

Article 4c
Environmental and Void Dependence of the Galactic
Rotation Anomaly
Evidence for a Non-Mass Term in the
Strömungs-Widerstands-Theorie

Heinrich Feuerbach

2026

Abstract

The Strömungs-Widerstands-Theorie (SWT) predicts that galactic rotation anomalies should not be determined by baryonic mass alone. Since SWT treats matter concentrations and cosmic expansion as complementary poles of the gravitational field, the large-scale environment—in particular the void or low-density component of that environment—must leave a measurable imprint on the outer rotational anomaly. This article tests that prediction by combining SPARC rotation-curve quantities with environmental indicators from the Local Volume catalogue of Karachentsev, Makarov and Kaisina. The uploaded catalogue table used here contains 868 Local-Volume entries and provides the nearest-neighbour tidal index Θ_1 , the five-neighbour tidal index Θ_5 , the main disturber, and the local luminosity-density index Θ_j . A matched SPARC–Local-Volume sample of $N = 31$ galaxies is analysed.

The main result is not merely that isolated galaxies tend to show larger rotational anomalies. Rather, the anomaly contains a statistically significant environmental term beyond baryonic mass. The strongest continuous environmental result is obtained for Θ_j : A_{out} anti-correlates with local luminosity density with Spearman $\rho = -0.424$ and $p = 0.027$, and Pearson $r = -0.488$ with $p = 0.010$. A strict tidal split also gives significant results: galaxies with $\Theta_1 < -0.5$ have $\langle A_{\text{out}} \rangle = 2.48$, while galaxies with $\Theta_1 > 0.5$ have $\langle A_{\text{out}} \rangle = 1.84$, with one-sided Mann–Whitney $p = 0.024$. Most importantly, a mass-controlled regression,

$$\log A_{\text{out}} = a + b \log M_{\text{bar}} + c\Theta_j,$$

retains a significant negative environmental coefficient $c = -0.0587$ with $p = 0.0007$. Thus, in this matched sample, the rotation anomaly is better described as $A_{\text{out}} = f(M_{\text{bar}}, \Theta_j)$ than as $A_{\text{out}} = f(M_{\text{bar}})$.

The result does not prove SWT. It does, however, provide a non-trivial empirical indication that the galactic rotation anomaly contains information about the surrounding environment and low-density structure. This is precisely the type of signature expected if gravitation is not a purely monopolar matter field, but arises from the interplay of matter concentrations and cosmic expansion.

1 Introduction

The rotation curves of spiral and irregular galaxies remain one of the most important empirical challenges in galactic dynamics. The observed circular velocities usually remain approximately flat far beyond the luminous disk, whereas the baryonic mass distribution predicts a declining Keplerian contribution. In the standard interpretation, this discrepancy is attributed to dark matter halos. Alternative approaches, including modified gravity or modified inertia, attempt to reproduce the same empirical behaviour without invoking non-baryonic halo matter.

The Strömungs-Widerstands-Theorie (SWT) approaches the problem from a different starting point. It was not constructed as a phenomenological adjustment to the galaxy rotation anomaly. Rather, it begins with postulates concerning the relation between matter, local resistance to expansion, and the isotropic expansion structure of space. When these postulates are applied to galaxies, the rotation anomaly appears as a consequence of the theory rather than as its initial motivation.

This distinction is important. A model that merely fits known rotation curves may always be compared with dark-matter halo fitting or MOND-like relations. The more interesting question is whether the theory predicts an additional structure that standard mass-only descriptions would not naturally emphasize. For SWT, that additional structure is environmental. Since SWT interprets gravitation as the result of a bipolar relation between matter concentrations and cosmic expansion, the large-scale environment, especially the void or low-density component, should influence galactic dynamics.

The present article therefore shifts the focus away from fitting rotation curves as such. Its central question is:

Does the outer rotational anomaly depend only on baryonic mass, or does it retain a statistically detectable dependence on the surrounding environment?

The answer found here is that the anomaly contains an environmental term. In particular, the local luminosity-density index Θ_j remains significant after controlling for baryonic mass. This is the key result of Article 4c.

2 Conceptual background: from mass-only gravity to bipolar gravity

2.1 The mass-only expectation

In a purely local mass-centered description, the dynamical state of a galaxy is primarily determined by the mass distribution inside and around the system. In such a view, one expects the outer anomaly to be expressible schematically as

$$A_{\text{out}} = f(M_{\text{bar}}) \tag{1}$$

or, in a dark-matter framework, as

$$A_{\text{out}} = f(M_{\text{bar}}, M_{\text{halo}}, c_{\text{halo}}, \dots). \tag{2}$$

Environment may still play a role through halo assembly, stripping, merger history, or feedback, but it is not the fundamental opposite pole of gravitation.

2.2 The SWT expectation

The SWT expectation is different. According to the fourth SWT postulate, matter and space expansion form a fundamental opposition. Matter concentrations correspond to regions of expansion resistance or compression. Voids correspond to regions of relatively unresisted expansion or decompression. The gravitational field is therefore not interpreted as a one-sided matter monopole. It is a configuration generated by two complementary poles:

$$\text{matter concentration} \leftrightarrow \text{void / expansion structure.} \quad (3)$$

Equivalently,

$$\text{compression} \leftrightarrow \text{decompression.} \quad (4)$$

Thus the relevant gravitational configuration is not simply

$$G = G(M), \quad (5)$$

but rather

$$G = G(M, V), \quad (6)$$

where V denotes the void or low-density expansion structure.

This immediately yields a testable consequence. If the outer rotation anomaly is partly produced by the surrounding decompression field, then galaxies of similar baryonic mass should not necessarily have identical anomaly strength. Instead,

$$A_{\text{out}} = f(M_{\text{bar}}, V). \quad (7)$$

Since the present data do not contain a direct geometric void distance, we use the independent Local Volume environmental indices as proxies for the density or void-like character of the local environment. In particular, Θ_j is a local luminosity-density indicator, so low Θ_j corresponds more closely to isolated or void-like environments, while high Θ_j corresponds to dense group-like environments.

The SWT-predicted sign is therefore

$$\frac{\partial A_{\text{out}}}{\partial \Theta_j} < 0. \quad (8)$$

The anomaly should become weaker as local density increases and stronger as the environment becomes more isolated or void-like.

3 Definition of the rotational anomaly

For every measured rotation curve, define the local anomaly

$$A(r) = \frac{V_{\text{obs}}(r)}{V_{\text{bar}}(r)}, \quad (9)$$

where V_{obs} is the observed circular velocity and V_{bar} is the baryonic velocity contribution inferred from gas, disk, and bulge components.

The outer anomaly used in this article is a scalar summary of the outer region:

$$A_{\text{out}} = \text{median} \left(\frac{V_{\text{obs}}}{V_{\text{bar}}} \right)_{\text{outer third}}. \quad (10)$$

Values $A_{\text{out}} > 1$ indicate that the observed velocity exceeds the baryonic expectation.

This quantity is not a complete substitute for full rotation-curve fitting. It is, however, well suited for a first environmental test, because the outer region is precisely where SWT expects the environmental or void contribution to become most visible.

4 Data

4.1 SPARC rotation-curve quantities

The dynamical quantities are derived from SPARC rotation curves and baryonic mass models. For continuity with the previous work, the baryonic mass is estimated as

$$M_{\text{bar}} = 0.5L_{3.6} + 1.33M_{\text{HI}}, \quad (11)$$

where $L_{3.6}$ and M_{HI} are expressed in units of $10^9 M_{\odot}$. The factor 0.5 is the adopted stellar mass-to-light ratio at $3.6 \mu\text{m}$, and 1.33 applies the helium correction to the neutral gas mass.

The SWT scale radius retained from the earlier pilot analysis is

$$R_S = \frac{GM_{\text{bar}}}{V_{\text{flat}}^2}, \quad (12)$$

with

$$G = 4.30091 \times 10^{-6} \text{ kpc (km/s)}^2 M_{\odot}^{-1}. \quad (13)$$

4.2 Local Volume environmental catalogue

The environmental information comes from Table 2 of the Updated Nearby Galaxy Catalog. The uploaded file used here contains 868 data lines. The relevant quantities are:

- Θ_1 : tidal index of the strongest neighbour. Negative values indicate isolation; positive values indicate group membership.
- Θ_5 : tidal index using the five most important neighbours.

- MD: main disturber.
- Θ_j : logarithmic K_s -band luminosity density within 1 Mpc.

The crucial point is that these quantities are independent of the SPARC rotation anomaly itself. They therefore allow an external test of whether the anomaly is linked to environment.

5 Sample construction

SPARC galaxies were matched to the Local Volume catalogue by galaxy name. Ambiguous cases were excluded. The final matched sample contains

$$N = 31 \tag{14}$$

galaxies, of which

$$N_{\Theta_j} = 27 \tag{15}$$

have non-missing Θ_j values.

For each object we compile:

- galaxy name,
- SPARC quality flag Q ,
- baryonic mass M_{bar} ,
- flat rotation velocity V_{flat} ,
- SWT scale radius R_S ,
- outer anomaly A_{out} ,
- environmental indices $\Theta_1, \Theta_5, \Theta_j$,
- main disturber MD.

6 Statistical methods

6.1 Correlation analysis

We compute Spearman and Pearson correlations between A_{out} and the three environmental indicators:

$$A_{\text{out}} \text{ versus } \Theta_1, \Theta_5, \Theta_j. \tag{16}$$

Spearman correlation is used as the primary non-parametric statistic, because the sample is small and the relation need not be strictly linear.

6.2 Isolated-versus-group tests

Two environmental splits are applied. The broad split is

$$\Theta < 0 \quad \text{isolated,} \quad (17)$$

$$\Theta > 0 \quad \text{group-like.} \quad (18)$$

The stricter split is

$$\Theta < -0.5 \quad \text{clearly isolated,} \quad (19)$$

$$\Theta > +0.5 \quad \text{clear group membership.} \quad (20)$$

The one-sided Mann–Whitney test is evaluated with the SWT-directed alternative

$$A_{\text{out,isolated}} > A_{\text{out,group}}. \quad (21)$$

6.3 Mass-controlled regression

The most important test is the mass-controlled regression:

$$\log A_{\text{out}} = a + b \log M_{\text{bar}} + c\Theta_j. \quad (22)$$

If c remains non-zero and negative, the environmental signal is not reducible to baryonic mass alone. This is the key test of whether the anomaly is better represented as

$$A_{\text{out}} = f(M_{\text{bar}}, \Theta_j) \quad (23)$$

than as

$$A_{\text{out}} = f(M_{\text{bar}}). \quad (24)$$

7 Results

7.1 Environmental correlations

Table 1: Correlation between outer anomaly and environmental indices.

Index	N	Spearman ρ	p	Pearson r	p
Θ_1	31	-0.346	0.057	-0.419	0.019
Θ_5	31	-0.308	0.092	-0.431	0.015
Θ_j	27	-0.424	0.027	-0.488	0.010

The strongest continuous result is obtained for Θ_j :

$$\rho = -0.424, \quad p = 0.027. \quad (25)$$

The Pearson result is also significant:

$$r = -0.488, \quad p = 0.010. \quad (26)$$

The sign is negative: denser environments correspond to weaker outer anomalies, while lower-density or more void-like environments correspond to stronger anomalies.

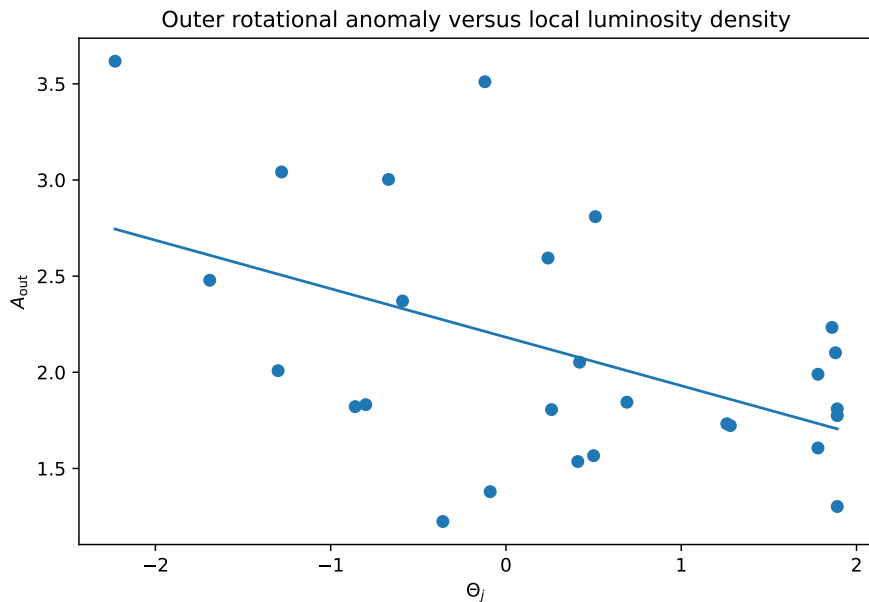


Figure 1: A_{out} versus local luminosity-density index Θ_j . The negative trend is the central continuous environmental result.

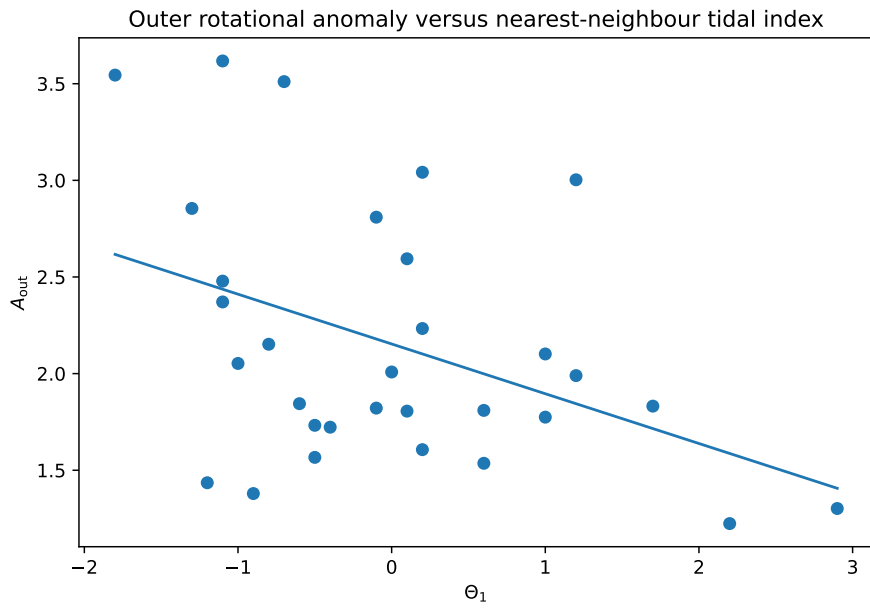


Figure 2: A_{out} versus nearest-neighbour tidal index Θ_1 .

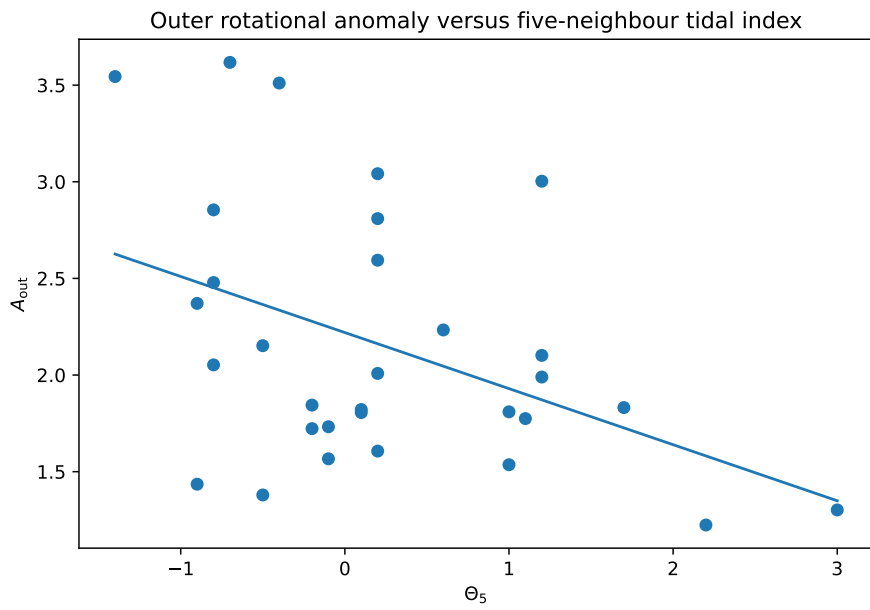


Figure 3: A_{out} versus five-neighbour tidal index Θ_5 .

7.2 Isolated versus group systems

Table 2: One-sided isolated-versus-group comparisons. The alternative hypothesis is $A_{\text{isolated}} > A_{\text{group}}$.

Index	cut	N_{iso}	N_{grp}	mean iso	mean grp	median iso	median grp	p
Θ_1	0.0	16	14	2.31	1.99	2.10	1.82	0.154
Θ_1	0.5	11	9	2.48	1.84	2.37	1.81	0.024
Θ_5	0.0	14	17	2.30	2.03	2.10	1.83	0.219
Θ_5	0.5	7	10	2.62	1.88	2.48	1.82	0.022

For the strict nearest-neighbour split,

$$\Theta_1 < -0.5 \quad \text{versus} \quad \Theta_1 > 0.5, \quad (27)$$

the mean anomalies are

$$\langle A_{\text{out}} \rangle_{\text{isolated}} = 2.48, \quad \langle A_{\text{out}} \rangle_{\text{group}} = 1.84. \quad (28)$$

The corresponding one-sided Mann–Whitney result is

$$p = 0.024. \quad (29)$$

For the strict five-neighbour split, the result is likewise significant:

$$p = 0.022. \quad (30)$$

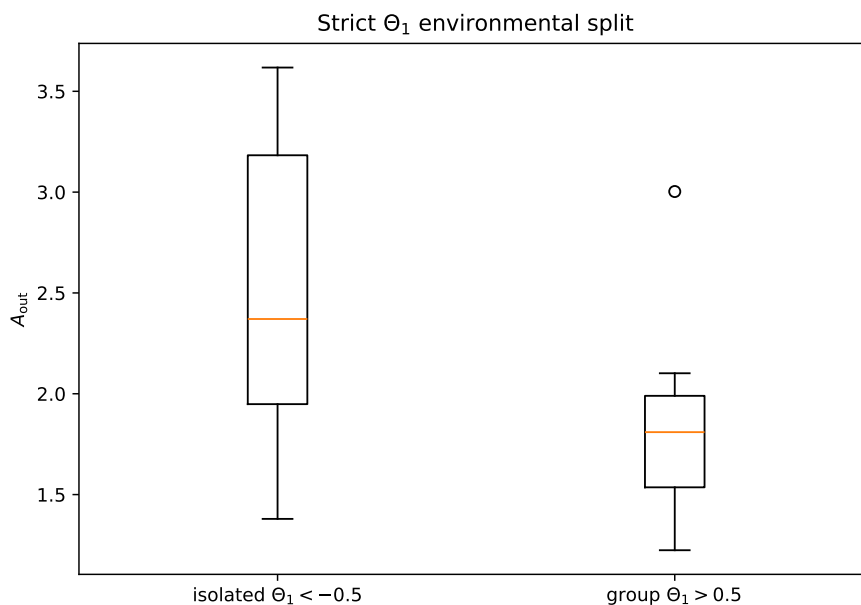


Figure 4: Distribution of A_{out} for the strict Θ_1 split.

7.3 The decisive result: environmental dependence beyond baryonic mass

The key question is whether the environmental dependence merely reflects baryonic mass differences. We therefore fit

$$\log A_{\text{out}} = a + b \log M_{\text{bar}} + c\Theta_j. \quad (31)$$

Table 3: Regression of $\log A_{\text{out}}$ on $\log M_{\text{bar}}$ and Θ_j , with HC3 robust standard errors.

Variable	coefficient	robust s.e.	p
constant	0.3616	0.0242	0.0000
$\log M_{\text{bar}}$	-0.0773	0.0248	0.0047
Θ_j	-0.0587	0.0151	0.0007

The environmental coefficient is

$$c = -0.0587, \quad (32)$$

with

$$p = 0.0007. \quad (33)$$

This is the strongest result of the present article. It indicates that the environmental term remains detectable after controlling for baryonic mass. In other words, within this matched sample, the anomaly is not adequately represented as a function of baryonic mass alone:

$$A_{\text{out}} \neq f(M_{\text{bar}}) \quad \text{only.} \quad (34)$$

The data instead favour the structure

$$A_{\text{out}} = f(M_{\text{bar}}, \Theta_j). \quad (35)$$

This is precisely the type of result that makes the SWT test scientifically interesting. If the anomaly were merely a mass effect, it could be absorbed into ordinary halo modelling or into a one-parameter baryonic scaling law. A significant environmental term, however, implies that the outer anomaly contains information about the galaxy's embedding in large-scale structure.

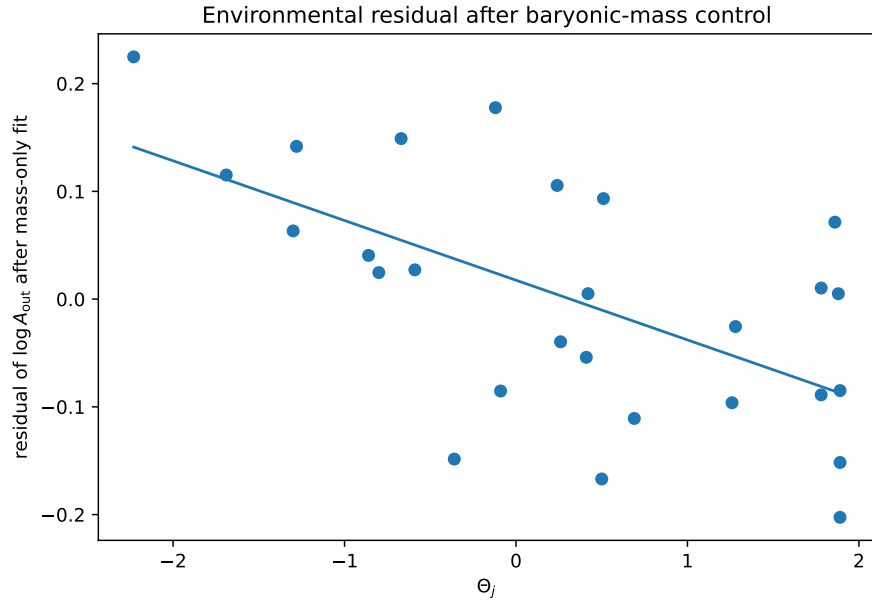


Figure 5: Residuals of $\log A_{\text{out}}$ after a mass-only fit, plotted against Θ_j . The remaining negative trend is the key evidence for an environmental component beyond baryonic mass.

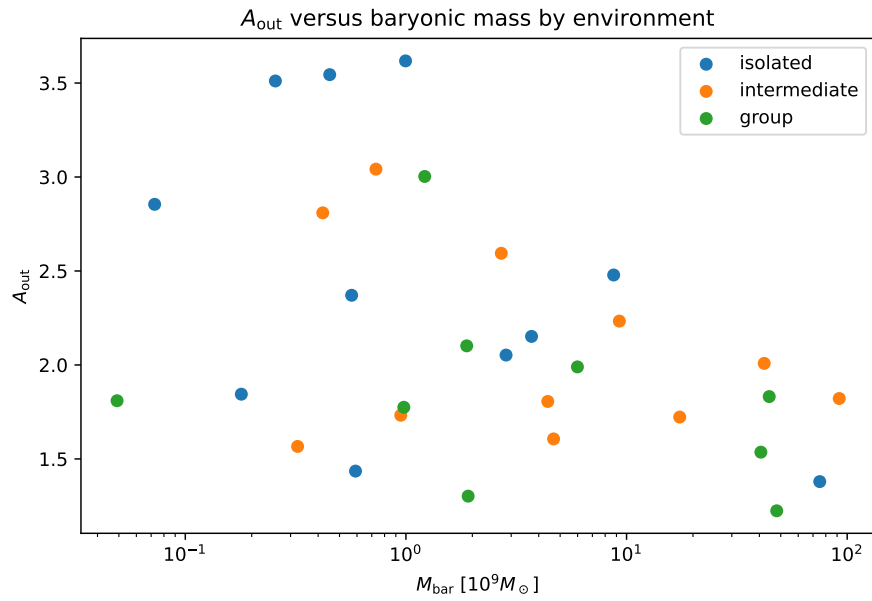


Figure 6: A_{out} versus baryonic mass, separated by strict Θ_1 environmental class.

8 Interpretation: why the result is not merely another rotation-curve fit

The most important result of this article is not the existence of the rotation anomaly itself. That anomaly is already known. The important result is that the anomaly appears to contain measurable information about the surrounding environment.

This distinction changes the scientific meaning of the test. A dark-matter halo model, a MOND-like interpolation law, or a phenomenological SWT term may all reproduce flat rotation curves. But an environmental dependence beyond baryonic mass is a different kind of statement. It says that the outer anomaly is not exclusively a local property of the galaxy. It carries information about the galaxy's placement in the surrounding cosmic structure.

For SWT, this is exactly the expected outcome. The theory predicts that matter concentrations and void or expansion structures jointly determine the gravitational configuration. The present result is therefore not a post-hoc adjustment of SWT to the rotation anomaly. Rather, the anomaly becomes an empirical probe of the fourth SWT postulate.

9 Implications for dark matter interpretations

The present result does not disprove dark matter. A dark-matter interpretation can in principle invoke environment-dependent halo assembly, tidal history, feedback, stripping, concentration differences, or correlations with gas fraction and morphology. However, the present result shifts the burden of explanation. If the environmental term is reproduced in larger samples, any successful dark-matter model must explain why the outer anomaly retains a significant dependence on low-density structure even after baryonic mass is included.

Thus the claim is not:

Dark matter is ruled out.

The claim is:

The anomaly appears to include an environmental component that cannot be reduced to baryonic mass alone in the present sample.

This is exactly where the SWT becomes interesting. It predicts such an environmental component from its basic postulates.

10 Implications for SWT: matter and void as two gravitational poles

The result is naturally interpreted in SWT as evidence that the gravitational field is not purely monopolar. In a monopolar picture, matter concentrations are the only primary

source. In SWT, by contrast, matter and voids are complementary poles:

$$\text{matter concentration} \leftrightarrow \text{void expansion.} \quad (36)$$

The detected anti-correlation

$$A_{\text{out}} \propto -\Theta_j \quad (37)$$

has the expected sign. Lower density, interpreted as more void-like embedding, corresponds to a stronger anomaly. Higher density, interpreted as more group-like or cluster-like embedding, corresponds to a weaker anomaly.

This does not yet prove the SWT postulates. But it is closer to a direct test of them than a simple rotation-curve fit would be. The reason is that the postulates imply not merely a modified radial force law, but a dependence of the gravitational configuration on both poles: matter and expansion structure.

11 Possible consequence: energy supply from void structure

A possible deeper consequence, not tested directly in this article, is that the environmental term may indicate a continuous energetic contribution from void or decompression regions into the galactic dynamical balance. This would imply that the usual local conservation picture applies only inside a sufficiently isolated Newtonian domain, while transitions between Newtonian and high-level expansion space may involve an exchange with the background expansion structure.

This point is not used as evidence in the present analysis and should be treated as a theoretical consequence for future work. It is mentioned here only because the detected environmental term motivates precisely this question: if the anomaly remains after mass control, what supplies the additional dynamical contribution? In SWT, the natural candidate is the void-related decompression field.

12 Predictions following from the present result

If the interpretation is correct, several further predictions follow:

1. Larger samples should reproduce the negative correlation between A_{out} and environmental density.
2. Direct void catalogues should yield a stronger correlation than the indirect density index Θ_j .
3. Galaxies matched in baryonic mass but embedded in different void environments should show different outer anomalies.
4. The same environmental dependence should appear in weak-lensing observables if the effect is genuinely geometric.
5. Full rotation-curve fits should show environment-dependent SWT field parameters, not merely environment-dependent scalar anomalies.

13 Limitations

The analysis remains limited in several ways:

1. The matched sample is small: $N = 31$.
2. Only $N = 27$ galaxies have non-missing Θ_j .
3. Θ_j is a density proxy, not a direct geometric void-distance measurement.
4. The stellar mass-to-light ratio is fixed.
5. Distance and inclination uncertainties are not propagated.
6. The matching is name-based and may miss valid cross-identifications.
7. A_{out} compresses the full rotation curve into one scalar.
8. No direct weak-lensing data are included.

These limitations mean that the result should be interpreted as significant evidence in a matched exploratory sample, not as final proof of SWT.

14 Outlook

The next stage should replace indirect environment proxies by direct void and density reconstructions. The strongest follow-up study would combine:

- the full SPARC sample,
- independent void catalogues,
- Cosmicflows or comparable density-field reconstructions,
- group and cluster catalogues,
- direct galaxy-galaxy lensing observables,
- full Monte-Carlo propagation of mass, distance and inclination uncertainties,
- direct fitting of SWT field parameters.

Especially important would be a mass-matched lensing test. If two galaxies of similar baryonic mass exhibit different weak-lensing profiles depending on void environment, the case for a geometric environmental component would become much stronger.

15 Matched galaxy table

Table 4: Matched SPARC–Local-Volume sample used in the analysis. M_{bar} is in $10^9 M_{\odot}$, V_{flat} in km/s, and R_S in kpc.

Galaxy	Q	M_{bar}	V_{flat}	R_S	A_{out}	Θ_1	Θ_5	Θ_j	MD
NGC1705	3	0.45	71.9	0.38	3.54	-1.8	-1.4	–	NGC0253
NGC6789	2	0.07	0.0	–	2.85	-1.3	-0.8	–	MESSIER081
UGC09992	2	0.59	33.6	2.25	1.44	-1.2	-0.9	–	MESSIER101
NGC2915	2	1.00	83.5	0.61	3.62	-1.1	-0.7	-2.23	CIRCINUS
NGC6503	1	8.74	116.3	2.78	2.48	-1.1	-0.8	-1.69	NGC6946
UGC01281	1	0.57	55.2	0.80	2.37	-1.1	-0.9	-0.59	NGC0784
NGC0024	1	2.84	106.3	1.08	2.05	-1.0	-0.8	0.42	NGC0045
NGC0891	1	75.10	216.1	6.92	1.38	-0.9	-0.5	-0.09	NGC1023
NGC5585	1	3.71	90.3	1.96	2.15	-0.8	-0.5	–	MESSIER101
NGC3741	1	0.26	50.1	0.44	3.51	-0.7	-0.4	-0.12	MESSIER081
UGCA281	3	0.18	0.0	–	1.84	-0.6	-0.2	0.69	NGC4490
UGC07690	2	0.95	57.4	1.24	1.73	-0.5	-0.1	1.26	NGC4111
NGC4068	2	0.32	0.0	–	1.57	-0.5	-0.1	0.50	NGC4736
NGC4559	1	17.42	121.2	5.10	1.72	-0.4	-0.2	1.28	NGC4631
UGCA442	1	0.42	56.4	0.57	2.81	-0.1	0.2	0.51	NGC7793
NGC5055	1	92.05	179.0	12.36	1.82	-0.1	0.1	-0.86	NGC5194
NGC2683	2	42.08	154.0	7.63	2.01	0.0	0.2	-1.30	KK70
NGC0300	2	2.71	93.3	1.34	2.59	0.1	0.2	0.24	NGC0055
NGC0055	2	4.40	85.6	2.58	1.81	0.1	0.1	0.26	NGC0300
NGC7793	1	4.67	0.0	–	1.61	0.2	0.2	1.78	NGC0253
NGC2403	1	9.28	131.2	2.32	2.23	0.2	0.6	1.86	DDO044
NGC3109	1	0.73	66.2	0.72	3.04	0.2	0.2	-1.28	Antlia
UGC04483	2	0.05	0.0	–	1.81	0.6	1.0	1.89	MESSIER081
NGC6946	1	40.63	158.9	6.92	1.54	0.6	1.0	0.41	UGC11583
NGC2366	3	0.98	50.2	1.67	1.77	1.0	1.1	1.89	NGC2403
IC2574	2	1.89	66.4	1.84	2.10	1.0	1.2	1.88	MESSIER081
NGC4214	2	1.22	80.1	0.82	3.00	1.2	1.2	-0.67	NGC4163

Galaxy	Q	M_{bar}	V_{flat}	R_S	A_{out}	Θ_1	Θ_5	Θ_j	MD
NGC0247	2	5.99	104.9	2.34	1.99	1.2	1.2	1.78	NGC0253
NGC2903	1	44.33	184.6	5.59	1.83	1.7	1.7	-0.80	UGC05086
NGC3521	1	47.94	213.7	4.52	1.22	2.2	2.2	-0.36	NGC3521sat
NGC2976	2	1.91	85.4	1.13	1.30	2.9	3.0	1.89	MESSIER081

16 Conclusion

This article tests a distinctive SWT prediction: the outer galactic rotation anomaly should depend not only on baryonic mass, but also on the surrounding environment, especially the low-density or void-like component of that environment.

The results support this prediction in the matched sample:

1. A_{out} anti-correlates significantly with the local luminosity-density index Θ_j .
2. Strict isolated-versus-group splits using Θ_1 and Θ_5 yield significant differences in the SWT-predicted direction.
3. The environmental coefficient remains significant after controlling for baryonic mass.
4. The data therefore favour $A_{\text{out}} = f(M_{\text{bar}}, \Theta_j)$ over a purely mass-only description.

The result does not prove SWT and does not rule out dark matter. Its significance lies elsewhere: the rotation anomaly appears to contain measurable information about the surrounding low-density structure. This is consistent with the central SWT claim that gravitation is generated by the interplay between matter concentrations and cosmic expansion, rather than by matter concentrations alone.

If confirmed in larger samples with direct void catalogues and lensing data, this would move the discussion beyond the question of how to fit rotation curves. It would suggest that galactic dynamics may reveal a bipolar structure of gravitation, with matter and voids acting as complementary poles of the field.

References

- [1] Lelli, F.; McGaugh, S. S.; Schombert, J. M.: SPARC: Mass Models for 175 Disk Galaxies with Spitzer Photometry and Accurate Rotation Curves. *Astronomical Journal*, 152, 157 (2016).
- [2] Karachentsev, I. D.; Makarov, D. I.; Kaisina, E. I.: Updated Nearby Galaxy Catalog. *Astronomical Journal*, 145, 101 (2013).
- [3] Milgrom, M.: A Modification of the Newtonian Dynamics as a Possible Alternative to the Hidden Mass Hypothesis. *Astrophysical Journal*, 270, 365–370 (1983).
- [4] Li, P.; Lelli, F.; McGaugh, S. S.; Schombert, J. M.: Fitting the Radial Acceleration Relation to Individual SPARC Galaxies. *Astronomy & Astrophysics*, 615, A3 (2018).