The Pivot Universe: A Stationary Kerr-Geometry Interpretation of JWST Observations

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Abstract

Recent observations from the James Webb Space Telescope (JWST) reveal massive galaxies, chemically evolved stellar populations, mature disk structures, and compact luminous systems known as Little Red Dots (LRDs) at redshifts exceeding $z \sim 8$. Within the standard ΛCDM cosmological framework, such observations can create tension with hierarchical structure-formation timescales because massive galaxies and black holes appear to be present when the Universe is conventionally interpreted to be very young.

This paper develops the Pivot Universe (PU), a stationary Kerr-geometry interpretation in which observed redshift is treated primarily as a spatial coordinate rather than as a direct measure of cosmic age. The visible Universe is modeled as a thin shell in the exterior Kerr-like spacetime generated by a central rotating mass, the Pivot. Within this framework, we derive a coordinate redshift relation, a Newtonian tidal-shear estimate, a Kerr-modified tidal amplification factor, a relativistic Hill radius, and a disk-stability criterion.

The present revision adds an explicit redshift dependence of the relativistic Hill radius. For an observer-normalized redshift, the Kerr lapse fixes the radial coordinate and the geometrical correction factor. At fixed object mass, the Newtonian part of the Hill radius changes only weakly across the thin PU shell, whereas the Kerr factor decreases toward the outer horizon. Consequently, the relativistic Hill radius decreases systematically with increasing redshift. This provides a quantitative mechanism by which high-redshift compact systems can occupy substantially smaller gravitational domains than otherwise similar low-redshift systems.

1 Introduction

JWST has substantially extended the observational record of galaxies and active nuclei at high redshift. Among the notable findings are massive galaxies, compact red objects, candidate overmassive black holes, and apparently mature stellar systems at redshifts $z > 8$. In the standard cosmological interpretation, redshift is primarily associated with cosmic expansion and look-back time. A galaxy observed at $z \approx 10$ is therefore interpreted as a system existing only a few hundred million years after the Big Bang. Massive or chemically evolved systems at such redshifts then require rapid early assembly, rapid star formation, efficient metal enrichment, and rapid black-hole growth.

The Pivot Universe proposes a different interpretation. Instead of interpreting redshift primarily as a measure of cosmic age, PU treats redshift as a coordinate position within a stationary gravitational structure. The large-scale geometry is modeled as a Kerr-like spacetime generated by a central rotating object called the Pivot. In this framework, high-redshift galaxies are not necessarily younger than low-redshift galaxies. Rather, they occupy deeper positions in the gravitational potential of the Pivot.

The central sequence of arguments is

$$\text{Kerr geometry} \rightarrow \text{tidal shear} \rightarrow \text{relativistic Hill radius} \rightarrow \text{observed morphology.} \qquad (1)$$

2 Fundamental Assumptions of the Pivot Universe

2.1 Stationarity

The large-scale spacetime is assumed to be stationary:

$$\frac{\partial g_{\mu\nu}}{\partial t} = 0. \tag{2}$$

Consequently, redshift is not attributed to time-dependent scale-factor expansion. It is instead interpreted as arising from position within a stationary gravitational field, together with possible kinematic contributions.

2.2 A central rotating Pivot

The spacetime is generated by a central rotating gravitating object with adopted parameters

$$M_P = 7.82 \times 10^{53}\ \text{kg}, \tag{3}$$

$$J_P = 1.06 \times 10^{87}\ \text{J s}. \tag{4}$$

2.3 Exterior Kerr-like geometry

Outside the Pivot, spacetime is approximated by a Kerr-like metric. This includes rotation, gravitational redshift, frame dragging, latitude dependence, and horizons within a single stationary geometry.

2.4 Redshift as a radial coordinate

The defining PU assumption is

$$z = z(r), \tag{5}$$

rather than the standard cosmological interpretation in which redshift is primarily a function of cosmic time.

3 Kerr Geometry of the Pivot

In Boyer–Lindquist coordinates (t, r, θ, ϕ), define

$$\rho^2 = r^2 + a^2 \cos^2\theta, \tag{6}$$

$$\Delta = r^2 - R_s r + a^2, \tag{7}$$

$$\Sigma = (r^2 + a^2)^2 - a^2 \Delta \sin^2\theta, \tag{8}$$

where

$$R_s = \frac{2GM_P}{c^2}, \tag{9}$$

and

$$a = \frac{J_P}{M_P c}. \tag{10}$$

For the adopted PU parameters, the characteristic values used in this paper are

$$R_s \simeq 122.766\ \text{Gly}, \qquad a \simeq 0.478\ \text{Gly}. \tag{11}$$

The Kerr horizons satisfy

$$\Delta = 0, \tag{12}$$

giving

$$r_\pm = \frac{R_s}{2} \pm \sqrt{\frac{R_s^2}{4} - a^2}. \tag{13}$$

The outer horizon r_+ defines the strong-field boundary in the PU model.

4 Coordinate Redshift from the Kerr Lapse

The Kerr lapse function is

$$\alpha^2 = \frac{\Delta\rho^2}{\Sigma}. \tag{14}$$

For stationary observers, a first approximation to the gravitational redshift is

$$1 + z_g \simeq \frac{1}{\alpha}. \tag{15}$$

For comparisons with an observer located at the Milky Way, the physically relevant redshift is normalized to the Milky Way lapse:

$$1 + z = \frac{\alpha_{\mathrm{MW}}}{\alpha(r)}. \tag{16}$$

This definition ensures that $z = 0$ at the Milky Way position.

In the Schwarzschild limit, this becomes

$$1 + z = \left[\frac{1 - R_s/r_{\mathrm{MW}}}{1 - R_s/r}\right]^{1/2}, \tag{17}$$

and therefore

$$r(z) = \frac{R_s}{1 - \dfrac{1 - R_s/r_{\mathrm{MW}}}{(1+z)^2}}. \tag{18}$$

For numerical examples below we use

$$r_{\mathrm{MW}} = 123.3265 \text{ Gly}. \tag{19}$$

5 Tidal Shear in the Pivot Universe

The gravitational acceleration produced by the Pivot is approximated by

$$g(r) = \frac{GM_P}{r^2}. \tag{20}$$

For an object of diameter $D \ll r$, the differential tidal acceleration is

$$\Psi \simeq \frac{2GM_P D}{r^3}. \tag{21}$$

Thus

$$\Psi \propto r^{-3}. \tag{22}$$

6 Kerr Modification of the Tidal Field

Near the Pivot horizon, relativistic effects cannot be neglected. We write

$$\Psi_{\mathrm{Kerr}} = \Psi\, \Xi(r, a, \theta), \tag{23}$$

where Ξ is a phenomenological Kerr amplification factor.

Frame dragging introduces the local effective energy

$$E_{\mathrm{local}} = E - \omega L, \tag{24}$$

so that

$$\frac{E_{\text{local}}}{E} = 1 - \frac{\omega L}{E}. \tag{25}$$

Combining lapse suppression and frame dragging gives the working approximation

$$\Xi(r, a, \theta) = \left[\frac{\Delta \rho^2}{\Sigma} \left(1 - \frac{\omega L}{E}\right)^2 \right]^{-1/2}. \tag{26}$$

This expression is phenomenological. A full calculation should ultimately use the electric part of the Kerr curvature tensor in a local orthonormal tetrad.

7 Newtonian Hill Radius

For an object of mass m at radial coordinate r, the Newtonian Hill radius is

$$R_{H,N} = r \left(\frac{m}{3M_P} \right)^{1/3}. \tag{27}$$

8 Relativistic Hill Radius

Because the Hill radius scales inversely as the cube root of the external tidal field,

$$R_H \propto \Psi^{-1/3}, \tag{28}$$

define

$$\Phi = \Xi^{-1/3}. \tag{29}$$

Using the working Kerr factor,

$$\Phi(r, a, \theta) = \left[\frac{\Delta \rho^2}{\Sigma} \left(1 - \frac{\omega L}{E}\right)^2 \right]^{1/6}. \tag{30}$$

The relativistic Hill radius is therefore

$$R_{H,K} = r \left(\frac{m}{3M_P} \right)^{1/3} \Phi(r, a, \theta). \tag{31}$$

8.1 Hill radius as a function of redshift

Since the PU model treats z as a radial coordinate, the relativistic Hill radius can be written explicitly as

$$R_{H,K}(z) = r(z) \left(\frac{m}{3M_P} \right)^{1/3} \Phi[r(z), a, \theta]. \tag{32}$$

For an equatorial orbit, $\theta = 90^\circ$, one has

$$\rho^2 = r^2, \tag{33}$$

$$\Sigma = (r^2 + a^2)^2 - a^2 \Delta. \tag{34}$$

To isolate the purely geometrical Kerr effect, first take

$$\frac{\omega L}{E} = 0. \tag{35}$$

Then

$$\Phi_0(r) = \left(\frac{\Delta r^2}{\Sigma}\right)^{1/6} = \alpha^{1/3}. \tag{36}$$

With the observer-normalized redshift relation,

$$\alpha(r) = \frac{\alpha_{\mathrm{MW}}}{1+z}, \tag{37}$$

so that the geometrical correction has the particularly simple dependence

$$\Phi_0(z) = \Phi_{\mathrm{MW}}(1+z)^{-1/3}. \tag{38}$$

Thus, for a fixed object mass, the redshift dependence is produced mainly by the Kerr correction rather than by the small change in the coordinate radius across the thin PU shell.

Table 1 gives a representative calculation for a fixed compact-object mass $m = 10^8 M_\odot$. The values use $M_P = 7.82 \times 10^{53}$ kg, $R_s = 122.766$ Gly, $a = 0.478$ Gly, $r_{\mathrm{MW}} = 123.3265$ Gly, and the equatorial geometrical correction with $\omega L/E = 0$.

Table 1: Redshift dependence of the Hill radius for a fixed mass $m = 10^8 M_\odot$. The Kerr radius is $R_{H,K} = R_{H,N}\Phi_0$.

z	r (Gly)	Φ_0	$R_{H,N}$ (kpc)	$R_{H,K}$ (kpc)
0	123.3265	0.407	166.1	67.6
1	122.9042	0.323	165.5	53.5
7	122.7729	0.204	165.4	33.7
10	122.7688	0.183	165.3	30.3

The Newtonian Hill radius changes by less than one percent over this interval,

$$R_{H,N} \simeq 166 \text{ kpc}, \tag{39}$$

because r remains close to 123 Gly. In contrast, the Kerr factor falls from approximately 0.407 at $z = 0$ to 0.183 at $z = 10$. Consequently,

$$R_{H,K}(z=10) \simeq 0.45\, R_{H,K}(z=0). \tag{40}$$

For the same $10^8 M_\odot$ object, the available Kerr-modified gravitational domain therefore contracts from approximately 67.6 kpc at $z = 0$ to approximately 30.3 kpc at $z = 10$.

For a different object mass, every value in the two Hill-radius columns scales as

$$R_H \propto m^{1/3}. \tag{41}$$

The table is therefore a scaling example rather than a universal galaxy-size prediction.

If the orbital frame-dragging term is retained, the full result becomes

$$R_{H,K}(z) = R^{(0)}_{H,K}(z) \left|1 - \frac{\omega L}{E}\right|^{1/3}. \tag{42}$$

A quantitative application to a specific orbit therefore requires a specified L/E.

9 Stability Criterion

A stable disk of radius R_{disk} requires

$$R_H \geq R_{\mathrm{disk}}. \tag{43}$$

The corresponding critical mass is

$$M_{\mathrm{crit}} = 3M_P \left(\frac{R_{\mathrm{disk}}}{r\Phi}\right)^3. \tag{44}$$

10 Application to JWST Objects

10.1 CANUCS-LRD-z8.6

CANUCS-LRD-z8.6 is treated here as a compact Little Red Dot near $z \simeq 8.6$. Representative values used in this manuscript are

$$M_{\rm BH} \sim 10^8 M_\odot, \tag{45}$$

$$M_{\rm gal} \sim 10^{10} M_\odot. \tag{46}$$

Its compact morphology and large central black-hole fraction make it a useful example of strong confinement in the PU framework.

10.2 CEERS-1019

CEERS-1019 is an extended galaxy with an active nucleus at

$$z = 8.679. \tag{47}$$

Representative values used here are

$$M_{\rm BH} \sim 9 \times 10^6 M_\odot, \tag{48}$$

$$M_{\rm gal} \sim 3 \times 10^9 M_\odot. \tag{49}$$

10.3 Direct comparison

Although CANUCS-LRD-z8.6 and CEERS-1019 have nearly the same redshift, their morphologies are substantially different. In PU they therefore occupy approximately the same radial shell, while their local masses, angular momenta, and effective Kerr factors can differ. The new redshift-dependent form of the Hill radius does not by itself explain the difference between objects at the same z; rather, it specifies the common background confinement associated with that shell. Object-to-object differences at fixed z still enter through m, θ, and the orbital factor $1 - \omega L/E$.

11 Compaction Parameter

To distinguish the gravitational boundary from the observed luminous size, define the dimensionless compaction parameter

$$\lambda = \frac{R_{\rm eff}}{R_{H,K}}. \tag{50}$$

Small λ means that the luminous system occupies only a small fraction of its available Kerr-modified Hill domain. Compact LRDs may therefore correspond to much smaller λ than extended galaxies even when both systems occupy nearly the same PU redshift shell.

The Hill radius is a limiting gravitational scale; it does not determine $R_{\rm eff}$ by itself. Predicting $R_{\rm eff}$ requires additional physics describing baryonic collapse, angular-momentum transport, star formation, feedback, and the distribution of matter within the Hill domain.

12 Predictions and Potential Tests

The revised PU framework generates the following testable expectations:

1. At fixed object mass and orbital state, the Kerr-modified Hill radius should decrease with increasing PU redshift.

2. The Newtonian Hill component should vary only weakly across the thin near-horizon visible shell.

3. The strongest redshift dependence should arise from the Kerr correction Φ.

4. Galaxies at the same redshift may still show substantial dispersion in observed radius because m, angular momentum, and compaction can differ.

5. Compact LRDs should generally exhibit smaller $\lambda = R_{\rm eff}/R_{H,K}$ than extended systems at comparable redshift.

13 Comparison with ΛCDM

The central difference between PU and standard cosmology is the meaning assigned to redshift. In ΛCDM, redshift is primarily related to cosmic expansion and look-back time. In PU, redshift is interpreted primarily as a radial coordinate in a stationary gravitational field.

The redshift-dependent Hill-radius calculation adds a further distinction: in PU, increasing z places an object closer to the Pivot horizon, where lapse suppression reduces the effective Hill domain. This is a spatial strong-field effect rather than an evolutionary age effect.

14 Discussion

The PU framework connects observable morphology to the local tidal environment through

$$\text{Kerr geometry} \rightarrow \text{tidal shear} \rightarrow R_{H,K}(z) \rightarrow \text{galaxy morphology}. \tag{51}$$

The new calculation shows that, at fixed mass, $R_{H,N}$ is almost constant across the thin visible shell, while Φ changes substantially. Therefore the principal redshift dependence of the relativistic Hill radius arises from the Kerr geometry itself. In the representative $10^8 M_\odot$ example, the Kerr-modified Hill radius decreases from about 67.6 kpc at $z = 0$ to about 30.3 kpc at $z = 10$.

This does not imply that the observed effective radius must equal the Hill radius. The Hill radius defines an available gravitational domain, while the compaction parameter describes how much of that domain is occupied by the luminous system.

The model remains phenomenological. In particular, the working factor Ξ should ultimately be replaced by a calculation based on the Kerr tidal tensor in a local orthonormal tetrad. Likewise, the orbital factor $\omega L/E$ must be evaluated for specific trajectories before a complete object-by-object prediction can be made.

15 Conclusions

The principal results of the revised manuscript are:

1. Redshift is interpreted as a radial coordinate rather than a direct measure of cosmic age.

2. The observer-normalized relation $1 + z = \alpha_{\rm MW}/\alpha(r)$ ensures that $z = 0$ corresponds to the Milky Way position.

3. The relativistic Hill radius is

$$R_{H,K} = r \left(\frac{m}{3M_P}\right)^{1/3} \Phi(r, a, \theta).$$

4. At fixed mass, the Hill radius becomes an explicit function of redshift,

$$R_{H,K}(z) = r(z) \left(\frac{m}{3M_P} \right)^{1/3} \Phi[r(z), a, \theta].$$

5. In the equatorial geometrical approximation with $\omega L/E = 0$, $\Phi_0 = \alpha^{1/3}$ and therefore

$$\Phi_0(z) = \Phi_{\mathrm{MW}}(1+z)^{-1/3}.$$

6. For a representative $10^8 M_\odot$ object, the Newtonian Hill radius remains near 166 kpc from $z = 0$ to $z = 10$, while the Kerr-modified radius decreases from approximately 67.6 kpc to 30.3 kpc.

7. The observed effective radius is distinguished from the Hill radius through $\lambda = R_{\mathrm{eff}}/R_{H,K}$.

The revised PU framework therefore predicts a systematic redshift dependence of the available Kerr-modified gravitational domain while retaining object-specific morphology through mass, angular momentum, and compaction.

References

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