Apeiron/AME-1 — Canonical Operational Model Specification

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1. Scope and epistemic boundary

This is the canonical operational definition of the homogeneous model that produced the frozen v7.13 classification. It specifies variables, pressure function, background equations, quantum-source closure, discrete fixed-point map, initial data, units and conventions.

It does **not** assert a unique fundamental covariant action, perturbation theory, ontology or empirical confirmation. For the narrowly scoped numerical-foundations paper, the equations and executable map below are authoritative. An action-level completion would be new physics and cannot be projected backward onto v7.13.

2. Units, geometry and time

- Natural units: $c = \hbar = 1$.
- Reduced Planck mass as internal mass unit: $M_{pl} = 1$.
- Spatially flat homogeneous FRW background, scale factor a, e-fold variable $N = \ln(a)$, expanding branch $H > 0$.
- A dot denotes differentiation with respect to cosmic time t.
- Dimensionless numerical time:

  $= H_{star}\, t$
  $d/d = (1/H_{star})\, d/dt$

- Noncanonical kinetic scalar:

  $X = 0.5\, (dot)^2$

- Scalar fields and mass parameters have mass dimension one. X, pressure and energy density have mass dimension four.

The operational sign convention is fixed by the equations below. A metric-signature convention not used explicitly by the homogeneous implementation is not added here.

3. Degrees of freedom and stored state

3.1 Homogeneous state

The full eight-column trajectory container is

y( ) = (, dot , , dot , , dot , H, N).

In the registered v7.13 map the homogeneous bookkeeping coordinate is fixed to zero. The dynamically iterated six-column state is

u( ) = (, dot , , dot , H, N).

The sector enters through the renormalized mode expectation values _q( ), p_q( ) and _q( ), not through an independently iterated homogeneous .

3.2 Discrete vector

The frozen grid has N_ = 15361 nodes. The solver vector is the flattened and scaled array

```
x = vec[
   /(1e-2),
  dot /(1e-8),
   /1,
  dot /(1e-8),
  H/(1e-6),
  N/(1e-1)
]
```

with shape (92166,) and Float64 dtype.

Array	Shape	dtype	Meaning
t	(15361,)	Float64	dimensionless grid
y	(15361, 8)	Float64	full trajectory container
x	(92166,)	Float64	scaled flattened six-column iterate
tau	scalar	Float64	active terminal value

During unpacking, first-node , dot , , dot and N are reset to the frozen background initial data. First-node H remains in the active state; the image map then imposes the positive Friedmann closure.

3.3 Auxiliary and constrained quantities

- H is algebraically reconstructed from the positive Friedmann branch inside the registered image map.
- N obeys dot N = H.

- Quantum modes and Pauli–Villars regulator sectors are auxiliary arrays used to construct _q, p_q and _q; they are not independent entries of x.
- Gate diagnostics are not additional dynamical degrees of freedom.

4. Frozen parameters

4.1 AME parameters

Symbol	Value	Code name
M_pl	1	Mpl
Λ	2.3e-3	Lambda
f_	2.5e-2	f_sigma
E_c / V_star	4.0e-2	Ec_over_V
H_star	2.0e-6	Hstar
b_star	0.35	bstar
d b / d(/M_pl)	-4.78e-2	b_slope
A_eff	6.86e-3	Aeff
B_eff	-1.74e-2	Beff

```
V_star = 3 M_pl² H_star²
E_c = 0.04 V_star
```

A_eff and B_eff remain in parameter provenance; the active global pressure completion in Section 5 is the quartic polynomial V_s( ).

4.2 Portal and regulator parameters

Quantity	Value
phase scale f_phase	0.8549468502440697
displacement v	0.03272387838931097
coupling	1.6740193604000272e-5
bare portal mass m_ ,0	9.817951142008693e-5
physical-mode support at initial slice	0 k 0.6 Λ
physical quadrature nodes	128
renormalization scale	_R = 1.5 Λ
UV order-0 switch	16 Λ
curvature-tail limit	64 Λ
tail nodes per octave	20

5. Effective AME pressure and derivatives

Define

```
z =  /f_
b(X,  ) = b_star + b_slope ( /M_pl) - 5X/Λ
F(z,b) = z /4 - z²/2 + bz
V_s( ) = Σ(i=0..4) c_i  ^i
```

with

```
(c_0,c_1,c_2,c_3,c_4) =
( 1.1971212004620583e-11,
  9.87022611239063e-14,
 -1.0336424891583054e-13,
  1.189490499106138e-10,
  1.2236365189926054e-10 )
```

The homogeneous pressure function is

```
P(X, , ) =
  X
  + [5/(3Λ )] (z - 2/√3)² X²
  - E_c F(z,b)
  - V_s( ).
```

The executable derivatives are

```
P_X =
  1
  + [10/(3Λ )] (z - 2/√3)² X
  + 5 E_c z/Λ

P_XX = [10/(3Λ )] (z - 2/√3)²

P_  =
  { [10/(3Λ )] (z - 2/√3) X²
    - E_c (z³ - z + b) } / f_

P_  = -E_c z b_slope/M_pl - V_s'( )

P_X  =
  { [20/(3Λ )] (z - 2/√3) X
    + 5 E_c/Λ  } / f_ .
```

AME stress:

```
 _AME = 0.5 (dot  )² + 2X P_X - P
p_AME = 0.5 (dot  )² + P.
```

Hyperbolicity diagnostics:

```
P_X > 0
P_X + 2X P_XX > 0.
```

6. Portal and quantum source

Field-dependent portal mass:

```
m_ ²( , ) =
  m_ ,0² + 2 (v+ )² cos(2 /f_phase)

 m_ ²/  = 4 (v+ ) cos(2 /f_phase)

 m_ ²/  =
  -[4 (v+ )²/f_phase] sin(2 /f_phase).
```

Four Pauli–Villars sectors:

```
C_j = (1,-3,3,-1)
J_j = (0,1,2,3)
M_j² = m_ ² + J_j  _R².
```

Modes are advanced by a three-substep Yoshida composition of the implicit-midpoint map for u = a^(3/2) . Initial mode data are

```
u_k(0) = 1/sqrt(2 _k(0))
dot u_k(0) = -i  _k(0) u_k(0).
```

The active source combines resolved modes, the analytic order-0 UV tail and auxiliary adiabatic curvature orders 2 and 4. Finite renormalization is fixed on the initial flat-space reference slice as recorded by the active runtime:

- _q(0) = 0;
- _q(0) = 0;
- initial quantum pressure is predicted by the fixed prescription rather than tuned as a gate;
- the Einstein–Hilbert response is fixed by the zero-curvature response;
- the finite R^2 coefficient is zero.

The routine returns _q( ), p_q( ) and _q( ). Its source identity is

```
dot  _q + 3H( _q+p_q)
  - 0.5 (dot m_ ²) < ²>_q = 0,
```

evaluated as a normalized numerical diagnostic.

7. Registered homogeneous equations

With

```
 _tot =  _AME +  _q
p_tot = p_AME + p_q,
```

the registered image map integrates

```
d /dt = v_
```

```
dv_ /dt =
  -3H v_  + P_
  - 0.5 ( m_ ²/ ) < ²>_q

d /dt = v_

dv_ /dt =
  { P_
    - 0.5 ( m_ ²/ ) < ²>_q
    - 3H P_X v_
    - P_X  v_  v_  }
  / (P_X + 2X P_XX)

H = +sqrt[ _tot/(3 M_pl²)]

dN/dt = H.
```

The Raychaudhuri relation

```
dH/dt = -( _tot+p_tot)/(2 M_pl²)
```

is evaluated independently rather than used as the evolution equation in this image map.

8. Initial data

```
 (0) = -0.690
 _0 = 2.35e-5
N(0) = 0

dot  (0) =
  -sqrt(2  _0) M_pl H_star / sqrt(1.3)

dot  (0) = 0.
```

(0) = f_ z_+, where z_+ is the positive local minimum satisfying

```
z³ - z + b( (0)) = 0
3z² - 1 > 0.
```

The initial Hubble value is the positive Friedmann root. Homogeneous portal bookkeeping data are (0) = dot (0) = 0. No spatial boundary conditions occur because the registered model is homogeneous.

9. Canonical discrete fixed-point map

For active endpoint _end,

```
Δ  =  _end / 15360.
```

The canonical image map G(x; _end):

1. creates the uniform 15361-node grid and frozen background seed;
2. unpacks x into the six active trajectory columns using Section 3.2;
3. imposes frozen first-node conditions;
4. calculates renormalized quantum-source arrays with the fixed portal and PV prescription;
5. advances (, dot , , dot , N) by classical fourth-order Runge–Kutta while imposing the positive Friedmann root for H;
6. lifts the result to the eight-column container and repacks the six active columns.

Residual and fixed-point diagnostic:

```
R(x; ) = x - G(x; )
 _FP = ||R||_infinity.
```

This is complete for the frozen homogeneous discrete map. It does not license continuum, perturbative, global-stability or observational claims.

10. Active-source provenance

Source file	SHA-256	Role
model.py	db4c0fa9cf4f2013fef299f558	parameters and [illegible] primitives
frw_noncanonical_background_v1.py	f961b13d8f88e6d6dce8f9bec07	and initial data
frw_pv_fixed_mpl_renormalized_v1.py	a1d1732b2604228d1a46c1a4	renormalization and diagnostics
frw_pv_covariant_uv_completion_v1.py	9e54b4095822687b9824dab0	UV completion
frw_pv_uv_yoshida_v6_3.py	3fa1b93a2f24377c751f3d9f	evolution
rb19_anderson_uv_v6_24.py	8323bbf6c6f3e23e1d466add	[illegible]
rb23_friedmann_closure_v3_8.py	873d8ec28.6d28b4261623957	Raychaudhuri audit
rb_recovery_fixedtau_v6_5.py	5082e44cf9c60ca9ef1eaa0b	base
rb_recovery_adaptive_v7_8.py	834e5847f9da3e67994701a2	schedule

Filename version labels record dependency origin. They appear only because these files form the active hash-frozen execution path of the Latest runtime. No alternative historical model is reconstructed.

11. Licensed publication statement

Maximum supported wording:

> Apeiron/AME-1 v7.13 is a frozen homogeneous FRW numerical model defined operationally by the equations, parameters, state map, quantum closure, discretization and hash-identified active runtime sources in this supplement.

Inadmissible stronger wording:

> The supplement proves a unique fundamental or covariant theory of Apeiron.

Current interpretive overlay - 14 September 2026

This section is an **interpretive addendum only**. It changes no frozen AME-1 equation, numerical parameter, gate, source hash or terminal classification.

Single-carrier principle

Apeiron is treated as one fundamental carrier. Effective sectors used in the operational model must not be read as ontologically separate fundamental substances.

- ordinary matter: organized/emergent Apeiron manifestation;
- dark-matter-like phenomena: possible Apeiron manifestation/state;
- dark-energy-like large-scale behavior: possible Apeiron dynamical/state manifestation;
- Higgs/QCD structures: possible organized low-energy manifestations under separate investigation, with Standard-Model/QCD structure retained;
- black-hole reconversion: possible transition of an organized manifestation toward more fundamental Apeiron states under extreme curvature.

The overlay is a model hypothesis and is not an empirical consequence of the frozen v7.13 calculation.

14. Internal EFT / microscopic-completion supplement - Version 1.3

This supplement is additive and does not alter the frozen v7.13 operational map above.

14.1 Result class

- **Derived result:** controlled internal EFT vacuum and physically normalized σ, θ, and Z_2^χ-protected χ eigenmodes.

- **Derived result:** neighboring tachyonic χ phases are delimited and retained as adjacent phases.
- **Derived result:** perturbative/tree-level control reaches the nominal EFT scale.
- **Conditional UV interpretation:** the minimal structurally preferred matching class is a heavy linearly coupled Gaussian scalar mediator.
- **Bounded parameter:** the surviving minimal UV family has one free microscopic parameter M_S.
- **Unresolved question:** the physical nonlocal response kernel has not been produced, so M_S is not independently pole-fixed.

14.2 Binding corrected local coefficients

$$c_{X^2}^{(\phi_1)} = 3.91305380277 \times 10^{11} M_{\rm Pl}^{-4}.$$

$$\Lambda_{\rm unit} = 1.28824506\,\Lambda.$$

$$C_6^{(\chi)} = -21.0925 M_{\rm Pl}^{-6}.$$

$$\beta_{C_6} = -2.85893108646 \times 10^{12} M_{\rm Pl}^{-6}.$$

The old intermediate value 2.9131×10^{11} for the canonical X^2 coefficient is rejected. The old dependent ratio $\Lambda_{\rm unit}/\Lambda = 1.38688$ is likewise rejected. No closed physics is recomputed by this documentation update; the Version 1.3 release merely propagates the already closed correction.

14.3 UV boundary

APEIRON UV MATCHING BOUNDARY: BOUNDED

The minimal branch is a **quantitative one-parameter UV family** with

$$1 < M_S/\Lambda \lesssim 1.28824506.$$

This must not be rewritten as a unique microscopic completion.

14.4 Open nonlocal test

physical nonlocal response kernel still required

The absent physical nonlocal response kernel is the remaining route to a possible independent pole/mediator determination. Until that object is produced and validated, M_S remains bounded but not independently fixed.