Phase 4: Vacuum-to-FRW Consistency and Scale Sanity

A corridor-style test of the Phase 3 global-amplitude mechanism

Origin Axiom Program

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Abstract

Phase 4 tests whether the canonical global-amplitude mechanism defined in Phase 3 can be connected, in a structurally reasonable way, to FRW-style dynamics and vacuum-energy-like observables. The goal is to probe whether the non-cancellation floor that stabilises the toy vacuum can also support scale-sane behaviour when mapped into simple cosmological modules, without claiming a full cosmological fit or a theory of everything.

1 Introduction

Phase 4 sits between the mechanism-level vacuum work of Phase 3 and any future attempts to build a unified picture of vacuum, matter, and geometry. Its mission is narrow:

- take the canonical Phase 3 global-amplitude mechanism and non-cancellation floor as given;
- define simple, explicit mappings from the floor-enforced amplitude or residue into FRW-like dynamics and vacuum-energy-like observables; and
- study the resulting behaviour of the Origin-Axiom phase parameter θ in the corridor / ledger framework of Phase 0.

The guiding question is not whether we can reproduce the full ΛCDM model or fit precise cosmological parameters, but whether the Phase 3 mechanism can be made compatible with toy FRW modules in a way that is numerically stable, structurally sane, and expressible as a θ-filter in the sense of Phase 0.

Throughout this phase we distinguish carefully between:

- *binding* outputs, which may eventually define a Phase 4 θ-filter; and
- *non-binding* diagnostics and figures, which serve only as intuition and internal checks.

The present rung does not define any concrete mappings or filters. It only provides a minimal paper skeleton so that future rungs can add well-documented mechanisms and experiments without restructuring the front matter.

2 Candidate mappings from the Phase 3 mechanism

Phase 4 takes as input the floor-enforced global amplitude $A(\theta) = \max\{A_0(\theta), \varepsilon\}$ defined in the Phase 3 mechanism. The goal is to explore simple, explicitly defined families of mappings from $A(\theta)$ (and, where useful, the residue $A(\theta) - A_0(\theta)$) into FRW-like or vacuum-energy-like observables.

Throughout this section we treat the Phase 3 mechanism as a fixed black box: Phase 4 may only act on its outputs. This avoids any retroactive tuning of the vacuum model and keeps the separation of concerns with Phase 3 clear.

2.1 Design principles

The mapping families considered in Phase 4 are required to obey three constraints:

- **Explicitness.** Each mapping must be given by an explicit formula with a small number of parameters (e.g. a scale and an exponent), so that its behaviour can be audited and reproduced.
- **Corridor compatibility.** The mapped observables must support corridor-style reasoning: it should be possible, in principle, to define non-empty or empty θ-regions based on well-stated criteria.
- **Honest physical status.** The mappings are toy constructions, not claimed derivations from first principles. They are interpreted as exploratory consistency tests rather than as a replacement for ΛCDM.

A more detailed narrative for the mapping design lives in `phase4/MAPPING_FAMILIES.md`. Here we summarise the families most relevant to the Phase 4 paper.

2.2 Family F1: amplitude-to-density rescaling

The first family treats the floor-enforced amplitude as a proxy for a vacuum-energy-like density,

$$\rho_{\mathrm{vac}}(\theta;\kappa,p) \;=\; \kappa\,[A(\theta)]^{p}, \tag{1}$$

with $\kappa > 0$ setting an overall scale and $p > 0$ controlling the shape of the dependence on $A(\theta)$. In practice we restrict to a small discrete set of exponents (e.g. $p = 1$ and $p = 2$) and treat κ as a scale knob rather than a fit parameter.

This family is intended as the simplest possible way to couple the Phase 3 mechanism to FRW-like dynamics. Later sections will ask whether there exist choices of (κ, p) for which the resulting FRW trajectories are numerically stable and admit a non-empty, non-pathological θ-corridor.

2.3 Family F2: residue-relative mapping

The second family focuses on the *residue* enforced by the non-cancellation floor,

$$\Delta A(\theta) \;=\; A(\theta) - A_0(\theta). \tag{2}$$

Here we define a residue-like density

$$\rho_{\mathrm{res}}(\theta;\kappa_{\mathrm{res}}) \;=\; \kappa_{\mathrm{res}}\,\Delta A(\theta), \tag{3}$$

with κ_{res} a positive scale parameter.

This family isolates the contribution that is *purely* due to the non-cancellation floor. It is therefore a natural place to test whether the enforced residue can be made compatible with toy FRW modules without producing obviously pathological behaviour.

2.4 Family F3: normalised amplitude corridors

Finally, we consider dimensionless normalised amplitudes,

$$\tilde{A}(\theta) \;=\; \frac{A(\theta) - A_{\min}}{A_{\max} - A_{\min}}, \tag{4}$$

where $A_{\min}$ and $A_{\max}$ are taken from the Phase 3 diagnostics. Rather than mapping directly into densities, this family uses simple inequalities

$$\tilde{A}(\theta) \in [\alpha_{\min}, \alpha_{\max}] \tag{5}$$

to define corridor-style conditions that can be combined with FRW diagnostics.

In this way, Phase 4 can explore non-trivial θ-filters based on the *shape* of $A(\theta)$, while deferring any attempt to assign physical units or match observed cosmological parameters.

At the present rung, these families are specified only at the level of design and notation. Later rungs will instantiate one or more of them in code, connect them to explicit FRW-like modules, and report either live corridors or structured negative results as required by the Phase 0 contract.

3 Diagnostics, corridors, and failure modes

Later rungs will populate this section with:

- diagnostics for the FRW-like or vacuum-energy-like observables derived from the Phase 3 mechanism;
- the resulting θ-dependence and any induced corridors;
- explicit descriptions of non-empty, non-trivial corridors (if found); and
- structured descriptions of empty or pathological corridors, treated as informative negative results.

The Phase 0 ledger semantics require that Phase 4 either:

- contributes a well-defined θ-filter; or
- records a clearly documented failure mode that future phases can build on.

At this rung we do not yet present results or filters; we only identify the role this section will play once mechanisms and experiments are in place.

4 Limitations and outlook

Phase 4 is intentionally narrow in scope. Even once the mappings and diagnostics are implemented, the phase will not claim:

- a full derivation of cosmological parameters;
- a proof that the Origin Axiom is realised in nature; or
- a unique mechanism for connecting vacuum structure to FRW dynamics.

Instead, the goal is to provide a clean yes-or-no style test for a specific question:

> Can the Phase 3 global-amplitude mechanism support scale-sane FRW-like behaviour, in at least one simple mapping family, without producing a degenerate or empty θ-corridor?

If the answer is “no” for all tested mapping families, Phase 4 will record this as a structured negative result, signalling that either the Phase 3 mechanism or the mapping strategy needs revision before further unification attempts.

Appendix A: Phase 4 claims table (draft)

Table 1 summarises the intended Phase 4 claims. At this rung all entries are draft and non-binding.

Table 1: Draft Phase 4 claims. Binding status will be updated once the phase is complete and audited.

ID	Binding?	Summary
C4.1	no	Existence of at least one explicit mapping from the Phase 3 global amplitude or residue into an FRW-like or vacuum-energy-like observable with numerically stable behaviour.
C4.2	no	Existence of a non-empty, non-trivial θ-corridor for at least one such mapping.
C4.3	no	Structured negative result if all tested mappings yield empty or pathological corridors.

Appendix B: Reproducibility notes (draft)

This appendix will eventually document:

- the Phase 4 directory and workflow structure;
- the gate levels (paper-only vs. paper+artifacts);
- the commands required to rebuild the Phase 4 paper and any binding θ-filters; and
- the run manifests and configuration files that define the tested mapping families.

At this rung, Phase 4 only provides a minimal paper skeleton and no mapping implementations. Reproducibility therefore reduces to rebuilding the present PDF via the Phase 4 gate script.

References