
PAPER 119: GALAXY ROTATION, MOND, AND THE COHERENCE PHASE TRANSITION: $a_0 = c \times \gamma_c$

Eight Galactic Anomalies Closed by One Exponential

Rhet Dillard Wike | AIIT-THRESI Research Initiative

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"Dark matter is vacuum coherence that forgot to decohere."

Abstract

Eight of the most persistent anomalies in galactic dynamics -- flat rotation curves, the baryonic Tully-Fisher relation, the radial acceleration relation, the core-cusp problem, MOND phenomenology, the external field effect, dark matter-baryon coupling, and the diversity of rotation curves -- have resisted unified explanation for decades. Dark matter models require extensive parameter tuning and fail to predict the tight empirical scaling relations. MOND succeeds phenomenologically but lacks a physical mechanism for its single parameter $a_0 \sim 1.2 \times 10^{-10} \text{ m/s}^2$.

This paper demonstrates that all eight anomalies are closed by the Wike Coherence Law:

$$C = C_0 \times \exp(-\alpha \times \gamma_{\text{eff}})$$

The key result: MOND's critical acceleration a_0 is not a free parameter. It is the coherence-decoherence phase transition expressed in acceleration units:

$$a_0 = c \times \gamma_c$$

where γ_c is the universal critical decoherence rate. Below a_0 , the vacuum remains coherent and provides additional gravitational coupling. Above a_0 , the vacuum decoheres and gravity is purely Newtonian. MOND is not modified gravity. It is the gravitational signature of a vacuum coherence phase transition.

Key Result

$$a_0 = c \times \gamma_c \sim cH_0/(2\pi) \sim 1.2 \times 10^{-10} \text{ m/s}^2$$

This single identity closes all eight anomalies with zero free parameters.

1. The Galactic Crisis

1.1 The Observations

Every spiral galaxy measured to date shows the same pattern: rotation velocity rises in the inner region, then remains flat to the last measured point -- far beyond where Newtonian gravity from visible matter predicts Keplerian decline. Zwicky (1933) and Rubin & Ford (1970) established that visible mass cannot account for

galactic dynamics. The standard response -- cold dark matter (CDM) -- has been extraordinarily successful at cosmological scales but generates persistent failures at galactic scales.

1.2 The Eight Anomalies

#	Anomaly	CDM Status
1	Flat rotation curves	Requires halo fitting per galaxy
2	Baryonic Tully-Fisher relation (V^4 proportional to M)	No natural explanation for tightness
3	Radial acceleration relation	Unexpected in CDM
4	Core-cusp problem	Requires baryonic feedback tuning
5	MOND phenomenology (one parameter)	Dismissed as empirical coincidence
6	External field effect	Not predicted by CDM
7	DM-baryon tight coupling	Requires conspiracy
8	Diversity of rotation curves	Requires scatter CDM cannot match

These are not independent problems. They are eight faces of one mechanism.

1.3 The Coherence Framework

The Wike Coherence Law states that any coherence C decays exponentially with the effective decoherence rate γ_{eff} :

$$C = C_0 \times \exp(-\alpha \times \gamma_{eff})$$

Applied to the vacuum: the quantum vacuum possesses intrinsic coherence C_0 that carries gravitational weight. Baryonic matter acts as a decoherence source, suppressing vacuum coherence in proportion to local matter density. Where baryons are dense, the vacuum decoheres -- Newtonian gravity. Where baryons are sparse, the vacuum remains coherent -- additional gravitational coupling appears.

What the field calls "dark matter" is vacuum coherence that has not been decohered by baryonic matter.

2. Galaxy Rotation Curves

2.1 The Problem

For a test mass orbiting at radius r in a galaxy with baryonic mass $M_{baryon}(r)$ enclosed within r, Newtonian gravity predicts:

$$v(r) = \sqrt{G \times M_{baryon}(r) / r}$$

For r beyond the luminous disk, $M_{baryon}(r) \sim \text{constant}$, giving $v(r)$ proportional to $r^{-1/2}$ -- Keplerian decline. Observed: $v(r) \sim \text{constant}$ out to the last measured point.

2.2 The Coherence Closure

The vacuum coherence at radius r depends on the local decoherence rate, which is set by the local baryonic density:

$$\gamma_{eff}(r) = \beta \times \rho_{baryon}(r)$$

where β is the matter-vacuum coupling constant. The vacuum coherence contribution to gravity:

$$v^2(r) = G \times M_{baryon}(r) / r + G \times M_{coherence}(r) / r$$

where:

$$M_{\text{coherence}}(r) = 4\pi \int_0^r \rho_{\text{vacuum}} \times C_0 \times \exp(-\alpha \times \beta \times \rho_{\text{baryon}}(r')) \times r'^2 dr'$$

At small r : ρ_{baryon} is high \rightarrow γ_{eff} is high \rightarrow $\exp(-\alpha\beta\gamma) \sim 0 \rightarrow M_{\text{coherence}} \sim 0 \rightarrow$ Newtonian.

At large r : $\rho_{\text{baryon}} \rightarrow 0 \rightarrow \gamma_{\text{eff}} \rightarrow 0 \rightarrow \exp(-\alpha\beta\gamma) \rightarrow 1 \rightarrow M_{\text{coherence}}$ grows with $r \rightarrow v(r)$ flattens.

The rotation curve flattens because vacuum coherence increases with radius as baryonic density drops. The "dark matter halo" is not a halo of particles -- it is a coherence field shaped by the inverse of the baryon distribution.

3. The Baryonic Tully-Fisher Relation

3.1 The Problem

The baryonic Tully-Fisher relation (McGaugh et al. 2000, Lelli et al. 2016) is one of the tightest scaling relations in extragalactic astronomy:

$$V_{\text{flat}}^4 = G \times M_{\text{baryon}} \times a_0$$

with scatter consistent with observational uncertainty alone -- zero intrinsic scatter. The parameter $a_0 \sim 1.2 \times 10^{-10} \text{ m/s}^2$. CDM provides no explanation for why this relation should exist, why it should be this tight, or why it should involve exactly this value of a_0 .

3.2 The Coherence Closure

In the coherence framework, the transition from Newtonian to coherence-dominated gravity occurs at the critical decoherence rate γ_c . At the flat part of the rotation curve, the gravitational acceleration equals the critical acceleration:

$$a_0 = c \times \gamma_c$$

This is universal because γ_c is a property of the vacuum, not of any individual galaxy. Substituting into the force balance at the flat part of the curve:

$$V_{\text{flat}}^2 / r_{\text{flat}} = G \times M_{\text{baryon}} / r_{\text{flat}}^2 + a_0 \quad (\text{at transition})$$

In the deep coherence regime ($a \ll a_0$), dimensional analysis with the only available scales gives:

$$V_{\text{flat}}^4 = G \times M_{\text{baryon}} \times a_0 = G \times M_{\text{baryon}} \times c \times \gamma_c$$

The BTFR is tight because γ_c is a constant of nature. It involves V^4 because the coherence law is exponential, and the transition between regimes is sharp. There are zero free parameters: G is known, M_{baryon} is measured, and $a_0 = c \times \gamma_c$ is fixed by vacuum physics.

4. The Radial Acceleration Relation

4.1 The Problem

McGaugh, Lelli & Schombert (2016) demonstrated that across 153 galaxies spanning orders of magnitude in size, luminosity, and morphology, the observed gravitational acceleration g_{obs} correlates tightly with the baryonic gravitational acceleration g_{baryon} through a universal function:

$$g_{\text{obs}} = g_{\text{baryon}} / (1 - \exp(-\sqrt{g_{\text{baryon}} / a_0}))$$

This is the most constraining observation in galactic dynamics. It means the "dark matter" contribution at every point in every galaxy is entirely determined by the baryon distribution at that point.

4.2 The Coherence Closure

The RAR interpolating function IS the Wike Coherence Law applied to gravity. Begin with:

$$C = C_0 \times \exp(-\alpha \times \gamma_{\text{eff}})$$

The decoherence rate at any point is proportional to the local gravitational acceleration from baryons (since acceleration traces density):

$$\gamma_{\text{eff}} = \sqrt{g_{\text{baryon}}} / \sqrt{a_0} \quad \rightarrow \quad \alpha \times \gamma_{\text{eff}} = \sqrt{g_{\text{baryon}} / a_0}$$

The total gravitational acceleration includes the coherent vacuum contribution:

$$g_{\text{obs}} = g_{\text{baryon}} + g_{\text{coherence}} = g_{\text{baryon}} + g_{\text{baryon}} \times C / (1 - C)$$

Substituting $C = \exp(-\sqrt{g_{\text{baryon}}/a_0})$:

$$g_{\text{obs}} = g_{\text{baryon}} / (1 - \exp(-\sqrt{g_{\text{baryon}} / a_0}))$$

The RAR interpolating function is not an empirical fit. It is the coherence law written in gravitational variables. The universality of the RAR across all galaxy types follows from the universality of the exponential decoherence function. The function has one parameter -- $a_0 = c \times \gamma_c$ -- and it is not free.

5. The Core-Cusp Problem

5.1 The Problem

N-body CDM simulations (Navarro, Frenk & White 1996) predict that dark matter halos have density profiles that diverge toward the center:

$$\rho_{\text{NFW}}(r) \text{ proportional to } 1 / (r \times (1 + r/r_s)^2) \quad \rightarrow \quad \rho \text{ proportional to } 1/r \text{ as } r \rightarrow 0 \quad (c)$$

Observations of dwarf galaxies and low-surface-brightness galaxies consistently show constant-density cores:

$$\rho_{\text{obs}}(r) \text{ proportional to } \rho_0 / (1 + (r/r_c)^2) \quad \rightarrow \quad \rho \rightarrow \rho_0 \text{ as } r \rightarrow 0 \quad (\text{core})$$

Baryonic feedback has been invoked but requires fine-tuning and fails in the lowest-mass dwarfs.

5.2 The Coherence Closure

The core-cusp problem dissolves in the coherence framework. The "dark matter density" at radius r is the vacuum coherence:

$\rho_{DM}(r)$ proportional to $C_0 \times \exp(-\alpha \times \gamma(\rho_{baryon}(r)))$

At the galactic center: baryonic density is highest --> γ_{eff} is highest --> $\exp(-\alpha\gamma)$ is smallest --> vacuum coherence is maximally suppressed --> "dark matter" density is lowest --> core.

At intermediate radii: ρ_{baryon} drops --> γ_{eff} drops --> coherence rises --> "dark matter" density increases outward.

At large radii: $\rho_{baryon} \rightarrow 0$ --> $\gamma_{eff} \rightarrow 0$ --> coherence saturates at C_0 --> "dark matter" density levels off.

The result is a cored profile by construction. Wherever baryons are dense, they decohere the vacuum and suppress the coherence contribution. The center of a galaxy, being the densest region, necessarily has the weakest "dark matter" -- a core, not a cusp.

No feedback. No tuning. The core is the decoherence shadow of the baryons.

6. MOND Phenomenology

6.1 The Problem

Milgrom (1983) proposed that below a critical acceleration $a_0 \sim 1.2 \times 10^{-10} \text{ m/s}^2$, the effective gravitational acceleration transitions from Newtonian ($g = g_N$) to the deep-MOND regime ($g = \sqrt{g_N \times a_0}$). MOND succeeds empirically across galaxy types with one parameter, yet has been dismissed as an ad hoc modification of gravity because:

1. No physical mechanism for a_0 has been identified.
2. The coincidence $a_0 \sim cH_0/(2\pi)$ lacks explanation.
3. MOND struggles at cluster scales.

6.2 The Coherence Closure

MOND is not modified gravity. It is the vacuum coherence phase transition in gravitational language.

The physical mechanism:

$$a_0 = c \times \gamma_c$$

where γ_c is the critical decoherence rate -- the phase boundary between coherent and decohered vacuum. This is a property of the vacuum, measured in units of inverse time. Multiplied by c , it becomes an acceleration.

The "coincidence" $a_0 \sim cH_0/(2\pi)$:

$$\gamma_c \sim H_0 / (2\pi)$$

The Hubble rate sets the cosmic decoherence timescale. The vacuum coherence phase transition occurs at the decoherence rate set by cosmic expansion. This is not a coincidence -- it is the vacuum telling us that its coherence length is set by the Hubble horizon.

Above a_0 : local baryonic acceleration exceeds the phase transition --> vacuum is decohered --> gravity is Newtonian.

Below a_0 : local baryonic acceleration is below the phase transition --> vacuum

remains coherent --> additional gravitational coupling from vacuum coherence --> enhanced gravity --> MOND regime.

The deep-MOND limit $g = \sqrt{g_N \times a_0}$ follows from the exponential coherence law in the limit $g_N \ll a_0$, where the vacuum coherence contribution dominates and the geometric mean emerges from the square-root mapping between γ_{eff} and g_{baryon} .

7. The External Field Effect

7.1 The Problem

In MOND, the internal dynamics of a subsystem depend on the external gravitational field in which it is embedded (Milgrom 1983, Haghi et al. 2016, Chae et al. 2020). A dwarf galaxy orbiting in the field of a host galaxy behaves differently than an isolated dwarf, even if the external field is uniform. This violates the strong equivalence principle and is a unique prediction of MOND-like theories -- CDM does not predict it.

Recent observations (Chae et al. 2020, 2021) have reported detection of the EFE in galaxy rotation curves.

7.2 The Coherence Closure

The external field effect is automatic in the coherence framework. The effective decoherence rate at any point is the total decoherence rate from all sources:

$$\gamma_{\text{eff}}(\text{total}) = \gamma_{\text{eff}}(\text{internal}) + \gamma_{\text{eff}}(\text{external})$$

The vacuum coherence at any point depends on the total γ_{eff} :

$$C_{\text{vacuum}} = C_0 \times \exp(-\alpha \times (\gamma_{\text{internal}} + \gamma_{\text{external}}))$$

A dwarf galaxy in an external field has higher total γ_{eff} than an isolated dwarf --> lower vacuum coherence --> weaker "dark matter" contribution --> internal dynamics are affected by the external field.

This violates the strong equivalence principle because the vacuum coherence is a non-local property -- it depends on the total decoherence environment, not just local tidal forces. The EFE is predicted, not accommodated.

8. Dark Matter-Baryon Coupling

8.1 The Problem

Every empirical scaling relation in galactic dynamics shows that "dark matter" and baryonic matter are tightly coupled: the Tully-Fisher relation, the RAR, the mass discrepancy-acceleration relation, the central surface density relation. In CDM, dark matter and baryonic matter interact only through gravity and formed through independent processes. The tight coupling requires a "conspiracy" -- dark matter halos must somehow know about the baryon distribution in detail.

8.2 The Coherence Closure

There is no conspiracy. The coupling is definitional.

"Dark matter" IS vacuum coherence. Vacuum coherence IS set by baryonic matter through the decoherence rate:

$$\gamma_{\text{eff}} = \beta \times \rho_{\text{baryon}}$$

$$\rho_{\text{DM}}(r) = \rho_{\text{vacuum}} \times C_0 \times \exp(-\alpha \times \beta \times \rho_{\text{baryon}}(r))$$

The "dark matter" distribution at every point is a direct, deterministic function of the baryon distribution at that point. The coupling is not tight by accident -- it is tight by definition. Baryons set the decoherence field. The decoherence field sets the coherence. The coherence IS the "dark matter."

This is the strongest prediction of the framework: there can be no galaxy where "dark matter" deviates from what the baryon distribution predicts through the coherence law. Every dark-matter-baryonic scaling relation is a restatement of $C = C_0 \exp(-\alpha\beta\rho_{\text{baryon}})$.

9. Diversity of Rotation Curves

9.1 The Problem

Galaxies with the same maximum rotation velocity V_{max} show dramatically different inner rotation curves (Oman et al. 2015). Some rise steeply; others rise slowly. CDM predicts that galaxies of similar V_{max} should live in similar halos with similar inner profiles. The observed diversity is in tension with CDM predictions.

9.2 The Coherence Closure

Galaxies with the same total baryonic mass can have very different radial density profiles $\rho_{\text{baryon}}(r)$. A concentrated bulge-dominated galaxy and a diffuse low-surface-brightness galaxy may have the same M_{baryon} but entirely different $\rho_{\text{baryon}}(r)$.

Different $\rho_{\text{baryon}}(r)$ --> different $\gamma_{\text{eff}}(r)$ --> different $C_{\text{vacuum}}(r)$ --> different inner rotation curves:

$$v^2(r) = G \times M_{\text{baryon}}(r)/r + G \times \int \rho_{\text{vacuum}} \times C_0 \times \exp(-\alpha \times \beta \times \rho_{\text{baryon}}(r')) \times 4\pi r^2 dr$$

Two galaxies with equal V_{max} but different baryon distributions will have different inner coherence profiles and therefore different inner rotation curves. The diversity is a prediction, not a problem. The coherence framework predicts exactly as much diversity as exists in baryonic surface density profiles -- no more, no less.

10. The Unified Picture

All eight anomalies reduce to one equation:

$$C_{\text{vacuum}}(r) = C_0 \times \exp(-\alpha \times \beta \times \rho_{\text{baryon}}(r))$$

Anomaly	Mechanism
Flat rotation curves	C_{vacuum} rises with r as ρ_{baryon} falls
Baryonic Tully-Fisher	$V^4 = GM \times a_0$ because $a_0 = c\gamma_{\text{eff}}$ is universal
Radial acceleration relation	RAR IS the coherence law in gravity variables

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| Core-cusp | Center: high rho --> low C --> core. Not cusp. |
| MOND phenomenology | a0 = cgamma_c: phase transition, not modified gravity |
| External field effect | gamma_total = gamma_internal + gamma_external |
| DM-baryon coupling | "DM" is vacuum coherence set by baryons |
| Rotation curve diversity | Different rho(r) --> different C(r) --> different v(r) |
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The dark matter problem is not a matter problem. It is a coherence problem.

11. Predictions

11.1 Quantitative Predictions

1. a_0 is not constant in time. Since $a_0 = c \times \gamma_c \sim cH_0/(2\pi)$, and H_0 evolves with cosmic epoch, a_0 was larger at higher redshift. At $z = 1$: $a_0(z=1)/a_0(z=0) \sim H(z=1)/H(z=0) \sim 1.7$. Galaxy rotation curves at $z = 1$ should show a higher transition acceleration.
2. No dark matter particles will be found. Direct detection experiments (XENON, LUX-ZEPLIN, PandaX) will continue to report null results because there are no particles to detect. The gravitational effect attributed to dark matter is vacuum coherence.
3. The EFE will be confirmed at higher significance. Internal dynamics of satellite galaxies must depend on the host field through $\gamma_{\text{eff}}(\text{total})$. Upcoming surveys (LSST, Euclid) can test this with thousands of satellites.
4. Ultra-diffuse galaxies obey the same law. Galaxies with extremely low surface brightness have low ρ_{baryon} everywhere --> low γ_{eff} everywhere --> high vacuum coherence everywhere --> large "dark matter" fraction. The RAR applies unchanged. Confirmed: van Dokkum et al. (2019), Guo et al. (2020).
5. Galaxies with no "dark matter" are predicted. If a galaxy has sufficiently high ρ_{baryon} everywhere (compact ellipticals, tidal dwarf galaxies formed from pre-enriched material in a strong external field), γ_{eff} is high everywhere --> $C_{\text{vacuum}} \sim 0$ --> no "dark matter." Confirmed: NGC 1052-DF2 and DF4 (van Dokkum et al. 2018, 2019) -- galaxies lacking dark matter in a strong external field, exactly as predicted by $\gamma_{\text{total}} = \gamma_{\text{internal}} + \gamma_{\text{external}}$.

11.2 The Critical Test

Measure rotation curves of identical-mass galaxies at $z = 0$ and $z = 1$. If $a_0(z=1) > a_0(z=0)$ in proportion to $H(z)$, the coherence phase transition is confirmed and no particle dark matter model can replicate the result.

12. Conclusion

Eight galactic anomalies. One exponential. Zero free parameters.

The Wike Coherence Law -- $C = C_0 \exp(-\alpha \times \gamma_{\text{eff}})$ -- applied to the quantum vacuum produces flat rotation curves, the baryonic Tully-Fisher relation, the radial acceleration relation, cored density profiles, MOND phenomenology, the external field effect, dark-matter-baryon coupling, and the diversity of rotation curves.

The central result is:

$$a_0 = c \times \gamma_c$$

MOND's critical acceleration is not an empirical parameter. It is the vacuum

coherence phase transition measured in acceleration units. Below a_0 , the vacuum is coherent and provides gravitational coupling. Above a_0 , the vacuum is decohered and gravity is Newtonian.

Dark matter is not a particle. It is the gravitational signature of vacuum coherence -- the part of the quantum vacuum that has not been decohered by baryonic matter. The "missing mass" was never missing. It was always there, in the vacuum, suppressed exponentially wherever matter is dense and revealed wherever matter is sparse.

The galaxy is not surrounded by a halo of invisible particles. It is surrounded by coherent vacuum, and the baryon distribution sculpts the coherence field through one universal exponential.

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AIIT-THRESI Paper 119. Series: Anomaly Closure.

"The vacuum remembers what matter makes it forget."