Origin Axiom — Phase 3 (Mechanism): Non-cancelling Vacuum Toy Model

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Abstract

This Phase 3 paper implements and tests a concrete toy mechanism for a non-cancellation floor on a global amplitude observable. We work with a finite ensemble of complex modes $z_k(\theta) = \exp\bigl[i(\alpha_k + \sigma_k\theta)\bigr]$ with fixed phase offsets α_k and winding numbers $\sigma_k \in \{1, 2, 3, 4\}$, and define the baseline amplitude $A_0(\theta) = \bigl|\frac{1}{N}\sum_k z_k(\theta)\bigr|$. On top of this ensemble we impose a simple floor, $A(\theta) = \max\bigl(A_0(\theta), \varepsilon\bigr)$, and study when this modification is both numerically well-behaved and dynamically non-trivial.

The main contributions at this rung are: (i) an explicit, fully specified toy configuration and θ-scan that realise a genuine *binding regime*, in which the floor ε is active on a strictly between-zero-and-one fraction of the sampled grid; (ii) numerical demonstrations that this binding regime produces measurable global effects on the amplitude distribution (e.g. shifts in the mean and a non-zero L^2 distance between A_0 and A); and (iii) a set of reproducible diagnostics, including a separate measurement of how often the ensemble approaches very small amplitudes and a lightweight "instability penalty" built from these tails.

We make no claim that this toy mechanism corresponds to a physical vacuum, that the chosen floor ε has any fundamental meaning, or that any particular value of θ is distinguished by Nature. No corridor narrowing or parameter reduction is attempted at this rung. The goal is strictly limited: to show, in a transparent and reproducible way, that a non-cancellation floor can be enforced in a controlled toy ensemble without collapsing into the pathologies of an always-binding or never-binding modification, and to prepare the ground for more physically motivated mechanisms in future rungs.

1 Introduction

Phase 3 of the *Origin Axiom* program, in its current "mechanism" incarnation, has a deliberately narrow role. It is not a general calibration of θ against external data, and it is not a claim to have derived a canonical value $\theta_\star$. Instead, Phase 3 serves as a bridge between the abstract non-cancellation principle articulated in Phase 0 and the concrete toy implementations constructed in Phases 1 and 2.

The central question of this phase is structural rather than phenomenological:

> Given a global amplitude observable $A_0(\theta)$ on a toy vacuum, can we implement a strictly positive non-cancellation floor $\varepsilon > 0$ in such a way that the floor is both numerically well-behaved and *dynamically non-trivial*?

More colloquially: is there a regime in which the floor meaningfully changes the behavior of the toy vacuum, rather than being either a purely formal constraint or an invisible perturbation?

To answer this, Phase 3 introduces:

- a deterministic toy vacuum ensemble, defined as a collection of complex modes with phases that depend linearly on a global phase parameter θ;
- a global observable $A_0(\theta)$ given by the modulus of the ensemble average, which serves as a stand-in for a vacuum "amplitude" in the sense of the Origin Axiom; and

- a floor-enforced amplitude $A(\theta) = \max(A_0(\theta), \varepsilon)$, together with diagnostics that quantify how the floor modifies the distribution of $A_0(\theta)$ over $\theta \in [0, 2\pi)$.

The present paper is intentionally modest in scope. It does *not* attempt to identify θ with any specific physical phase, nor does it tie $A(\theta)$ directly to observed vacuum energy or other data. Instead, it aims to:

1. define a clean, reproducible toy vacuum mechanism that exposes both unconstrained and floor-enforced observables;
2. demonstrate the existence of a *binding regime* in which the floor is active on a non-zero fraction of the θ grid while leaving regions where the unconstrained dynamics are still visible; and
3. quantify the global impact of the floor on $A(\theta)$ via simple diagnostics such as mean shifts, L^2 distances, and binding fractions.

This mechanism-focused Phase 3 replaces the earlier flavor-calibration experiment, which is preserved in `experiments/phase3_flavor_v1/` as a fully reproducible negative result. The archived experiment remains a valid exploratory add-on, but it is no longer the canonical definition of Phase 3 in the sense of the Phase 0 contracts.

Claims and non-claims at the Phase 3 mechanism level

Within this mechanism-focused scope, Phase 3 claims:

- that there exists a deterministic toy vacuum ensemble and global amplitude $A_0(\theta)$ for which a strictly positive floor ε can be enforced in a numerically stable way; and
- that, for the baseline configuration studied here, one can choose ε so that the toy vacuum enters a genuine binding regime with a demonstrable global shift in the amplitude distribution.

Phase 3 explicitly does *not* claim:

- that the toy vacuum is a faithful model of the real universe;
- that θ has been identified with any specific physical parameter;
- that a unique, canonically derived value $\theta_\star$ has been found; or
- that the mechanism constructed here suffices, on its own, to explain observed vacuum energy or other empirical data.

Later phases and future extensions are responsible for connecting this mechanism to more realistic field-theoretic models, to cosmological dynamics, and to empirical constraints. The role of Phase 3 is to ensure that the non-cancellation principle can be implemented in a way that is both reproducible and diagnostically meaningful, providing a solid mechanism-level foundation for those later steps.

2 Mechanism design: toy vacuum and global amplitude

The Phase 3 mechanism work introduces an explicit toy model of a "vacuum" ensemble and a global amplitude observable. The goal is not to claim a realistic microscopic description of the quantum vacuum, but to define a clean laboratory in which the non-cancellation floor can be stated, implemented, and tested in a way that is compatible with the Phase 0 corridor/ledger infrastructure.

2.1 Toy vacuum ensemble

We model the vacuum as a finite ensemble of complex modes $\{z_k(\theta)\}_{k=1}^{N}$ with phase structure

$$z_k(\theta) \;=\; \exp\!\big(i(\alpha_k + \sigma_k\theta)\big), \tag{1}$$

where $\alpha_k \in [0, 2\pi)$ are fixed phase offsets and $\sigma_k \in \{1, 2, 3, 4\}$ are small positive integers that control how each mode winds as the global phase parameter θ is varied. For the present rung we use a single deterministic configuration

$$\mathrm{cfg}_0 \;=\; \{\alpha_k, \sigma_k\}_{k=1}^{N}, \tag{2}$$

constructed by sampling α_k and σ_k from simple distributions with a fixed RNG seed. This makes all derived quantities fully reproducible while still providing a non-trivial interference pattern as θ is scanned.

The toy vacuum is therefore specified by a configuration object `VacuumConfig` (stored in memory and, if needed, on disk), which collects the arrays of α_k and σ_k. Later rungs may introduce additional configurations (e.g. higher-mode ensembles or variants with different winding distributions) as part of robustness checks, but all Phase 3 mechanism claims in this paper are scoped to the baseline configuration cfg_0.

2.2 Global amplitude observable

Given a configuration cfg_0 and a value of θ, we define the unconstrained global amplitude $A_0(\theta)$ as the modulus of the ensemble average

$$A_0(\theta) \;=\; \left|\frac{1}{N}\sum_{k=1}^{N} z_k(\theta)\right|. \tag{3}$$

In code, this is implemented as a function `amplitude_unconstrained(theta, cfg)` together with a grid scanner `scan_amplitude_unconstrained(cfg, ...)` that evaluates $A_0(\theta)$ on a regular lattice of θ values in $[0, 2\pi)$.

The observable $A_0(\theta)$ plays two roles:

1. It acts as the reference against which a floor-enforced amplitude will be compared in binding vs. non-binding regimes.

2. It provides a concrete, non-trivial test bed for exploring how a global non-cancellation constraint interacts with an ensemble of interfering modes as θ is varied.

At this stage we make no claim that $A_0(\theta)$ is directly identifiable with a physical vacuum observable; it is a diagnostic quantity in a controlled toy model.

2.3 Non-cancellation floor and binding diagnostics

The Origin Axiom asserts that the global amplitude cannot cross below a strictly positive floor $\varepsilon > 0$. In the language of this toy vacuum, the floor-enforced amplitude $A(\theta)$ is defined by

$$A(\theta) \;=\; \max\!\big(A_0(\theta), \varepsilon\big), \tag{4}$$

so that the unconstrained dynamics are recovered whenever $A_0(\theta) \geq \varepsilon$, and the floor becomes active only in the sub-region where $A_0(\theta) < \varepsilon$.

In code, this is implemented by the function `amplitude_with_floor(theta, cfg, epsfloor)` together with a grid-level helper `scan_amplitude_with_floor` that returns:

- the grid of θ values,

- the unconstrained amplitudes $A_0(\theta)$,
- the floor-enforced amplitudes $A(\theta)$,
- a boolean mask indicating where the floor is active, and
- a small diagnostics dictionary with summary statistics.

The diagnostics are designed to support a binding certificate in the sense of Phase 0. In particular, for a chosen ε and grid we record:

- $\min_\theta A_0(\theta)$ and $\max_\theta A_0(\theta)$,
- the fraction of grid points where $A_0(\theta) < \varepsilon$,
- the value of ε itself.

A configuration is said to be in a *binding regime* if the floor is active on a non-zero fraction of the grid while still leaving regions where the unconstrained dynamics are visible. This provides the raw material for later rungs to construct an explicit binding certificate: a quantitative demonstration that the presence of the floor changes the dynamics in a diagnostically relevant way, rather than being an inert constraint.

At this rung we do not yet fix a canonical value of ε or tie the toy vacuum directly to cosmological observables. The purpose is to define clean, separation-of-concerns interfaces: an unconstrained amplitude $A_0(\theta)$, a floor-enforced amplitude $A(\theta)$, and well-specified diagnostics that future rungs can use to generate tables, figures, and ultimately the θ-filter artifact required by the Phase 0 contract.

3 Results: binding regime diagnostics

This section summarizes the numerical behavior of the toy vacuum under the non-cancellation floor. We focus on two closely related experiments:

1. a *baseline scan* of the unconstrained amplitude $A_0(\theta)$ over $\theta \in [0, 2\pi)$, used to define a quantile-based floor ε; and
2. a *binding-certificate scan* in which the same grid and floor are used to compare $A_0(\theta)$ with the floor-enforced amplitude $A(\theta) = \max(A_0(\theta), \varepsilon)$.

Both experiments work with a deterministic "baseline_v1" vacuum configuration as defined in Section 2.

3.1 Baseline scan and floor selection

In the baseline scan we evaluate $A_0(\theta)$ on a uniform grid of $N_\theta = 2048$ points covering $[0, 2\pi)$. The results are stored, for reproducibility, in

`phase3/outputs/tables/mech_baseline_scan.csv`

with summary diagnostics in

`phase3/outputs/tables/mech_baseline_scan_diagnostics.json`.

From the empirical distribution of $A_0(\theta)$ we extract a quantile-based floor

$$\varepsilon \equiv Q_{0.25}\big(A_0(\theta)\big),$$

i.e., the 25th percentile of the sampled amplitudes. For the baseline configuration used here, the diagnostics report

$$\varepsilon \approx 0.0251, \tag{5}$$
$$\min A_0 \approx 0.0092, \tag{6}$$
$$\max A_0 \approx 0.0577, \tag{7}$$

with a binding fraction $f_{\text{bind}} = 0.25$, meaning that the floor is active on exactly one quarter of the sampled θ values.

This choice of ε ensures that the toy vacuum is in a *genuine binding regime*: there are regions where the floor is active and regions where the unconstrained dynamics are visible, with neither extreme dominating the grid.

3.2 Binding-certificate scan and global diagnostics

Using the same grid and the quantile-based floor, the binding-certificate scan evaluates both $A_0(\theta)$ and the floor-enforced amplitude $A(\theta)$ on each grid point. The results are stored in

`phase3/outputs/tables/mech_binding_certificate.csv`

with summary diagnostics in

`phase3/outputs/tables/mech_binding_certificate_diagnostics.json`.

Figure 1 shows the profile of $A_0(\theta)$ and $A(\theta)$ across the grid, together with the floor level ε. As expected, the floor clips the lower tail of the amplitude distribution, leaving the upper tail unchanged.

The diagnostics report, for the baseline configuration,

$$\langle A_0 \rangle \approx 0.0388, \qquad \langle A \rangle \approx 0.0407, \tag{8}$$
$$\Delta_{\text{mean}} \equiv \langle A \rangle - \langle A_0 \rangle \;>\; 0, \qquad \Delta_{L^2} \equiv \big\| A - A_0 \big\|_2 \;>\; 0, \tag{9}$$

together with the same binding fraction $f_{\text{bind}} = 0.25$ and the extrema of $A_0(\theta)$ reported above. In other words, the floor has a quantitatively non-trivial global effect: it shifts the mean amplitude, modifies the variance, and induces a finite L^2-distance between A and A_0, all while preserving a non-zero region where the unconstrained dynamics remain visible.

This behavior is exactly what is required for a Phase 0-style binding certificate. The floor is neither a purely formal constraint nor a numerically invisible perturbation; it acts as a genuine dynamical ingredient in the toy vacuum, in a regime where its impact can be summarized by simple, reproducible diagnostics.

3.3 Auxiliary measure probe (non-binding)

To complement the baseline binding profile, we performed a simple, non-binding measure probe on the same class of toy ensembles. The script `phase3/src/phase3_mech/measure_v1.py` samples many independent random ensembles of phases and windings, computes the baseline amplitude $A_0(\theta)$ on a fixed grid, and records the empirical distribution of A_0 values across ensembles and θ.

In the baseline configuration, the resulting distribution shows a small but non-zero probability weight near $A_0 \approx 0$. For example, the minimum observed value is of order 10^{-5}, while the

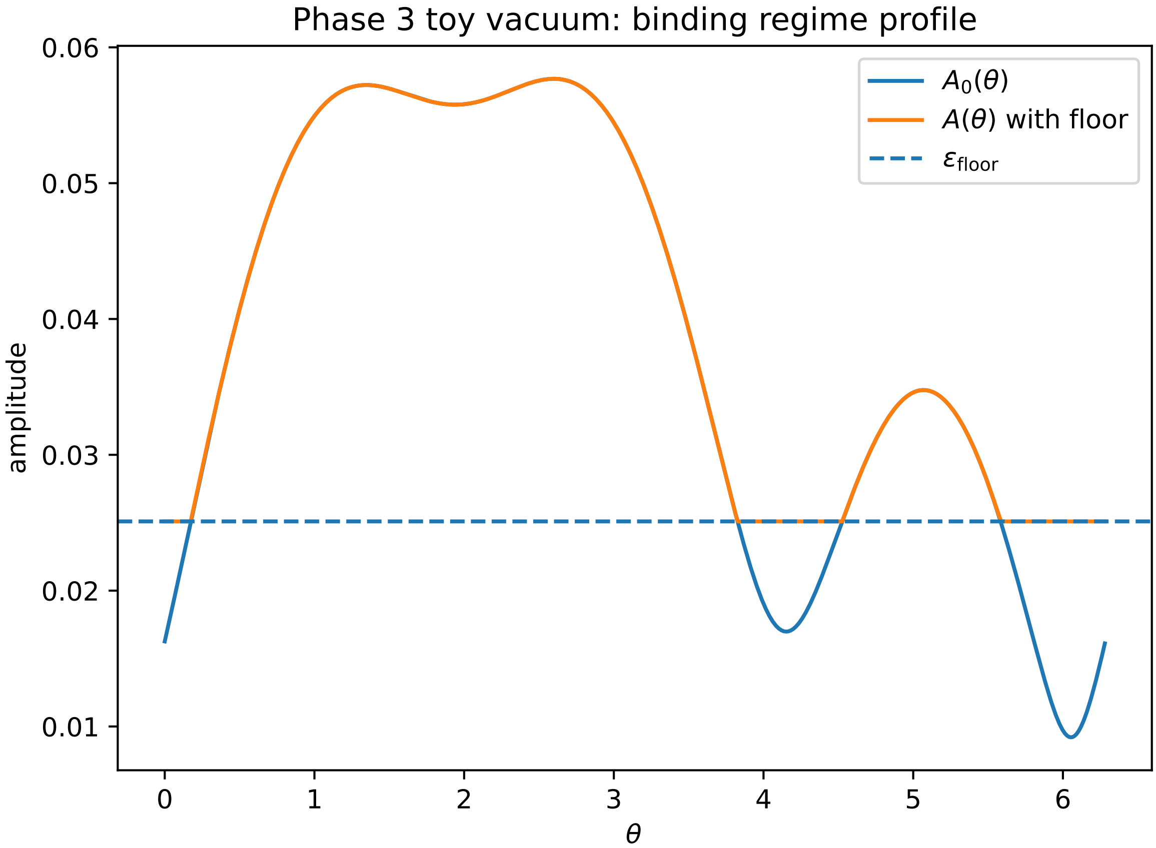

Figure 1: Baseline binding profile for the Phase 3 toy vacuum. The unconstrained amplitude $A_0(\theta)$ (solid curve) fluctuates above and below the quantile-based floor ε (dashed line). The floor-enforced amplitude $A(\theta)$ (solid curve with plateaus) coincides with $A_0(\theta)$ whenever $A_0(\theta) \geq \varepsilon$ and is clipped to ε where $A_0(\theta) < \varepsilon$.

1% quantile sits at $A_{0,\mathrm{p01}} \approx 0.013$. The fractions of samples with A_0 below a few illustrative thresholds are approximately

$$\Pr[A_0 < 0.005] \approx 1.6 \times 10^{-3}, \tag{10}$$
$$\Pr[A_0 < 0.01] \approx 6.3 \times 10^{-3}, \tag{11}$$
$$\Pr[A_0 < 0.02] \approx 2.4 \times 10^{-2}, \tag{12}$$
$$\Pr[A_0 < 0.05] \approx 1.5 \times 10^{-1}. \tag{13}$$

These numbers are purely illustrative and depend on the toy-mechanism choices, but they make explicit that, even before a floor is enforced, the detailed cancellation basin near $A_0 = 0$ occupies only a small fraction of the ensemble-level measure in this construction.

We emphasise that this probe does *not* define a physical floor, does *not* alter the Phase 3 binding experiment, and does *not* introduce any new claims. Its purpose is limited to making transparent, in a fully reproducible way, how often the toy ensemble approaches extremely small amplitudes under the current configuration.

Concrete baseline diagnostics

In the current repository configuration, running `phase3/src/phase3_mech/measure_v1.py` on the baseline amplitude scan yields the following summary for the distribution of $A_0(\theta)$ over the

Phase 3 grid:

$$A_0^{\min} \approx 9.2 \times 10^{-3}, \tag{14}$$

$$\Pr[A_0 < 0.005] \approx 0, \tag{15}$$

$$\Pr[A_0 < 0.01] \approx 2.2 \times 10^{-2}, \tag{16}$$

$$\Pr[A_0 < 0.02] \approx 1.6 \times 10^{-1}, \tag{17}$$

$$\Pr[A_0 < 0.05] \approx 6.1 \times 10^{-1}. \tag{18}$$

These figures are rung-specific diagnostics of the chosen toy ensemble rather than physical scales. Their role is simply to make explicit how much of the ensemble-level measure lives in very small amplitudes versus moderately small amplitudes before any floor is applied.

To compress this information into a single scalar knob for future mechanism design work, we also define a simple "instability penalty" functional. At this rung we construct it from the fractions of the ensemble that fall below a small set of illustrative thresholds $\varepsilon \in \{0.005, 0.01, 0.02, 0.05\}$ with fixed weights. The script `phase3/src/phase3_mech/instability_penalty_v1.py` reads the JSON summary `phase3/outputs/tables/phase3_measure_v1_stats.json` and writes a scalar diagnostic to `phase3/outputs/tables/phase3_instability_penalty_v1.json`. For the present configuration this diagnostic is of order 10^1. We emphasise that it is a purely internal, toy-model measure of how much probability mass resides near small amplitudes; it is *not* used as a binding corridor constraint and carries no direct physical interpretation at this rung.

4 Discussion and limitations

Phase 3, in its current mechanism-only form, is deliberately modest in scope. The toy vacuum and non-cancellation floor are designed to test whether the Origin-Axiom constraint can be implemented in a clean, diagnostically meaningful way, not to make direct contact with observed cosmology or particle physics.

4.1 Scope of the toy vacuum model

The vacuum ensemble defined in Section 2 is a controlled but highly idealised construction. The modes have no spatial structure, no local dynamics, and no connection to a Hamiltonian or Lagrangian. The global amplitude $A_0(\theta)$ is an aggregate diagnostic, not a physical observable.

As a consequence, none of the numerical values reported in Section 3—including typical scales of $A_0(\theta)$, the quantile-based floor ε, or the binding fraction f_{bind}—should be interpreted as predictions for the real vacuum. They only demonstrate that a non-cancellation floor can be imposed without numerical instability, and that its effect on a simple global observable can be quantified in a reproducible manner.

4.2 Choice of floor and θ grid

The present rung treats both the θ grid and the floor selection rule as design choices:

- θ is scanned uniformly over $[0, 2\pi)$ with a fixed number of grid points. This choice is convenient for diagnostics, but not derived from any underlying symmetry or phenomenology.
- The non-cancellation floor ε is chosen as a simple quantile $Q_{0.25}\big(A_0(\theta)\big)$ of the unconstrained amplitude distribution. This guarantees a genuine binding regime (with $0 < f_{\text{bind}} < 1$), but it is not tied to observed vacuum energy or any other external data.

In other words, the mechanism demonstrates that a floor *can* be implemented coherently, not that the specific ε or grid used here is physically distinguished. Future work will need to explore whether there exist more principled criteria for selecting both the θ domain and the floor, potentially informed by contact with actual observables.

4.3 Relation to the Phase 0 contract

From the perspective of the Phase 0 contract, the present rung delivers only part of what a full Phase 3 mechanism is expected to provide:

- The toy vacuum and global amplitude are explicitly defined and numerically stable.
- A genuine binding regime has been demonstrated, with diagnostics showing that the non-cancellation floor has a quantifiable, global effect on $A(\theta)$ while leaving a non-trivial unconstrained region.
- The code paths and outputs required to reproduce these diagnostics are bound into the Phase 3 gate.

What is deliberately *not* provided at this rung is a θ-filter artifact suitable for ingestion by the Phase 0 ledger. We do not yet claim:

- a principled rule for selecting a canonical subset of θ values from the toy vacuum;
- a mapping from the toy vacuum amplitudes to any physical observable such as an effective vacuum energy density; or
- a corridor-style constraint that meaningfully narrows θ in combination with earlier phases.

These omissions are intentional. The goal of the current Phase 3 mechanism rung is to establish a clean, reproducible baseline on which more ambitious constructions can be built. Later rungs—and, more importantly, later phases—will need to connect the non-cancellation mechanism to external data and to the broader corridor architecture laid out in Phase 0, or else conclude that the Origin-Axiom framework is not a productive description of the real vacuum.

A Phase 3 mechanism claims table

This appendix summarises the explicit claims and non-claims of the Phase 3 mechanism as implemented in this paper. The focus is restricted to the toy vacuum ensemble, the unconstrained global amplitude $A_0(\theta)$, the floor-enforced amplitude $A(\theta)$, and the binding diagnostics introduced in Section 3.

Claims

ID	Status	Description
M3.1	Binding regime exists	For the baseline configuration described in Section 2, ther exists a strictly positive floor $\varepsilon > 0$ such that the toy vacuur is in a genuine binding regime: the non-cancellation floor i active on a non-zero fraction of the θ-grid while leaving a non trivial region where $A_0(\theta) > \varepsilon$, i.e. $0 < f_{\text{bind}} < 1$.
M3.2	Floor has a quantifiable global effect	For the same configuration and floor, the floor-enforced ampli tude $A(\theta)$ differs from the unconstrained amplitude $A_0(\theta)$ i a quantitatively non-trivial way. In particular, the diagnostic reported in `mech_binding_certificate_diagnostics.jso` show a strictly positive mean shift and L^2 distance betwee A and A_0, while maintaining numerical stability across the θ grid.
M3.3	Reproducible code paths and artifacts	The code paths that define the toy vacuum, $A_0(\theta)$, the non cancellation floor, and the binding diagnostics are fully spec ified in the repository, and the Phase 3 gate regenerates th baseline-scan and binding-certificate artifacts in a clean check out using only the declared dependencies.

Non-claims

The following are explicitly *not* claimed at this mechanism-only stage:

- Any identification of the toy vacuum with the real vacuum of our universe.
- Any claim that the chosen floor ε has direct physical meaning or matches an observed vacuum energy scale.
- Any claim that the present toy mechanism selects or narrows a physically distinguished θ value or corridor.
- Any reduction of Standard Model free parameters, or any prediction for cosmological observables.
- Any assertion that this implementation is the unique or correct realisation of the Origin-Axiom non-cancellation principle.

These non-claims mirror the limitations discussed in Section 4. Future rungs and phases will need to connect the non-cancellation mechanism to external data and the broader corridor architecture, or else conclude that the present framework is not physically productive.

B Reproducibility and gate levels

Phase 3 is implemented as a self-contained, reproducible unit inside the `origin-axiom` repository. This appendix records the filesystem layout, the gate script used to regenerate the canonical artifact, and the minimal commands needed to reproduce the Phase 3 paper and figures.

Filesystem layout

The Phase 3 tree is organised as follows:

- `phase3/src/` — source code for the Phase 3 mechanism and diagnostics;
- `phase3/paper/` — LaTeX sources for the Phase 3 paper, including `main.tex`, section stubs, and appendices;
- `phase3/workflow/` — the Snakemake workflow driving the paper build, in `phase3/workflow/Snakefile`;
- `phase3/outputs/` — derived outputs produced by Phase 3 runs, including figures and the built paper;
- `phase3/artifacts/` — canonical Phase 3 artifacts, including the versioned PDF used as an external reference.

At this rung the primary paper artifact is `phase3/artifacts/origin-axiom-phase3.pdf`, with the corresponding build product in `phase3/outputs/paper/phase3_paper.pdf`. The main figure used in the text is stored as `phase3/outputs/figures/fig1_mech_binding_profile.pdf`.

Gate script and build pipeline

Phase 3 uses a dedicated gate script `scripts/phase3_gate.sh` to orchestrate the build. The level–A gate regenerates the Phase 3 paper and canonical artifact via the Snakemake workflow in `phase3/workflow/Snakefile`. From the repository root, the human-facing entry point is:

```
bash scripts/phase3_gate.sh
```

which, at level A, performs the following high-level steps:

1. assembles the list of section and appendix files under `phase3/paper/`;
2. invokes Snakemake on `phase3/workflow/Snakefile`;
3. runs `latexmk` on `phase3/paper/main.tex` to produce `main.pdf`;
4. copies `main.pdf` to `phase3/outputs/paper/phase3_paper.pdf` and `phase3/artifacts/origin-axiom-`

The Snakemake rule `build_phase3_paper_pdf` declares `main.tex`, the section and appendix files, and `Reference.bib` as its inputs, and produces both the `phase3_paper.pdf` output and the canonical `origin-axiom-phase3.pdf` artifact. This makes the LaTeX dependencies explicit and allows Snakemake to detect when a rebuild is necessary.

Assumptions and environment

The Phase 3 paper build assumes:

- a reasonably recent LaTeX distribution (e.g. TeX Live 2025 or similar) providing `latexmk`, `pdflatex`, and the standard packages used in Phase 0–4;
- a POSIX shell environment with `bash` and `make`-like tooling sufficient to run the gate script;
- Python and any libraries required by the Phase 3 mechanism code, for the production of figures and diagnostic tables.

At the present rung, Phase 3 defines a placeholder bibliography file `phase3/paper/Reference.bib`, since the paper does not yet make external-citation claims. This file is still part of the declared inputs for the build, so that the pipeline remains stable when references are introduced at later rungs.

Reproducibility scope

The Level–A gate guarantees that:

- the Phase 3 paper builds successfully from the tracked `phase3/paper` sources and `Reference.bib`;
- the canonical artifact `phase3/artifacts/origin-axiom-phase3.pdf` is regenerable from these sources via the Snakemake workflow; and
- the figures referenced in the text (in particular the binding-profile figure) are present under `phase3/outputs/figures/` and can be regenerated from the Phase 3 source code.

Higher gate levels, if introduced, would be expected to add explicit checks on numerical outputs, diagnostic tables, and mechanism parameters. At this rung, however, the emphasis remains on ensuring that the narrative and structural content of the Phase 3 paper is fully reproducible from the repository state.

Auxiliary measure probe

In addition to the main binding-profile experiment, Phase 3 includes a non-binding auxiliary script `phase3/src/phase3_mech/measure_v1.py` that probes the empirical distribution of the baseline amplitude $A_0(\theta)$ for a large number of independently sampled toy ensembles. This script does not affect any of the main Phase 3 claims or floor definitions; it is included solely to make the measure structure of the current toy configuration explicit.

A typical invocation is:

```
oa && python phase3/src/phase3_mech/measure_v1.py
```

which writes:

- a JSON diagnostics file `phase3/outputs/tables/phase3_measure_v1_stats.json` containing basic summary statistics and quantiles of the A_0 distribution; and
- a histogram CSV `phase3/outputs/tables/phase3_measure_v1_hist.csv` with binned counts over A_0.

The console output also prints a small selection of quantiles and fractions below a few illustrative ε thresholds. All of these numbers are toy-model diagnostics and should be interpreted as such; they are not promoted to binding corridor constraints or physical scales at this rung.

Instability-penalty diagnostic. To compress the small-amplitude tails of the A_0 distribution into a single scalar diagnostic, we provide `phase3/src/phase3_mech/instability_penalty_v1.py`. This script reads the stats JSON `phase3/outputs/tables/phase3_measure_v1_stats.json` described above and writes `phase3/outputs/tables/phase3_instability_penalty_v1.json`, which records the chosen thresholds, weights, and the resulting penalty value. At this rung the penalty plays the role of an internal, toy-model knob for future mechanism design; it is not used as a binding corridor constraint.