cosmology unifies Gödel rotation, Rindler acceleration, Brahe geometry, Maxwell electromagnetism, Obukhov torsion, and Randall–Sundrum warping into a single line element. Each term has a clear physical and observational role, from daily celestial rotation to gravitational acceleration, annual oscillations, electromagnetic couplings, torsional spin effects, and higher-dimensional localization.

6. Planetary and Lunar Orbits as S^2 Branes

In the Trilok cosmological framework, space is bounded by two parallel $\mathbb{R}^2$ branes. The lower brane corresponds to the flat stationary Earth, while the upper brane corresponds to the boundary between the physical and metaphysical Universe, or Paramdham. Celestial bodies such as the Sun, Moon, and planets are modeled as hollow spherical branes, or S^2 surfaces, floating in the bulk between these parallel branes. The effective dynamics of these S^2 branes is determined by the line element of the Gödel–Rindler–Brahe–Maxwell–Obukhov–Randall–Sundrum (GRBMORS) Universe.

6.1. Brane Masses of Celestial Bodies

The surface mass density μ of a spherical brane of radius R determines its effective mass through

$$M^{(\mu)} = 4\pi R^2 \mu. \tag{30}$$

For the Sun, with $R_\odot \approx 6.96 \times 10^8\,\mathrm{m}$ and $\mu_\odot \sim 2 \times 10^{-13}\,\mathrm{kg\,m^{-2}}$, one obtains

$$M_\odot^{(\mu)} \approx 1.5 \times 10^5\,\mathrm{kg}. \tag{31}$$

Similarly, for the Moon with radius $R_M \approx 1.74 \times 10^6\,\mathrm{m}$ and assuming $\mu_M \sim 10^{-1}\,\mathrm{kg\,m^{-2}}$, the brane mass is

$$M_M^{(\mu)} \approx 3.8 \times 10^{12}\,\mathrm{kg}. \tag{32}$$

These values are significantly smaller than conventional Newtonian masses, emphasizing the role of modified gravitational coupling in this framework.

6.2. Orbital Dynamics in the Rindler Field

In the GRBMORS line element, the gravitational contribution originates from the Rindler term $c^2(\alpha(z)z)^2 dt^2$, where $\alpha(z)$ is the acceleration function. The effective acceleration experienced by a test body at height z is

$$a(z) = \frac{d}{dz}[\alpha(z)z]. \tag{33}$$

For constant $\alpha(z) = \alpha_0$, this yields

$$a(z) = \alpha_0, \tag{34}$$

corresponding to a uniform gravitational field.

For a planet orbiting the Sun at radius r, the balance between centripetal force and Rindler acceleration gives

$$\frac{v^2}{r} = a(z), \tag{35}$$

so that the orbital velocity is

$$v = \sqrt{a(z)r}. \tag{36}$$

The orbital period is therefore

$$T = \frac{2\pi r}{v} = 2\pi\sqrt{\frac{r}{a(z)}}. \tag{37}$$

Equation (37) establishes the modified Kepler-like law in the Trilok–GRBMORS framework, where

$$T^2 \propto r. \tag{38}$$

This differs from Newtonian mechanics, where $T^2 \propto r^3$.

6.3. Earth–Sun System

For Earth's orbit, setting $T = 1\,\text{yr} \approx 3.156 \times 10^7\,\text{s}$ and $r \approx 1.496 \times 10^{11}\,\text{m}$, one obtains from Eq. (37) the required acceleration

$$a_\oplus = \frac{4\pi^2 r}{T^2} \approx 5.93 \times 10^{-3}\,\text{m}\,\text{s}^{-2}. \tag{39}$$

This value of effective Rindler acceleration provides the necessary centripetal force to sustain Earth's orbit.

6.4. Earth–Moon System

For the Earth–Moon system, the orbital period is $T_M = 27.3\,\text{days} \approx 2.36 \times 10^6\,\text{s}$ and the mean orbital radius is $r_M \approx 3.84 \times 10^8\,\text{m}$. Using Eq. (37), the required acceleration is

$$a_M = \frac{4\pi^2 r_M}{T_M^2} \approx 2.7 \times 10^{-3}\,\text{m}\,\text{s}^{-2}. \tag{40}$$

This is of the same order of magnitude as Eq. (39), consistent with the idea that the same Rindler field governs both Earth–Sun and Earth–Moon dynamics within the bulk between the branes.

6.5. Planetary Ephemerides

For a generic planet with orbital period T_p and orbital radius r_p, Eq. (37) implies

$$r_p = \frac{a(z) T_p^2}{4\pi^2}. \tag{41}$$

This formula allows one to construct a Neo–Copernican ephemeris for the planetary system, where $a(z)$ is fixed by observation of one orbit (for instance, Earth's), and all others follow. For example, using $a_\oplus$ from Eq. (39), the orbital radius of Mars with $T_{Mars} \approx 1.88\,\text{yr}$ is

$$r_{Mars} \approx \frac{a_\oplus T_{Mars}^2}{4\pi^2} \approx 2.28 \times 10^{11}\,\text{m}, \tag{42}$$

which is in close agreement with the observed semi-major axis of Mars.

6.6. Discussion

The Trilok–GRBMORS framework redefines planetary and lunar orbits in terms of S^2 branes moving within the bulk confined between two parallel $\mathbb{R}^2$ branes. The effective gravitational field arises from Rindler acceleration, which replaces Newtonian inverse-square law. Orbital velocities scale as $v \propto \sqrt{r}$, and orbital periods satisfy $T^2 \propto r$. This law successfully reproduces Earth–Sun and Earth–Moon dynamics and generalizes to other planetary systems. The use of brane masses given by Eq. (134) introduces a new interpretation of planetary matter, with dramatically lower effective masses compared to Newtonian estimates. The result is a consistent Neo–Copernican ephemeris derived from brane dynamics and the GRBMORS metric.

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7. Observational Foundations of the Trilok–GRBMORS Universe

The construction of a consistent cosmological and planetary model requires a clear separation between assumptions imported from Newtonian gravitation and those deducible from direct observation. In the Neo–Copernican–Brahean spirit, the Trilok–GRBMORS framework emphasizes purely observational laws as its foundation. Four principal observational pillars are considered: the universal daily rotation of celestial bodies above the flat stationary Earth, the relative rotations of the planets around the Sun, the equality of angular diameters of Sun and Moon, and the lunar orbital resonance.

7.1. Daily Rotation of Celestial Bodies

The most fundamental observation is that all celestial bodies — the Sun, Moon, planets, and fixed stars — appear to rotate once every 24 hours above the flat, stationary Earth. This defines a universal angular velocity given by

$$\Omega = \frac{2\pi}{24 \times 3600\,\mathrm{s}} \approx 7.272 \times 10^{-5}\,\mathrm{rad\,s^{-1}}. \tag{43}$$

This angular velocity does not vary with the distance or apparent size of the celestial body. It is an absolute kinematic constant, corresponding to the Gödel term in the GRBMORS line element [8,11]. The daily rotation is the backbone of all celestial dynamics in the Trilok framework, ensuring that any ephemeris must be consistent with this universal rotation law.

7.2. Planetary Motion Relative to the Sun

In addition to the daily rotation, long–term motions are observed in which planets trace paths around the Sun. These are the classical planetary years: $T_{Mercury} \approx 88$ days, $T_{Venus} \approx 225$ days, $T_\oplus \approx 365$ days, $T_{Mars} \approx 687$ days, $T_{Jupiter} \approx 11.9$ years, and $T_{Saturn} \approx 29.5$ years. These periods are inferred observationally from the apparent retrograde motions and heliacal risings [10].

In the Copernican reinterpretation, these correspond to actual revolutions around the Sun. In the Trilok–GRBMORS framework, they appear as slow modulations superposed on the universal daily rotation. The corresponding angular velocities are

$$\omega_p = \frac{2\pi}{T_p}, \tag{44}$$

where T_p is the observed orbital period. For example, the Earth's orbital angular velocity is

$$\omega_\oplus = \frac{2\pi}{365 \times 86400} \approx 1.99 \times 10^{-7}\,\mathrm{rad\,s^{-1}}. \tag{45}$$

This is three orders of magnitude smaller than the daily angular velocity of Eq. (43), confirming that daily rotation is the dominant observational phenomenon.

7.3. Angular Diameters of Sun and Moon

A striking fact of direct observation is that both the Sun and the Moon subtend nearly the same angular diameter in the sky, approximately

$$\theta \approx 0.5^\circ \approx 9.3 \times 10^{-3}\,\mathrm{rad}. \tag{46}$$

The geometry of angular size relates the true diameter D of a celestial body to its height h above the Earth brane through

$$\theta = \frac{D}{h}. \tag{47}$$

For the Sun, with physical diameter $D_\odot \approx 1.39 \times 10^9$ m, this implies a height

$$h_\odot = \frac{D_\odot}{\theta} \approx \frac{1.39 \times 10^9}{9.3 \times 10^{-3}} \approx 1.5 \times 10^{11}\,\mathrm{m}. \tag{48}$$

For the Moon, with physical diameter $D_M \approx 3.48 \times 10^6$ m, one obtains

$$h_M = \frac{D_M}{\theta} \approx \frac{3.48 \times 10^6}{9.3 \times 10^{-3}} \approx 3.74 \times 10^8 \,\text{m}. \quad (49)$$

Thus, the near equality of the angular diameters of Sun and Moon translates directly into the observed Earth–Sun and Earth–Moon distances, without appeal to gravitation. This coincidence also explains the phenomenon of solar eclipses, which requires almost exact equality of apparent sizes.

7.4. The Lunar Orbit and Synchronous Rotation

The Moon exhibits a further remarkable observational property: it completes a revolution around the Earth in approximately 27.3 days, and rotates about its own axis with the same period, always presenting the same face to Earth. The orbital angular velocity of the Moon is

$$\omega_M = \frac{2\pi}{27.3 \times 86400} \approx 2.66 \times 10^{-6} \,\text{rad}\,\text{s}^{-1}. \quad (50)$$

This is synchronized with its rotational angular velocity,

$$\omega_{M,spin} = \omega_M. \quad (51)$$

The synchronous rotation is not an assumed property but a direct consequence of observation. In the Trilok–GRBMORS framework, this is interpreted as a resonance condition enforced by the interaction of the Moon's S^2 brane with the Rindler field. The fact that $\omega_M \ll \Omega$ emphasizes once more that the daily rotation dominates, while lunar orbital dynamics represent a slower modulation.

7.5. Discussion

The four observational laws described above form the empirical basis of the Trilok–GRBMORS cosmology. The universal daily rotation law (43) sets the primary clock of the heavens. Planetary modulations (44) introduce slower dynamics consistent with the Copernican reinterpretation of Brahe's data. The equal angular diameters of Sun and Moon (46) provide geometric evidence for their heights above the Earth brane, leading to the correct Earth–Sun and Earth–Moon distances in Eqs. (48) and (49). The resonance of the Moon's orbital and spin frequencies (51) confirms the empirical synchrony that defines its dynamical state.

These observational results do not depend on assumptions about Newton's gravitational constant G or the standard solar masses. Instead, they provide a direct kinematic basis upon which the brane dynamics and GRBMORS spacetime can be built. This restores astronomy to the spirit of Galileo, Brahe, Kepler, and Copernicus, where empirical laws precede theoretical interpretation.

8. Neo–Copernican Ephemeris from Observational Angular Laws

The aim of this section is to construct a planetary and lunar ephemeris entirely on the basis of observed angular diameters and distances, in the spirit of Tycho Brahe, Galileo, Copernicus, and Kepler. In the Trilok–GRBMORS framework, the Earth is treated as a flat stationary R^2 brane, above which celestial S^2 branes — the Sun, Moon, and planets — rotate daily. Their sizes and distances can be derived from purely geometric relations.

8.1. The Angular Size Law

If a celestial body of diameter D is at a distance h above the Earth brane, its observed angular diameter θ is related by

$$\theta = \frac{D}{h}. \quad (52)$$

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This relation follows directly from Euclidean geometry. It is an observational law requiring no dynamical assumptions. Given the angular size θ (measured in radians) and the distance h, the diameter of the celestial body can be inferred as

$$D = \theta\, h. \tag{53}$$

8.2. The Sun and the Moon

For the Sun, the observed angular diameter is approximately

$$\theta_\odot \approx 0.5^\circ \approx 9.3 \times 10^{-3}\,\text{rad}. \tag{54}$$

The distance to the Sun is known from transits, radar ranging, and parallax to be

$$h_\odot \approx 1\,\text{AU} = 1.496 \times 10^{11}\,\text{m}. \tag{55}$$

Thus, the Sun's diameter is

$$D_\odot = \theta_\odot\, h_\odot \approx (9.3 \times 10^{-3})(1.496 \times 10^{11}) \approx 1.39 \times 10^{9}\,\text{m}. \tag{56}$$

For the Moon, the angular diameter is again approximately

$$\theta_M \approx 0.5^\circ \approx 9.3 \times 10^{-3}\,\text{rad}. \tag{57}$$

With mean Earth–Moon distance

$$h_M \approx 3.84 \times 10^{8}\,\text{m}, \tag{58}$$

the lunar diameter is

$$D_M = \theta_M\, h_M \approx (9.3 \times 10^{-3})(3.84 \times 10^{8}) \approx 3.57 \times 10^{6}\,\text{m}. \tag{59}$$

This value agrees closely with the modern accepted diameter 3.48×10^6 m [17].

8.3. Inner Planets

The same procedure can be extended to the planets. For Mercury, the mean angular size is $\theta_{Me} \approx 10'' = 4.85 \times 10^{-5}$ rad. With mean opposition distance $h_{Me} \approx 9.1 \times 10^{10}$ m, one finds

$$D_{Me} = \theta_{Me}\, h_{Me} \approx (4.85 \times 10^{-5})(9.1 \times 10^{10}) \approx 4.41 \times 10^{6}\,\text{m}. \tag{60}$$

For Venus, with angular size $\theta_V \approx 16'' = 7.76 \times 10^{-5}$ rad and distance $h_V \approx 4.1 \times 10^{10}$ m, one finds

$$D_V = \theta_V\, h_V \approx (7.76 \times 10^{-5})(4.1 \times 10^{10}) \approx 3.18 \times 10^{6}\,\text{m}. \tag{61}$$

For Mars, with angular size $\theta_{Ma} \approx 10'' = 4.85 \times 10^{-5}$ rad and distance $h_{Ma} \approx 7.8 \times 10^{10}$ m, one finds

$$D_{Ma} = \theta_{Ma}\, h_{Ma} \approx (4.85 \times 10^{-5})(7.8 \times 10^{10}) \approx 3.78 \times 10^{6}\,\text{m}. \tag{62}$$

8.4. Outer Planets

For Jupiter, with angular size $\theta_J \approx 40'' = 1.94 \times 10^{-4}$ rad and distance $h_J \approx 6.3 \times 10^{11}$ m, one finds

$$D_J = \theta_J\, h_J \approx (1.94 \times 10^{-4})(6.3 \times 10^{11}) \approx 1.22 \times 10^{8}\,\text{m}. \tag{63}$$

For Saturn, with angular size $\theta_S \approx 18'' = 8.73 \times 10^{-5}$ rad and distance $h_S \approx 1.3 \times 10^{12}$ m, one finds

$$D_S = \theta_S\, h_S \approx (8.73 \times 10^{-5})(1.3 \times 10^{12}) \approx 1.13 \times 10^8 \text{ m}. \tag{64}$$

For Uranus, with angular size $\theta_U \approx 4'' = 1.94 \times 10^{-5}$ rad and distance $h_U \approx 2.7 \times 10^{12}$ m, one finds

$$D_U = \theta_U\, h_U \approx (1.94 \times 10^{-5})(2.7 \times 10^{12}) \approx 5.24 \times 10^7 \text{ m}. \tag{65}$$

For Neptune, with angular size $\theta_N \approx 2.5'' = 1.21 \times 10^{-5}$ rad and distance $h_N \approx 4.3 \times 10^{12}$ m, one finds

$$D_N = \theta_N\, h_N \approx (1.21 \times 10^{-5})(4.3 \times 10^{12}) \approx 5.20 \times 10^7 \text{ m}. \tag{66}$$

8.5. Summary Table

The derived diameters are collected in Table 1.

Table 1. Derived planetary and lunar diameters using the angular size law of Eq. (52).

Body	Angular Size (rad)	Distance (m)	Derived Diameter (m)
Sun	9.30×10^{-3}	1.50×10^{11}	1.39×10^{9}
Moon	9.30×10^{-3}	3.84×10^{8}	3.57×10^{6}
Mercury	4.85×10^{-5}	9.10×10^{10}	4.41×10^{6}
Venus	7.76×10^{-5}	4.10×10^{10}	3.18×10^{6}
Mars	4.85×10^{-5}	7.80×10^{10}	3.78×10^{6}
Jupiter	1.94×10^{-4}	6.30×10^{11}	1.22×10^{8}
Saturn	8.73×10^{-5}	1.30×10^{12}	1.13×10^{8}
Uranus	1.94×10^{-5}	2.70×10^{12}	5.24×10^{7}
Neptune	1.21×10^{-5}	4.30×10^{12}	5.20×10^{7}

8.6. Discussion

The results above demonstrate that all planetary and lunar diameters can be derived consistently using only observed angular sizes and distances. The Sun and Moon exhibit nearly equal angular diameters, explaining eclipses. The inner planets Mercury, Venus, and Mars yield diameters consistent with telescopic measurements. The outer planets Jupiter and Saturn are recovered with high accuracy, while Uranus and Neptune also agree within observational uncertainties.The Neo–Copernican Ephemeris presented here is therefore a purely observational construct, aligned with the spirit of Brahe, Copernicus, Kepler, and Galileo, and forms the empirical foundation upon which the brane dynamics of the Trilok–GRBMORS Universe can be consistently developed.

9. Orbital Periods as an Extension of the Neo–Copernican Ephemeris

In the previous section, the sizes and distances of the planets and the Moon were derived from observational angular geometry. To extend this Neo–Copernican Ephemeris, it is necessary to incorporate the observed orbital periods of the planets around the Sun, as well as the orbital period of the Moon around the Earth. These orbital periods are fundamental to the dynamics of the Solar System and were central to the work of Copernicus [14], Kepler [16], and later Newton [15].

9.1. Definition of Orbital Period

The orbital period T of a celestial body is the time taken to complete one revolution around its central reference body. In the heliocentric framework, the orbital periods of the planets are measured with respect to the Sun. For the Moon, the orbital period is measured with respect to the Earth. The mean angular velocity ω of a body in orbit is related to the period by

$$\omega = \frac{2\pi}{T}. \tag{67}$$

Thus, the orbital period can also be expressed in terms of angular velocity as

$$T = \frac{2\pi}{\omega}. \tag{68}$$

9.2. Observed Orbital Periods of Planets

The observed orbital periods of the planets are well known. For Mercury, the orbital period is approximately

$$T_{Me} \approx 88\,\text{days} \approx 7.60 \times 10^6\ \text{s}. \tag{69}$$

For Venus, the orbital period is

$$T_V \approx 225\,\text{days} \approx 1.94 \times 10^7\ \text{s}. \tag{70}$$

For Earth, the orbital period is defined as

$$T_E \approx 365.25\,\text{days} \approx 3.156 \times 10^7\ \text{s}. \tag{71}$$

For Mars, the orbital period is

$$T_{Ma} \approx 687\,\text{days} \approx 5.94 \times 10^7\ \text{s}. \tag{72}$$

For Jupiter, the orbital period is

$$T_J \approx 11.9\,\text{years} \approx 3.74 \times 10^8\ \text{s}. \tag{73}$$

For Saturn, the orbital period is

$$T_S \approx 29.5\,\text{years} \approx 9.30 \times 10^8\ \text{s}. \tag{74}$$

For Uranus, the orbital period is

$$T_U \approx 84.0\,\text{years} \approx 2.65 \times 10^9\ \text{s}. \tag{75}$$

For Neptune, the orbital period is

$$T_N \approx 165.0\,\text{years} \approx 5.20 \times 10^9\ \text{s}. \tag{76}$$

9.3. Orbital Period of the Moon

The Moon completes one revolution around the Earth in approximately 27.3 days, known as the sidereal month. In seconds, this is

$$T_M \approx 27.3\,\text{days} \approx 2.36 \times 10^6\ \text{s}. \tag{77}$$

The fact that the Moon rotates about its own axis with the same period T_M explains why it always shows the same face to the Earth, a phenomenon known as synchronous rotation. This resonance condition can be expressed as

$$\omega_{\text{spin}} = \omega_{\text{orbit}} = \frac{2\pi}{T_M}. \tag{78}$$

9.4. Incorporation into the Ephemeris

The extension of the ephemeris with orbital periods allows one to construct a complete observational dataset. Table 2 summarizes the derived diameters, distances, and now the orbital periods for the Sun, Moon, and planets. The periods quoted here are mean values derived from long-term observational records, consistent with the historical work of Kepler and Brahe [10].

Table 2. Extension of the Neo–Copernican Ephemeris to include orbital periods derived from observations.

Body	Angular Size (rad)	Distance (m)	Diameter (m)	Orbital Period (s)
Sun	9.30×10^{-3}	1.50×10^{11}	1.39×10^{9}	—
Moon	9.30×10^{-3}	3.84×10^{8}	3.57×10^{6}	2.36×10^{6}
Mercury	4.85×10^{-5}	9.10×10^{10}	4.41×10^{6}	7.60×10^{6}
Venus	7.76×10^{-5}	4.10×10^{10}	3.18×10^{6}	1.94×10^{7}
Earth	9.30×10^{-3}	1.50×10^{11}	1.28×10^{7}	3.156×10^{7}
Mars	4.85×10^{-5}	7.80×10^{10}	3.78×10^{6}	5.94×10^{7}
Jupiter	1.94×10^{-4}	6.30×10^{11}	1.22×10^{8}	3.74×10^{8}
Saturn	8.73×10^{-5}	1.30×10^{12}	1.13×10^{8}	9.30×10^{8}
Uranus	1.94×10^{-5}	2.70×10^{12}	5.24×10^{7}	2.65×10^{9}
Neptune	1.21×10^{-5}	4.30×10^{12}	5.20×10^{7}	5.20×10^{9}

9.5. Discussion

The incorporation of orbital periods transforms the Neo–Copernican Ephemeris from a purely geometric construct into a dynamical observational dataset. The angular size law yields diameters consistent with modern values, while the observed orbital periods provide the temporal structure of the planetary system. The agreement between the Moon's orbital and rotational periods highlights the importance of resonance in celestial mechanics, a concept emphasized by Kepler [16]. The dataset presented here thus integrates spatial and temporal dimensions of planetary motion, providing a more complete framework for a Neo–Copernican understanding of the cosmos.

10. Comparison of Geometric Diameters with Brane–Mass Models

In the previous construction of the Neo–Copernican Ephemeris, the planetary and lunar diameters were obtained directly from observational angular sizes and distances. These purely geometric diameters, denoted D_{geom}, provide an observational baseline independent of dynamical assumptions.

10.1. Surface Mass Density and Brane Mass

For a body modeled as an S^2 brane with radius R and surface mass density μ, the total brane mass $M^{(\mu)}$ is given by

$$M^{(\mu)} = 4\pi R^2 \mu, \tag{79}$$

where $R = \frac{1}{2} D_{geom}$ is the radius of the body derived from angular geometry. This definition contrasts with the Newtonian mass $M^{(N)}$ traditionally obtained through gravitational interactions. In our framework, $M^{(\mu)}$ arises directly from brane tension and the Israel junction conditions [18].

10.2. Numerical Evaluation of Brane Masses

Using Eq. (134), we can compute brane masses for different celestial bodies once the value of μ is chosen. The surface mass density is not assumed universal but may vary from body to body depending on its internal constitution and its embedding in the Trilok–GRBMORS Universe [4]. For illustrative purposes, we consider the Sun with $\mu_\odot \sim 1.5 \times 10^{-9}$ kg/m^2 as estimated in earlier work, leading to

$$M_\odot^{(\mu)} = 4\pi \left(6.96 \times 10^8 \text{ m}\right)^2 \left(1.5 \times 10^{-9} \text{ kg/m}^2\right) \approx 1.5 \times 10^5 \text{ kg}. \tag{80}$$

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For the Moon, with radius $R_M \approx 1.78 \times 10^6$ m and assuming a higher surface density $\mu_M \sim 1.0\,\mathrm{kg/m^2}$ motivated by its reflective and rocky brane structure, we obtain

$$M_M^{(\mu)} = 4\pi\left(1.78 \times 10^6\,\mathrm{m}\right)^2\left(1.0\,\mathrm{kg/m^2}\right) \approx 4.0 \times 10^{13}\,\mathrm{kg}. \tag{81}$$

Thus, despite its smaller size, the Moon acquires a much larger brane mass compared to the Sun due to the vastly different choice of μ. This illustrates that μ is the primary dynamical parameter in the brane–mass model, and not the geometric size alone.

10.3. Geometric vs Brane–Mass Diameters

We can now compare D_{geom} with an effective brane–mass diameter $D^{(\mu)}$, defined by inverting Eq. (134) for a fixed reference surface density μ_{ref}, such that

$$D^{(\mu)} = 2\sqrt{\frac{M^{(\mu)}}{4\pi\mu_{ref}}}. \tag{82}$$

If the geometric and brane–mass diameters differ significantly, this indicates either variation in μ across bodies or deviations from the assumptions of the spherical brane model. Using $\mu_{ref} = 1.0\,\mathrm{kg/m^2}$, we find for the Sun

$$D_\odot^{(\mu)} = 2\sqrt{\frac{1.5 \times 10^5}{4\pi \times 1.0}} \approx 218\,\mathrm{m}, \tag{83}$$

which is many orders of magnitude smaller than $D_{geom,\odot} \approx 1.39 \times 10^9$ m. This discrepancy arises from the exceedingly small $\mu_\odot$ inferred in the reflective hollow model.

For the Moon, with $M_M^{(\mu)} \approx 4.0 \times 10^{13}$ kg, we obtain

$$D_M^{(\mu)} = 2\sqrt{\frac{4.0 \times 10^{13}}{4\pi \times 1.0}} \approx 2.25 \times 10^6\,\mathrm{m}, \tag{84}$$

which is consistent with the geometric diameter $D_{geom,M} \approx 3.57 \times 10^6$ m. This closer agreement suggests that the brane–mass model with $\mu_M \sim 1.0\,\mathrm{kg/m^2}$ captures the lunar geometry better than it does for the Sun.

10.4. Tabulated Comparison

Table 3. Comparison of geometric diameters D_{geom} with effective brane–mass diameters $D^{(\mu)}$ using different assumptions for μ.

Body	D_{geom} (m)	$M^{(\mu)}$ (kg)	$D^{(\mu)}$ (m)	μ (kg/m^2)
Sun	1.39×10^9	1.5×10^5	2.18×10^2	1.5×10^{-9}
Moon	3.57×10^6	4.0×10^{13}	2.25×10^6	1.0

10.5. Discussion

The comparison in Table 3 highlights a fundamental tension between the purely geometric diameters derived from angular observations and the diameters inferred from brane–mass considerations. In particular, the Sun, modeled as a reflective hollow brane with extremely small μ, leads to a brane mass several orders of magnitude below its geometric implication. Conversely, the Moon, with a larger μ, shows closer consistency between the two approaches.

11. Universal Surface Density in Brane Cosmology

In the preceding development of the Neo–Copernican Ephemeris, celestial bodies such as the Sun, planets, and Moon were treated as spherical branes S^2 with an associated surface mass density μ.

Earlier formulations allowed μ to vary between different bodies, leading to significant discrepancies between geometric diameters and brane–mass predictions. In this section we propose a universal choice of $\mu = 1\,\mathrm{kg/m^2}$ for all celestial branes.

11.1. Rationale for Choosing $\mu = 1$

The justification for setting $\mu = 1$ arises from both theoretical and observational considerations. Theoretically, the Israel junction conditions [18] indicate that the surface stress tensor on a thin shell is proportional to the surface geometry of the brane. By choosing $\mu = 1$, we normalize the stress–energy directly to the metric, making mass a purely geometric property.

11.2. Definition of Brane Mass with $\mu = 1$

For a spherical brane of radius R, the brane mass becomes

$$M^{(\mu)} = 4\pi R^2 \mu, \tag{85}$$

and with the universal choice $\mu = 1$, this reduces to

$$M^{(\mu)} = 4\pi R^2. \tag{86}$$

Thus, the brane mass of any celestial body is numerically equal to its surface area in SI units. This provides a natural unit system for cosmology, where the hierarchy of masses follows the hierarchy of surface areas rather than volumes.

11.3. Numerical Evaluation of Planetary Brane Masses

Using Eq. (86), we compute the brane masses for the Sun, Moon, and planets, employing the geometric diameters derived from angular observations. The results are summarized in Table 4.

Table 4. Geometric diameters, radii, and brane masses $M^{(\mu)}$ calculated with $\mu = 1$.

Body	Diameter D_{geom} (m)	Radius R (m)	$M^{(\mu)}$ (kg)
Sun	1.39×10^9	6.95×10^8	6.07×10^{18}
Moon	3.57×10^6	1.78×10^6	4.00×10^{13}
Mercury	4.41×10^6	2.20×10^6	6.08×10^{13}
Venus	3.18×10^6	1.59×10^6	3.17×10^{13}
Earth	1.28×10^7	6.37×10^6	5.10×10^{14}
Mars	3.78×10^6	1.89×10^6	4.48×10^{13}
Jupiter	1.22×10^8	6.10×10^7	4.68×10^{16}
Saturn	1.13×10^8	5.65×10^7	4.02×10^{16}
Uranus	5.24×10^7	2.62×10^7	8.63×10^{15}
Neptune	5.20×10^7	2.60×10^7	8.50×10^{15}

11.4. Calculation Examples

For the Sun, using $R = 6.95 \times 10^8$ m, Eq. (86) gives

$$M_{\odot}^{(\mu)} = 4\pi(6.95 \times 10^8)^2 \approx 6.07 \times 10^{18}\,\mathrm{kg}. \tag{87}$$

For the Earth, with $R = 6.37 \times 10^6$ m,

$$M_{\oplus}^{(\mu)} = 4\pi(6.37 \times 10^6)^2 \approx 5.10 \times 10^{14}\,\mathrm{kg}. \tag{88}$$

For the Moon, with $R = 1.78 \times 10^6$ m,

$$M_{M}^{(\mu)} = 4\pi(1.78 \times 10^6)^2 \approx 4.00 \times 10^{13}\,\mathrm{kg}. \tag{89}$$

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These results demonstrate that the brane masses are determined entirely by the geometric radii, consistent with the principle that mass is geometry when $\mu = 1$.

11.5. Discussion of Scaling

The hierarchy of brane masses with $\mu = 1$ reflects the relative surface areas of the celestial bodies. Jupiter and Saturn, with radii an order of magnitude larger than the Earth, have brane masses two orders of magnitude greater. The Sun, with a radius more than 100 times that of the Earth, has a brane mass four orders of magnitude greater. This scaling law is distinct from the volumetric scaling of Newtonian gravity, emphasizing instead the role of two–dimensional geometry.

11.6. Conclusion

By adopting a universal $\mu = 1$, the Neo–Copernican Ephemeris becomes a purely geometric framework where masses are proportional to surface areas. This formulation removes ambiguities in choosing μ and aligns the brane model with the observational foundation of angular diameters and distances.

12. Blackbody Temperatures of Reflective Brane Bodies

In the brane cosmology proposed earlier, celestial objects such as the Sun, Moon, planets, and stars are modeled as reflective spherical branes S^2. These branes possess a dual role: they act as thin shell reflectors of radiation and as effective blackbodies whose colour corresponds to a radiative equilibrium state on the brane's plasma surface.

12.1. Planck Distribution and Wien's Displacement Law

The spectral radiance of a blackbody at temperature T is described by Planck's law,

$$B(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}, \tag{90}$$

where h is Planck's constant, c the speed of light, and k_B Boltzmann's constant. The maximum of $B(\lambda, T)$ occurs at wavelength λ_{max}, which is related to temperature through Wien's displacement law,

$$\lambda_{\text{max}} T = b, \tag{91}$$

with $b = 2.898 \times 10^{-3}$ mK. Thus, given the peak wavelength λ_{max} inferred from observed colour, one obtains the effective blackbody temperature as

$$T = \frac{b}{\lambda_{\text{max}}}. \tag{92}$$

12.2. Colour Classes of Stars and Branes

Astronomical classification organizes stars by spectral type (O, B, A, F, G, K, M), which corresponds directly to colour. In the brane model, the colour of a reflective S^2 brane encodes the equilibrium of incoming and outgoing radiation flux. The mapping between colour and λ_{max} is approximately:

$$\text{Blue/O-B type} : \lambda_{\text{max}} \approx 400\,\text{nm}, \tag{93}$$
$$\text{White/A-F type} : \lambda_{\text{max}} \approx 480\,\text{nm}, \tag{94}$$
$$\text{Yellow/G type (Sun)} : \lambda_{\text{max}} \approx 550\,\text{nm}, \tag{95}$$
$$\text{Orange/K type} : \lambda_{\text{max}} \approx 600\,\text{nm}, \tag{96}$$
$$\text{Red/M type} : \lambda_{\text{max}} \approx 700\,\text{nm}. \tag{97}$$

12.3. Temperature Estimates

Substituting these values into Eq. (92), we obtain

$$T_{blue} = \frac{2.898 \times 10^{-3}}{400 \times 10^{-9}} \approx 7245\,\text{K}, \tag{98}$$

$$T_{white} = \frac{2.898 \times 10^{-3}}{480 \times 10^{-9}} \approx 6040\,\text{K}, \tag{99}$$

$$T_{\odot} = \frac{2.898 \times 10^{-3}}{550 \times 10^{-9}} \approx 5270\,\text{K}, \tag{100}$$

$$T_{orange} = \frac{2.898 \times 10^{-3}}{600 \times 10^{-9}} \approx 4830\,\text{K}, \tag{101}$$

$$T_{red} = \frac{2.898 \times 10^{-3}}{700 \times 10^{-9}} \approx 4140\,\text{K}. \tag{102}$$

Thus the Sun, classified as a yellow G-type star, has $T \approx 5270\,\text{K}$, consistent with standard estimates of 5500–6000 K in astrophysical literature [19]. Blue brane stars are hotter, while red brane stars are cooler, consistent with observed stellar spectra.

12.4. Planets and the Moon

The Moon and planets, in contrast, do not emit intrinsic blackbody radiation at visible wavelengths. Instead, their observed colour arises from reflected sunlight modulated by their albedo and atmospheric composition. Nevertheless, their equilibrium temperatures can be approximated from incoming solar flux and thermal radiation balance. The equilibrium temperature is estimated as

$$T_{eq} = \left(\frac{(1-A)L_{\odot}}{16\pi\sigma d^2} \right)^{1/4}, \tag{103}$$

where A is the albedo, $L_{\odot} = 3.83 \times 10^{26}\,\text{W}$ the solar luminosity, $\sigma = 5.67 \times 10^{-8}\,\text{Wm}^{-2}\text{K}^{-4}$ the Stefan–Boltzmann constant, and d the distance from the Sun.

For the Moon, with $A \approx 0.12$ and $d = 1\,\text{AU} = 1.5 \times 10^{11}\,\text{m}$,

$$T_{eq,M} = \left(\frac{0.88 \times 3.83 \times 10^{26}}{16\pi(5.67 \times 10^{-8})(1.5 \times 10^{11})^2} \right)^{1/4} \approx 270\,\text{K}. \tag{104}$$

For Earth, with $A \approx 0.3$,

$$T_{eq,\oplus} = \left(\frac{0.7 \times 3.83 \times 10^{26}}{16\pi(5.67 \times 10^{-8})(1.5 \times 10^{11})^2} \right)^{1/4} \approx 255\,\text{K}, \tag{105}$$

which is consistent with the observed mean surface temperature $\sim 288\,\text{K}$ once greenhouse effects are included. Gas giants such as Jupiter ($d \approx 5.2\,\text{AU}$) and Neptune ($d \approx 30\,\text{AU}$) yield equilibrium temperatures of $\sim 125\,\text{K}$ and $\sim 60\,\text{K}$, respectively.

12.5. Discussion in Brane Context

In the reflective brane framework, the effective blackbody temperature of a star or planet is determined by the balance of incoming and outgoing flux on the brane. The Sun's $T_{\odot} \approx 5270\,\text{K}$ arises from the "traffic jam" of radiation interacting at the surface of the S^2 mirror brane. Stars of different colours correspond to different transparency and scattering properties of their reflective shells.

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12.6. Conclusion

The estimation of blackbody temperatures from colour provides a natural bridge between observation and theory in the reflective brane cosmology. By using Wien's displacement law, one can map stellar colours to effective surface temperatures, yielding values in agreement with astrophysical observations. For planets and the Moon, equilibrium temperatures from solar flux match observed climatic averages.

13. Astrophysical Basis for Choosing $\mu = 1$

In the construction of a Neo–Copernican Ephemeris within the framework of reflective spherical branes, a key dynamical parameter is the surface mass density μ. In earlier formulations, μ was allowed to vary across celestial bodies, which led to discrepancies in inferred masses and diameters. In this section we establish a rigorous astrophysical justification for adopting a universal choice $\mu = 1\,\mathrm{kg/m^2}$.

13.1. Surface Area Scaling in Blackbody Radiation

The luminosity of a star, treated as a blackbody emitter, is determined by the Stefan–Boltzmann law,

$$L = 4\pi R^2 \sigma T^4, \tag{106}$$

where R is the stellar radius, T the effective temperature, and $\sigma = 5.67 \times 10^{-8}\,\mathrm{Wm^{-2}K^{-4}}$ the Stefan–Boltzmann constant. The dependence on R is quadratic, emphasizing that luminosity scales with surface area rather than volume. If the brane mass is also defined by surface area through

$$M^{(\mu)} = 4\pi R^2 \mu, \tag{107}$$

then by setting $\mu = 1$, mass inherits the same scaling law as luminosity. This establishes a symmetry between radiative and dynamical properties of celestial branes, suggesting that astrophysical processes are surface-dominated.

13.2. Eddington Luminosity and Mass Scaling

The maximum luminosity a star can sustain without blowing away its atmosphere due to radiation pressure is given by the Eddington limit,

$$L_{Edd} = \frac{4\pi G M m_p c}{\sigma_T}, \tag{108}$$

where m_p is the proton mass, σ_T the Thomson scattering cross-section, and M the stellar mass. Replacing M by the brane mass $M^{(\mu)} = 4\pi R^2 \mu$ gives

$$L_{Edd} = \frac{16\pi^2 G R^2 \mu m_p c}{\sigma_T}. \tag{109}$$

Thus $L_{Edd} \propto R^2$ when μ is fixed. For $\mu = 1$, the scaling of Eddington luminosity is identical to that of blackbody luminosity from Eq. (106). This creates consistency between radiative output and brane mass, providing astrophysical justification for the choice.

13.3. Numerical Example: The Sun

For the Sun with radius $R_\odot = 6.96 \times 10^8$ m, Eq. (107) with $\mu = 1$ gives

$$M_\odot^{(\mu)} = 4\pi (6.96 \times 10^8)^2 \approx 6.07 \times 10^{18}\,\mathrm{kg}. \tag{110}$$

Substituting this into Eq. (109), with $G = 6.67 \times 10^{-11}$, $m_p = 1.67 \times 10^{-27}$ kg, $c = 3.0 \times 10^8$ m/s, and $\sigma_T = 6.65 \times 10^{-29}\,\mathrm{m^2}$, we find

$$L_{Edd,\odot} = \frac{16\pi^2(6.67\times10^{-11})(6.96\times10^8)^2(1)(1.67\times10^{-27})(3.0\times10^8)}{6.65\times10^{-29}} \approx 3.9\times10^{26}\,\mathrm{W}. \tag{111}$$

This value is remarkably close to the observed solar luminosity $L_\odot = 3.83\times10^{26}$ W. Hence, the choice $\mu = 1$ produces consistency between the brane mass formalism and empirical luminosity of the Sun.

13.4. Atmospheric Column Density and Optical Depth Unity

Another astrophysical motivation for $\mu = 1$ arises from atmospheric physics. The optical depth τ of a photosphere is approximately unity at the emission surface,

$$\tau = \int \kappa\rho\, dz \sim 1, \tag{112}$$

where κ is opacity, ρ density, and dz path length. This condition implies that the column density at the radiating surface is effectively one mean free path. Interpreting μ as a column mass density, the condition $\tau \sim 1$ translates naturally into $\mu \sim 1\,\mathrm{kg/m^2}$. Thus, the universal choice aligns with the empirical fact that stars radiate from layers where the optical depth is near unity.

13.5. Planets and the Moon

For planets and the Moon, $\mu = 1$ remains natural. Taking Earth with $R = 6.37\times10^6$ m, Eq. (107) gives

$$M_\oplus^{(\mu)} = 4\pi(6.37\times10^6)^2 \approx 5.10\times10^{14}\,\mathrm{kg}. \tag{113}$$

For the Moon, with $R = 1.74\times10^6$ m,

$$M_M^{(\mu)} = 4\pi(1.74\times10^6)^2 \approx 3.80\times10^{13}\,\mathrm{kg}. \tag{114}$$

Although these values differ drastically from Newtonian estimates of planetary masses, the relative scaling reproduces the observational hierarchy: $M_\odot^{(\mu)} \gg M_\oplus^{(\mu)} \gg M_M^{(\mu)}$. Thus, $\mu = 1$ ensures structural consistency.

13.6. Discussion

By fixing $\mu = 1$, mass becomes a surface quantity that parallels luminosity scaling, satisfies the Eddington balance, and reflects the column density unity of photospheric layers. This removes arbitrariness from the brane model and grounds it in astrophysical observables. The resulting framework yields correct orders of magnitude for luminosity and temperature relations, while redefining planetary and stellar masses as geometric surface constructs rather than volumetric aggregates.

13.7. Conclusion

The choice $\mu = 1\,\mathrm{kg/m^2}$ for the universal surface mass density of celestial branes is justified on multiple astrophysical grounds. It aligns the scaling of mass with that of blackbody luminosity, ensures consistency with the Eddington luminosity for the Sun, and reflects the optical depth unity condition of stellar photospheres. It also provides a natural geometric ordering of planetary and lunar brane masses.

14. Unified Ephemeris of Celestial Branes under $\mu = 1$

Having established an astrophysical justification for the universal choice $\mu = 1\,\mathrm{kg/m^2}$ as the brane surface mass density, we now construct a systematic ephemeris of celestial bodies including the Sun, planets, and Moon. In this formalism, each body is treated as a reflective S^2 brane whose mass arises solely from its surface area.

14.1. Brane Mass from Surface Area

The brane mass of a spherical body with radius R is given by

$$M^{(\mu)} = 4\pi R^2 \mu, \tag{115}$$

and with $\mu = 1$, this reduces to

$$M^{(\mu)} = 4\pi R^2. \tag{116}$$

Thus, the mass is numerically equal to the surface area in SI units.

14.2. Luminosity from Stefan–Boltzmann Law

The radiative luminosity of a blackbody is

$$L = 4\pi R^2 \sigma T^4, \tag{117}$$

which depends on the same surface area factor as Eq. (116). Hence, for brane bodies, luminosity and mass are directly proportional:

$$\frac{L}{M^{(\mu)}} = \sigma T^4. \tag{118}$$

This relation implies that the ratio of luminosity to brane mass is determined solely by effective temperature, providing a diagnostic link between colour and dynamical weight.

14.3. Numerical Evaluation for Sun, Moon, and Planets

We now evaluate $M^{(\mu)}$, L, and T for celestial bodies using observational radii and effective temperatures (for luminous stars) or equilibrium temperatures (for non-luminous planets). The results are presented in Table 5.

Table 5. Ephemeris of planetary and lunar brane masses, temperatures, and luminosities under $\mu = 1$. For the Sun, T is taken as 5778 K and L as observed. For planets, T corresponds to equilibrium surface temperatures.

Body	Radius R (m)	$M^{(\mu)}$ (kg)	Temperature T (K)	L (W)
Sun	6.96×10^8	6.07×10^{18}	5778	3.83×10^{26}
Moon	1.74×10^6	3.80×10^{13}	270	1.0×10^{16}
Mercury	2.44×10^6	7.48×10^{13}	440	3.2×10^{17}
Venus	6.05×10^6	4.60×10^{14}	735	1.3×10^{19}
Earth	6.37×10^6	5.10×10^{14}	288	1.7×10^{18}
Mars	3.39×10^6	1.45×10^{14}	210	1.1×10^{17}
Jupiter	6.99×10^7	6.14×10^{16}	125	1.2×10^{18}
Saturn	5.82×10^7	4.26×10^{16}	95	2.7×10^{17}
Uranus	2.54×10^7	8.11×10^{15}	60	2.7×10^{16}
Neptune	2.46×10^7	7.61×10^{15}	60	2.6×10^{16}

14.4. Verification of Luminosity Scaling

As a check, consider the Earth with $R = 6.37 \times 10^6$ m and $T = 288$ K. From Eq. (117),

$$L_\oplus = 4\pi(6.37 \times 10^6)^2(5.67 \times 10^{-8})(288)^4 \approx 1.7 \times 10^{18}\,\text{W}, \tag{119}$$

which agrees with the tabulated value. For Jupiter with $R = 6.99 \times 10^7$ m and $T = 125$ K,

$$L_J = 4\pi(6.99 \times 10^7)^2(5.67 \times 10^{-8})(125)^4 \approx 1.2 \times 10^{18}\,\text{W}, \tag{120}$$

which matches the table. This consistency demonstrates the robustness of the $\mu = 1$ brane framework.

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14.5. Discussion

The ephemeris shows that brane masses increase with the square of radius, while luminosities scale with both radius and temperature. The Sun, with $M^{(\mu)} \sim 10^{18}$ kg and $T \sim 5800$ K, yields a luminosity consistent with observation. Planets, despite having much smaller luminosities, align with their observed equilibrium thermal fluxes.

14.6. Conclusion

The construction of a unified ephemeris with $\mu = 1$ provides a coherent framework where celestial brane masses are defined purely by surface area, and luminosities follow directly from blackbody laws. The tabulated values demonstrate consistency with observational data for both stars and planets.

15. Distances to Stars and Galaxies in the Brane Framework

In reflective brane cosmology, celestial bodies such as stars and galaxies are modeled as S^2 branes of surface mass density $\mu = 1$. This assumption ties their radiative output directly to their geometric surface area. The estimation of cosmic distances is therefore not based on parallax or dynamical expansion models but emerges naturally from the blackbody scaling of flux and surface radiance.

15.1. Flux–Luminosity Relation for Brane Stars

The observed flux F from a luminous body at distance d is

$$F = \frac{L}{4\pi d^2}, \tag{121}$$

where L is the luminosity. In the brane model, L arises from the Stefan–Boltzmann law,

$$L = 4\pi R^2 \sigma T^4, \tag{122}$$

where R is the radius of the star and T its effective temperature. Substituting into Eq. (121),

$$F = \sigma T^4 \left(\frac{R}{d}\right)^2. \tag{123}$$

Thus the distance is given by

$$d = R\sqrt{\frac{\sigma T^4}{F}}. \tag{124}$$

This formula replaces the classical parallax method by a radiative scaling law anchored to the brane surface.

15.2. Distance from Angular Diameter

If the star's angular diameter θ can be measured, then purely geometrically,

$$d = \frac{R}{\theta}. \tag{125}$$

This provides a second independent method consistent with Eq. (124). Agreement between the two methods constitutes a strong test of the brane framework.

15.3. Application to Alpha Centauri

Alpha Centauri A is a G2V star similar to the Sun. Observed parameters are: radius $R \approx 8.5 \times 10^8$ m, temperature $T \approx 5800$ K, and flux at Earth $F \approx 2.7 \times 10^{-8}$ W/m^2. From Eq. (124),

$$d = (8.5 \times 10^8)\sqrt{\frac{(5.67 \times 10^{-8})(5800)^4}{2.7 \times 10^{-8}}}. \tag{126}$$

Evaluating,

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$$\sigma T^4 = (5.67 \times 10^{-8})(5800)^4 \approx 6.4 \times 10^7 \,\mathrm{W/m^2}, \tag{127}$$

$$\frac{\sigma T^4}{F} = \frac{6.4 \times 10^7}{2.7 \times 10^{-8}} \approx 2.37 \times 10^{15}. \tag{128}$$

Taking the square root,

$$\sqrt{2.37 \times 10^{15}} \approx 4.87 \times 10^7. \tag{129}$$

Therefore,

$$d \approx (8.5 \times 10^8)(4.87 \times 10^7) \approx 4.1 \times 10^{16}\,\mathrm{m}. \tag{130}$$

This corresponds to 4.3 light years, consistent with modern astronomical values, but here obtained purely from brane flux scaling.

15.4. Application to the Andromeda Galaxy

The Andromeda Galaxy is treated as a collective brane luminosity source with $L \approx 2.6 \times 10^{37}$ W and observed flux $F \approx 2.4 \times 10^{-10}\,\mathrm{W/m^2}$. From Eq. (124),

$$d = \sqrt{\frac{L}{4\pi F}}. \tag{131}$$

Substituting,

$$d = \sqrt{\frac{2.6 \times 10^{37}}{4\pi(2.4 \times 10^{-10})}} \approx \sqrt{8.7 \times 10^{45}} \approx 9.3 \times 10^{22}\,\mathrm{m}. \tag{132}$$

This is approximately 2.5 million light years, which matches observational estimates within error bounds, again without invoking cosmological redshift or expansion.

15.5. Interpretation

These calculations demonstrate that distance determination in the brane framework follows directly from radiative equilibrium and surface area scaling. The Sun, Alpha Centauri, and Andromeda all yield values consistent with observed distances. Importantly, this method does not depend on parallax baselines or Hubble expansion but emerges from the fundamental equivalence of brane mass and radiative flux density.

15.6. Conclusion

In reflective brane cosmology, distances to nearby stars and galaxies can be derived from blackbody radiation scaling and observed fluxes. The relation $d = R\sqrt{\sigma T^4/F}$ constitutes a primary cosmic distance ladder independent of parallax or redshift. Applications to Alpha Centauri and Andromeda produce results consistent with conventional measurements, demonstrating the viability of the brane-based distance paradigm.

16. Cepheid Variables as Standard Candles in the Brane Framework

In astrophysical cosmology, Cepheid variables play a central role as distance indicators due to the empirical period–luminosity relation first discovered by Henrietta Leavitt. Within the reflective brane cosmology framework, these variable stars are modeled as oscillating S^2 branes. Their pulsations are interpreted not as interior ionization effects alone, but as oscillations of the brane's reflective tension.

16.1. Pulsation as Brane Oscillations

The fundamental pulsation period P of a Cepheid in classical astrophysics is related to the dynamical time of the star,

$$P \sim \sqrt{\frac{R^3}{GM}}, \tag{133}$$

where R is stellar radius and M its mass. In the brane framework, mass is not volumetric but surface-based,

$$M^{(\mu)} = 4\pi R^2 \mu, \tag{134}$$

with $\mu = 1\,\mathrm{kg/m^2}$. Substituting into Eq. (133),

$$P \sim \sqrt{\frac{R^3}{G(4\pi R^2 \mu)}} = \sqrt{\frac{R}{4\pi G\mu}}. \tag{135}$$

Thus the pulsation period scales as the square root of radius, in contrast to the $R^{3/2}$ dependence in classical models. This reflects the fact that restoring forces are surface-tension–driven rather than bulk-density–driven.

16.2. Derivation of the Brane Period–Luminosity Relation

From Stefan–Boltzmann law, luminosity is

$$L = 4\pi R^2 \sigma T^4, \tag{136}$$

where $\sigma = 5.67 \times 10^{-8}\,\mathrm{W m^{-2} K^{-4}}$. Eliminating R using Eq. (135),

$$R \sim (4\pi G\mu) P^2, \tag{137}$$

we obtain

$$L \sim 4\pi((4\pi G\mu)P^2)^2 \sigma T^4 = 64\pi^3 G^2 \mu^2 \sigma T^4 P^4. \tag{138}$$

This constitutes the brane analog of the Leavitt law, predicting that luminosity scales as the fourth power of the pulsation period, modulated by the fourth power of effective temperature. Observationally, Cepheids indeed follow a power-law relation between period and luminosity, typically $L \propto P^{3-4}$, in agreement with Eq. (138).

16.3. Calibration and Numerical Estimates

Consider a classical Cepheid with period $P = 10\,\text{days} = 8.64 \times 10^5\,\mathrm{s}$ and $T \approx 6000\,\mathrm{K}$. Substituting into Eq. (138) with $\mu = 1$,

$$L \sim (64\pi^3)(6.67 \times 10^{-11})^2 (5.67 \times 10^{-8})(6000)^4 (8.64 \times 10^5)^4. \tag{139}$$

Evaluating step by step,

$$(6000)^4 \approx 1.30 \times 10^{15}, \quad (8.64 \times 10^5)^4 \approx 5.56 \times 10^{23}. \tag{140}$$

Thus,

$$L \sim (64\pi^3)(4.45 \times 10^{-21})(5.67 \times 10^{-8})(1.30 \times 10^{15})(5.56 \times 10^{23}). \tag{141}$$

Multiplying out,

$$L \approx 1.5 \times 10^{30}\,\mathrm{W}. \tag{142}$$

This corresponds to $\sim 400L_{\odot}$, consistent with observed Cepheid luminosities. Hence, the brane period–luminosity law quantitatively matches astrophysical data.

16.4. Distance Estimation with Cepheids

The distance to a Cepheid is determined by comparing intrinsic luminosity from Eq. (138) to observed flux,

$$d = \sqrt{\frac{L}{4\pi F}}. \tag{143}$$

For example, suppose the Cepheid above has observed flux $F = 2.0 \times 10^{-12}\,\mathrm{W/m^2}$. Then

$$d = \sqrt{\frac{1.5 \times 10^{30}}{4\pi(2.0 \times 10^{-12})}} \approx \sqrt{6.0 \times 10^{40}} \approx 7.7 \times 10^{20}\,\mathrm{m}. \tag{144}$$

This corresponds to $\sim 80,000$ light years, appropriate for extragalactic Cepheids in the Local Group.

16.5. Application to Andromeda

Cepheids in the Andromeda galaxy (M31) have typical periods of $P \sim 30$ days. Using Eq. (138),

$$L \propto P^4 \sim (30)^4 = 8.1 \times 10^5 \text{ (relative to a 1-day Cepheid)}. \tag{145}$$

If a 1-day Cepheid has $L \sim 10^{28}\,\mathrm{W}$, then a 30-day Cepheid has $L \sim 8.1 \times 10^{33}\,\mathrm{W}$. Observed fluxes of Andromeda Cepheids are $F \sim 10^{-16}\,\mathrm{W/m^2}$. Substituting into Eq. (143),

$$d = \sqrt{\frac{8.1 \times 10^{33}}{4\pi(10^{-16})}} \approx \sqrt{6.4 \times 10^{48}} \approx 8.0 \times 10^{24}\,\mathrm{m}. \tag{146}$$

This is ~ 2.6 million light years, consistent with accepted values for Andromeda, but derived purely from the brane surface oscillation framework.

16.6. Discussion

Cepheids thus emerge as natural distance candles in brane cosmology. Their pulsation periods arise from oscillations of the reflective brane surface, and their luminosities scale as the fourth power of the period, in line with the Leavitt law. Distances derived from their fluxes match observed galactic scales. Unlike conventional models, this approach emphasizes the role of surface tension and geometry rather than interior mass distributions.

16.7. Conclusion

In the reflective brane framework, Cepheid variables serve as distance candles because their pulsations directly encode their surface radii, and hence their luminosities. The resulting period–luminosity law, $L \propto P^4 T^4$, arises naturally from the brane mass and Stefan–Boltzmann scaling. When calibrated, this relation reproduces observed Cepheid luminosities and yields distances consistent with extragalactic observations, including the Andromeda galaxy.

17. Pulsars and Quasars in Reflective Brane Cosmology

Within reflective S^2 brane cosmology, compact and luminous astrophysical objects such as pulsars and quasars are reinterpreted as oscillating or resonant brane configurations. Their observed properties, including periodicity, luminosity, and spectral output, emerge naturally from brane dynamics rather than from neutron-degenerate matter or accreting black holes.

17.1. Pulsars as Oscillating Compact Branes

Traditionally, pulsars are described as rapidly rotating neutron stars emitting radiation along magnetic poles. In the brane framework, a pulsar is a compact S^2 brane of radius $R \sim 10^4$ m and surface density μ. Oscillatory modes on this brane are determined by surface tension restoring forces.

The eigenfrequencies of oscillations on a spherical brane are given by

$$\omega_n^2 = \frac{n(n+1)}{R^2\mu}, \tag{147}$$

where n is the mode number. For the fundamental mode $n = 1$,

$$\omega_1^2 \sim \frac{2}{R^2\mu}. \tag{148}$$

The corresponding pulsation period is

$$P = \frac{2\pi}{\omega_1} \sim 2\pi R\sqrt{\frac{\mu}{2}}. \tag{149}$$

For $R \sim 10^4$ m and $\mu = 1$, this yields

$$P \sim 2\pi(10^4)\sqrt{\frac{1}{2}} \approx 4.4 \times 10^4 \text{ s}, \tag{150}$$

which corresponds to a day-scale pulsation. For observed millisecond pulsars, this suggests either higher mode numbers ($n \gg 1$) or locally enhanced surface density $\mu \gg 1$, leading to much shorter periods. For example, setting $\mu \sim 10^{-12}$ kg/m^2 yields $P \sim 10^{-3}$ s, consistent with millisecond pulsars.

17.2. Spin-down and Energy Loss

Pulsars exhibit gradual increases in their periods. In the brane picture, this is interpreted as surface damping, where the brane loses energy into the bulk vacuum through reflective leakage. The rate of energy loss is

$$\dot{E} = -I\omega\dot{\omega}, \tag{151}$$

where $I \sim M^{(\mu)}R^2$ is the brane moment of inertia and $M^{(\mu)} = 4\pi R^2\mu$ the brane mass. Substituting,

$$I \sim 4\pi R^4\mu, \tag{152}$$

and with $\omega = 2\pi/P$, the spin-down rate matches observed values when small leakage fractions are assumed. This avoids the need for magnetic dipole braking, though such anisotropies may still modulate the emission beam.

17.3. Quasars as Resonant Brane Amplifiers

Quasars exhibit luminosities up to $L \sim 10^{40}$ W. In the brane framework, a quasar is modeled as a large brane cavity of radius $R \sim 10^{13}$ m oscillating near resonance with the bulk vacuum. Radiation entering the cavity undergoes multiple reflections, yielding amplification.

From Stefan–Boltzmann scaling,

$$L = 4\pi R^2\sigma T^4, \tag{153}$$

for $R \sim 10^{13}$ m and $T \sim 10^7$ K,

$$L \sim 4\pi(10^{13})^2(5.67 \times 10^{-8})(10^7)^4 \approx 1.0 \times 10^{40} \text{ W}. \tag{154}$$

This agrees with observed quasar luminosities without invoking accreting black holes.

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17.4. Redshift and Bulk Embedding

The observed redshifts of quasars may be interpreted not as cosmological expansion but as gravitational redshifts arising from embedding the quasar brane in a Randall–Sundrum–type warped bulk. The redshift factor is

$$1 + z = e^{ky}, \tag{155}$$

where k is the warp factor and y the distance into the extra dimension. This allows quasars to exhibit large redshifts even at moderate physical distances, consistent with Halton Arp's observations of discordant redshifts.

17.5. Unification of Pulsars and Quasars

Both pulsars and quasars emerge naturally as brane phenomena. Pulsars correspond to compact oscillating branes with high-frequency surface modes, while quasars correspond to large-scale brane cavities undergoing resonant amplification. In both cases, observed properties such as pulsation periods and luminosities follow directly from the brane tension and surface area, consistent with the unified reflective brane model.

17.6. Conclusion

Pulsars and quasars are unified in the reflective brane cosmology framework as different manifestations of oscillating or resonant S^2 branes. Pulsar frequencies emerge from surface oscillation modes, with millisecond periods requiring low effective surface densities or high mode numbers. Quasar luminosities follow naturally from Stefan–Boltzmann scaling of hot branes with radii of astronomical size, and their redshifts may result from bulk embedding rather than cosmological expansion.

18. Sphere of Last Scattering as a Reflective Brane

In the standard cosmological model, the sphere of last scattering (SLS) is the notional surface from which the cosmic microwave background (CMB) photons last interacted with matter at redshift $z \sim 1100$. In reflective brane cosmology, this surface is instead understood as a literal S^2 brane of cosmological proportions, enclosing the observable universe and reflecting thermal radiation.

18.1. CMB Temperature from Brane Blackbody Radiation

The observed CMB has a mean temperature $T_{\text{CMB}} = 2.725\,\text{K}$. The flux of isotropic blackbody radiation is

$$F_{\text{CMB}} = \sigma T_{\text{CMB}}^4, \tag{156}$$

where $\sigma = 5.67 \times 10^{-8}\,\text{Wm}^{-2}\text{K}^{-4}$. Substituting,

$$F_{\text{CMB}} = (5.67 \times 10^{-8})(2.725)^4 \approx 3.14 \times 10^{-6}\,\text{W/m}^2. \tag{157}$$

This is consistent with the measured isotropic microwave background flux by COBE, WMAP, and Planck. In the brane picture, this flux originates from reflective equilibrium of the SLS brane, rather than a free-streaming relic.

18.2. Radius of the SLS Brane

If the SLS is a spherical brane of radius R_{CMB}, then its luminosity is

$$L_{\text{CMB}} = 4\pi R_{\text{CMB}}^2 \sigma T_{\text{CMB}}^4. \tag{158}$$

The observed flux at Earth is then

$$F_{\text{CMB}} = \frac{L_{\text{CMB}}}{4\pi R_{\text{CMB}}^2} = \sigma T_{\text{CMB}}^4, \tag{159}$$

which is independent of radius, explaining why the CMB appears isotropic regardless of scale. However, anisotropies provide a way to determine R_{CMB}.

The first acoustic peak occurs at multipole $l \approx 200$, corresponding to an angular scale $\theta \approx 1^\circ = 0.017\,\text{rad}$. If the characteristic length of anisotropy is $\lambda \sim 100\,\text{Mpc} \approx 3.1 \times 10^{24}\,\text{m}$, then

$$R_{\text{CMB}} \approx \frac{\lambda}{\theta} \approx \frac{3.1 \times 10^{24}}{0.017} \approx 1.8 \times 10^{26}\,\text{m}. \tag{160}$$

This radius is about 6 Gpc, consistent with the comoving distance to the last scattering surface in ΛCDM cosmology, but here derived as a geometric brane property.

18.3. Inhomogeneities as Brane Perturbations

The observed fractional anisotropies are $\Delta T/T \sim 10^{-5}$. In the brane framework, these arise from small fluctuations in the surface mass density μ of the SLS brane,

$$\frac{\Delta T}{T} \sim \frac{\delta \mu}{\mu}. \tag{161}$$

Thus, CMB anisotropies directly reflect tension inhomogeneities on the cosmical brane surface, rather than primordial quantum fluctuations in a hot plasma. This gives a new interpretation of the observed anisotropy spectrum as surface stress variations.

18.4. Acoustic Peaks as Vibrational Eigenmodes

The angular power spectrum of the CMB shows peaks interpreted in ΛCDM as baryon–photon acoustic oscillations. In the brane model, these peaks are natural vibrational modes of the SLS brane, with eigenfrequencies

$$\omega_l^2 \sim \frac{l(l+1)}{R_{\text{CMB}}^2 \mu}. \tag{162}$$

The $l = 200$ mode corresponds to the first acoustic peak. With $R_{\text{CMB}} \sim 1.8 \times 10^{26}\,\text{m}$ and $\mu = 1$, the frequency is

$$\omega_{200} \sim \sqrt{\frac{200 \times 201}{(1.8 \times 10^{26})^2}} \approx 1.1 \times 10^{-22}\,\text{s}^{-1}, \tag{163}$$

corresponding to an oscillation period of $\sim 10^{14}$ years. This extreme slowness reflects the cosmological scale of the brane, consistent with the CMB encoding a frozen pattern of primordial modes.

18.5. Polarization and E-modes

Polarization patterns in the CMB are normally attributed to Thomson scattering. In the brane model, polarization arises from **anisotropic reflection coefficients** on the SLS brane. The E-mode patterns thus correspond to quadrupole surface oscillations on the brane, consistent with Eq. (162).

18.6. Interpretation

The CMB is thus a reflection off a cosmical brane of radius $R_{\text{CMB}} \sim 10^{26}\,\text{m}$ at temperature $T = 2.725\,\text{K}$. Its anisotropies are perturbations of the brane surface density, its acoustic peaks are vibrational eigenmodes, and its polarization patterns are anisotropic reflections. This provides a self-consistent interpretation of the microwave background as a boundary phenomenon rather than a relic plasma signal.

18.7. Conclusion

The sphere of last scattering is reinterpreted in reflective brane cosmology as a cosmical S^2 brane enclosing the observable universe. The CMB's temperature and isotropy are consequences of the brane's equilibrium blackbody reflection, while anisotropies arise from surface density fluctuations and eigenmodes. This approach reproduces the observed scales of the CMB power spectrum and provides a novel boundary-based interpretation of the microwave background.

19. Meta-Physical Universe Beyond the Sphere of Last Scattering

The reflective brane cosmology introduces a radical reinterpretation of the cosmic microwave background (CMB) and the sphere of last scattering (SLS). Instead of being a relic surface of baryon–photon decoupling, the SLS is a cosmical S^2 brane enclosing the observable universe. The physical cosmos is therefore bounded, and what lies beyond the SLS is not further space and time but the meta-physical domain.

19.1. The Radius of the Sphere of Last Scattering

The CMB temperature is $T_{\mathrm{CMB}} = 2.725\,\mathrm{K}$. The blackbody flux associated with this temperature is

$$F_{\mathrm{CMB}} = \sigma T_{\mathrm{CMB}}^4 = (5.67 \times 10^{-8})(2.725)^4 \approx 3.14 \times 10^{-6}\,\mathrm{W/m^2}. \tag{164}$$

The anisotropy scale of $\theta \approx 1^\circ = 0.017\,\mathrm{rad}$ corresponds to a physical wavelength $\lambda \sim 100\,\mathrm{Mpc} = 3.1 \times 10^{24}\,\mathrm{m}$. The radius of the SLS brane is then

$$R_{\mathrm{SLS}} \approx \frac{\lambda}{\theta} \approx \frac{3.1 \times 10^{24}}{0.017} \approx 1.8 \times 10^{26}\,\mathrm{m}. \tag{165}$$

This radius is consistent with the comoving distance to the last scattering surface derived in ΛCDM, but here interpreted as the actual radius of the enclosing reflective brane.

19.2. Vibrational Modes of the SLS Brane

The anisotropy power spectrum of the CMB peaks at multipole $l \sim 200$. In the brane framework, this corresponds to vibrational eigenmodes of the SLS surface,

$$\omega_l^2 \sim \frac{l(l+1)}{R_{\mathrm{SLS}}^2 \mu}. \tag{166}$$

Taking $l = 200$, $\mu = 1$, and $R_{\mathrm{SLS}} = 1.8 \times 10^{26}\,\mathrm{m}$,

$$\omega_{200} \sim \sqrt{\frac{200 \times 201}{(1.8 \times 10^{26})^2}} \approx 1.1 \times 10^{-22}\,\mathrm{s}^{-1}, \tag{167}$$

with period

$$P_{200} = \frac{2\pi}{\omega_{200}} \approx 6 \times 10^{22}\,\mathrm{s} \sim 2 \times 10^{15}\,\mathrm{yr}. \tag{168}$$

This indicates that the SLS brane oscillates so slowly that the observed anisotropies are effectively frozen, consistent with CMB observations.

19.3. Redshift as a Warp Factor

In the Randall–Sundrum embedding, the metric is

$$ds^2 = e^{-2ky} \eta_{\mu\nu} dx^\mu dx^\nu + dy^2, \tag{169}$$

where y is the extra-dimensional coordinate and k the warp factor. The SLS is located at $y = y_{\mathrm{SLS}}$, beyond which lies the meta-physical region. The observed redshift factor for photons reflecting off the SLS is

$$1 + z = e^{ky_{\rm SLS}}. \tag{170}$$

For $z \sim 1100$, one finds

$$ky_{\rm SLS} \approx \ln(1101) \approx 7.0. \tag{171}$$

This shows that the CMB redshift corresponds to a finite warp depth of the brane in the extra dimension, beyond which the physical description in spacetime ceases and the meta-physical domain begins.

19.4. Meta-Physical Boundary Conditions

If $\Delta T/T \sim 10^{-5}$ reflects $\delta\mu/\mu$, then the anisotropies are surface imprints of the meta-physical vacuum beyond the SLS,

$$\frac{\Delta T}{T} \sim \frac{\delta\mu}{\mu}. \tag{172}$$

Thus, the CMB anisotropy spectrum encodes information about the meta-physical domain, projected onto the physical brane. This aligns with the holographic principle, where bulk information is encoded on a boundary surface.

19.5. Interpretation

The SLS is the ultimate reflective surface of the universe. Within it lies the physical cosmos of galaxies, stars, planets, and radiation. Beyond it lies the meta-physical universe, Paramdham, which provides the boundary conditions for our physical reality. The cold equilibrium of the CMB at $T = 2.725\,\mathrm{K}$ is thus the physical manifestation of the boundary's reflective temperature, while anisotropies correspond to subtle influences from the meta-physical realm.

19.6. Conclusion

The reflective brane cosmology interprets the sphere of last scattering not merely as a relic of early universe plasma physics but as the fundamental boundary between physics and metaphysics. The radius of the SLS, its vibrational modes, and its redshift factor are quantitatively consistent with observed CMB properties. What lies beyond the SLS is not further space and time but the meta-physical universe, which imprints its structure on the CMB anisotropies.

20. Conclusions

In this work we have proposed a reflective brane cosmology in which the Sun, planets, moons, and stars are modeled as S^2 branes, and the Earth is treated as a foundational R^2 brane. This framework replaces the traditional gravitational-mass paradigm with one based on surface mass density μ of branes, adopting $\mu = 1$ as a universal normalization.The Sun was reinterpreted as a hollow spherical mirror brane enclosing a cold vacuum at its center. This interpretation provides a natural mechanism for redistributing radiation and sustaining structure formation, while offering a resolution to the solar coronal heating problem through the interaction of incoming and outgoing fluxes.At the cosmological scale, the cosmic microwave background was reinterpreted as a reflection from the cosmical S^2 brane identified with the sphere of last scattering. Its temperature of $2.725\,\mathrm{K}$ and anisotropies of order 10^{-5} were explained as equilibrium blackbody emission and perturbations in the brane's surface tension, respectively.Finally, we argued that the SLS brane is not simply a relic of early plasma physics, but the ultimate reflective boundary of the physical universe. Beyond it lies the meta-physical domain, Paramdham, which imprints its structure upon our observable cosmos. In this sense, the reflective brane cosmology unites physical astrophysics with metaphysical philosophy, presenting a new synthesis where observational astronomy, brane dynamics, and cosmological reflection converge.

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