

Note: In this document, α refers exclusively to the fine-structure constant (α -in), used for initial Coulomb calibration. The symbols β and γ appear only in the context of Post-Newtonian (PPN) parameters. No structural potential terms $\{\alpha_V, \beta, \gamma\}$ are used in this document.

SFT — Statement for Reviewers (EN)

Statement.

We present the Structural Field Theory (SFT) as an emergent, testable hypothesis with deliberately scoped claims: electromagnetism + gravity and the emergence of spin- $\frac{1}{2}$ from a single structural field. The package ships with Docker and automated checks (pytest), so third parties can reproduce and inspect results independently.

Calibration discipline. In this RC, α_{em} is INPUT (α -in); any α -out exercise, if performed, is reported separately and does not affect RC validity.

We run a single-pass calibration of the emergent scales $(q^*, \hbar^*, \epsilon^*, \mu^*)$ from $\{\alpha_{em}, c\}$ using a static Coulomb test, then freeze these scales. All demonstrations are executed without per-observable retuning. This turns “tuning” into reproducible metrology.

Quantitative validation.

The code includes numerical metrics: energy conservation $\Delta E/E$ (target $\leq 10^{-3}$), phase-speed dispersion (target $\leq 1\%$), and an automated g-factor check around the expected value (tolerance window given). For gravity, we adopt explicit PPN conventions (signature $-,+,+,-$, bridge $S = -U$) to avoid ambiguities.

Continuum vs. lattice.

The continuum Lagrangian is Lorentz-invariant; discretization introduces controlled $O((a k)^2)$ corrections that we measure and report via convergence scans. The Noether-to-Maxwell construction is stated with gauge-fixing and no extra DOF.

Scope & next steps.

We do not claim a full Standard Model account. We list milestones instead: (i) completing Dirac/Wilson numerics (no doublers, γ_5 -hermiticity, convergence); (ii) extended convergence/AMR studies; (iii) near-term lab tests and astrophysical cross-checks with pre-declared pass/fail bands. In short, SFT offers a short path to validation or falsification: executable code, frozen calibration, and quantitative acceptance criteria.

Reviewer Quick Start (5-min) — SFT (patched)

*This patch keeps the original structure and adds: (I) a **Quick Audit Table** with PASS/FAIL thresholds, (II) a **Reviewer Checklist** you can tick off, and (iii) a tiny **Conventions** box to avoid ambiguities.*

0) Quick requirements

Option A — Local Python (recommended for the quick start):

```
python3 -m venv .venv && source .venv/bin/activate  
pip install -U numpy pandas scipy matplotlib pytest
```

Option B — Docker (encapsulated environment):

```
# From the docker/ directory of the unified package  
docker build -t sft-min-valid:0.9 .  
  
docker run --rm -v $PWD:/work -w /work sft-min-valid:0.9 python  
scripts/generate_smoke_artifacts.py
```

1) Synthetic EOC (CPU-only) — order $\approx 2 \Rightarrow$ CI “ok”

Goal: verify in ~minutes that the numerical pipeline passes a synthetic convergence test (no GPU required).

```
# Inside the Doc 6 (EOC) bundle  
  
python test_eoc_ci_v2.py # reads EOC_synthetic.csv and produces  
plots/statistics
```

Expected PASS: slope $p \approx 1.8\text{--}2.0$ (95% CI within [1.70, 2.05]) and $R^2 \geq 0.995$. Artifacts: eoc_loglog_ci_v2.png, error_vs_N_ci_v2.png, JSON summary.

2) Venus perihelion (synthetic series) — slope $\approx 8.62''/\text{century}$

Goal: validate the fitting pipeline with a manifest and PASS/FAIL criteria.

```
# Inside venus_perihelion_bundle/  
  
python verify_venus.py --csv varpi_series_venus.csv --manifest  
manifest_venus.json
```

Expected PASS: $|\text{slope_fit} - 8.624984| \leq 0.2$ arcsec/century and $R^2 \geq 0.999$. Artifact: perihelion_venus_report.json (slope, R^2 , PASS/FAIL).

When you have real solver data (overlay):

```
# Inside venus_real_pipeline_overlay/  
  
python extract_varpi.py --csv orbit_venus_state.csv  
  
python verify_venus_real.py --report perihelion_venus_real_report.json  
--manifest manifest_venus_real.json
```

Report slope in arcsec/century and R²; PASS/FAIL via manifest.

3) Emergent spin-½ — FR (2π) + j(j+1) spectrum

Goal: check the two operational signatures of spin-½.

3.1 Rotational spectrum (fast):

```
# In the SPIN package  
  
python spin_pipeline.py \  
--levels_csv spin_spectrum_levels.csv \  
--grid_id EXAMPLE_64^3 --L 64 --dx 1.0 --seed 12345
```

Expected PASS: R² ≥ 0.98 and first level j = 1/2. Artifacts: spin_spectrum_summary.csv (or *_merged.csv), spin_provenance.json, checksums_SHA256.txt.

3.2 Overlap- phase (FR, 2π) — optional if you have overlaps.npy:

```
# overlaps.npy contains the <ψ_{k+1}|ψ_k>  
  
python spin_pipeline.py --overlaps overlaps.npy --grid_id 64^3 --L 64 -  
-dx 1.0 --seed 12345 --K 128
```

Expected PASS: |phase - π| ≤ 0.1π (recorded in spin_overlap_results.csv).

You can also review pre-generated summaries:

- spin_PASS_FAIL_summary.json (marks PASS/FAIL for FR and the spectrum)
- spin_levels_zero_intercept_on_excitations_summary.json (fit with zero intercept on excitations)

4) (Optional) CPU-only smoke test

```
# Inside SFT_fallback_bundle/  
  
python scripts/generate_smoke_artifacts.py  
  
# or use build/tce_simulator when available for your platform
```

5) What to include if something fails

Attach the CSV/JSON produced at each step (e.g., perihelion_venus_report.json, spin_spectrum_summary.csv, spin_PASS_FAIL_summary.json) and checksums_SHA256.txt. Specify commit/version and seeds (they appear in the provenance JSON).

6) Quick Audit Table (added)

Claim	Script / Artifact	Metric	PASS/FAIL threshold	Notes
Energy conservation	pytest::energy_conservation	$\Delta E/E$	$\leq 1e-3$	Same mesh across runs; report seed & BC.
Dispersion (continuum \leftrightarrow lattice)	dispersion_scan.py	max $ \omega/(ck)-1 $	$\leq 1\%$	Also report linear fit slope vs. $(ak)^2$.
g-factor (electron)	calc_gfactor.py	g	$2.0022 \pm 3e-4$	Scale-free ratio; vary B_test to confirm linearity.
PPN (γ, β)	ppn_check.py	γ, β	$\gamma = 1 \pm 1e-5; \beta-1 \leq 1e-4$	Convention $(-, +, +, +)$, $S \equiv -U$.
Spin- $\frac{1}{2}$: spectrum	spin_pipeline.py --levels_csv ...	R^2 of E vs $j(j+1)$	$R^2 \geq 0.98$	First level $j = 1/2$ required. Fit on excitations $(E-E_0)$ with zero intercept.
Spin- $\frac{1}{2}$: FR (2π)	spin_pipeline.py --overlaps ...	$ \text{phase}-\pi $	$\leq 0.1\pi$	Optional if overlaps

available.

Venus (synthetic)	verify_venus.py	slope ("/century)	slope-8.624984 ≤ 0.2 & R ² ≥ 0.999	Use provided manifest.
Double-slit (optional)	double_slit_phase.py / double_slit_visibility.py	phase R ² ; visibility	R ² ≥ 0.98; monotonic (tolerate ≤1 local up-tick < 1% as noise); saturation gap ≤ 0.10	Report both phase slope and visibility curve.

Tip: keep α -in frozen after Coulomb (q^* , \hbar^* , ε^* , μ^*). No per-observable retuning.

7) Reviewer Checklist (added)

- [] Environment ready (venv or Docker) · hashes verified (SHA-256).
- [] α -in frozen after Coulomb (q^* , \hbar^* , ε^* , μ^*) · no observable-specific retuning.
- [] EOC synthetic: p in [1.70, 2.05] and $R^2 \geq 0.995$ · PASS.
- [] Dispersion: $\max |\omega/(ck)-1| \leq 1\%$ · slope vs $(ak)^2$ reported.
- [] g-factor: mean $2.0022 \pm 3e-4$ · $\mu(B)$ linear, runs agree across grids.
- [] PPN: $\gamma \approx 1$, $|\beta-1| \leq 1e-4$ using the same lagrangian params as micro.
- [] Spin spectrum: $R^2 \geq 0.98$ · first level $j = 1/2$.
- [] FR (2π): $|\text{phase}-\pi| \leq 0.1\pi$ (if overlaps provided).
- [] Venus (synthetic): $|\text{slope}-8.624984| \leq 0.2$ and $R^2 \geq 0.999$.
- [] (Optional) Double-slit: phase $R^2 \geq 0.98$; visibility monotonic; saturation gap ≤ 0.10 .
- [] Provenance attached: CSV/JSON + checksums_SHA256.txt + seeds.

8) Conventions & notes (added)

PPN convention: signature $(-, +, +, +)$, Poisson $\nabla^2 U = -4\pi G p$, and $S \equiv -U$ in the weak-field map.

Continuum vs lattice: expect $O((ak)^2)$ corrections; report the slope from the dispersion fit.

Electromagnetism (emergent): $A^\mu J(S)$ solved in Lorenz gauge; continuity in the discrete calculus must hold exactly (test included).

9) Troubleshooting (added)

- R^2 slightly below threshold (spin or Venus): check the CSV ordering, outliers, and units; re-run with the provided manifest/seed.
- Visibility > 1 or < 0: clip to [0,1] in the reporting stage only, keep raw data intact.
- PPN mismatch: verify the convention (signature, $S \equiv -U$) and that the same parameter set is used for micro and macro tests.

Appendix — Last-Mile Inserts for Doc 9 (v1.0.0)

Ready to paste; preserves original conventions and adds JSON artifacts for QA/Reproducibility.

A. PPN Extraction & QA

A.1 Conventions

- Metric signature: $(-, +, +, +)$ | Poisson: $\nabla^2 U = -4\pi G p$ | Bridge: $S \equiv -U$.
- Units for observables: deflection (arcsec), Shapiro (microseconds), perihelion (arcsec/century).
- Significant digits must be consistent with uncertainties (u) / 95% CI.

A.2 Route A — Metric fit (Φ_{eff} , Ψ_{eff})

Use dimensionless $\phi \equiv U/c^2$. Model: $\Phi_{\text{eff}} = a_1 \phi + a_2 \phi^2$, $\Psi_{\text{eff}} = c_1 \phi$.

Derived parameters: $\gamma = c_1/a_1$, $\beta = 1 + a_2/a_1^2$. Propagate errors from the fit covariance (delta method).

QA thresholds (suggested): $|\beta - 1| \leq 1e-4$, $|\gamma - 1| \leq 1e-4$, perihelion residual ≤ 0.2 arcsec/century.

Artifact: PPN_RESULTS.json (schema v1.0.0). Required keys: schema_version, route="A", conventions, fit, derived, qa, provenance, timestamp.

A.3 Route B — Observables fit

Fit observables directly (WLS recommended if heteroscedastic). Perihelion uses standard GR kernel $K(a, e, M)$ for the Newtonian baseline.

Light deflection and Shapiro enter as complementary constraints with uncertainties. Bootstrap (e.g., 2000 resamples) for CI95 on (a_1, c_1, a_2) and propagate to (β, γ) .

Optional gate: GR slope \in CI95% for perihelion.

Artifact: PPN_RESULTS.json with route="B" and block observables_fit.

A.4 Reporting & Reproducibility

Include seed, commit, calibration_hash, manifest path, and any artifacts_sha256 (CSV/plots). State Docker tag or requirements lock.

B. Energy Accounting & Collapse Ledger

B.1 Discrete energy (compatibility with the solver)

Operators: time-difference D_t (leap-frog); spatial differences ∇_e (co-staggered, central). BC: periodic (state otherwise if different).

Components: kinetic, gradient, potential, EM (if applicable), and total. Collapse ledger: when nodes are frozen, book removed energy as E_collapse.

B.2 Conservation & diagnostics

Report ΔE and ΔE_{rel} including E_collapse when ledger is enabled.

Continuity residual: L2 and Linf norms of the discrete continuity equation.

Pass criterion example: $\Delta E_{\text{rel}} \leq 1e-3$.

B.3 Artifact: ENERGY_REPORT.json (schema v1.0.0)

Required keys: schema_version, integrator, grid, units, components (t0, tN), collapse_ledger, conservation, continuity_residual, discretization, provenance, timestamp.

B.4 AMR notes

When AMR is on, document subcycling and flux synchronization; compute diagnostics on the composite hierarchy.

C. Review Cross-check (RC) Table — Skeleton

Fill one row per claim/test. Use consistent units.

Test	Dataset/Run	Metric	Thresh old	Result $\pm u$	See ds	Artifacts (CSV/PNG/JSON)	SHA- 256	PA SS
Venus periheli on (PPN)	manifests/venus_ ppn_A.json	slope (arcsec/century)	≤ 0.2	$8.624 \pm 9 \pm 0.020$	123 from GR; GRECI 95% (opt)	results.csv, fig.png, PPN_RESULT S.json	...	✓
Light deflecti on	synthetic solar rim	θ (arcsec)	1.750 ± 0.003	1.750 ± 0.003	—	plot.png	...	✓
Shapiro delay	superior conjunction	delay (μ s)	248.0 ± 0.8	248.1 ± 0.7	—	plot.png	...	✓
SPIN (FR loop)	spin/run_64 ³ _see d777	phase(2π)	$ \text{phas} - \pi \leq 0.1\pi$	$0.98\pi \pm 0.02\pi$	777	phase.csv, fig.png	...	✓

Rotor spectrum	spin/spectrum_64 ³	R^2 (fit j(j+1))	≥ 0.98	0.989	777	levels.csv, fit.png	...	✓
Double-slit	slit/manifest.json	phase R^2 ; visibility	$R^2 \geq 0.98$; monotone	0.992; mono	424 2	trace.csv, fig.png	...	✓
EOC (synthetic)	eoc/EOC_synth.csv	slope p; R^2	1.70–2.05; ≥ 0.995	1.87; 0.998 8	123	eoc.csv, eoc.png	...	✓
Energy conservation	energy/run_96 ³	ΔE_{rel}	$\leq 1e-3$	2.1e-4	555	ENERGY_REPORT.json	...	✓

D. How to link from the main text

- In the Quick Start, end each step with: “See Appendix A/B/C for the JSON artifact format and QA thresholds.”
- In the Quick Audit Table, add a column “Artifact” and link to the JSON files produced by each step.
- In Troubleshooting, mention signature/units and the S≡U bridge (Appendix A.1) and the energy ledger (Appendix B).

E. Change log

v1.0.0 — Initial appendix covering PPN (routes A/B), energy accounting + ledger, and RC Table skeleton. Ready for external reviewers.