Newtonian Gravity, Kerr Frame Dragging, and Spiral Geometry in the Pivot Universe Model

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Abstract

Newton's law of gravitation and Einstein's General Relativity describe gravity in fundamentally different ways. Newtonian theory treats gravity as an interaction between masses, whereas General Relativity describes gravity through spacetime geometry. Nevertheless, Newtonian gravity remains an excellent approximation in appropriate weak-field conditions.

This paper considers a possible connection between the two descriptions within the Pivot Universe (PU) model. The universe is assumed to contain a central massive rotating object, called the Pivot, whose angular momentum produces large-scale Kerr frame dragging. Matter is proposed to move with this rotating spacetime rather than through an otherwise stationary space.

A further hypothesis is examined. In the usual Newtonian circular-orbit relation,

$$v^2 = \frac{GM}{R},$$

R represents radial distance from the gravitating body. The PU model considers whether, for matter following an extremely long spiral trajectory generated by frame dragging, an effective dynamical length L could replace R,

$$v^2 = \frac{GM}{L}.$$

For the Milky Way, the conventional Newtonian calculation using the Pivot mass and radial distance produces a velocity much larger than the Kerr frame-dragging coordinate velocity. Their direct ratio is approximately 183. A differential-frame-rotation spiral is then constructed using a common elapsed time, $\phi(r) = \Omega(r)T_{\mathrm{MW}}$. Applying the correct polar arc-length formula gives the formal coordinate length $L \simeq 1.53 \times 10^6$ Gly. Substitution into $v_N(L) = \sqrt{GM_P/L}$ gives

$$\frac{v_N(L)}{v_{\mathrm{Kerr}}} \simeq 1.64.$$

This numerical proximity is not a derivation from Newtonian gravity or General Relativity. The plotted spiral is not a Kerr geodesic, and its continuation inside the event horizon is formal.

1 Newtonian Gravity

For a body of mass m orbiting a central mass M, Newton's gravitational force is

$$F_G = \frac{GMm}{R^2}.$$

For a circular orbit, the centripetal force is

$$F_c = \frac{mv^2}{R}.$$

Equating the two gives

$$\frac{GMm}{R^2} = \frac{mv^2}{R},$$

and therefore

$$\boxed{v_N = \sqrt{\frac{GM}{R}}.}$$

In conventional Newtonian mechanics, R is the instantaneous radial separation between the two masses. It is not the accumulated distance travelled along the orbit.

2 General Relativity and Rotating Space

Einstein's General Relativity replaces the Newtonian concept of gravitational force with curved spacetime. A rotating gravitating body introduces an additional effect: frame dragging.

For an approximately Kerr spacetime, the equatorial frame-dragging angular velocity can be written [1, 3]

$$\omega_{\text{Kerr}}(r) = \frac{2Marc}{A},$$

where

$$\Delta = r^2 - 2Mr + a^2,$$

and

$$A = (r^2 + a^2)^2 - a^2\Delta.$$

Here,

$$M = \frac{GM_P}{c^2}$$

is the geometrical mass parameter and

$$a = \frac{J_P}{M_P c}$$

is the Kerr spin parameter.

In the PU interpretation, this frame dragging is extended to cosmological dimensions. Celestial bodies are proposed to participate in the motion of the dragged spacetime.

Thus the PU interpretation is not simply

body moves through stationary space,

but rather

$$\boxed{\text{body participates in the motion of rotating spacetime.}}$$

3 Application to the Milky Way

The representative PU parameters are

$$M_P = 7.82 \times 10^{53} \text{ kg},$$

and

$$R_{\text{MW}} = 123.3265 \text{ Gly}.$$

Applying the ordinary Newtonian circular-orbit equation gives approximately

$$v_N = \sqrt{\frac{GM_P}{R_{\mathrm{MW}}}} \approx 2.12 \times 10^5 \ \mathrm{km\,s^{-1}}.$$

Therefore,

$$\boxed{v_N \approx 0.706c.}$$

This is very different from the Kerr frame-dragging velocity calculated using the PU parameters. At the Milky Way radius,

$$\omega_{\mathrm{Kerr}}(R_{\mathrm{MW}}) \approx 0.3128 \times 10^{-13} \ \mathrm{rad\,yr^{-1}}.$$

The corresponding coordinate tangential speed is approximately

$$v_{\mathrm{Kerr}} = R_{\mathrm{MW}}\omega_{\mathrm{Kerr}} \approx 1156 \ \mathrm{km\,s^{-1}},$$

or

$$\boxed{v_{\mathrm{Kerr}} \approx 0.00386c.}$$

Consequently,

$$\frac{v_N}{v_{\mathrm{Kerr}}} \approx 183.$$

The ordinary Newtonian calculation and the PU Kerr frame-dragging calculation therefore describe substantially different velocity scales.

3.1 Kerr lapse and observer frame

Velocity in General Relativity is observer-dependent. In the equatorial plane,

$$\alpha_{\mathrm{lapse}} = \sqrt{\frac{\Delta\Sigma}{A}}, \qquad \sqrt{g_{\phi\phi}} = \sqrt{\frac{A}{\Sigma}}.$$

At R_{MW}, $\alpha_{\mathrm{lapse}} \approx 0.06789$. For a body with angular velocity Ω_{body}, a ZAMO measures

$$\frac{v^{(\hat{\phi})}_{\mathrm{ZAMO}}}{c} = \frac{\sqrt{g_{\phi\phi}}}{\alpha_{\mathrm{lapse}}} \left(\frac{\Omega_{\mathrm{body}} - \omega}{c}\right).$$

Matter exactly comoving with the dragged frame has zero velocity relative to the ZAMO. A local stationary observer assigns the frame-dragging motion the lapse-corrected value $v^{(\mathrm{local})}_{\mathrm{drag}} \approx 17{,}038 \ \mathrm{km\,s^{-1}}$. This differs from the Boyer–Lindquist coordinate value $1156 \ \mathrm{km\,s^{-1}}$.

4 The Spiral-Trajectory Hypothesis

The PU model proposes that matter expelled during the primordial event did not move purely radially away from the Pivot.

If spacetime itself was rotating, the outward motion and frame dragging would combine to produce a spiral trajectory.

Let

$$r = r(t)$$

describe radial motion and

$$\phi = \phi(t)$$

describe angular motion.

The radial velocity is

$$\frac{dr}{dt} = v_r(r),$$

while the angular motion associated with Kerr frame dragging is

$$\frac{d\phi}{dt} = \omega_{\text{Kerr}}(r).$$

Consequently,

$$\boxed{\frac{d\phi}{dr} = \frac{\omega_{\text{Kerr}}(r)}{v_r(r)}.}$$

The spiral can therefore be obtained from

$$\phi(r) = \int \frac{\omega_{\text{Kerr}}(r)}{v_r(r)}\, dr.$$

Its Cartesian representation is

$$x = r\cos\phi,$$

$$y = r\sin\phi.$$

The exact PU spiral therefore depends on both the Kerr frame-dragging field and the still-unknown radial history $v_r(r)$.

For the visualization used here, one common elapsed time is selected:

$$T_{\text{MW}} = \frac{2\pi}{\omega_{\text{Kerr}}(R_{\text{MW}})} \approx 2.008 \times 10^5 \text{ Gyr}, \qquad \phi(r) = \omega_{\text{Kerr}}(r) T_{\text{MW}}.$$

This prescription produces a differential-frame-rotation snapshot rather than a particle trajectory.

5 Spiral Path Length

For motion in polar coordinates,

$$dL^2 = dr^2 + r^2 d\phi^2.$$

Hence,

$$dL = \sqrt{dr^2 + r^2 d\phi^2}.$$

Using the PU spiral equation,

$$\frac{d\phi}{dr} = \frac{\omega_{\text{Kerr}}(r)}{v_r(r)},$$

gives

$$\boxed{L = \int \sqrt{1 + \left[\frac{r\omega_{\text{Kerr}}(r)}{v_r(r)}\right]^2}\, dr.}$$

Defining

$$v_\phi(r) = r\omega_{\text{Kerr}}(r),$$

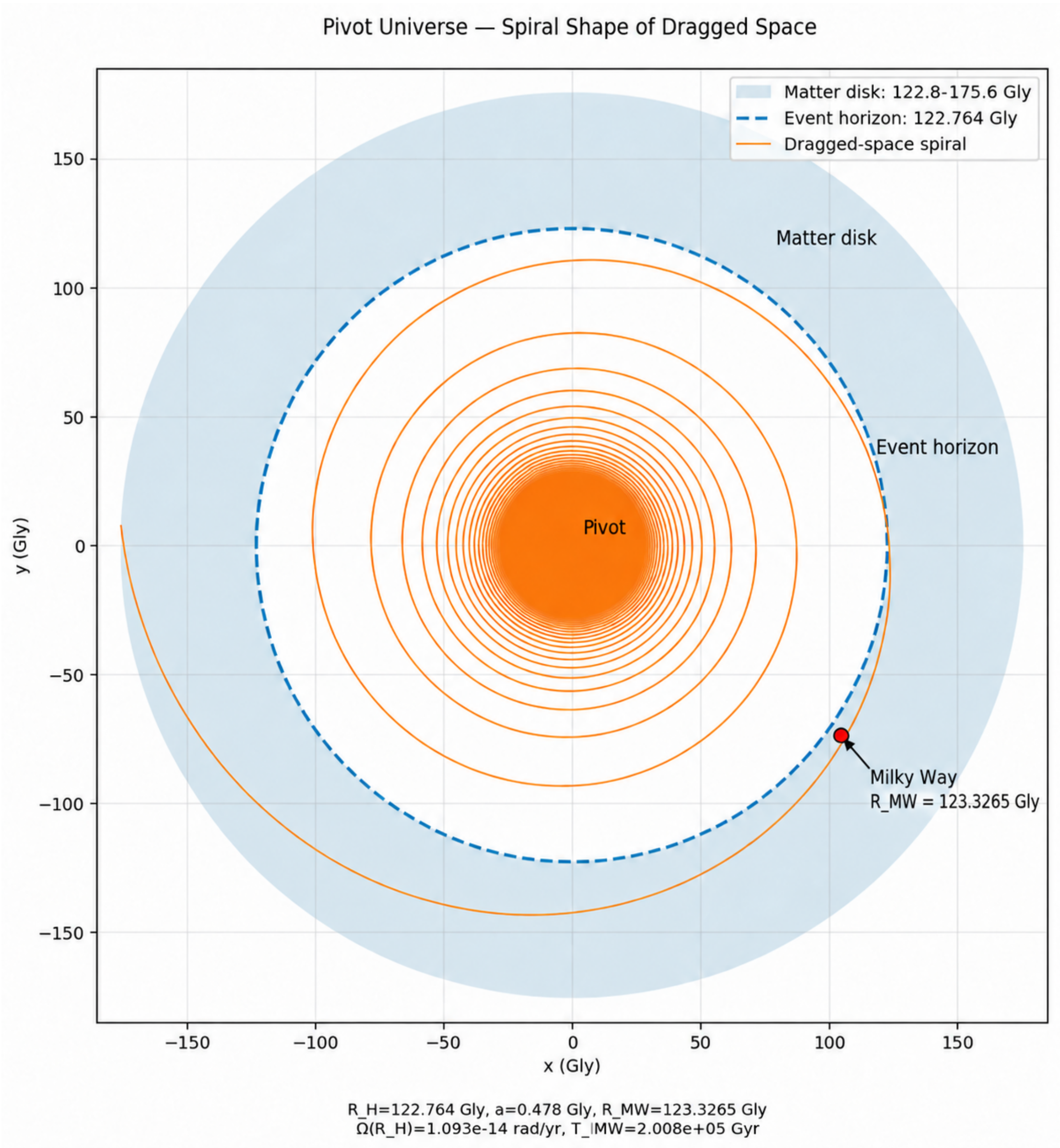

Figure 1: Formal spiral shape of dragged space for the current PU parameters. The blue annulus represents the proposed matter disk, the dashed circle is the event horizon, and the Milky Way is marked at $R_{\mathrm{MW}} = 123.3265$ Gly. The spiral is a differential coordinate rotation map, not a standard Kerr geodesic. Its continuation inside the event horizon is formal.

this can also be written

$$\boxed{\frac{dL}{dr} = \sqrt{1 + \left(\frac{v_\phi}{v_r}\right)^2}.}$$

When radial motion dominates,

$$v_r \gg v_\phi,$$

the trajectory is nearly radial and

$$L \approx R.$$

If rotational motion dominates for a sufficiently long interval,

$$v_\phi \gg v_r,$$

then the trajectory can become strongly wound and

$$L \gg R.$$

6 Replacing R by L

The central proposal considered here is whether the Newtonian expression

$$v^2 = \frac{GM_P}{R}$$

could acquire an effective PU form

$$\boxed{v^2 = \frac{GM_P}{L},}$$

where L represents a dynamically relevant spiral length rather than the instantaneous radial separation.

Solving for L,

$$\boxed{L = \frac{GM_P}{v^2}.}$$

For the plotted differential-rotation spiral, the corrected polar-coordinate arc length is

$$\boxed{L_{\mathrm{MW}} \simeq 1.530 \times 10^6 \text{ Gly.}}$$

Compared with

$$R_{\mathrm{MW}} \approx 123.33 \text{ Gly},$$

this corresponds to approximately

$$\frac{L_{\mathrm{MW}}}{R_{\mathrm{MW}}} \simeq 1.24 \times 10^4.$$

Thus the effective length required by this hypothesis is tens of thousands of times larger than the present radial distance of the Milky Way from the Pivot.

Substitution into the proposed effective Newtonian expression gives

$$v_N(L) = \sqrt{\frac{GM_P}{L}} \approx 1899 \text{ km s}^{-1},$$

and therefore

$$\boxed{\frac{v_N(L)}{v_{\text{Kerr}}} \approx 1.64.}$$

For clarity, the preceding result follows directly from the polar line element, not from an external numerical worksheet. If one instead differentiates $r\phi(r)$, then

$$\frac{d}{dr}[r\phi(r)] = \phi(r) + r\frac{d\phi}{dr}.$$

The extra $\phi(r)$ term does not occur in $ds^2 = dr^2 + r^2 d\phi^2$, and therefore describes a different curve-length calculation.

This is an important numerical result, but it does not by itself prove the substitution $R \to L$. In standard Newtonian gravity, gravitational acceleration depends upon radial separation,

$$g = \frac{GM}{R^2},$$

rather than accumulated orbital distance. A derivation from the PU spacetime geometry is therefore required before L can be interpreted as the appropriate gravitational length.

7 Comparison with the Sun and a Neutron Star

The effective-path hypothesis was previously applied to the Sun and to the rapidly rotating neutron star PSR J1748-2446ad [6]. These examples are useful because they span weak- and strong-field regimes. The earlier paper used the same general procedure: calculate a frame-dragging angular function, construct a curved coordinate path, and compare its length (L) with the straight radial separation (R).

7.1 Earth-Sun example

The reported solar inputs were

$$M_\odot = 1.99 \times 10^{30} \text{ kg}, \qquad R_\odot = 696{,}342 \text{ km},$$

$$R_{\text{ES}} = 1.495 \times 10^8 \text{ km}, \qquad T_\odot \approx 27 \text{ days}.$$

The cited calculation reported

$$L_{\text{ES}} \approx 1.488 \times 10^8 \text{ km}, \qquad \frac{L_{\text{ES}}}{R_{\text{ES}}} \approx 0.995 \approx 1.$$

It therefore concluded that frame dragging produces a negligible correction at the Earth's orbit and that Newtonian gravity is an excellent approximation. This qualitative conclusion is consistent with the weakness of solar frame dragging. Quantitatively, however, an arc length between the same radial endpoints should satisfy $L \geq R$. The reported value $L < R$ is therefore best treated as a rounding, transcription, or numerical-definition issue and should be recalculated using

$$L = \int \sqrt{1 + r^2 \left(\frac{d\phi}{dr}\right)^2}\, dr.$$

Figure 2 plots the cited angular prescription,

$$\phi(r) = \Omega(r) T_{\text{Earth}}, \qquad \Omega(r) = \frac{R_H \alpha c}{r^3 + \alpha^2 r + R_H \alpha^2}.$$

Because the physical solar deflection is visually negligible on the Earth–Sun scale, the plotted angle alone is multiplied by 10^8, following the display convention of the cited paper. This graphical magnification must not be used when calculating L.

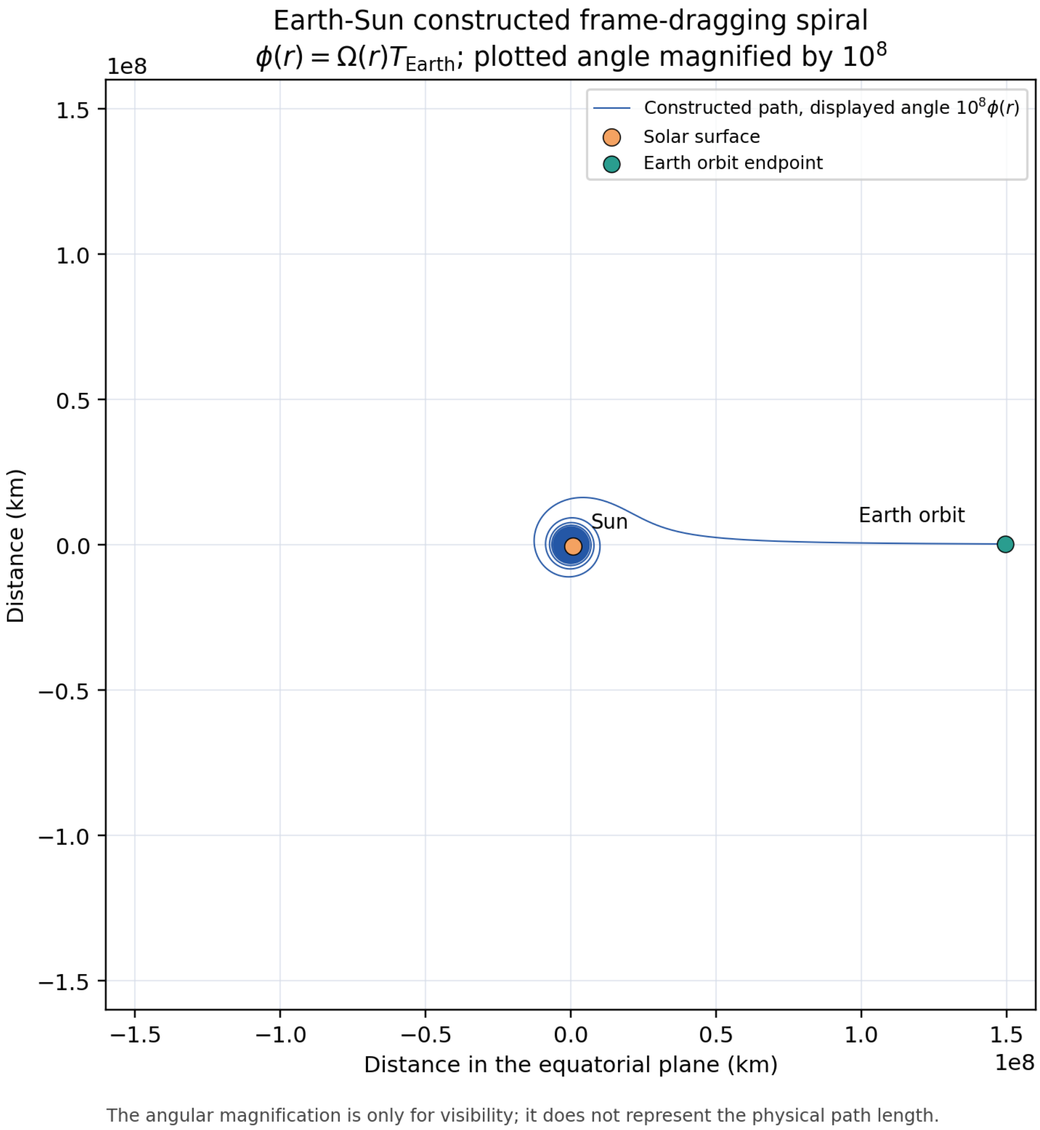

Figure 2: Constructed Earth–Sun frame-dragging spiral. The radial coordinate runs from the solar surface to the mean Earth–Sun separation. Only the displayed angle is magnified by 10^8; therefore the visible winding is not the physical angular deflection and does not determine the physical path length.

7.2 Neutron-star example

For PSR J1748-2446ad, the cited calculation adopted approximately

$$M_{\mathrm{NS}} = 2M_\odot \approx 3.98 \times 10^{30}\ \mathrm{kg}, \qquad R_{\mathrm{NS}} \approx 10.67\ \mathrm{km},$$

$$f_{\mathrm{NS}} = 716\ \mathrm{s}^{-1}, \qquad R_{\mathrm{out}} = 20\ \mathrm{km},$$

and reported a constructed path length

$$L_{\mathrm{NS}} \approx 39.4\ \mathrm{km}.$$

Thus

$$\boxed{\frac{L_{\rm NS}}{R_{\rm out}} \approx 1.97.}$$

Within the hypothesis, this was interpreted as a much larger departure from the straight radial distance than in the solar example. The compactness and rapid rotation of a neutron star make relativistic rotational effects more important. Nevertheless, the reported 39.4 km is still a constructed coordinate-curve length. It is not, without solving the geodesic equations and specifying a spatial slice, an invariant Kerr geodesic distance.

Figure 3 shows the corresponding construction for the neutron-star parameters. The shaded disk identifies the assumed stellar interior. Kerr's vacuum exterior formula is physically relevant only outside the stellar surface; the portion drawn at $r < R_{\rm NS}$ is retained solely to reproduce the formal continuation used in the earlier calculation.

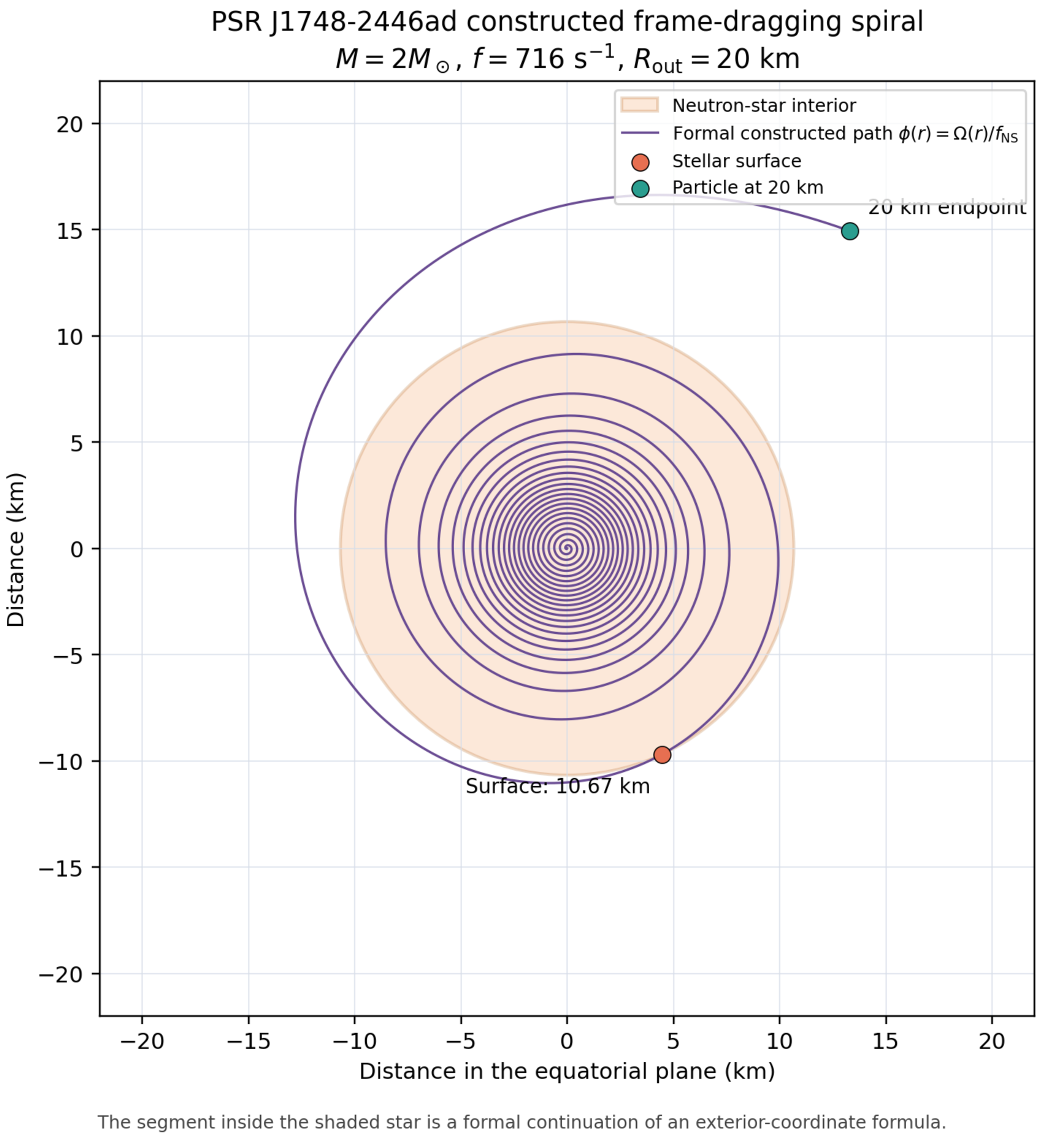

Figure 3: Constructed spiral for PSR J1748-2446ad using $\phi(r) = \Omega(r)/f_{\rm NS}$, with $f_{\rm NS} = 716$ s^{-1} and $R_{\rm out} = 20$ km. The orange disk marks the assumed $R_{\rm NS} = 10.67$ km stellar radius. The interior part is a formal coordinate continuation, not a physical Kerr-vacuum trajectory or a solved geodesic.

Table 1: Previously reported tests of the effective-path hypothesis [6].

System	Radial scale R	Reported L	L/R
Earth-Sun	1.495×10^8 km	1.488×10^8 km	$0.995 \approx 1$
PSR J1748-2446ad	20 km	39.4 km	1.97
Pivot-Milky Way	123.3265 Gly	1.530×10^6 Gly	1.24×10^4

These three examples illustrate the intended trend of the hypothesis: a negligible correction in a weak solar field, a larger constructed correction near a rapidly rotating compact star, and an extremely large formal winding in the PU calculation. They do not by themselves establish that (R) can be replaced by (L) in Newton's law; that replacement still requires a derivation from a metric and an equation of motion.

8 Domain of Applicability at the Event Horizon

The distinction between an algebraic continuation and a physical measurement is essential. The function

$$\omega = -\frac{g_{t\phi}}{g_{\phi\phi}}$$

may be evaluated algebraically at many coordinate points, and its limiting value at $r = r_+$ is the angular velocity of the Kerr horizon. However, the usual ZAMO decomposition used outside the horizon has

$$\alpha_{\text{lapse}}^2 = \frac{\Delta\Sigma}{A}.$$

Between the outer and inner horizons, $\Delta < 0$, so this exterior stationary slicing does not provide a real lapse or stationary observers at fixed r. The ZAMO velocity formula and the Euclidean polar arc-length formula used above therefore do not have their exterior physical interpretation for $r < r_+$ [2, 3].

Accordingly, two lengths must be distinguished:

$$L_{\text{formal}}(0, R_{\text{MW}}) \approx 1.530 \times 10^6 \text{ Gly},$$

which is the mathematical continuation drawn in Figure 1, and

$$\boxed{L_{\text{exterior}}(r_+, R_{\text{MW}}) \approx 10.8 \text{ Gly},}$$

which applies the same coordinate-plane construction only over the exterior interval. Neither quantity is a relativistic invariant proper length. A calculation through the horizon must instead use a horizon-penetrating coordinate system and a specified timelike observer or tetrad [4]. It must then be derived from the Kerr metric rather than from the exterior Euclidean spiral formula.

It follows that the ratio $v_N(L)/v_{\text{Kerr}} \approx 1.64$ uses the formal interior extrapolation. It cannot presently be claimed as a physical inside-horizon prediction of standard Kerr geometry.

9 Matter Moving with Dragged Space

The physical interpretation proposed by the PU model is that celestial bodies do not independently travel through an otherwise stationary cosmic space. Instead, their large-scale motion is coupled to the rotating spacetime generated by the Pivot.

Schematically,

$$\boxed{\text{Pivot rotation} \to \text{frame dragging} \to \text{rotating space} \to \text{large-scale motion of matter.}}$$

In this interpretation, the persistence of large-scale celestial motion does not require matter continually to be accelerated through a stationary background merely to maintain its velocity.

It is important, however, to distinguish this from ordinary mechanical friction. In Newtonian mechanics and General Relativity, an isolated body does not normally require a continuous force to prevent its velocity from spontaneously decaying. Inertia already provides persistent motion in the absence of dissipative forces.

The distinctive PU claim is therefore more specific: the model proposes that the common large-scale rotational component of celestial motion is associated with the motion of frame-dragged spacetime itself.

10 Possible Connection Between Newton and Einstein

Newton's expression

$$v_N^2 = \frac{GM_P}{R}$$

and the PU Kerr calculation

$$v_{\text{Kerr}} = R\omega_{\text{Kerr}}$$

appear at first to give incompatible velocities for the Milky Way.

Numerically,

$$v_N \approx 2.12 \times 10^5 \ \text{km}\,\text{s}^{-1},$$

whereas

$$v_{\text{Kerr}} \approx 1.16 \times 10^3 \ \text{km}\,\text{s}^{-1}.$$

The proposed effective length

$$L \simeq 1.530 \times 10^6 \ \text{Gly}$$

produces

$$\frac{\sqrt{GM_P/L}}{v_{\text{Kerr}}} \simeq 1.64.$$

This numerical correspondence suggests a question rather than an established reconciliation:

$$\boxed{\begin{array}{c}\text{Can an effective gravitational length derived from the PU spiral geometry transform} \\ \text{the Newtonian limit into the Kerr-dragged velocity?}\end{array}}$$

Answering this requires deriving the effective equation from the metric or equations of motion rather than inserting L phenomenologically.

11 Relation to Standard Kerr Geodesics

The plotted spiral is not a standard Kerr geodesic. A freely falling particle must satisfy $u^\nu \nabla_\nu u^\mu = 0$, with constants of motion E, L_z, and Carter constant Q. Its trajectory follows from $(d\phi/d\tau)/(dr/d\tau)$, not from $\omega(r)$ alone.

For the current PU spin $a/M \approx 0.00779$, the prograde Kerr innermost stable circular orbit is approximately

$$r_{\text{ISCO}} \approx 366.7 \ \text{Gly}.$$

Because $R_{\mathrm{MW}} = 123.3265$ Gly $< r_{\mathrm{ISCO}}$, standard Kerr geometry does not permit a stable timelike circular geodesic at the proposed Milky Way radius. A zero-angular-momentum timelike geodesic there is a plunging, nearly radial trajectory in horizon-penetrating coordinates.

12 Superluminal Primordial Phase

A literal path length of millions of Gly raises an immediate timescale problem if propagation is restricted to c throughout the complete history.

The PU model may consider an additional hypothesis: during the primordial explosion, spacetime entered a temporary non-standard state in which the ordinary vacuum structure was altered and the usual propagation limit did not apply.

This has been described qualitatively as a temporary "tearing of space."

Such a state could be represented phenomenologically by

$$c_{\mathrm{eff}}(t) > c$$

during a short primordial interval, followed by

$$c_{\mathrm{eff}} \to c.$$

No physical mechanism or quantitative field equation for this proposed state is presently provided. Therefore, superluminal primordial propagation should be identified explicitly as a PU hypothesis rather than an established consequence of quantum field theory or General Relativity.

Apparent superluminal phenomena such as light echoes should likewise not be treated by themselves as evidence for local matter or information propagation faster than c.

13 Predictions and Required Development

The proposed connection can become physically meaningful only if several presently assumed quantities are derived.

First, the primordial radial velocity function

$$v_r(r)$$

must be determined. Together with

$$\omega_{\mathrm{Kerr}}(r),$$

it determines the spiral trajectory.

Second, the resulting trajectory should independently predict

$$L_{\mathrm{MW}} = \int \sqrt{1 + \left[\frac{r\omega_{\mathrm{Kerr}}(r)}{v_r(r)}\right]^2}\, dr.$$

The important test is whether this independently calculated length approaches

$$L_{\mathrm{MW}} \simeq 1.530 \times 10^6 \text{ Gly}$$

without choosing the path length beforehand.

Third, it must be demonstrated why this geometrical path length enters the effective gravitational equation as

$$v^2 = \frac{GM_P}{L}.$$

This is the crucial theoretical step required to turn the observed numerical correspondence into a physical derivation.

14 Conclusion

Within the Pivot Universe model, the Milky Way is assumed to participate in a global rotating spacetime generated by the massive rotating Pivot.

At the Milky Way radius, the ordinary Newtonian circular-orbit calculation based on the Pivot mass gives approximately

$$v_N \approx 2.12 \times 10^5 \ \mathrm{km\,s^{-1}},$$

whereas the PU Kerr frame-dragging calculation gives approximately

$$v_{\mathrm{Kerr}} \approx 1.16 \times 10^3 \ \mathrm{km\,s^{-1}}.$$

The PU hypothesis considered in this paper proposes that the relevant dynamical scale may be associated with the much longer spiral trajectory of dragged space rather than simply with radial distance. Replacing R phenomenologically by L gives

$$v = \sqrt{\frac{GM_P}{L}},$$

and the corrected spiral construction gives approximately

$$L_{\mathrm{MW}} \simeq 1.530 \times 10^6 \ \mathrm{Gly}.$$

This produces

$$\boxed{\frac{v_N(L)}{v_{\mathrm{Kerr}}} \simeq 1.64,}$$

rather than exact equality.

The numerical correspondence is intriguing within the PU framework, but it is not yet a reconciliation of Newtonian gravity and General Relativity. A physical reconciliation would require deriving the effective length L, and its appearance in the gravitational equation, from the underlying spacetime geometry.

The central proposal can therefore be summarized as

$$\boxed{\begin{array}{c}\text{Newtonian radial dynamics} + \text{Kerr frame dragging} + \text{PU spiral geometry}\\ \longrightarrow \text{possible effective gravitational dynamics.}\end{array}}$$

The next theoretical task is to derive this relationship rather than assume it.

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