Great Attractor Explanation Using the Pivot Universe Model

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Abstract

The observed motion of the Solar System and the Local Group relative to the cosmic microwave background (CMB) is conventionally interpreted as a peculiar velocity produced by the gravitational influence of the surrounding large-scale matter distribution, including the Virgo region, the Great Attractor, the Shapley concentration, and cosmic voids. The Solar-System barycenter moves relative to the CMB at approximately 369.8 $\mathrm{km\,s^{-1}}$, while transformation to the Local-Group barycenter gives a velocity of approximately 627 $\mathrm{km\,s^{-1}}$. This paper examines an alternative interpretation within the Pivot Universe (PU) model. The universe is treated as a rotating system described approximately by Kerr geometry generated by a central massive rotating Pivot. Matter in the observable universe is assumed to participate approximately in the frame-dragged rotation generated by the Pivot. For $M_P = 7.82 \times 10^{53}$ kg, $J_P = 1.06 \times 10^{87}$ J s, $R_{\mathrm{MW}} = 123.3265$ Gly, and $R_{\mathrm{CMB}} = 123.36$ Gly, the Kerr frame-dragging angular velocity at the Milky-Way shell is approximately $0.313 \times 10^{-13}\mathrm{rad\,yr^{-1}}$. A locally normalized differential Kerr quantity between the MW and CMB shells is approximately 495 $\mathrm{km\,s^{-1}}$. This value lies between the Solar-System/CMB and Local-Group/CMB velocities, but it is shown that this numerical correspondence cannot itself be identified with an invariant relative velocity. An invariant Kerr photon-frequency calculation instead separates a predominantly gravitational monopole shift from a much smaller directional frame-dragging contribution. The PU interpretation therefore requires the observed CMB dipole to contain a combination of global Kerr geometry and local peculiar motions. The model yields quantitative predictions that can, in principle, be tested against the direction and magnitude of observed large-scale peculiar-velocity fields.

1. Introduction

The Local Group does not follow a perfectly uniform cosmological rest frame. The CMB exhibits a strong dipole anisotropy which, under the conventional kinematic interpretation, indicates that the Solar-System barycenter moves at approximately

$$v_{\odot/\mathrm{CMB}} \simeq 369.8\ \mathrm{km\,s^{-1}}.$$

After correcting for the Solar System's motion within the Milky Way and the Milky Way's motion within the Local Group, the Local-Group barycenter has a velocity of approximately

$$v_{\mathrm{LG/CMB}} \simeq 627\ \mathrm{km\,s^{-1}}.$$

The direction of the Local-Group velocity is approximately

$$(l, b)_{\mathrm{LG}} \simeq (276^\circ, 30^\circ).$$

Historically, a significant component of this motion was associated with the region known as the Great Attractor, lying broadly in the direction of the Hydra-Centaurus/Norma region. Modern analyses indicate that no single concentration is responsible for the entire velocity; structures on several scales contribute.

The Pivot Universe model [5] and [6] suggests a different global context. In PU, galaxies do not reside in an approximately nonrotating global background. Instead, the observable matter universe participates in a large-scale rotating geometry generated by a central massive rotating object, called the Pivot.

The purpose of this paper is to investigate whether Kerr frame dragging associated with the Pivot can contribute to the observed large-scale motions conventionally associated with the Great Attractor.

2. Pivot Universe parameters

The parameters adopted here are

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

$$J_P = 1.06 \times 10^{87}\ \mathrm{J\,s}.$$

The present radial positions are taken as

$$\boxed{R_{\mathrm{MW}} = 123.3265\ \mathrm{Gly}}$$

and

$$\boxed{R_{\mathrm{CMB}} = 123.36\ \mathrm{Gly}}.$$

Therefore,

$$R_{\mathrm{CMB}} - R_{\mathrm{MW}} = 0.0335\ \mathrm{Gly} = 33.5\ \mathrm{Mly}.$$

The Kerr mass length is

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

which gives approximately

$$M \simeq 61.38\ \mathrm{Gly}.$$

The Kerr spin length is

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

giving

$$a \simeq 0.478\ \mathrm{Gly}.$$

Thus the dimensionless spin parameter is

$$a_* = \frac{a}{M} \simeq 7.8 \times 10^{-3}.$$

The outer Kerr horizon is

$$r_+ = M + \sqrt{M^2 - a^2},$$

which for these parameters is approximately

$$\boxed{r_+ \simeq 122.764 \text{ Gly}}.$$

Consequently, both the Milky-Way and CMB shells lie close to the outer Kerr horizon in the PU coordinate system.

3. Primordial mass and angular momentum

The PU model assumes that the present system originated from a rapidly rotating primeval compact object. The representative primordial mass and angular momentum used here are

$$M_{\text{primordial}} \simeq 1.24 \times 10^{54} \text{ kg},$$

and

$$J_{\text{primordial}} \simeq 2.13 \times 10^{87} \text{ J s}.$$

The revised mass budget does not assume that the mass of the visible matter universe is equal to the Pivot mass. Instead, the adopted values are

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

and

$$\boxed{M_{\text{ring}} \simeq 1.5 \times 10^{53} \text{ kg}}.$$

The remaining primordial mass-energy is assigned, in this simplified bookkeeping, mainly to radiation and other non-rest-mass channels generated during the primordial event. If no additional channel is included, its mass-equivalent is

$$M_{\text{rad,eq}} = M_{\text{primordial}} - M_P - M_{\text{ring}} \simeq \boxed{3.08 \times 10^{53} \text{ kg}}.$$

Equivalently,

$$M_{\text{primordial}} c^2 = M_P c^2 + M_{\text{ring}} c^2 + E_{\text{radiation}} + \cdots .$$

The visible matter universe is represented approximately as a thin annular disk outside the PU Kerr horizon, following the structural geometry described in [7], with

$$R_{\text{in}} = 122.8 \text{ Gly}, \qquad R_{\text{out}} = 175.6 \text{ Gly},$$

and a thickness of order 1 Gly. Its arithmetic mean radius is

$$R_{\text{avg}} = \frac{R_{\text{in}} + R_{\text{out}}}{2} = 149.2 \text{ Gly}.$$

For a uniform annulus rotating approximately as a single angular-momentum component, the moment of inertia is

$$I_{\text{ring}} = \frac{1}{2} M_{\text{ring}} \left(R_{\text{in}}^2 + R_{\text{out}}^2 \right).$$

It is useful to define an effective angular-momentum radius

$$R_{\rm eff} = \sqrt{\frac{R_{\rm in}^2 + R_{\rm out}^2}{2}} \simeq \boxed{151.5\ \text{Gly}}.$$

The earlier PU treatment used the simplifying assumption that the primordial angular momentum divided approximately equally between the Pivot and the visible matter universe,

$$J_P \simeq J_{\rm ring} \simeq 1.06 \times 10^{87}\ \text{J s}.$$

Angular-momentum conservation, however, requires only

$$J_{\rm primordial} = J_P + J_{\rm ring} + J_{\rm radiation} + \cdots ,$$

and does not require a 50/50 partition. Because the revised visible-matter mass is much smaller than the Pivot mass, the equal-division assumption is not imposed in the present calculation. Instead, the matter angular momentum is constrained by the proposed PU synchronization condition

$$\boxed{\Omega_{\rm ring} \simeq \omega_{\rm Kerr}}.$$

Thus,

$$J_{\rm ring} = I_{\rm ring}\Omega_{\rm ring} \simeq I_{\rm ring}\omega_{\rm Kerr}(R_{\rm eff}).$$

This formulation treats the angular-momentum partition as a quantity to be derived from the adopted mass distribution and Kerr geometry rather than fixed a priori.

4. Relation to Birch's proposed cosmic rotation

Birch (1982) [1] reported an observational interpretation corresponding to a possible universal angular velocity of order

$$\omega_{\rm Birch} \sim 10^{-13}\ \text{rad yr}^{-1}.$$

Earlier PU calculations adopted

$$\omega_{\rm MW} = 0.395 \times 10^{-13}\ \text{rad yr}^{-1}.$$

Rather than treating this number as an adjustable fraction of Birch's estimate, it is preferable to derive the angular velocity directly from the Kerr geometry.

For an equatorial Kerr geometry, define

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

and

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

The frame-dragging angular velocity is

$$\boxed{\omega(r) = \frac{2Marc}{A}}.$$

At

$$R_{\mathrm{MW}} = 123.3265 \text{ Gly},$$

the resulting angular velocity is approximately

$$\boxed{\omega_{\mathrm{MW}} \simeq 0.3128 \times 10^{-13} \ \mathrm{rad\,yr^{-1}}.}$$

This is of the same order as Birch's proposed value. In the revised mass budget, however, the earlier numerical equality obtained by assigning $M_{\mathrm{ring}} = M_P$ is not used. The visible-matter mass is instead taken as $M_{\mathrm{ring}} \simeq 1.5 \times 10^{53}$ kg, and the matter distribution extends over an annulus from 122.8 to 175.6 Gly.

At the annulus effective radius,

$$R_{\mathrm{eff}} \simeq 151.5 \text{ Gly},$$

the same Kerr expression gives approximately

$$\boxed{\omega_{\mathrm{Kerr}}(R_{\mathrm{eff}}) \simeq 1.687 \times 10^{-14} \ \mathrm{rad\,yr^{-1}}.}$$

The PU synchronization condition is therefore treated as a dynamical hypothesis,

$$\boxed{\Omega_{\mathrm{ring}} \simeq \omega_{\mathrm{Kerr}}(R_{\mathrm{eff}}),}$$

rather than as a consequence of equal division of primordial angular momentum.

5. Coordinate frame-dragging velocity

The equatorial circumferential metric coefficient is

$$g_{\phi\phi} = \frac{A}{r^2}.$$

A coordinate-type circumferential dragging quantity can therefore be written as

$$V_{\mathrm{drag}}(r) = \omega(r)\sqrt{g_{\phi\phi}(r)}.$$

At the Milky-Way radius,

$$V_{\mathrm{drag,MW}} \simeq 1156.5 \ \mathrm{km\,s^{-1}},$$

while at the CMB radius,

$$V_{\mathrm{drag,CMB}} \simeq 1155.8 \ \mathrm{km\,s^{-1}}.$$

Thus,

$$V_{\mathrm{drag,MW}} - V_{\mathrm{drag,CMB}} \simeq 0.6 \ \mathrm{km\,s^{-1}}.$$

The frame-dragging angular velocity itself therefore changes only slightly across the (33.5)-Mly radial separation.

6. Locally normalized Kerr quantity

The Kerr lapse on the equatorial plane is

$$\alpha(r) = \sqrt{\frac{r^2\Delta}{A}}.$$

A locally normalized dragging quantity can be defined as

$$V_K^{(\mathrm{local})}(r) = \frac{\omega(r)\sqrt{g_{\phi\phi}(r)}}{\alpha(r)}.$$

For the adopted radii,

$$\alpha_{\mathrm{MW}} \simeq 0.0676,$$

while

$$\alpha_{\mathrm{CMB}} \simeq 0.0695.$$

Consequently,

$$V_K^{(\mathrm{local})}(R_{\mathrm{MW}}) \simeq 17,119\ \mathrm{km\,s^{-1}},$$

and

$$V_K^{(\mathrm{local})}(R_{\mathrm{CMB}}) \simeq 16,624\ \mathrm{km\,s^{-1}}.$$

Their numerical difference is therefore

$$\boxed{\Delta V_K^{(\mathrm{local})} \simeq 494.6\ \mathrm{km\,s^{-1}}.}$$

This result requires careful interpretation.

The approximately 495 $\mathrm{km\,s^{-1}}$ difference does not arise mainly from the variation of ω. The raw dragging velocities differ by less than 1 $\mathrm{km\,s^{-1}}$. The much larger difference results primarily from the variation of the lapse factor:

$$V_K^{(\mathrm{local})} \propto \frac{1}{\alpha}.$$

Since both radii lie close to the PU Kerr horizon, a modest radial displacement produces a significant change in $1/\alpha$.

Thus $\Delta V_K^{(\mathrm{local})}$ is best interpreted as a diagnostic of the radial variation of the locally normalized Kerr field.

It must not automatically be identified with the physical velocity of the Milky Way relative to the CMB.

7. Comparison with observed CMB velocities

The three relevant magnitudes are

$$v_{\odot/\mathrm{CMB}} \simeq 369.8\ \mathrm{km\,s^{-1}},$$

$$\Delta V_K^{(\mathrm{local})} \simeq 494.6\ \mathrm{km\,s^{-1}},$$

and

$$v_{\mathrm{LG/CMB}} \simeq 627\ \mathrm{km\,s^{-1}}.$$

Numerically,

$$494.6 - 369.8 = 124.8\ \mathrm{km\,s^{-1}},$$

and

$$627 - 494.6 = 132.4\ \mathrm{km\,s^{-1}}.$$

The PU value therefore lies almost midway between the Solar-System and Local-Group CMB-frame velocity magnitudes.

This numerical symmetry is interesting, but it must not be overinterpreted. The velocities are vectors, and there is no physical principle requiring the Kerr quantity to equal the arithmetic mean of the two observed magnitudes.

If one provisionally writes

$$\mathrm{V}_{\mathrm{obs}} = \mathrm{V}_{\mathrm{global,Kerr}} + \mathrm{V}_{\mathrm{local}},$$

then the local terms must be determined vectorially.

For an angle θ between the global Kerr vector and an observed velocity,

$$V_{\mathrm{local}} = \sqrt{V_{\mathrm{obs}}^2 + V_K^2 - 2V_{\mathrm{obs}}V_K\cos\theta}.$$

Consequently, the values 124.8 and 132.4 $\mathrm{km\,s^{-1}}$ are only minimum residual magnitudes, obtained when the corresponding vectors are exactly parallel.

8. Direct Kerr photon-frequency calculation

A more rigorous connection to the CMB must use the photon four-momentum rather than subtracting velocities defined at different spacetime points.

The frequency measured by an observer with four-velocity u^μ is

$$\boxed{\nu = -k_\mu u^\mu,}$$

where k^μ is the photon four-momentum.

For a ZAMO,

$$u^\mu = \frac{1}{\alpha}(1, 0, 0, \omega).$$

Kerr stationarity and axial symmetry provide conserved photon quantities

$$E_\gamma = -k_t$$

and

$$L_\gamma = k_\phi.$$

The measured frequency is therefore proportional to

$$\nu \propto \frac{E_\gamma - \omega L_\gamma}{\alpha}.$$

For a CMB emitter and MW observer,

$$\frac{\nu_{\mathrm{MW}}}{\nu_{\mathrm{CMB}}} = \frac{\alpha_{\mathrm{CMB}}}{\alpha_{\mathrm{MW}}} \frac{1 - \omega_{\mathrm{MW}} b_\gamma}{1 - \omega_{\mathrm{CMB}} b_\gamma},$$

where

$$b_\gamma = \frac{L_\gamma}{E_\gamma}.$$

For a zero-angular-momentum photon,

$$b_\gamma = 0,$$

and therefore

$$\frac{\nu_{\mathrm{MW}}}{\nu_{\mathrm{CMB}}} = \frac{\alpha_{\mathrm{CMB}}}{\alpha_{\mathrm{MW}}}.$$

With the adopted radii this produces a gravitational frequency shift substantially larger than the CMB dipole. However, it is predominantly an isotropic monopole effect, not a dipole.

The directional frame-dragging term enters through

$$\frac{1 - \omega_{\mathrm{MW}} b_\gamma}{1 - \omega_{\mathrm{CMB}} b_\gamma}.$$

Because ω_{MW} and ω_{CMB} differ only slightly, this differential directional effect is much smaller than the observed CMB dipole under the simple assumption that both emitter and observer exactly comove with the ZAMO frame.

Therefore,

$$\boxed{\Delta V_K^{(\mathrm{local})} \simeq 495\ \mathrm{km\,s^{-1}}}$$

should not presently be described as a Kerr prediction of the observed CMB dipole.

9. Norma Cluster and the Great Attractor

The Norma Cluster, Abell 3627, lies approximately 220 Mly from the Milky Way and is an important structure in the historical Great-Attractor region.

An interesting PU possibility is that Norma and the Milky Way occupy nearly the same Pivot orbital shell:

$$R_{\mathrm{Norma}} \simeq R_{\mathrm{MW}}.$$

Taking

$$R = 123.3265 \text{ Gly}$$

and their mutual separation

$$d = 0.220 \text{ Gly},$$

the angular separation about the Pivot would be

$$d = 2R \sin \frac{\Delta\phi}{2}.$$

Therefore,

$$\Delta\phi = 2 \sin^{-1} \left(\frac{0.220}{2(123.3265)} \right).$$

giving approximately

$$\boxed{\Delta\phi \simeq 0.00178 \text{ rad} \simeq 0.102^\circ.}$$

If both objects participate in the same Kerr-dragged rotation,

$$\mathrm{V} = \omega \times \mathrm{R},$$

their global rotational velocity vectors differ in direction by only about

$$0.102^\circ.$$

Hence

$$\cos \Delta\phi \simeq 0.9999984.$$

Thus, to very high accuracy,

$$\boxed{\mathrm{V}_{\text{Norma,Kerr}} \parallel \mathrm{V}_{\text{MW,Kerr}}.}$$

The global Kerr motion would therefore constitute an almost perfectly common bulk flow for the Milky Way and Norma.

Using a coordinate dragging speed of approximately 1156 $\mathrm{km\,s^{-1}}$, the relative velocity produced purely by their small angular separation would be only

$$\Delta V = 2V \sin \frac{\Delta\phi}{2} \approx 2.1 \text{ km}\,\text{s}^{-1}.$$

Therefore any substantially larger relative motion between the Milky Way and Norma must arise from local gravitational dynamics or from departures from the same-shell approximation, rather than from their common Pivot-induced rotation.

10. Reinterpretation of the Great Attractor

In the conventional picture, the Local Group's peculiar motion results from the integrated gravitational field of surrounding density inhomogeneities. The Great Attractor is an important component of this environment but is not a single object responsible for the complete observed motion.

The PU interpretation suggests a decomposition

$$\mathrm{V}_{\mathrm{observed}} = \mathrm{V}_{\mathrm{global,PU}} + \mathrm{V}_{\mathrm{peculiar}}.$$

The first component represents the common large-scale Kerr-dragged motion associated with the Pivot.

The second represents local deviations caused by structures such as the Local Group, Virgo, Norma, Hydra-Centaurus, Shapley and large-scale voids.

Under this interpretation, galaxies separated by hundreds of millions of light-years can nevertheless possess nearly parallel global velocity vectors because their separation is small compared with their approximately (123)-Gly Pivot orbital radius.

The Great Attractor phenomenon would then not necessarily represent galaxies moving through otherwise stationary cosmic space toward one dominant mass concentration. Instead, the observed velocity field would be a perturbation superposed on a much larger common rotational background.

This is the central PU hypothesis examined here.

11. Directional test

The magnitude alone is insufficient.

The observed Local-Group CMB velocity is approximately directed toward

$$(l, b) \simeq (276^\circ, 30^\circ).$$

The traditional Great-Attractor direction differs substantially from this direction. This is consistent with the conventional conclusion that several structures contribute to the Local Group velocity.

In Kerr geometry, the frame-dragging direction is azimuthal:

$$\boxed{\mathrm{V}_{\mathrm{Kerr}} \parallel \mathrm{J}_P \times \mathrm{R}.}$$

Therefore the PU model must specify the Pivot rotation-axis orientation J_P before it can predict the velocity direction on the sky.

A quantitative test requires

$$\mathrm{V}_{\mathrm{residual}} = \mathrm{V}_{\mathrm{observed}} - \mathrm{V}_{\mathrm{Kerr}}.$$

The resulting residual must then agree, in both magnitude and direction, with independently reconstructed peculiar velocities generated by the nearby matter distribution.

This is a substantially stronger test than fitting the scalar velocity magnitude alone.

12. Newtonian orbital velocity and Kerr dragging

A Newtonian calculation using

$$V_N = \sqrt{\frac{GM_P}{R_{\mathrm{MW}}}}$$

gives approximately

$$V_N \simeq 0.705c.$$

This is dramatically larger than the Kerr coordinate dragging value,

$$V_{\mathrm{drag}} \simeq 1156 \text{ km}\,\mathrm{s}^{-1}.$$

This discrepancy does not imply that Newtonian distance R_{MW} should necessarily be replaced by an accumulated spiral path length.

The two expressions describe different quantities.

The Newtonian equation derives from the circular-orbit condition

$$\frac{V_N^2}{R} = \frac{GM}{R^2}.$$

Kerr frame dragging,

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

describes rotation of local inertial frames.

Therefore,

$$\boxed{V_N \neq \omega R}$$

in general.

An earlier possibility considered replacing R in Newton's formula by a spiral path L,

$$V = \sqrt{\frac{GM_P}{L}}.$$

Requiring $V = 1156$ km s^{-1} produces

$$L \sim 4.1 \times 10^6 \text{ Gly}.$$

Such a literal accumulated trajectory would require an implausibly long propagation time. It is therefore preferable not to use this construction unless an independent PU dynamical derivation produces such an effective length.

13. Angular-momentum interpretation

The revised PU treatment distinguishes between the angular momentum of the Pivot and that of the visible matter universe. The visible matter mass is taken as

$$M_{\mathrm{ring}} \simeq 1.5 \times 10^{53} \text{ kg},$$

distributed approximately over the annulus

$$R_{\mathrm{in}} = 122.8 \text{ Gly}, \qquad R_{\mathrm{out}} = 175.6 \text{ Gly}.$$

For a uniform annulus,

$$I_{\rm ring} = \frac{1}{2} M_{\rm ring} \left(R_{\rm in}^2 + R_{\rm out}^2 \right),$$

and therefore

$$J_{\rm ring} = I_{\rm ring} \Omega_{\rm ring}.$$

The corresponding effective radius is

$$R_{\rm eff} \simeq 151.5 \text{ Gly}.$$

Using the Pivot Kerr parameters $M = 61.38$ Gly and $a = 0.478$ Gly, the Kerr frame-dragging angular velocity at this radius is approximately

$$\omega_{\rm Kerr}(R_{\rm eff}) \simeq 1.687 \times 10^{-14} \text{ rad yr}^{-1}.$$

If the PU synchronization hypothesis

$$\Omega_{\rm ring} \simeq \omega_{\rm Kerr}(R_{\rm eff})$$

is imposed, the angular momentum required for the visible matter annulus is

$$\boxed{J_{\rm ring} \simeq 1.65 \times 10^{86} \text{ J s.}}$$

This is substantially smaller than the earlier simplifying value 1.06×10^{87} J s. Consequently, equal division of the primordial angular momentum between Pivot and visible matter is not required and, with the revised visible-matter mass, is not compatible with the synchronization condition in this simple annular model.

Retaining

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

and

$$J_{\rm primordial} = 2.13 \times 10^{87} \text{ J s},$$

the residual angular momentum is

$$J_{\rm residual} = J_{\rm primordial} - J_P - J_{\rm ring} \simeq \boxed{9.05 \times 10^{86} \text{ J s}}.$$

In the PU framework this residual must be assigned to radiation, other ejecta, fields, or additional angular-momentum channels associated with the primordial event. A detailed dynamical model of the explosion is required before this partition can be regarded as a prediction.

The revised interpretation is therefore that primordial angular momentum fixes the total budget, while the proposed synchronization with Kerr frame dragging constrains the portion carried by the visible matter universe.

14. Interpretation

The calculations lead to four distinct velocity concepts that should not be conflated:

$$V_{\rm drag} = \omega\sqrt{g_{\phi\phi}},$$

the coordinate-type Kerr dragging rate;

$$V_K^{(\rm local)} = \frac{\omega\sqrt{g_{\phi\phi}}}{\alpha},$$

the locally normalized Kerr quantity;

$$\Delta V_K^{(\rm local)} = V_K^{(\rm local)}(R_{\rm MW}) - V_K^{(\rm local)}(R_{\rm CMB}),$$

a diagnostic radial difference; and

$$V_{\rm obs},$$

the actual observer-relative velocity inferred from the CMB dipole.

For the adopted PU parameters,

$$V_{\rm drag} \sim 1156\ {\rm km\,s^{-1}},$$

$$\Delta V_K^{(\rm local)} \sim 495\ {\rm km\,s^{-1}},$$

while observations give

$$V_{\odot/\rm CMB} \simeq 369.8\ {\rm km\,s^{-1}}$$

and

$$V_{\rm LG/CMB} \simeq 627\ {\rm km\,s^{-1}}.$$

The numerical proximity is worthy of further investigation, but the invariant photon calculation demonstrates that these quantities cannot simply be equated.

15. Predictions and tests

For the PU explanation to become quantitatively viable, several tests are required.

First, the Pivot spin-axis direction must be independently specified. This determines the predicted Kerr velocity direction through

$$\mathrm{V}_{\rm Kerr} \parallel \mathrm{J}_P \times \mathrm{R}.$$

Second, the complete photon propagation problem should be solved using Kerr null geodesics from the proposed CMB shell to the observer. The predicted sky temperature should be calculated from

$$T_{\rm obs} = T_{\rm em}\,\frac{(k_\mu u^\mu)_{\rm obs}}{(k_\mu u^\mu)_{\rm em}}.$$

The monopole, dipole and higher multipoles should then be extracted directly.

Third, the model should calculate the peculiar-velocity field

$$\mathrm{V}_{\text{peculiar}} = \mathrm{V}_{\text{observed}} - \mathrm{V}_{\text{PU}}.$$

for the Milky Way, Local Group, Norma Cluster and other nearby structures.

Fourth, the residual field should be compared with observed galaxy peculiar-velocity surveys. A successful model must reproduce not merely one velocity magnitude but the three-dimensional velocity field over a substantial region.

Finally, the primordial mass and angular-momentum budgets must be treated simultaneously. With the revised visible-matter mass,

$$M_{\text{ring}} \simeq 1.5 \times 10^{53} \text{ kg},$$

mass-energy conservation requires

$$E_{\text{primordial}} = E_{\text{Pivot}} + E_{\text{ring}} + E_{\text{radiation}} + \cdots ,$$

while angular-momentum conservation requires

$$J_{\text{primordial}} = J_{\text{Pivot}} + J_{\text{ring}} + J_{\text{radiation}} + \cdots .$$

The angular momentum carried by radiation and other ejecta should therefore be included explicitly in a future dynamical treatment of the primordial event.

16. Conclusion

The Pivot Universe provides a different possible framework for interpreting the Great Attractor and the peculiar motion of the Local Group.

For

$$M_P = 7.82 \times 10^{53} \text{ kg}, \qquad J_P = 1.06 \times 10^{87} \text{ J s},$$

and

$$R_{\text{MW}} = 123.3265 \text{ Gly}, \qquad R_{\text{CMB}} = 123.36 \text{ Gly},$$

the Kerr frame-dragging angular velocity at the Milky-Way shell is approximately

$$\boxed{\omega_{\text{MW}} \simeq 0.313 \times 10^{-13} \text{ rad yr}^{-1}.}$$

This value is of the same order as Birch's proposed cosmic rotation. In the revised PU mass budget, the visible matter universe is assigned $M_{\text{ring}} \simeq 1.5 \times 10^{53}$ kg and is represented as an annulus extending from 122.8 to 175.6 Gly. The earlier 50/50 division of primordial angular momentum is no longer imposed. Instead, the proposed relation $\Omega_{\text{ring}} \simeq \omega_{\text{Kerr}}$ is treated as a synchronization hypothesis that constrains J_{ring}.

The coordinate Kerr dragging speed is approximately

$$\boxed{V_{\text{drag}} \simeq 1156 \text{ km s}^{-1}}.$$

A locally normalized differential quantity between the Milky-Way and CMB shells is

$$\boxed{\Delta V_K^{(\text{local})} \simeq 495 \text{ km s}^{-1}.}$$

This lies between the measured Solar-System/CMB and Local-Group/CMB velocities,

$$369.8 < 494.6 < 627 \qquad \mathrm{km\,s^{-1}}.$$

However, $\Delta V_K^{(\mathrm{local})}$ is not itself an invariant relative velocity. A direct Kerr photon-frequency calculation shows that the strong lapse variation primarily generates a gravitational monopole shift, while differential frame dragging alone gives a much smaller directional contribution.

The strongest PU interpretation is therefore not that the Great Attractor velocity is simply equal to a Kerr velocity difference. Rather, the observable velocity field may be written provisionally as

$$\mathrm{V}_{\mathrm{observed}} = \mathrm{V}_{\mathrm{global,PU}} + \mathrm{V}_{\mathrm{local}}.$$

The global component represents common rotational motion associated with the Pivot, while the local component represents gravitational perturbations produced by nearby overdensities and voids.

If the Milky Way and Norma Cluster occupy approximately the same Pivot radius, their global Kerr velocity vectors would be parallel to within approximately 0.1°, despite their $\sim$ 220-Mly separation. The Great Attractor phenomenon would then describe local departures from a common large-scale rotating flow rather than the entire motion of galaxies through a stationary cosmic background.

For the revised annular mass model, $R_{\mathrm{eff}} \simeq 151.5$ Gly and $\omega_{\mathrm{Kerr}}(R_{\mathrm{eff}}) \simeq 1.687 \times 10^{-14}\ \mathrm{rad\,yr^{-1}}$. Enforcing $\Omega_{\mathrm{ring}} \simeq \omega_{\mathrm{Kerr}}$ requires $J_{\mathrm{ring}} \simeq 1.65 \times 10^{86}$ J s, rather than an equal division $J_{\mathrm{ring}} = J_P$. This revised partition must ultimately be tested with a dynamical model of the primordial explosion and its radiation/ejecta angular momentum.

The revised treatment also distinguishes the coordinate quantity $V = r\Omega$ from a locally measured physical velocity. Equation (4.15) gives a maximum coordinate value $V \simeq 3.32c$ deep inside the horizon, but this result alone is not proof of local superluminal propagation. A specified local-observer calculation is required for that question.

This interpretation remains a hypothesis. Its decisive test is a full Kerr null-geodesic and peculiar-velocity calculation capable of reproducing simultaneously the observed CMB dipole magnitude, its direction, and the three-dimensional velocity field of the Local Group, Norma/Great-Attractor region and surrounding large-scale structure.

17. Dragged-space velocity and superluminal coordinate values

The earlier PU treatment defines the dragged-space angular velocity by Eq. (4.8) of Ref. [8],

$$\Omega(r) = \frac{R_H a c}{r^3 + a^2 r + R_H a^2},$$

and the corresponding tangential quantity by Eq. (4.15),

$$V(r) = \Omega(r) r.$$

Using the current PU parameters,

$$R_H = 122.764 \text{ Gly}, \qquad a = 0.478 \text{ Gly},$$

the dimensionless velocity defined by these equations is

$$\boxed{\frac{V(r)}{c} = \frac{R_H a r}{r^3 + a^2 r + R_H a^2}}.$$

The function reaches approximately

$$\boxed{V_{\max} \simeq 3.32c}$$

at

$$\boxed{r \simeq 2.41 \text{ Gly}}.$$

The two solutions of $V(r) = c$ occur at approximately

$$r \simeq 0.482 \text{ Gly}, \qquad r \simeq 7.39 \text{ Gly}.$$

Thus Eq. (4.15) gives $V(r) > c$ over the approximate interval

$$0.482 \lesssim r \lesssim 7.39 \text{ Gly}.$$

This entire interval is deep inside the adopted outer event horizon,

$$r_+ = 122.764 \text{ Gly}.$$

At the horizon,

$$\frac{V(r_+)}{c} \simeq 0.00389,$$

or approximately $1.17 \times 10^3 \text{ km s}^{-1}$. Across the adopted matter annulus, $122.8 \leq r \leq 175.6$ Gly, the same coordinate quantity decreases from approximately $0.00389c$ to $0.00190c$.

The result $V_{\max} \simeq 3.32c$ requires careful interpretation. Equation (4.15) defines V as the product of an angular frame-dragging quantity and the radial coordinate. In general relativity, a coordinate velocity, pattern velocity, recession velocity, or a velocity assigned to a particular spacetime slicing may exceed c without implying that a local observer measures matter, radiation, or information passing at a speed greater than c. In Kerr geometry, $r\Omega$ is therefore not automatically identical to a locally measured tangential velocity.

Consequently, the PU calculation is not presented as proof that matter or radiation locally propagates at $3.32c$. It establishes that the PU coordinate quantity defined by Eqs. (4.8) and (4.15) becomes superluminal in a region well inside the horizon. To determine whether this has a stronger physical meaning, the corresponding velocity must be formulated relative to a specified local observer frame and compared with the local light cone.

The PU hypothesis may separately consider whether an extreme primordial event produces a transient altered-vacuum state or a "tearing of space" in which the usual propagation assumptions are modified. Such a mechanism is presently speculative and is not demonstrated by Eq. (4.15). It would require an independent dynamical theory, a defined duration and causal structure, and observational tests. Apparent superluminal phenomena such as light echoes should likewise be distinguished from locally measured superluminal transport.

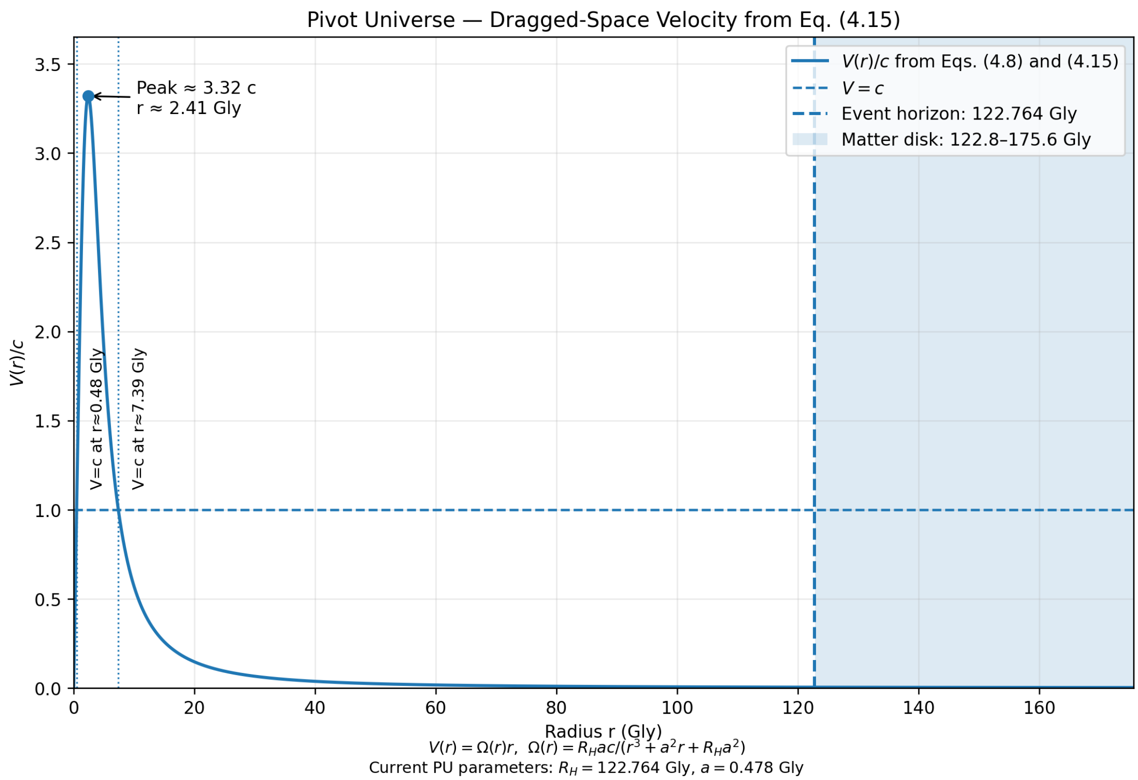

Figure 1: The PU dragged-space coordinate quantity $V(r)/c$ calculated from Eqs. (4.8) and (4.15) of Ref. [8] using $R_H = 122.764$ Gly and $a = 0.478$ Gly. The maximum is approximately $3.32c$ near $r = 2.41$ Gly. The dashed vertical line marks the outer event horizon and the shaded annulus marks the adopted visible-matter zone. Values above unity are coordinate values in this formulation and are not by themselves proof of locally measured superluminal propagation.

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