Cosmic Expansion from Rotating Spacetime: A Geometric Alternative to Dark Energy

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Abstract

We revisit the hypothesis that the observed acceleration of the universe may result from the centrifugal effects of a rotating spacetime fabric. This idea, first proposed by the author in 2016, is examined here in the context of general relativity with rotation. We derive a modified Friedmann equation incorporating vorticity and show how rotation naturally leads to expansion without invoking exotic dark energy. Furthermore, recent observations — such as anomalies in the cosmic microwave background and large-scale structure alignments — offer potential empirical support for this interpretation. This work provides a geometric foundation for cosmic acceleration rooted in the rotational dynamics of spacetime.

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1. Introduction

The accelerated expansion of the universe remains one of the most profound puzzles in modern cosmology. Conventionally attributed to a mysterious form of energy called **dark energy**, this phenomenon is encoded in Einstein's field equations through the cosmological constant Λ [1]. However, the physical origin of dark energy remains unknown, and the required fine-tuning of Λ troubling.

In 2016, the author proposed an alternative explanation: if spacetime itself is rotating, then the observed expansion could be a manifestation of centrifugal effects acting on matter embedded in this rotating frame [2]. Much like a particle on a rotating disc experiences an outward acceleration, matter in a rotating universe would naturally recede from one another.

In this paper, we formalize this idea using general relativity. We show that rotating solutions to Einstein's equations exist, introduce vorticity into the cosmological equations, and demonstrate how this rotational term can mimic dark energy. We also explore recent observational anomalies — including the "Axis of Evil" in the CMB and the Hubble tension — as potential evidence for global rotation.

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2. Rotating Spacetime in General Relativity

General relativity allows for solutions to the Einstein field equations where the universe possesses global angular momentum. One such solution is the **Gödel metric**, discovered in 1949 [3], which describes a rotating universe:

$$ds^2 = -(dt + e^x dz)^2 + dx^2 + dy^2 + \frac{1}{2}e^{2x}dz^2$$

This solution permits closed timelike curves, but more generally shows that rotation is compatible with general relativity.

In cosmology, rotation is described using the **vorticity tensor** $\omega_{\mu\nu}$, which measures the rotation of fluid elements in spacetime:

$$\omega_{\mu\nu} = \frac{1}{2}\left(\nabla_\upsilon u_\mu - \nabla_\mu u_\nu\right)$$

Its scalar magnitude is given by:

$$\omega^2 = \frac{1}{2}\,\omega_{\mu\nu}\omega^{\mu\nu}$$

Incorporating this into the **Raychaudhuri equation** gives:

$$\frac{d\theta}{d\tau} = -\frac{1}{3}\theta^2 - \sigma_{\mu\nu}\sigma^{\mu\nu}\omega_{\mu\nu}\omega^{\mu\nu} - R_{\mu\nu}$$

Here, θ is the expansion scalar, $\sigma_{\mu\upsilon}$ the shear tensor, and $\omega_{\mu\nu}$ the vorticity. Importantly, vorticity contributes a **positive** term to the expansion — it resists gravitational collapse and promotes expansion [4].

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3. Modified Friedmann Equation with Vorticity

The standard Friedmann equation, under the assumptions of homogeneity and isotropy, reads:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{k}{a^2} + \frac{\Lambda}{3}$$

To account for rotation, we introduce a **vorticity term $\boldsymbol{\omega^2}$**, yielding:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{k}{a^2} + \omega^2 + \frac{\Lambda}{3}$$

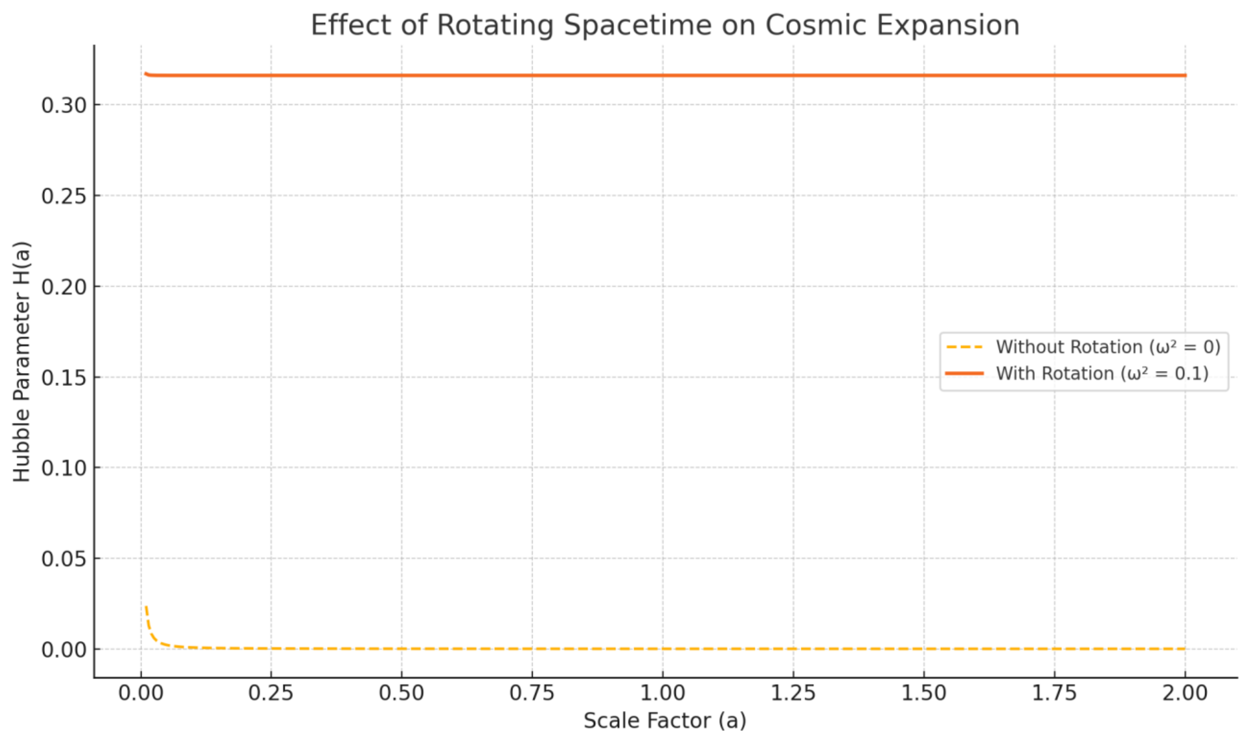

Figure 1: *Comparison of the Hubble parameter H(a) as a function of the scale factor a, with and without the rotational vorticity term ω^2 . The presence of rotation increases the expansion rate, mimicking the effect of dark energy in the late universe.*

If $\boldsymbol{\omega^2}$ is large enough, it can **replace or reduce the need for Λ**, providing a **geometric origin** of the observed acceleration.

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4. Centrifugal Analogy and Physical Insight

In classical mechanics, a body at rest on a rotating platform experiences an outward acceleration:

$$a = r\omega^2$$

We extend this analogy to spacetime itself:

“If a body is at rest and the spacetime fabric is rotating around it, the body will experience outward acceleration.”

This leads to a natural explanation for cosmic expansion: galaxies recede from one another not due to an unknown repulsive energy but because they are embedded in a **rotating spacetime geometry**.

This idea aligns with the **Machian view** of inertia, where the behavior of local objects is influenced by the global properties of the universe.

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5. Observational Clues for Rotation

5.1. Cosmic Microwave Background (CMB) Anomalies

- **Quadrupole and octopole alignments** in the CMB suggest a preferred direction [5].
- The so-called **"Axis of Evil"** — a large-scale alignment in the CMB — contradicts the standard isotropic cosmology.

5.2. Large-Scale Anisotropies

- Recent studies show dipole anisotropies in galaxy distributions [6].
- Some researchers have reported a statistically significant **dipole modulation** inconsistent with an isotropic universe.

5.3. Hubble Tension

- The discrepancy between local and early-universe measurements of the Hubble constant may hint at a **mischaracterization of the global geometry** [7].
- A rotating universe may introduce anisotropic expansion, affecting the interpretation of local data.

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6. Constraints and Predictions

Constraints

- Observational limits on global rotation exist: the vorticity must be small enough to not violate CMB isotropy at smaller scales [8].
- Rotation must be **slow** — consistent with the article "The Universe Is Rotating Slowly, According to New Measurements" [9].

Predictions

- Possible detection of large-scale frame dragging through quasar polarization
- Deviations in time delay or lensing patterns due to rotating spacetime
- Dipole modulation in redshift-distance relations across hemispheres

7. Conclusion

We have proposed a reinterpretation of cosmic acceleration as arising from the **rotational geometry of spacetime** rather than a mysterious dark energy. This hypothesis is consistent with general relativity and leads to a modified Friedmann equation that includes a **vorticity term**.

This framework provides a natural physical mechanism for expansion via centrifugal effects. Furthermore, several modern observations — from CMB anomalies to the Hubble tension — are potentially aligned with the presence of a **cosmic-scale rotational axis**.

As a geometric alternative to dark energy, this theory invites new lines of observational testing and could reshape our understanding of the universe's evolution.

References

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