

ATTRACTOR-BASIN EVOLUTION

A mathematical roadmap for the recoil test

BY

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A mathematical roadmap for distinguishing standard structure growth from late-time recoil amplification, built around the Hydra–Centaurus / Great Attractor basin.

1 Purpose

This note defines a possible observational test of a specific UDEL claim:

If the recoil phase has begun, already-established gravitational basins should strengthen first, as adjacent t -layers begin to re-merge and add effective mass contribution into existing structures.

The goal is to determine whether observed attractor basins evolve with redshift in a way that can be explained by standard structure growth alone, or whether they show excess convergence, anisotropic amplification, or pull-to-mass mismatch consistent with a UDEL recoil contribution.

This is not yet a full theory derivation. It is a roadmap: observable, null model, UDEL extension, measurable quantities, and falsifiers.

2 Central Question

Let a known attractor basin be represented by a region B in comoving space. We ask:

Does the dynamical strength of B evolve with redshift in a way consistent with standard Λ CDM growth, or does it show late-time amplification beyond what mapped matter predicts?

If the latter occurs systematically, it may indicate that the basin is being enhanced by something other than ordinary in-layer mass growth. In UDEL, that 'something else' would be modeled as cross-layer effective mass reinforcement during recoil.

3 Observational Input

For each galaxy i , define:

- Sky position: (α_i, δ_i)
 - Observed redshift: z_i
 - Independent distance estimate: d_i
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- Uncertainty in distance: $\sigma_{d,i}$
- Optional group/cluster assignment: G_i

From redshift and distance, infer the line-of-sight peculiar velocity.

4 First-Layer Kinematics

For sufficiently low or moderate redshift, observed recession can be decomposed as:

$$v_{\text{obs},i} \approx H(z_i) * d_i + v_{\text{pec},\parallel,i}$$

Therefore:

$$v_{\text{pec},\parallel,i} = v_{\text{obs},i} - H(z_i) * d_i$$

This gives the first observable field: deviation from smooth Hubble flow.

5 Reconstructing the Flow Field

Using radial peculiar velocities from many galaxies, reconstruct a smoothed 3D velocity field $v(x,z)$ using Wiener filtering, Bayesian reconstruction, constrained realization, or other standard methods.

From this field, compute the divergence:

$$\Theta(x,z) \equiv \nabla \cdot v(x,z)$$

$\Theta < 0$: convergent flow, attractor-like region

$\Theta > 0$: divergent flow, repeller-like region

For a basin B , define its convergence strength:

$$A(z) = -\langle \Theta(x,z) \rangle_{x \in B}$$

Larger $A(z)$ means a deeper or stronger attractor basin.

6 Basin Metrics

For each redshift shell z_k , define the following quantities for a target basin:

6.1 Basin depth:

$$A_k = -\langle \nabla \cdot v \rangle_{B,k}$$

6.2 Basin center:

Let $x_{c,k}$ be the location of maximal convergence. Track whether the basin center drifts with shell.

6.3 Basin width:

Define a characteristic radius R_k over which convergence exceeds a fixed threshold.

6.4 Inferred pull:

Approximate the dynamical inward pull by integrating the velocity gradient field over the basin.

7 Standard Null Model

Under standard cosmology, structure growth is sourced by ordinary matter clustering in an expanding background. The expected basin observables $A(\Lambda\text{CDM})$, $R(\Lambda\text{CDM})$, $P(\Lambda\text{CDM})$ follow from ordinary structure formation, peculiar-velocity theory, and the mapped matter distribution.

In this picture: basin evolution is gradual; growth follows ordinary clustering; apparent pull is matched by visible and inferred dark matter; anisotropy follows known cosmic-web structure.

8 UDEL Extension

In UDEL recoil, adjacent t-layers begin to re-merge, adding effective mass contribution into already-established wells. The effective potential is modified:

$$\Phi_{\text{eff}}(x,z) = \Phi_{\Lambda\text{CDM}}(x,z) + \Delta\Phi_{\text{recoil}}(x,z)$$

The UDEL term satisfies these qualitative conditions:

8.1 Basin preference

Amplification should occur preferentially where structure already exists, defined by a structural maturity function $M(x) \geq 0$ with higher values in established wells.

8.2 Late-time activation

Recoil should be weak or absent at early times and strengthen at late times, defined by an activation function $f_{\text{recoil}}(z)$ that grows toward lower redshift.

8.3 Possible anisotropy

If recoil is geometrically directional, include an anisotropy factor $Q(x, n^{\wedge})$. The simplest schematic form is:

$$\Delta\Phi_{\text{recoil}}(x, z) = \lambda * f_{\text{recoil}}(z) * M(x) * Q(x, n^{\wedge})$$

where λ is the recoil coupling strength.

This is the minimal placeholder needed for a fit-test framework, not yet the final physical law.

9 UDEL-Predicted Signatures

9.1 Excess late-time basin deepening

$A_k(\text{UDEL}) \succ A_k(\Lambda\text{CDM})$ especially at low redshift

9.2 Pull-to-mass mismatch

$R_k \equiv P_k(\text{flow}) / P_k(\text{mass}) \succ 1$ systematically in affected basins

9.3 Distributed amplification

Enhancement should not appear as one unique attractor only, but as strengthening of multiple existing basins.

9.4 Possible anisotropic bias

If recoil has directional structure, basin enhancement may correlate with an axis not predicted by ordinary isotropic growth.

10 Redshift-Shell Test

Partition galaxies into shells and compute shell-to-shell deepening:

$$\Delta A_{\{k \rightarrow k+1\}} = A_{\{k+1\}} - A_k$$

Under standard growth, this should remain within a predictable range. Under UDEL recoil, late-time shells may show excess deepening — particularly in mature basins. This is one of the cleanest direct tests.

11 Pull-to-Mass Comparison

This is likely the strongest discriminator. For each basin, compare the dynamical pull inferred from flow against the pull predicted from mapped matter (visible baryons, cluster catalogs, halo reconstructions, weak-lensing mass maps where available).

$$R_k = P_k(\text{flow}) / P_k(\text{mass})$$

$R_k \approx 1$: standard mass accounts for the pull

$R_k > 1$: flow suggests stronger gravity than mapped mass supports

A systematic low-redshift increase in R_k would be especially interesting for UDEL.

12 Likelihood Framework

Compare model fit quality using Bayesian evidence, information criteria, posterior predictive checks, and shell-by-shell residual structure. If the UDEL term reduces structured residuals without overfitting, the case strengthens.

13 Minimal Falsifiers

The UDEL interpretation weakens sharply if any of the following hold:

F1. No excess deepening: observed basin evolution matches standard growth within uncertainty.

F2. No pull-to-mass mismatch: $R_k \approx 1$ across all shells and basins.

F3. No late-time activation: no measurable shell trend toward stronger low-redshift amplification.

F4. No distributed signature: only random basin scatter, no coherent multi-basin strengthening.

F5. No anisotropy: if the recoil version predicts directional preference and none appears, that version is constrained.

These falsifiers are not a weakness. They are what makes the program scientific.

14 Most Practical First Implementation

Before attempting a full survey-wide analysis, begin with one basin:

1. Select one known attractor basin with strong existing flow data.

2. Gather galaxies in and around that basin with redshift, independent distances, and uncertainty estimates.
3. Divide into 3 radial/redshift shells.
4. Reconstruct basin depth A_k , pull-to-mass ratio R_k , basin-center stability, and basin-width change.
5. Compare against a standard-growth mock.

This smaller test would not prove UDEL, but it would show whether the idea survives first contact with data.

15 Conclusion

This program turns a qualitative UDEL insight into a measurable question. Standard cosmology interprets attractor basins as the natural result of uneven mass distribution in the cosmic web. UDEL accepts the observed basin landscape, but proposes that at late times these same wells may receive additional effective mass contribution as neighboring t-layers begin to re-merge during recoil.

The observational challenge is therefore not to show that attractors exist. It is to determine whether their evolution, strength, and pull-to-mass relation remain fully explainable by standard growth, or whether they show the first measurable signatures of late-time recoil amplification.

If such signatures appear, this would not yet fully prove UDEL — but it would mark one of the first places where UDEL stops being only interpretive and begins making contact with a distinct empirical signal.