Structural Field Theory (SFT): A Verification-First Protocol

A verification-ready protocol for testing a single-field structural-medium model (v0.2 draft)

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Abstract

Structural Field Theory (SFT) is a monistic structural-medium framework in which observed phenomena arise as stable configurations of a single scalar field S. Definition (Ontology): there is only underlying phenomenon—structural micro-distortion of S—whose localized, topological, and propagating configurations realize all observed entities and interactions. Mass, spin, charge, gauge-like behavior, and gravitational response are manifestations of tensional geometry and its evolution, not independent postulates. This paper delivers a verification-ready protocol— artifacts, schemas, hash manifests, and pre-registered pass/fail gates—so independent reviewers can evaluate claims without trusting the authors. We enforce a strict separation between calibration (C) and prediction (P), and we provide an external-verification contract specifying the minimal solver outputs required to test key modules (EM mapping, a gravity/PPN bridge, and an emergent spin-½ signature). The distributed bundles in this release certify the verification pipeline (CPU-only checks, schema validation, deterministic gating) and include reference datasets for regression and audit. Physical confirmation of SFT requires third-party generation of real solver outputs on at least two resolutions under the published gates. This release validates the verification pipeline; physical validation requires independent real-solver runs.

Keywords:
Verification protocol; reproducibility; external audit; artifact contract; schema validation; pre-registered thresholds; computational physics; emergent phenomena.

1. Introduction

Many physical quantities currently enter our best models as inputs: coupling constants, particle properties, and medium-like parameters that are measured rather than derived. SFT explores an alternative stance: treat the "vacuum" as a structural medium and treat what we call matter as stable, medium-compatible configurations of a single underlying field.

This paper is deliberately verification-first: we focus on what an external reviewer can run, check, and falsify.

SFT is not presented as a replacement for the Standard Model, but as a complementary structural-medium hypothesis aimed at explaining why the observed stable configurations exist.

The Standard Model remains the reference phenomenology; SFT targets a causal/mechanistic layer beneath it. Nothing in this release disputes the Standard Model's empirical success; the intent is a reinterpretation at the level of existence/conditions, evaluated only through pre-registered gates and external runs.

- Deliverable: a protocol and tooling that minimizes trust in authors (schemas, manifests, deterministic seeds, pass/fail gates).
- Scope: EM + gravity/PPN bridge + an emergent spin-½ route; not a full Standard Model replacement (yet).
- Status: ready-to-test, not yet globally confirmed end-to-end without external solver outputs.

2. Minimal framework (what is being tested)

SFT assumes a single real scalar field S (dimensionless in the discrete model), interpreted as the structural degree of freedom of the medium often called "vacuum." Matter corresponds to stable, localized or topological configurations of S; dynamics is discrete-first with a controlled continuum limit.

Interpretation (minimal): S encodes the local structural/tensional state of the medium. Stable, medium-compatible configurations of S correspond to what we describe as matter; propagating disturbances correspond to radiation modes. All statements in this paper are operationalized via exported artifacts and pass/fail gates.

2.1 Minimal dynamics (presentation-level)

We keep the main text minimal; detailed model choices live in the accompanying corpus.

Continuum reference (for orientation):

```
L0 = 1/2 (∂µ S)(∂^µ S) − V(S)
```

Discrete runs must demonstrate controlled systematics (energy/continuity budgets, dispersion fits, convergence checks).

2.2 Operational notion of existence (natural vs maintained)

A configuration "exists" in SFT if it is stably compatible with its medium, in a way that can be certified over a non-empty region of medium parameters under declared gates.

- Natural existence: stability holds in the ambient medium (no declared upkeep).
- Maintained existence: stability holds only when minimal declared controls (BCs, confinement, fields, filtering, etc.) are applied; ablation removes PASS.

3. Operational dictionary and audit artifacts

3.1 Compatibility operator and "existence region"

For a target configuration S and medium levers M, SFT defines a compatibility operator $\mathcal{C}$ [S;M] collecting constraints such as continuity, energy ledgers, dispersion control, EM consistency constraints (as implemented), and (when applicable) PPN mapping checks. Existence is certified by scanning or optimizing M to minimize $\|\mathcal{C}\|$ and by exporting an existence region $\mathcal{R}$ where gates PASS. Constraints are implemented as explicit verifiers over exported artifacts, not as hidden fit degrees of freedom.

3.2 Electromagnetism: derived potential and domain of validity (brief)

In this release, electromagnetism is treated as a derived description over the structural field rather than as an additional independent set of degrees of freedom. Specifically, the effective phase/angle variable θ is defined only under explicit coarse-graining assumptions (e.g., narrowband / slowly-varying regimes), and the electromagnetic potential Aμ is introduced as a functional of exported S-artifacts via a fixed Green/operator construction. Aμ is therefore not an independently tunable DOF, although it may be non-local at the potential level.

- Domain notes:
- θ-definition: valid in regimes where phase extraction is stable under declared windows (narrowband / coarse-grain). Outside those regimes, θ is treated as undefined rather than forced.
- Near R≈0 (core/defect center): EM mapping may require excision/regularization; the excision rule and window are treated as declared inputs and must be reported in SCAN metadata.
- No extra DOF: any apparent freedom in Aμ is fixed by the chosen Green/operator and boundary conditions; changes must be treated as model variants and pre-registered.

3.3 Artifact contract (SCAN → REGION → REPORT)

Any externally verifiable claim must provide a minimal artifact chain:

- SCAN: raw sweep results (CSV/JSON) with provenance (grid, BCs, solver version/hash, seed).
- REGION: a mask or list of PASS points defining an existence region $\mathcal{R}$ with at least one PASS voxel.
- REPORT: compact JSON summarizing verdict (natural/maintained/fail), thresholds, maintenance cost ΔM, robustness τ (with CI), and hashes.

JSON policy: sanitize NaN/Inf to null; enforce schema_version='1.0.0'; validate against published schemas; hash everything (SHA-256) with a manifest including a self-hash.

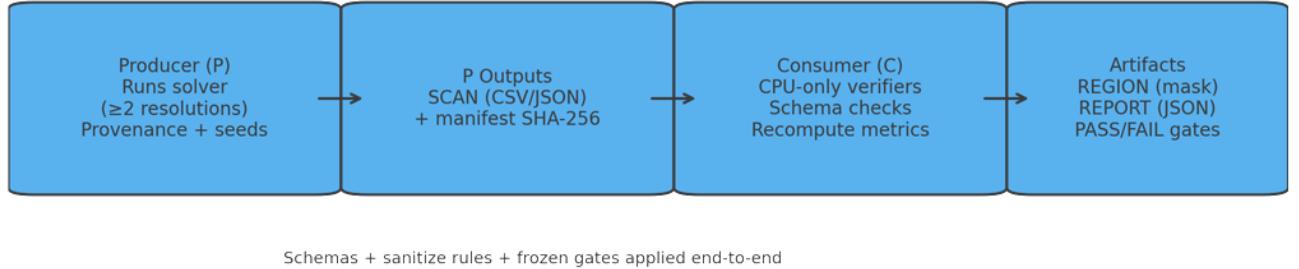Schemas + sanitize rules + frozen gates applied end-to-end

Figure 1. Verification pipeline: Producer (P) generates SCAN artifacts; Consumer (C) re-computes metrics, validates schemas/hashes, and emits REGION + REPORT under frozen gates. All PASS/FAIL results must be reproducible from SCAN alone (single source of truth).

3.4 Calibration (C) vs prediction (P) discipline

To limit degrees of freedom, SFT uses a single-pass calibration pipeline. Calibration outputs (q^*, $\hbar^*$, ε^*, μ^*, etc.) are frozen and reused across demonstrations without per-observable retuning. Any "α-out" estimation is a separate, pre-registered exercise and does not affect the validity of α-in runs.

- α-in: α is treated strictly as an input used during EM calibration.
- α-out: optional pipeline estimating α from SFT-native observables without injecting α during calibration.
- Doc 15 (Alpha-Elasticity CI Suite) provides a CI/synthetic, verification-first protocol for alpha-like estimators (anti-leakage + preregistered gates) and should not be conflated with α-out.

4. Verification protocol and gates

This section summarizes default gates used in the distributed runner packs. Gates may be tightened, but should never be loosened post hoc for a claim. All gates must be declared in the REPORT and repeated in the REGION/SCAN metadata. For any REAL run, all thresholds must be locked (pre-registered) before solver execution and referenced by gate_id in the REPORT.

Module / claim	Status	Key P output	C verifier	Metric	Default gate	Notes (CI vs REAL)
Energy/continuity QA	REAL-ready	ENERGY_REPORT.json	verify_energy.py	$\Delta E/E$	$\Delta E/E \leq$ 1e−3	[REAL] Also report ledger/continuity residuals + convergence.
Dispersion (small-k)	REAL-ready	dispersion_smallk.csv	fit_dispersion.py	c, R^2_smallk	$R^2 \geq 0.98$; $|\Delta c|/c \leq$ 1%	[REAL] Declare k-window; run ≥2 grids.
EOC / convergence (CI)	CI	EOC_synthetic.csv	test_eoc_ci.py	p, R^2	$1.70 \leq p \leq$ 2.05; $R^2 \geq$ 0.995	[CI] Pipeline health-check only (synthetic).
AtomX existence	CI	synthetic_atom_scan.csv	verify_atomX.py	split, compat, R^2	split ≤ 0.19 meV; compat ≤ 0.02; $R^2 \geq$ 0.98	[CI] Demonstration thresholds; use ablation for maintained vs natural.
Hydrogen 2s–2p	CI	COMPATIBILITY_SCAN_H.*	verify_hydrogen.py	split, compat, R^2	split ≤ 0.10 meV; compat ≤ 0.02; $R^2 \geq$ 0.98	[CI] Demonstration; REAL validation requires solver outputs + convergence.
Double slit	CI	visibility.csv, shift.csv	verify_double_slit.py	phase R^2, V monotone	$R^2 \geq 0.98$; sat ≤ 0.10; monotone↓	[CI] Synthetic by default; REAL requires solver-generated CSVs.
Venus perihelion (overlay)	REAL-ready	varpi_series.csv	verify_venus_real.py	slope, R^2	|slope−8.624984| ≤ 0.20; R^2 ≥ 0.999	[REAL] Fit interval predeclared; report sensitivity.

| α-out (optional) | REAL-ready | DISPERSION_LINEAR.json, HBAR_FROM_ROTOR.json, Q_EPS_SOLUTION.json | compose_alpha_out.py | tier error | Tier-1 ≤ 1%; Tier-2 ≤ 1e−4; Tier-3 ≤ 1e−6 | [CI+REAL] CI validates plumbing; tiers require REAL components without α injection. |
| PPN bridge (optional) | REAL-ready | ppn_summary.json | verify_ppn.py | | \|β−1\| ≤ 1e−2; \|γ−1\| ≤ 1e−2 (placeholder) | [REAL] Thresholds must be pre-registered (locked in a gates file/commit) before any REAL run; REPORT must reference the gate_id. |

Note: An additional CI-only protocol for an **alpha-like estimator** (anti-leakage, preregistered decision rule hashing, null/adversarial controls) is provided in **Doc 15**. This is a verification methodology appendix and is not a physical α validation.

Important: CI bundles certify the verification pipeline only; physical claims require REAL solver outputs under the published gates.

Synthetic CI modules certify tooling integrity (schemas, manifests, regression gates) in CPU-only environments. Scientific claims require P outputs produced by a real solver on at least two resolutions under the declared gates.

5. Alpha as a normalized elastic property of the structural medium

We adopt a monistic structural-medium view: all observables arise as stable configurations of a single field S. In this context, dimensionless couplings may be interpreted as normalized material properties of the underlying medium rather than arbitrary numbers.

We define a measurable stiffness proxy via the energetic response to controlled perturbations. For a baseline state S0, impose $\delta S(x) = \varepsilon \cos(k \cdot x)$ and compute the energy increment $\Delta E(\varepsilon, k)$. The effective spectral stiffness is $K_{eff}(k) = (1/V) * \partial^2 \Delta E / \partial \varepsilon^2 |_{(\varepsilon=0)}$. This definition is operational and directly auditable from solver outputs.

In SFT the fine-structure constant is expressed as $\alpha = q^{*2}/(4\pi \varepsilon^* \hbar^* c)$, highlighting α as a dimensionless ratio between an emergent electrostatic scale ($q^{*2}/4\pi \varepsilon^*$) and the medium's action–propagation scale ($\hbar^* c$). We therefore interpret α as a normalized compliance

parameter of the structural medium. An extended note (definitions, dimensional sanity, and external-verification contract) is provided in Appendix C.

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K_eff(k) = (1/V) * ∂²ΔE/∂ε² |_(ε=0)

α = q*^2 / (4π ε* ℏ* c)
```

6. External verification contract

6.1 Producer (P): what third parties must generate

To evaluate SFT claims, a third party must generate solver outputs with full provenance and at least two resolutions:

- Solver provenance: version/hash, grid(s), Δt/CFL, BCs, seeds, and any AMR thresholds.
- Module outputs: the CSV/JSON artifacts listed in Table 1 for the modules under test.
- Integrity: MANIFEST_SHA256.txt with SHA-256 of all exported files (plus self-hash).

6.2 Consumer (C): CPU-only verification

A reviewer runs CPU-only scripts that:

- Verify hashes and schema compliance (schema_version='1.0.0', JSON sanitize).
- Recompute metrics and PASS masks from the SCAN artifacts (single source of truth).
- Emit REGION and REPORT artifacts with explicit thresholds and PASS/FAIL outcomes.

7. Limitations and roadmap (explicit)

We adopt strict scope and labeling to avoid overclaim.

- Experimental validation is pending for several proposed tests; this release focuses on making validation short and auditable.
- Scope is currently limited to EM + gravity mapping and an emergent spin-½ route; weak/flavor/hadronic completeness remains future work.
- Discrete vs continuum tension is treated as controlled systematics: $O((a k)^2)$ corrections are measured and reported via dispersion and EOC scans.
- α-out is optional and must be reported separately from α-in calibration; it is a falsifiable add-on via predeclared tiers.

Roadmap (verification-first):

1. Complete a Global Consistency Index (GCI) across all validated systems under a single frozen parameter set.
2. Add tests/verifiers for EM mapping uniqueness/domain (fixed operator + gauge fixing; no extra DOF; BC sensitivity).
3. Upgrade at least one macro module (e.g., Venus overlay) to a real-solver run with published PASS/FAIL JSON and manifests.
4. Publish a minimal GPU run recipe for third parties (config + expected output files + gates) per module.
5. Collapse is treated as an effective rule in this release.

7.1 Known failure modes (reviewer checklist)

To keep the evaluation robust and non-permissive, reviewers should treat the following as common failure modes and reject runs that exhibit them unless explicitly pre-registered and justified.

- Leakage (features vs targets): any predictor derived using the target observable (directly or via rescaling) invalidates the claim. Use strict C vs P discipline and group-wise LOO where applicable.
- Post-hoc gate changes: thresholds must be declared before solver runs. Tightening is allowed only if applied retroactively to all runs; loosening is disallowed.
- Insufficient resolution / pre-asymptotic regime: claims require ≥2 resolutions and evidence of convergence (or an explicit pre-asymptotic analysis).
- Boundary-condition artifacts: show BC sensitivity (or mitigation) and document BC choices in SCAN metadata; reject results that vanish under modest BC perturbations.
- Non-reproducible PASS masks: PASS/FAIL must be reconstructible from SCAN alone (single source of truth) using the published verifiers and schemas.

8. Conclusion

SFT is released as a verification-ready protocol: definitions, artifacts, schemas, and pass/fail gates. The present status is ready-to-test rather than confirmed. Independent third-party solver runs producing the published P outputs are required to evaluate the main claims under the declared gates.

Appendix A. Notation and conventions (short)

- Signature and units; normalization of S in the discrete model.
- Definition of c from small-k dispersion; definition of correlation length if used.
- PPN mapping conventions if the gravity bridge is tested.

Note on units: energy units such as "meV" in CI bundles are internal labels unless explicitly mapped; any physical-unit mapping must be declared per module in the REPORT metadata.

Appendix B. Verification Pack contents (one page)

Bundles included (representative):

- External Review Pack [CI] (ALL_CHECKSUMS): Top-level reviewer bundle: schema validation + manifest checks + demo SCAN→REGION→REPORT artifacts.
- AtomX [CI] (Designed matter demo): Step-by-step recipe + CI scan/region/report; illustrates natural vs maintained via declared controls/ablation.
- Hydrogen radial [CI] (Phase-2 golden): Numerical QA bundle: 2s–2p degeneracy gate, normalization + virial checks (solver correctness sanity test).
- EOC CI synthetic [CI]: CPU-only regression test ensuring observed order-of-convergence tooling behaves correctly (synthetic smoke test).
- Optics null tests [CI]: Birefringence/dispersion null-analysis gates; demonstrates proceed/hold logic and stability checks.
- Double-slit verifier [CI]: Phase-fit and visibility saturation gates; synthetic-by-default CI harness + hooks for real solver CSVs.
- Venus perihelion verifier + real overlay [REAL-ready]: Extraction/fit/verification pipeline for perihelion slope; ready to consume third-party orbit outputs.
- Spin Appendix S runner [REAL-ready]: Fermi-rotation ($2\pi \rightarrow \pi$ phase) + rotor spectrum gates; robustness requires ≥2 grids and ≥2 seeds in REAL runs.
- α-out runner [REAL-ready] (with schema checks): Optional pipeline composing α from dispersion, rotor, and Coulomb/energy components; CI validates plumbing; REAL needed for tiers.
- Alpha-Elasticity CI Suite [CI] (Doc 15): Synthetic verification protocol for an alpha-like estimator (DECISION_RULE.json + decision_rule_sha256 + null/adversarial gates + manifest integrity). Demonstrates PASS/FAIL audit semantics; not a physical α claim.

Quickstart (reviewer):

1) Verify hashes → 2) Validate schemas → 3) Run verifiers on provided artifacts → 4) Swap synthetic CI inputs for real solver outputs (P) and re-run gates.

Recommended minimal external (P) deliverables for a 'REAL' verification run:

- At least two resolutions (grids) per module; report convergence or GCI.
- Full provenance (solver version/hash, BCs, Δt/CFL, seed(s), platform).
- Module outputs exactly as named in Table 1 (or documented equivalents), plus MANIFEST_SHA256.txt.
- No post-hoc gate changes: thresholds must be declared before running the solver.

Appendix C. Alpha note (extended)

This appendix contains the longer, reviewer-safe note supporting Section 5. It is included for completeness and for external verifiers who wish to implement α-out and stiffness diagnostics.

Purpose. This note rewrites the intuition "alpha measures the rigidity of the S medium" in a reviewer-safe way: dimensionally consistent, operationally defined, and externally verifiable without requiring the author to run GPU-scale simulations.

1. Paper-ready text (3 paragraphs)

We adopt a monistic structural-medium view: all observables arise as stable configurations of a single field S. In this context, dimensionless couplings are naturally reinterpretable as normalized material properties of the underlying medium rather than as arbitrary numbers.

We define a measurable stiffness proxy of the medium through its energetic response to controlled perturbations. For a baseline state S0, impose $\delta S(x) = \varepsilon \cos(k \cdot x)$ and compute the total energy increment $\Delta E(\varepsilon, k)$. The effective spectral stiffness is defined as $K\_eff(k) = (1/V) * \partial^2 \Delta E / \partial \varepsilon^2 \,|\_{(\varepsilon=0)}$. This definition is operational and directly auditable from solver outputs.

In SFT the fine-structure constant is expressed as alpha = $q^{*\wedge}2 / (4\pi \, \varepsilon^* \, \hbar^* \, c)$. This highlights alpha as a dimensionless ratio between an emergent electrostatic scale ($q^{*\wedge}2/4\pi \, \varepsilon^*$) and the structural action–propagation scale ($\hbar^* \, c$) of the medium. We therefore interpret alpha as a normalized compliance parameter of the structural medium; its quantitative value is delegated to external verification via the alpha-out pipeline.

2. Definitions and dimensional sanity

Key point: alpha is dimensionless. A Young's modulus E has dimensions (energy/volume). So the correct statement is not "alpha equals Young's modulus", but that alpha can parameterize a normalized stiffness/compliance once a reference scale is fixed by the model's dimensional constants (a, t0, kappa, $\hbar^*$, q^*, etc.).

3. Operational stiffness proxy (external-verification friendly)

Baseline: choose a background state S0 (vacuum or specified steady background).

Perturbation: $\delta S(x) = \varepsilon \cos(k \cdot x)$ with small ε and chosen wavevector k.

Measurement: for each (ε, k), compute total energy $E(\varepsilon, k)$ from the solver's energy functional.

Definition: $\Delta E(\varepsilon, k) = E(\varepsilon, k) - E(0, k)$. Then define:

$K\_eff(k) = (1/V) * (\partial^2 \Delta E/\partial \varepsilon^2)$ evaluated at $\varepsilon = 0$.

Practical estimation: evaluate ΔE at a small symmetric set of ε values (e.g., $\pm \varepsilon 1$, $\pm \varepsilon 2$) and fit a quadratic in ε. Report $K\_eff(k)$ with confidence intervals and convergence checks across at least two grid resolutions.

4. Length scales without ad hoc assumptions

If the linearized dynamics around S0 admits a dispersion $\omega^2 \approx c^2 k^2 + m\_eff^2$, then a natural correlation length is:

$\xi = c / m\_eff$.

Here m_eff^2 can be estimated either from the curvature of the effective potential around S0 (V''(S0)) or from a small-k dispersion fit. This avoids asserting $\xi = 1/alpha$ without derivation.

5. What "alpha as rigidity" means in SFT (reviewer-safe wording)

Because alpha $= q^{*\wedge}2/(4\pi \varepsilon^* \hbar^* c)$, alpha quantifies how strongly the emergent electrostatic scale competes with the medium's action–propagation scale. Interpreting alpha as a normalized compliance is therefore a statement about a ratio of scales, not an identification with a dimensional modulus.

Optional (one-sentence intuition): smaller alpha corresponds to a medium that is harder to polarize into EM response per unit structural action–propagation, in the chosen normalization.

6. External verification contract (minimal P outputs + C verifiers)

To validate the interpretation with third-party compute, separate:

P (producer): generates solver outputs on target grids/BCs.

C (consumer): runs CPU-only verifiers that compute K_eff(k), ξ, and alpha-out components.

Minimum producer outputs (examples):

energy_vs_eps_k.csv (or JSON) with E(ε,k) on at least two grids.

dispersion_smallk.csv with ω(k) for small k on matching grids.

coulomb_profile.csv and field_energy.json (if composing q*, ε*), using declared windows/cutoffs.

rotor_spectrum.csv plus I(S) report (if composing ℏ*).

Minimum consumer verifiers (CPU-only):

fit_stiffness.py: estimates K_eff(k) + CI + convergence summary.

fit_dispersion.py: estimates c and m_eff (and thus ξ) + CI.

compose_alpha_out.py: composes alpha-out with tier thresholds.

7. Framing notes (avoid overclaim)

Use "interpret" / "parameterizes" / "is consistent with" rather than "equals" when speaking about elastic moduli. Mark toy profiles (e.g., hedgehog) as illustrations, not derivations. Reserve "validated" for cases where producer (P) outputs from the real solver are provided and pass the published gates.

Appendix D.

• "The Standard Model answers *what we observe* with extraordinary precision."

• "SFT asks a different question: *under what structural conditions do the observed stable configurations exist at all?*"

• "This is a shift from phenomenological description to constraints on existence and stability."

• "It is not presented as competition, but as complementarity."

Conflict of Interest

The author declares no conflict of interest.

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Data Availability Statement

The data and verification artifacts supporting this study are available in the project repository (see "Repository" section) and in the associated release assets/manifests.

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10.17605/OSF.IO/S9UDZ

Repository Github: https://github.com/Xaquer69/sft-theory-and-runners MIT License

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