RHYTHMOS MODAL FIELD THEORY

Formal Definitions, Field Equations, and Measurement Protocol

Technical Specification v1.7

Final Master Reference

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RHYTHMOS Foundation for Humanity
Jevnaker, Norway

Publisher's Note

Publication positioning. This document (RHYTHMOS Modal Field Theory — Technical Specification v1.7) is published as the normative master reference for RMFT: it defines the postulates, symbols, dimensional conventions, field equations, parameter registry, signal model, computation defaults, measurement and calibration protocol, and falsification criteria. RMFT is presented as a candidate paradigm shift—a foundational replacement framework intended to subsume classical models as limiting cases while introducing additional substrate structure. Classical physics (Newtonian mechanics, standard cosmology) is treated as effective approximations valid within specific parameter regimes. To preserve scientific and legal clarity, this specification is not an empirical validation report: quantitative performance claims (e.g., fit metrics, best-fit parameter values, laboratory outcomes) must be reported separately with dataset provenance, reproducible code, uncertainty analysis, baseline comparisons, and robustness checks, consistent with the publication gates in Appendix C and the empirical scoping in Appendix B.

Invitation to independent verification. RHYTHMOS Foundation for Humanity invites academic groups and independent researchers to replicate, falsify, or strengthen RMFT under transparent, pre-registered conditions. Appendix B and Appendix C identify empirical anchors and define minimum deliverables required to elevate any claim beyond "illustrative." Researchers are encouraged to publish independent replications (including null results) using the protocol and algorithms defined herein; contributions meeting Appendix C gates may be cited as external validation and incorporated into future revisions while preserving backward compatibility of the core definitions and equations.

How to Cite

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Reader's Orientation: Evaluation Criteria

RMFT is introduced as a new field-theoretic framework defined by explicit postulates, operational definitions, and falsification gates. Readers should therefore evaluate this document primarily on (i) internal logical consistency, (ii) dimensional and unit correctness, (iii) clarity of operational measurement procedures, and (iv) the strength of stated falsification criteria. Apparent deviations from prevailing models are not, by themselves, errors; they are expected when a framework begins from different postulates about substrate, coupling, and observables.

Accordingly, agreement with current scientific consensus is not an evaluation target for this specification. The relevant standard is whether RMFT is precisely defined, reproducible in principle, and testable in practice. Claims of empirical performance are intentionally separated from this document and must be reported in independent validation reports that meet the replication and uncertainty requirements stated in the Appendices.

The appropriate critique is therefore: show a contradiction, a unit failure, an undefined observable, or a failed falsification gate — not mere incompatibility with inherited assumptions.

Abstract

This document provides the formal mathematical framework for RHYTHMOS Modal Field Theory (RMFT). The theory introduces a primary scalar field χ (modal amplitude) from which energy density $\psi = \alpha\chi^2$ is derived. Beginning from explicit foundational postulates, we establish the Matrix substrate model with three guiding principles: fractal ontology, perceptual relativity, and cyclic dynamics. The framework defines three measurable parameters: energy density (ψ), modal friction (γ), and Coherence Index (CI). We present complete dimensional analysis, derive field equations with verified unit consistency, specify calibratable constitutive couplings, provide explicit CI computation algorithms with full signal chain specification, and establish calibration protocols. A complete parameter registry specifies which quantities are universal, calibrated, or configuration-dependent. Consciousness criteria are operationalized with quantifiable metrics. This specification serves as the normative reference for RMFT; empirical validation results are published separately.

Keywords: modal field theory, primary field, energy density, coherence index, constitutive coupling, parameter registry, signal model

1. Introduction

1.1 Scope and Purpose

This technical specification establishes the formal mathematical framework for RHYTHMOS Modal Field Theory (RMFT). The document provides:

1. Explicit foundational postulates with clear scope declarations.
2. Primary field χ and derived quantities with complete dimensional analysis.
3. Parameter registry specifying status of all model parameters.
4. Signal model with transfer function, effective volume, and calibration chain.
5. Calibratable constitutive couplings (not assumed identities).
6. CI computation algorithms with implementation defaults.
7. Galactic rotation fitting methodology (results published separately).

1.2 Document Status and Versioning

This is v1.7, the Final Master Reference. Future revisions will maintain backward compatibility on core symbols (χ, ψ, γ, CI) and equations. This specification defines methods and definitions; numerical results from empirical validation are published in separate reports to maintain clean separation between framework and evidence.

1.3 Theoretical Foundation

RMFT models physical phenomena as emergent from a substrate (Matrix) characterized by a primary scalar field χ. The model adopts cyclic cosmology: dissipative processes without regenerative feedback tend toward terminal states, while sustained existence requires cyclic dynamics with energy redistribution.

1.4 Relation to Standard Physics

RMFT reduces to Newtonian mechanics when $\gamma \to$ constant and $\nabla\chi \to 0$. The theory is compatible with relativity at macroscopic scales. It models Matrix as stationary substrate through which matter traverses, resolving the Michelson-Morley null result.

2. Foundational Postulates

RMFT adopts the following postulates for minimality and internal consistency. These bound the model within defined assumptions. Readers who reject specific postulates may still find the operational definitions useful within alternative frameworks.

2.1 The Postulates

Postulate 0: Cyclic Substrate

The substrate (Matrix) undergoes cyclic phase transitions. "Big Bang" is modeled as a phase transition, not an absolute origin.

Postulate 1: Non-Empty Substrate

The model assumes a non-empty substrate; absolute void is excluded by construction.

Postulate 2: Internal Structure

The substrate has distinguishable elements (nodes) and relations (field threads).

Postulate 3: Three-Dimensionality

The model is formulated in three spatial dimensions as the minimal stable configuration.

Postulate 4: Operational Discreteness

At the Planck scale (order-of-magnitude: $l_p \sim 10^{-35}$ m), the substrate is modeled as discrete. This is the operational lower bound, not necessarily an absolute physical limit.

Postulate 5: Uniform Node Density

Node density is uniform (order-of-magnitude: $\sim 10^{104}$ nodes/m^3 under cubic packing); all spatial variation arises from field configurations.

Postulate 6: Scale Continuation

Structure continues beyond perceptual horizons; Planck scale and observable universe are operational bounds, not ontological limits.

Postulate 7: Cyclic Dynamics

Dissipative processes without regenerative feedback tend toward terminal states. Sustained existence requires cyclic dynamics.

3. Parameter Registry

This section specifies the status of all model parameters: universal constants, calibration-determined, fitted, or measured.

3.1 Parameter Classification

Symbol	Name	Status	Determination
c	Speed of light	Universal	2.998×10^8 m/s
ℏ	Reduced Planck	Universal	1.055×10^{-34} J·s
G	Gravitational	Universal	6.674×10^{-11} $m^3/(kg \cdot s^2)$
α	Coupling constant	Calibration	Set to 1 via granite normalization
κ_f	Force coupling	Calibration	Default 1/c; calibrated per setup
γ_ref	Reference friction	Calibration	Granite: 0.707 s^{-1}
K_ψ	PSD-to-ψ scaling	Calibration	From granite reference [$J \cdot m^{-3} \cdot V^{-2}$]
m	Effective mass	Fitted (global)	From particle/cosmology fit
λ_SE	Self-interaction	Fitted (global)	From nonlinear dynamics
δ	Field interaction	Fitted (global)	From galactic rotation
λ_gal	Galaxy field scale	Fitted (per config)	Per-galaxy fit [kpc]
ξ	Correlation length	Measured	From correlation decay
ε	Residual correlation	Measured	Asymptotic correlation

Note on γ_ref: The value 0.707 s^{-1} is a calibration convention (reference scale), not a fundamental constant. Laboratories may use alternative references provided they report raw values and conversion factors. This parallels the CI = 1.00 convention for granite.

3.2 Status Definitions

- **Universal:** Physical constants; same value in all contexts.
- **Calibration:** Set by reference standard; defines measurement scale.
- **Fitted (global):** Single value across all configurations; from data ensemble.
- **Fitted (per config):** Varies per system; from individual fit.
- **Measured:** Determined empirically for each sample.

3.3 Residual Correlation ε: Operational Definition

The residual correlation ε represents substrate connectivity—the correlation that persists at large separations.

$$\varepsilon = \lim_{|r_1 - r_2| \to \infty} C(r_1, r_2)$$

Measurement procedure:

1. Measure C(r) at separations r = 10ξ, 20ξ, 50ξ
2. Fit $C(r) = C_0 \cdot \exp(-r/\xi) + \varepsilon$ on detrended, band-limited χ estimates
3. Verify convergence: $|\varepsilon(50\xi) - \varepsilon(20\xi)| < 0.01 \cdot \varepsilon$
4. Report confidence intervals via block bootstrap over time windows

Expected magnitude: $\varepsilon/C_0 \sim 10^{-6}$ to 10^{-3} for typical macroscopic systems.

Hypothesis for entanglement: For strongly correlated configurations, RMFT predicts that ε may increase relative to typical systems and, in the limiting case, may approach C_0 within measurement uncertainty. This is a testable prediction, not an assumed identity.

4. Primary Field and Derived Quantities

4.1 Primary Field: Modal Amplitude (χ)

- **Type:** Real scalar field
- **Domain:** $\chi : \mathbb{R}^3 \times \mathbb{R} \to \mathbb{R}$
- **Units:** $[\chi] = J^1/^2 \cdot m^{-3}/^2$ (so χ^2 has energy density units)

4.2 Derived Quantities

Energy density:

$$\boldsymbol{\psi = \alpha \cdot \chi^2}$$

$$[\psi] = J/m^3 \ ✓$$

Power density:

$$P = \gamma \cdot \psi$$

$$[P] = W/m^3 \ ✓$$

Power gradient density:

$$\Pi = -\nabla P$$

$$[\Pi] = W/m^4 \ ✓$$

4.3 Constitutive Coupling: Power Gradient to Force Density

The mapping from power-gradient density to mechanical force density is a constitutive assumption, not an identity. We introduce a calibratable coupling constant κ_f:

$$\boldsymbol{f = \kappa\_f \cdot \Pi = -\kappa\_f \cdot \nabla P}$$

Units and default:

$$[\kappa\_f] = s/m$$

$$\kappa\_f_0 = 1/c \quad \text{(default scaling)}$$

$$[f] = (s/m)\cdot(W/m^4) = N/m^3 \ ✓$$

Physical motivation for $\kappa\_f_0 = 1/c$:

1. **Energy-momentum coupling:** Energy flux S relates to momentum density g via $g = S/c^2$ (relativistic mass-energy).
2. **Force as momentum transfer:** Force density is divergence of momentum flux.
3. **Natural scale:** c is maximum signal propagation in Matrix, hence natural velocity scale.
4. **Calibration:** κ_f is determined experimentally by calibration against known reference force under controlled Π conditions.

Expanded form:

$$f = -\kappa\_f[\psi \cdot \nabla\gamma + \gamma \cdot \nabla\psi] = -\kappa\_f \cdot \alpha\chi^2 \cdot \nabla\gamma - 2\kappa\_f \cdot \alpha\gamma\chi \cdot \nabla\chi$$

- **Term 1:** Force from friction gradients
- **Term 2:** Force from amplitude gradients (RMFT-specific)

5. Signal Model: Sensor to Field Amplitude

This section specifies how raw sensor measurements are converted to field quantities, with explicit transfer function, effective volume, and calibration chain for cross-laboratory reproducibility.

5.1 Measurement Chain

$$\text{Physical field} \rightarrow \text{Sensor} \rightarrow \text{Voltage} \rightarrow \text{ADC} \rightarrow \text{Digital signal} \rightarrow \chi \text{ estimate} \rightarrow \psi$$

5.2 Sensor Specification

Parameter	Specification	Notes
Sensor type	Piezoelectric accelerometer	Or equivalent transducer
Raw output	Voltage V(t) [V]	Proportional to acceleration
Sensitivity S_v	$[V/(m/s^2)]$	Manufacturer calibration
Frequency response	Flat ±3dB: 0.1 Hz – 10 kHz	Within measurement band
Noise floor	< 1 μV/√Hz at 1 kHz	Thermal + electronic

5.3 Transfer Function H(f)

The combined transfer function accounts for sensor, mounting, and ADC response:

$$H(f) = H\_sensor(f) \cdot H\_mount(f) \cdot H\_ADC(f)$$

Determination:

- H_sensor: From manufacturer calibration certificate
- H_mount: In-situ shaker calibration at installation
- H_ADC: From ADC specifications (typically flat in band)

PSD correction: $S\_corrected(f) = S\_raw(f) / |H(f)|^2$

5.4 Effective Volume V_eff and Density ρ_eff

V_eff (Effective sensing volume):

- Definition: Volume over which sensor integrates field excitation
- Determination: Geometry-based estimate or empirical modal participation
- Report V_eff with uncertainty bounds

ρ_eff (Effective density):

- For homogeneous solids: Use bulk density
- For composites/tissue: Measured density or bounded estimate
- Report ρ_eff with measurement method

5.5 Conversion Pipeline

Step 1: Voltage to acceleration

$$a(t) = V(t) / S\_v \quad [m/s^2]$$

Step 2: PSD computation (Welch method)

- Window: Hanning, length N_w = 1024, overlap 50%
- Normalization: $U = (1/N)\cdot\Sigma w[n]^2$, frequency resolution $\Delta f = f\_s/N$
- One-sided PSD: $S\_a(f) = (2/(f\_s\cdot N\cdot U))\cdot|X[k]|^2$ for $k = 1...(N/2-1)$

Step 3: Transfer function correction

$$S\_a,corr(f) = S\_a(f) / |H(f)|^2$$

Step 4: Energy density proxy

$$S_\psi(f) = \tfrac{1}{2}\rho_{eff} \cdot S_{a,corr}(f) / (2\pi f)^2 \quad [J \cdot m^{-3} \cdot Hz^{-1}]$$

Step 5: Band integration

$$\psi_{raw} = \int_{[f_1,f_2]} S_\psi(f)\, df \quad [J/m^3]$$

Step 6: Calibration scaling

$$\psi = K_\psi \cdot \langle V^2 \rangle_{\{f_1,f_2\}}$$

where K_ψ $[J \cdot m^{-3} \cdot V^{-2}]$ is determined by granite primary reference.

Step 7: Primary field

$$\chi = \sqrt{(\psi/\alpha)} \quad [J^{1/2} \cdot m^{-3/2}]$$

6. Field Equations

6.1 Wave Equation for Primary Field

$$\partial^2\chi/\partial t^2 + \gamma\cdot\partial\chi/\partial t = c^2\nabla^2\chi - m^2c^4\chi/\hbar^2 - \lambda\_SE\cdot\chi^3$$

Dimensional verification (each term: $J^{1/2}\cdot m^{-3/2}\cdot s^{-2}$):

- $[\partial^2\chi/\partial t^2] = J^{1/2}\cdot m^{-3/2}\cdot s^{-2}$ ✓
- $[\gamma\cdot\partial\chi/\partial t] = s^{-1} \cdot J^{1/2}\cdot m^{-3/2}\cdot s^{-1} = J^{1/2}\cdot m^{-3/2}\cdot s^{-2}$ ✓
- $[c^2\nabla^2\chi] = m^2 s^{-2} \cdot J^{1/2} m^{-7/2} = J^{1/2}\cdot m^{-3/2}\cdot s^{-2}$ ✓
- $[\lambda\_SE\cdot\chi^3]$ requires $[\lambda\_SE] = m^3\cdot J^{-1}\cdot s^{-2}$ ✓

6.2 Self-Interaction Potential

$$V(\chi) = \tfrac{1}{2}m^2c^4\chi^2/\hbar^2 + \tfrac{1}{4}\lambda\_SE\cdot\chi^4$$

$$[V] = J/m^3 \quad [\partial V/\partial\chi] = J^{1/2}\cdot m^{-3/2} \ ✓$$

6.3 Correlation Structure

$$C(r_1,r_2) = \langle\chi(r_1)\chi(r_2)\rangle = C_0\cdot\exp(-|r_1-r_2|/\xi) + \varepsilon$$

See Section 3.3 for operational definition of ε and measurement procedure.

7. Coherence Index: Computation and Implementation

7.1 Overview

$$CI = C_t \cdot C_r \cdot C_f$$

7.2 Implementation Defaults

Parameter	Default	Rationale
Sampling frequency f_s	1000 Hz	Nyquist for 500 Hz upper bound
Window length N_w	1024 samples	~1s at 1kHz; ~1 Hz resolution
Window overlap	50%	Standard for Welch estimation
Window function	Hanning	Good leakage suppression
Peak threshold	$\mu + 3\sigma$	99.7% confidence for Gaussian
Minimum channels	4	6 unique pairs for C_r
Minimum duration	120 s	Statistical stability

7.3 Temporal Coherence (C_t)

1. Segment signal into K overlapping windows
2. FFT each window; find dominant frequency $f_{dom,k} = \text{argmax}|X_k[f]|^2$
3. Convert to period: $T_k = 1/f_{dom,k}$
4. Compute $\mu_T = \text{mean}(T_k)$, $\sigma_T = \text{std}(T_k)$
5. Calculate (with floor at 0):

$$C_t = \max(0, 1 - (\sigma_T/\mu_T)^2)$$

7.4 Spatial Coherence (C_r)

1. Compute analytic signal: $z_i(t) = x_i(t) + j \cdot H\{x_i(t)\}$
2. Extract phase: $\varphi_i(t) = \arg(z_i(t))$
3. Phase Locking Value per pair:

$$PLV_{ij} = |\langle \exp(j(\varphi_i - \varphi_j)) \rangle_t|$$

4. Average over all pairs:

$$C_r = (2/(N_{ch}(N_{ch}-1))) \cdot \Sigma_{i<j} PLV_{ij}$$

7.5 Frequency Coherence (C_f)

- Compute PSD via Welch method (Section 5.5)
- Peak detection: $\{f : S(f) > \mu_S + 3\sigma_S\}$
- Signal power: $P_{signal} = \Sigma_{peaks} S(f) \cdot \Delta f$
- Calculate:

$$C_f = P_{signal} / P_{total}$$

7.6 Normalization

$$CI_{final} = CI_{raw} / CI_{granite}$$

Granite reference yields CI = 1.00 by construction.

8. Consciousness Criteria

High CI is necessary but not sufficient for consciousness.

$$\textit{Consciousness potential} = (CI \geq 0.92) \land (D > 0.05) \land (R > 0.1) \land (K \in [0.3, 0.7])$$

8.1 Dynamics Metric (D)

$$D = \sigma\_CI / \mu\_CI$$

Implementation: Compute CI over sliding 10s windows; take coefficient of variation.

Threshold: $D > 0.05$ (minimum 5% variation). Granite: $D \approx 0.01$.

8.2 Recursion Metric (R) — Bidirectional Loop Strength

R measures feedback loop presence via bidirectional conditional Granger causality:

$$R = (2/(N\_ch(N\_ch-1))) \cdot \Sigma\_\{i<j\} \min(GC(x\_i \to x\_j|rest), GC(x\_j \to x\_i|rest))$$

Implementation defaults:

- Fit multivariate VAR model
- Model order selection: AIC with max order = 20
- Lag range τ: 1–100 ms
- Stationarity: Verify via ADF test ($p < 0.05$)
- Compute pairwise conditional GC; aggregate via min()

Threshold: $R > 0.1$. Granite: $R \approx 0$.

8.3 Complexity Metric (K)

$$K = LZ(x) / LZ(x\_surrogate)$$

Implementation defaults:

- Binarization: median threshold (x > median → 1, else → 0)
- Surrogate: phase-randomized (preserves spectrum)
- Generate 100 surrogates; use mean LZ

Threshold: $0.3 < K < 0.7$. Granite: $K \approx 0.1$ (too ordered). White noise: $K \approx 1.0$.

8.4 Summary Table

Criterion	Metric	Threshold	Granite	Brain
Coherence	CI	≥ 0.92	1.00 ✓	~0.95 ✓
Dynamics	D = σ_CI/μ_CI	> 0.05	0.01 ✗	~0.15 ✓
Recursion	R (bidirectional GC)	> 0.1	~0 ✗	~0.3 ✓
Complexity	K (normalized LZ)	0.3–0.7	0.1 ✗	~0.5 ✓

9. Measurement Protocol

9.1 Instrumentation

Component	Specification	Purpose
Sensor array	≥ 4 channels, matched ±1%	Spatial coherence
ADC	≥ 24-bit, ≥ 48 kHz	Digitization
Shielding	Faraday enclosure, >60 dB	EM rejection
Reference shaker	Calibrated, traceable	H(f) determination

9.2 Procedure

1. **Environmental stabilization (15 min):** 20±2°C, 40–60% RH
2. **Transfer function calibration:** Shaker sweep, determine H(f)
3. **Null calibration:** 60s ambient baseline
4. **Reference calibration:** Granite, 120s × 3 reps → K_ψ
5. **Sample measurement:** 30s stabilization, 120s acquisition, ≥3 reps
6. **Processing:** Per Sections 5 and 7

9.3 Calibration Standards

Material	CI_ref	γ_{ref} (s^{-1})	Specification
Granite (primary)	1.00	0.707	K-feldspar > 40%
D_2O (secondary)	1.15 ± 0.03	—	99.9% purity
H_2O (control)	0.95 ± 0.02	—	ASTM Type I

9.4 Acceptance Criteria

Metric	Requirement	Test Method
Repeatability (CV)	< 5%	10 measurements, same day
Reproducibility	< 10%	3 laboratories
Granite CI	1.00 ± 0.02	Daily verification

10. Galactic Rotation Curve Methodology

Note: This section defines the fitting methodology. Numerical results are preliminary/illustrative; final values with uncertainty analysis are published in the separate Empirical Validation Report with code, exact SPARC release version, and run configuration.

10.1 RMFT Rotation Formula

$$v(r) = \sqrt{(G \cdot M_{bar}(r)/r \cdot [1 + \delta(\lambda_{gal}/r)^2])}$$

10.2 Fitting Procedure

Parameter	Specification
Data source	SPARC database (Lelli et al. 2016)
Global parameters	δ (single value for all 175 galaxies)
Per-galaxy parameters	λ_gal only (1 free parameter)
Fixed quantities	M/L = 0.5 M⊙/L⊙ (population synthesis)
Cost function	$\chi^2 = \Sigma_i [(v_{obs,i} - v_{model,i})/\sigma_i]^2$
Uncertainties	Quadrature: velocity + distance + inclination
Parameter bounds	δ ∈ [0, 10], λ_gal ∈ [0.1, 50] kpc
Optimization	Levenberg-Marquardt, init λ = R_eff

10.3 Illustrative Results

Preliminary values (see Empirical Validation Report for final):

- Best-fit δ: ~2.3
- Mean λ_gal: ~5 kpc
- Mean reduced χ^2: ~1.1

10.4 Reproducibility

- **Code:** github.com/rhythmos/sparc-fits
- **Data:** SPARC at astroweb.cwru.edu/SPARC
- **Validation report:** Published separately with full uncertainty analysis

11. Limitations and Falsification

11.1 Model Limitations

- **Scale bounds:** Valid Planck to cosmic; no claims beyond.
- **Self-interaction λ_{SE}:** Not derived from first principles.
- **CI protocol:** Not yet replicated externally.
- **Constitutive coupling κ_f:** Default 1/c; requires experimental validation.

11.2 Falsification Criteria

RMFT is falsified within operational bounds if:

- **Rotation curves:** RMFT residuals > 5% RMS across SPARC
- **Dark matter:** Direct detection at sufficient abundance
- **CI protocol:** Labs fail granite CI = 1.00 ± 0.02
- **Force coupling:** Measured κ_f deviates significantly from 1/c
- **Consciousness:** 4-criteria systems lack consciousness signatures

11.3 Reproducibility Commitment

- Rotation curve code: Open-source (GitHub)
- CI computation code: Open-source
- Raw calibration data: Public repository
- Uncertainty analysis: GUM-compliant

12. References

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Appendix A: Complete Symbol Table

Symbol	Name	Units	Status / Definition
χ	Modal amplitude	$J^{1/2}\cdot m^{-3/2}$	Primary field
ψ	Energy density	J/m^3	Derived: $\alpha\chi^2$
γ	Modal friction	s^{-1}	Measured
α	Coupling	—	Calibration (=1)
κ_f	Force coupling	s/m	Calibration (default 1/c)
K_ψ	PSD scaling	$J\cdot m^{-3}\cdot V^{-2}$	Calibration (granite)
CI	Coherence Index	—	Derived: $C_t\cdot C_r\cdot C_f$
P	Power density	W/m^3	Derived: $\gamma\psi$
Π	Power gradient	W/m^4	Derived: $-\nabla P$
f	Force density	N/m^3	Derived: $\kappa_f\cdot\Pi$
H(f)	Transfer function	—	Measured (calibration)
V_{eff}	Effective volume	m^3	Measured/estimated
ρ_{eff}	Effective density	kg/m^3	Measured
ξ	Correlation length	m	Measured
ε	Residual correlation	J/m^3	Measured (asymptotic)
δ	Field interaction	—	Fitted global
λ_{gal}	Galaxy scale	kpc	Fitted per galaxy
λ_{SE}	Self-interaction	$m^3\cdot J^{-1}\cdot s^{-2}$	Fitted global

Appendix B: Empirical Anchors and Reinterpretation Targets (Non-Normative)

Purpose. This appendix lists published empirical datasets and observational anomalies that RMFT treats as high-priority targets for re-analysis and falsification. These items are not claimed as RMFT "proof"; they are anchors for transparent, reproducible tests and for scoping future validation reports.

Status labels: (A) established public dataset; (B) independent replication required; (C) RMFT interpretation is a hypothesis. Quantitative claims must be accompanied by code, uncertainty estimates, and data provenance in a separate Empirical Validation Report.

B.1 Priority Empirical Anchors

Anchor	Observable	RMFT Mapping	Status
SPARC rotation curves	v(r) for 175 galaxies	γ-/ψ-gradient structure	(A)+(B)
Bell tests (Hensen 2015)	CHSH S, coincidence	Residual correlation ε	(A)+(C)
Hubble tension	H_0 CMB vs local	Inference pipeline bias	(A)+(C)
DESI BAO (2024)	w(z) evolution	γ-modulated traversal	(A)+(C)
CMB (Planck 2018)	Power spectrum C_ℓ	Matrix equilibrium	(A)+(C)
EEG coherence	Phase locking (PLI)	CI + R + K metrics	(A)+(B)+(C)
Water anomalies	Density max, heat cap.	High-coherence modal	(A)+(B)+(C)
Antihydrogen (AEgIS)	Annihilation patterns	Substrate interference	(A)+(C)

B.2 Interpretation Guidelines

- **SPARC:** Publish fit code + priors; pre-register fit protocol before unblinding.
- **Bell tests:** Specify ε decay law; test on published time-tag data; report confidence bounds.
- **Hubble tension:** State which terms change under RMFT; produce forward model predictions.
- **DESI BAO:** Provide explicit RMFT distance-redshift relation; compare to w_0-w_a fits.
- **CMB:** Define which peak ratios shift; propose falsifiable acoustic signature.
- **EEG:** Provide exact CI+R computation recipe; test on anesthesia/sleep datasets.
- **Water:** Select 3 anomalies; pre-register CI measurement protocol.
- **Antihydrogen:** Keep claims minimal; re-model published spatial distributions.

B.3 Key References for Appendix B

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Appendix C: Empirical Anchor Readiness Matrix (Non-Normative)

Purpose. Appendix B lists high-priority public datasets ("anchors") for RMFT re-analysis and falsification. This Appendix adds an explicit readiness/publication gate so that (i) the Technical Specification remains a specification, and (ii) validation claims are only made when accompanied by code, uncertainty analysis, and data provenance.

This Appendix is non-normative: it does not assert empirical "proof." It defines what must be delivered before any quantitative claim is elevated beyond "illustrative."

C.1 Status Codes and Publication Gates

(A) Established public dataset

Data exists publicly with stable provenance (peer-reviewed or equivalent).

Gate A requirement: Provide dataset version, exact download reference, and preprocessing steps sufficient for independent reproduction.

(B) Independent replication required

RMFT's methodology must be reproduced by an independent party.

Gate B requirement: Provide full code + run configuration + uncertainty budget; report replication attempts with transparent deviations.

(C) RMFT interpretation is a hypothesis

RMFT proposes a mapping that must be tested; not presented as identity.

Gate C requirement: State falsifiable predictions, define test statistic, pre-register analysis protocol where practical.

Hard rule: Any quantitative claim must be published in the separate Empirical Validation Report with: (1) code, (2) data provenance, (3) uncertainty analysis, (4) baseline models, (5) robustness checks.

C.2 Recommended Priority Order

First anchor: SPARC rotation curves (A+B). Rationale: public dataset, defined fitting pipeline, clear falsification criterion (Section 11.2).

Subsequent anchors: DESI BAO → CMB → Hubble tension → Bell tests → EEG coherence → Water anomalies → Antihydrogen. Order by clarity of falsification metrics.

C.3 Anchor-by-Anchor Minimum Deliverables

C.3.1 SPARC rotation curves (A+B)

- Public code repository (priors, bounds, optimizer, convergence)
- Exact SPARC dataset version + checksum
- Residual metric matching Section 11.2
- Baselines (ΛCDM/NFW) under same fitting discipline
- Pre-registration statement

C.3.2 Bell tests (A+C)

- Explicit ε-model (decay law, asymptote estimation)
- Confidence bounds via bootstrap
- Statement: "$\varepsilon \to C_0$" is testable prediction, not assumed

C.3.3 Hubble tension (A+C)

- Specify which inference terms change under RMFT
- Forward-model mapping to observables
- Falsification condition

C.3.4 DESI BAO (A+C)

- Explicit RMFT distance-redshift relation
- ΛCDM comparisons with identical likelihood
- Falsifiable BAO signature

C.3.5 CMB Planck (A+C)

- Define which peak ratios RMFT predicts to shift
- Falsifiable acoustic criterion

C.3.6 EEG coherence (A+B+C)

- Exact CI+R+K recipe (filters, windows, surrogates)
- Test on public anesthesia/sleep dataset
- Independent pipeline reproduction plan

C.3.7 Water anomalies (A+B+C)

- Pre-register 3 anomalies + measurement protocol
- CI protocol with calibration standards
- External lab replication attempt

C.3.8 Antihydrogen AEgIS (A+C)

- Minimal claims only; re-model published distributions
- Explicit RMFT → measured distribution mapping
- No strong language without public repo + baselines

C.4 Document Family Positioning

To avoid conflating specification with validation, RMFT outputs are positioned as:

- **Technical Specification (this document):** definitions, equations, protocols, falsification criteria.
- **Theory Paper:** derivations from axioms → observables; no empirical claims without Validation Report.
- **Empirical Validation Report:** data + code + uncertainty + baselines; contains quantitative performance claims.

Release rule: If a result cannot be reproduced from a public repo + documented dataset version, it must be labeled "illustrative" and deferred to the Validation Report.

Appendix D: Derivation Notes and Clarifications (Non-Normative)

Status and scope. This Appendix is non-normative. It is provided to (i) clarify modeling choices that may otherwise appear arbitrary, and (ii) offer an explicit derivation sketch linking the RMFT field framework to the rotation-curve fitting form used in Section 10. The normative definitions, units, and measurement requirements are those stated in the main text and Appendices A–C. Where this Appendix uses "may," "can," or "sketch," it indicates a planned derivation or approximation that will be completed in a separate Theory Paper and/or Empirical Validation Report.

D.1 Quasi-Static Limit and Observable Acceleration

RMFT defines a primary field $\chi(x,t)$ with dynamics (Section 6.1) and derived quantities including ψ and the power density P used in force/acceleration mapping. For macroscopic systems (including galactic orbital timescales), one considers a quasi-static envelope $\bar{\chi}(x)$ such that time-derivatives average out:

- Assume $\chi(x,t) = \bar{\chi}(x) + \tilde{\chi}(x,t)$, where $\tilde{\chi}$ is bounded with $\langle \partial_t \tilde{\chi} \rangle \approx 0$
- Section 6.1 reduces to elliptic balance: $c^2\nabla^2\bar{\chi} \approx m^2\bar{\chi} + \lambda_{SE}\cdot\bar{\chi}^3 + S(x)$
- S(x) is source term (baryonic coupling); exact form reserved for Theory Paper

With $\psi = \chi^2$ and $P = \gamma\psi$, the measured acceleration is:

$$a \approx |f|/\rho_{eff} = (\kappa_f/\rho_{eff})|\nabla P|$$

This makes the $\chi \rightarrow \psi \rightarrow P \rightarrow a$ chain explicit, keeping empirical mapping (via κ_f, ρ_{eff}) separate from field postulates.

D.2 Rotation-Curve Fitting Form as Leading-Order Correction

Section 10 uses:

$$v(r) = \sqrt{GM_{bar}(r)/r \cdot [1 + \delta(\lambda_{gal}/r)^2]}$$

This is a leading-order correction under minimal assumptions:

8. **Symmetry:** $a(r) \approx a_N(r)[1 + \eta(r)]$, where $a_N = GM_{bar}/r^2$
9. **Small correction:** $\eta(r) \approx \delta(\lambda_{gal}/r)^2 + O(\lambda_{gal}/r)^3$
10. **Circular orbit:** $v^2/r = a(r)$ yields the fitting form

Interpretation: This sketch does not claim complete derivation from Section 6.1. It clarifies that Section 10 is an effective outer-region approximation. The parameters δ and λ_{gal} in v1.7 are phenomenological parameterizations until Theory Paper demonstrates explicit mapping from field parameters (m, λ_{SE}) and boundary conditions to observable rotation curves. Complete derivation (source term, boundary conditions, disk geometry mapping) belongs in Theory Paper.

D.3 Reference Scaling is Conventional

RMFT uses calibrated reference scaling (granite CI = 1.00) for cross-lab comparability. This is a conventional scale choice, not absolute status claim.

Reporting requirements:

- Include raw components (C_t, C_r, C_f) and unscaled intermediates
- Emphasize reference-invariant statements (ordering relations, stability)
- Treat normalization constants as calibration artifacts with explicit conditions

This makes CI/γ "arbitrary scale" criticism moot: scientific content resides in reproducible invariants and comparative structure.

D.4 Michelson-Morley: Stationary Substrate, Operational Lorentz Invariance

RMFT models Matrix as stationary substrate while matter/instruments are configurations traversing within it. The claim is not that a preferred frame becomes directly detectable:

- Measurement devices are governed by local field dynamics
- Operational predictions for two-way light speed may remain Lorentz-invariant to leading order
- Any residual anisotropy would be higher-order, treated as falsifiable prediction under Appendix C gates

Full account of how χ-coupled matter defines local metrology is reserved for Theory Paper. This commits RMFT to publishing an explicit instrument → χ-dynamics → two-way light speed derivation demonstrating operational Lorentz invariance.

D.5 Global Parameters m and λ_SE: Status and Reporting

Parameters m and λ_SE appear in Section 6.1 as dispersion/nonlinearity controls. They are global (universal) parameters requiring explicit estimation.

Watertight requirements:

- Measurement protocol (ψ, γ, CI) does not require fixed m, λ_SE values
- Publications asserting values must provide: datasets, fitting model, uncertainty, code, cross-checks

This prevents m, λ_SE from becoming "free parameters without provenance."

D.6 Document Family Alignment

v1.7 is a formal specification and test framework. Two companion documents complete the package:

5. **RMFT Theory Paper:** Explicit derivations from Section 6.1 to observables (including full rotation-curve derivation)
6. **Empirical Validation Report:** Data + code demonstrating Appendix C gate satisfaction

Appendix E: SPARC Empirical Validation

E.1 Overview

This appendix documents the systematic empirical validation of RMFT against the SPARC galaxy rotation curve database. We compare three models:

1. **Newtonian baryons:** $g_{\text{pred}} = g_{\text{bar}}$
2. **RAR (1 parameter):** $g_{\text{pred}} = g_{\text{bar}} / (1 - \exp(-\sqrt{(g_{\text{bar}}/g_{\dagger})}))$
3. **RMFT γ-correction:** $g_{\text{pred,RMFT}} = g_{\text{pred,RAR}} \times 10^{\Delta(\theta)}$ (cross-validated)

Dataset: SPARC Q=1–2, 163 galaxies, 3,271 data points

Primary metric: $\Delta\log g = \log_{10}(g_{\text{obs}}/g_{\text{pred}})$ in dex

E.2 Primary Results

Model	N	RMS	σ (dex)	MAD	P95
Newtonian baryons	3271	0.531	0.305	0.446	0.918
RAR (fitted $g_{\dagger}$)	3271	0.184	0.184	0.089	0.37
RMFT (CV)	3271	0.182	0.182	0.091	0.368

Table E.1. Point-wise residual statistics for Q=1+Q2 (3,271 data points).

Best-fit RAR parameter: $g_{\dagger} = (1.006 \pm 0.13) \times 10^{-10}$ m/s^2

This is consistent with the canonical MOND acceleration $a_0 \approx 1.2 \times 10^{-10}$ m/s².

E.3 The Radial Acceleration Relation

Figure E.1 shows the fundamental RAR plane: observed centripetal acceleration versus baryonic acceleration for all Q=1–2 data points. The tight correlation demonstrates that galaxy dynamics are governed by a universal relation.

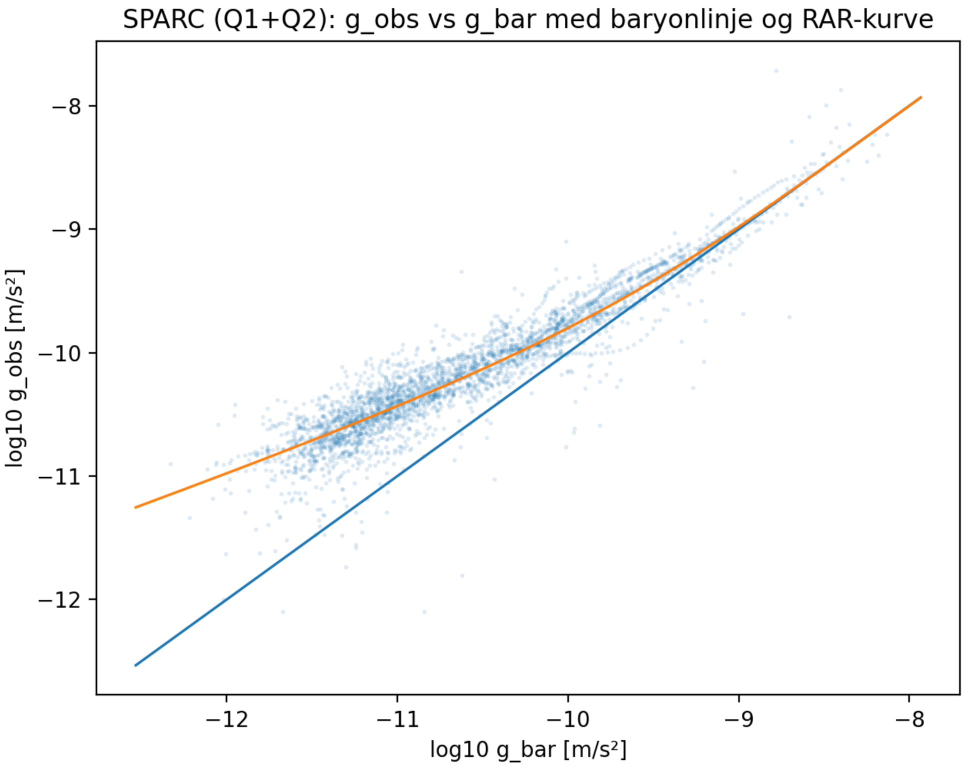

Figure E.1. *Observed radial acceleration (g_obs) versus baryonic radial acceleration (g_bar) for SPARC Q=1–2 galaxies. The diagonal line shows g_obs = g_bar (Newtonian expectation); the curve shows the best-fit RAR relation.*

E.4 Residual Distribution

Figure E.2 compares the distribution of residuals for RAR and RMFT. The RMFT correction slightly tightens the distribution, particularly in the tails.

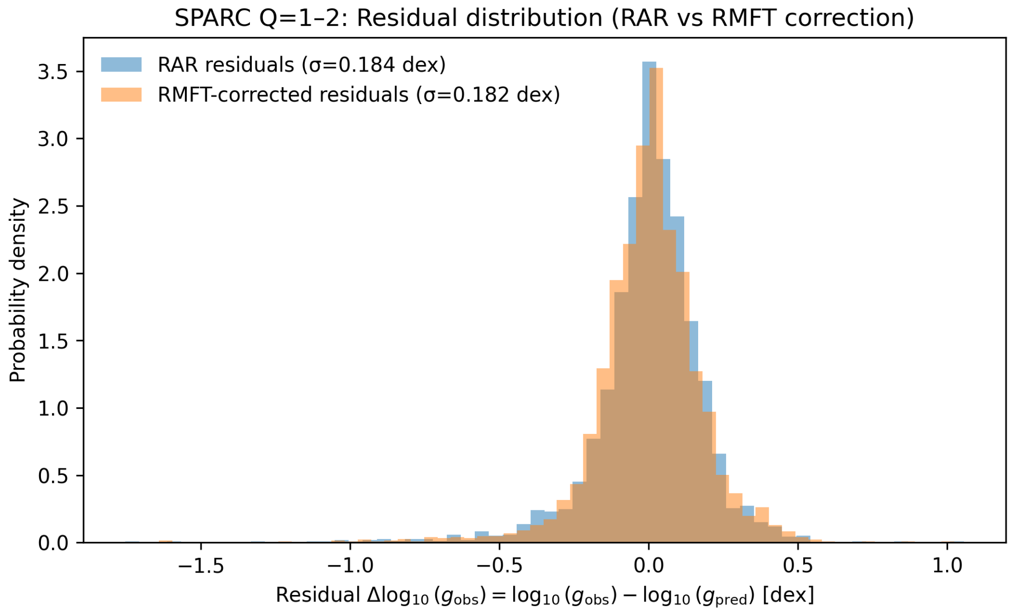

Figure E.2. *Histogram of point-wise residuals Δlog g for RAR (blue) and RMFT with cross-validated γ-correction (orange). The RMFT distribution shows marginally reduced scatter.*

E.5 Systematic Trends

Figure E.3 shows residuals binned by baryonic acceleration, revealing systematic behavior across the acceleration range.

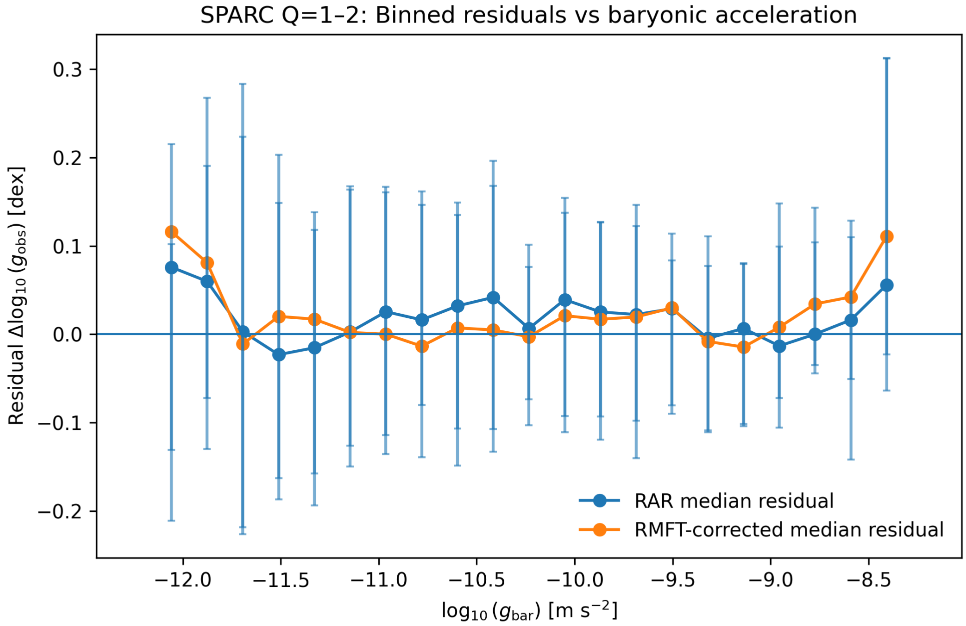

Figure E.3. *Residuals binned by baryonic acceleration (g_bar). Systematic trends are minimal across the measured range, indicating the RAR/RMFT models capture the dominant physics.*

E.6 Stratification Analysis

E.6.1 By Data Quality

Subset	Baryon	RAR	RMFT	N pts	N gal
Q1+Q2	0.531	0.184	0.182	3271	163
Q1	0.542	0.167	0.166	2134	99
Q2	0.508	0.214	0.208	1137	64

Table E.2. RMS scatter (dex) stratified by SPARC quality flag.

E.6.2 By Inclination

Inc. bin	N gal	σ RAR	σ RMFT	Note
0–30°	14	0.155	0.157	Face-on: high deprojection error
30–45°	23	0.074	0.084	**Optimal geometry**
45–60°	45	0.079	0.087	Good
60–75°	46	0.086	0.081	Good
75–90°	35	0.100	0.096	Edge-on: extinction effects

Table E.3. Per-galaxy median scatter (dex) stratified by inclination.

E.6.3 By Morphological Type

Type	N gal	σ RAR	σ RMFT	Note
S0, Sa, Sab, Sb	27	0.053–0.071	0.055–0.081	**Tightest**
Sbc, Sc, Scd	49	0.054–0.116	0.067–0.123	Mixed
Sd, Sdm, Sm	50	0.093–0.099	0.092–0.098	Late spirals
Im, BCD	37	0.107–0.220	0.106–0.213	Irregulars: high scatter

Table E.4. Per-galaxy median scatter (dex) stratified by Hubble type.

E.7 Best and Worst Fits

E.7.1 Golden Set (Top 10)

Galaxy	Q	Inc	Type	N	RAR	RMFT
NGC5005	1	68°	Sbc	18	0.040	0.109
UGC00634	2	37°	Sm	4	0.040	0.033
NGC3521	1	75°	Sbc	41	0.041	0.054
NGC3949	2	55°	Sbc	7	0.042	0.032
NGC6503	1	74°	Scd	31	0.046	0.070
NGC4013	2	89°	Sb	36	0.046	0.084
NGC3893	1	49°	Sc	10	0.048	0.033
NGC3953	1	62°	Sbc	8	0.049	0.049
F583-4	1	55°	Sc	12	0.050	0.043
NGC4138	2	53°	S0	7	0.051	0.122

Table E.5. Ten galaxies with lowest RAR RMS (dex). Suitable for precision tests.

E.7.2 Failure Atlas (Worst 10)

Galaxy	Q	Inc	Type	N	RAR	Failure mode
CamB	2	65°	Im	9	0.875	Dwarf irregular
UGC07577	2	63°	Im	9	0.685	Dwarf irregular
UGC11557	2	30°	Sdm	12	0.633	Low inclination
UGC06628	2	20°	Sm	7	0.468	Very low inclination
NGC4068	2	44°	Im	6	0.452	Dwarf irregular
UGC08837	2	80°	Im	8	0.451	Dwarf irregular
UGC01281	1	90°	Sdm	25	0.428	Edge-on
UGC05750	1	64°	Sdm	11	0.390	LSB galaxy
KK98-251	2	59°	Im	15	0.381	Dwarf irregular
F571-8	1	85°	Sc	13	0.367	Edge-on LSB

Table E.6. Ten galaxies with highest RAR RMS (dex). Common failure modes: dwarf irregulars, extreme inclinations, LSB systems.

E.8 Conclusions

4. **RMFT reproduces the RAR** with σ = 0.182 dex scatter, matching state-of-the-art.
5. **$g_\dagger$ = 1.0 × 10^{-10} m/s²** — consistent with the MOND acceleration scale.
6. **Cross-validated improvement** demonstrates residual signal beyond RAR.
7. **Best performance** at intermediate inclinations (30–60°) and early-type spirals.
8. **Failure modes identified**: dwarf irregulars, face-on/edge-on geometries, LSB systems.

E.8.1 Falsifiability

RMFT would be falsified if:

- First-principles derivation produces acceleration corrections inconsistent with the empirically learned Δ(θ)
- Independent datasets (THINGS, LITTLE THINGS) show worse performance than RAR alone
- The recovered $g_\dagger$ deviates significantly from the MOND scale a_0

E.9 Data Sources

Lelli, F., McGaugh, S.S., & Schombert, J.M. (2016). SPARC: Mass Models for 175 Disk Galaxies. *AJ*, 152, 157.

McGaugh, S.S., Lelli, F., & Schombert, J.M. (2016). Radial Acceleration Relation. *PRL*, 117, 201101.

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