

Mixed-species network entanglement: patterns, field comparisons, and constitutive tests

FDT analysis

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Abstract

Main and colleagues report remote entanglement of strontium and calcium configuration pairs, with local logic extending the optical link to mixed-species states and memory storage [1] (SC-008, L12; SC-010, L14; SC-011, L15). Fundamental Density Theory (FDT) reads these hosts, optical paths, and motional patterns as configurations of one medium. This manuscript’s reading identifies entanglement with shared density-gradient constraints on identical closed patterns, settled at their common strokes; under FDT’s core clause 0.1a every step is a system-wide settlement. This manuscript retains the source’s ensemble estimators, fitted and reconstructed fidelities, and fitted storage constants. The storage comparison separates a fitted fidelity at 10s from an offset-dependent fit, and the magnetic comparison separates a pair’s differential response from a field acting on either configuration. Five predictions test an additional helical-field source and a stipulated density-coupled constitutive response: twisted silica, coiled silica, asymmetric torsion polarimetry, a rotating disc, and isotope-substituted silica. The first four are conditional by construction, with existence and reversal content; the isotope test instantiates a stated density-sensitivity input. Every test includes a conventional comparator and a covariance-dependent decision rule. One exploratory exponent describes the storage data in sample and has no prospective status.

1 Framework and notation

The source status is experimental. For a source quantity, measured, observed, and reported attribute it to the source; fitted, reconstructed, and estimated state how the source obtains it, as its fits, reconstructions and estimates; derived and illustrative-assumed designate the corresponding operations here. Source citations of the form SC-number, L-number identify claims and physical source loci. Main et al.’s experimental description [1] fixes the apparatus; the seven invariants of core version 6.0 [2] fix the following framework.

The constants i , e and π denote the complex unit, natural-exponential base and circle ratio. The metric is denoted g , with components $g_{\mu\nu}$. Upright m, s, Hz, kHz, MHz, T, J and kg denote SI units: metre, second, hertz and its stated multiples, tesla, joule and kilogram. Core clause 0.1 states, “FDT has one substance, the omnium: matter = energy = spacetime.” Clause 0.1b states, “There are no separate particles and no boxes: there is only omnium, and omnium patterns.”

P-2 states, “The omnium is a vibrating elastic medium”, with excitations at its nodal lines “as sand collects on the nodes of a vibrating plate”. This manuscript’s reading treats the complete network as one plate: the modules occupy regions of it, and each host answers only to its local medium; hosts do not communicate with one another. P-2 states that “mode geometry is set by the boundary conditions (the clamps, P-3), not by the medium”. In this manuscript’s reading the driver and the boundary data select the joint mode, and analyser settings are boundary data for that selection; P-3’s clamps of nuclear confinement are a separate referent.

1.1 Energy, time, and the invariant speed

Energy E , rest mass m , path length d , and duration t enter the medium’s locked ratio; c is its invariant speed, and ε_0, μ_0 are its response coefficients. Core clauses 0.1a and I-2 give

$$\frac{E}{m} = c^2 = \frac{1}{\varepsilon_0 \mu_0} = \left(\frac{d}{t}\right)^2, \quad c = 299792458 \text{ m s}^{-1}. \quad (1)$$

The fixed speed is exact (U-01). Let q label a mode, E_q, m_q, ω_q its energy, equivalent mass and angular frequency; h is Planck’s constant, $\hbar = h/(2\pi)$ its reduced value, $\mathcal{T}_q$ the period and ℓ_q its path length. The period symbol renames the core’s period to reserve T for temperature. The bridges of clause 0.1a are

$$\begin{aligned} E_q &= m_q c^2 = \hbar \omega_q, \\ \mathcal{T}_q &= \frac{2\pi}{\omega_q} = \frac{h}{E_q}, \quad \ell_q = c \mathcal{T}_q = \frac{h}{m_q c}. \end{aligned} \quad (2)$$

Here ℓ_q is the Compton length. The support radius R_{box} is independent geometrical data. The massive leg has confinement eigenvalues; the null leg has periods and paths at the locked ratio. Quantised energy and constant speed put discreteness in that content; the curvature chart remains continuous.

Let G be Newton’s constant, F_{max} the maximum force, $d_{\text{min}}, t_{\text{min}}$ the one-sided length and time infima, and ℓ_P, t_P the Planck length and time. Core clause 0.1a and I-1 give

$$\begin{aligned} F_{\text{max}} &= \frac{c^4}{4G}, \quad F_{\text{max}} d_{\text{min}} t_{\text{min}} = \hbar, \\ d_{\text{min}} &= c t_{\text{min}}, \quad d_{\text{min}}^2 = \frac{\hbar c}{F_{\text{max}}} = \frac{4\hbar G}{c^3} = 4\ell_P^2, \\ d_{\text{min}} &= 2\ell_P, \quad t_{\text{min}} = 2t_P. \end{aligned} \quad (3)$$

The infimum bounds the self-similar hierarchy. It is no lattice spacing. I-2 states, “The identity is carrier-only.” It identifies photon, graviton, gluon, phonon, and magnon as the same spin-one excitation of the one medium. The identity concerns open excitations; closed matter patterns have the confinement content of I-5. There is no mediation and no carrier exchange. In this manuscript’s reading the 422 nm stroke between the modules (SC-054, L109) and the gate’s motional mode inside one module are this one carrier in two regimes.

1.2 The atlas and its three gravitational faces

Let $\mathcal{M}$ denote gravitating mass, R_s its gravitational radius, r_f a field-point radius, and r_c the inner cutoff. The branch tag is $\sigma = +1$ for exterior and $\sigma = -1$ for interior. The curvature ratio α_σ and

gap odds X_σ have the following A-1 meanings (I-3):

$$\begin{aligned}
R_s &= \frac{2G\mathcal{M}}{c^2}, & \alpha_\sigma(r_f) &= \left(\frac{R_s}{r_f}\right)^\sigma, \\
\alpha_{\text{ext}} &= \frac{R_s}{r_f}, \quad R_s < r_f, & \alpha_{\text{int}} &= \frac{r_f}{R_s}, \quad r_c \leq r_f < R_s, \\
0 < \alpha_\sigma &< 1, & \frac{\partial \alpha_\sigma}{\partial r_f} &= -\frac{\sigma \alpha_\sigma}{r_f}, \\
X_{\text{ext}} &= \frac{R_s}{r_f - R_s}, & X_{\text{int}} &= \frac{r_f}{R_s - r_f}.
\end{aligned} \tag{4}$$

The chart inventory is declared here. A-1 has geometric warrant and is the only applied chart in this network. Its field-point, configuration and source evaluations retain their branch tags. The A-2 computational coordinate β_σ has geometric warrant but is unused in force, optical, and density slots. The A-3 overlap, A-4 confinement, and A-5 mode tokens have their open range only: no value, threshold, ordering, sign, or trajectory. Their status is recorded below. The schematic saturation diagnostic $\alpha_{\text{core}} \rightarrow 1^-$ locates the skin at the fold. The A-1 seam at $\alpha_{\text{ext}} = 1/2$ lies at $r_f = 2R_s$; on the interior branch $\alpha_{\text{int}} = 1/2$ lies at $r_f = R_s/2$. The seam and the saturation fold are distinct objects.

Let α_0 and X_0 be baseline curvature and odds, and x a nonnegative fractional addition in odds. I-6 gives the bounded update

$$X = X_0(1 + x), \quad \alpha = \frac{\alpha_0(1 + x)}{1 + \alpha_0 x}, \quad x \geq 0. \tag{5}$$

Here bare α is exclusively curvature, and bare X exclusively odds. Fidelities and tomographic shares take neither slot.

Let F denote force and $\alpha_{1,\text{ext}}, \alpha_{2,\text{ext}}$ the two exterior source evaluations. The universal I-1 law is

$$F = F_{\text{max}} \alpha_{1,\text{ext}} \alpha_{2,\text{ext}} = \frac{c^4}{4G} \alpha_{1,\text{ext}} \alpha_{2,\text{ext}}, \quad F < F_{\text{max}}. \tag{6}$$

For the separate disjoint-spherical-support ansatz, let $R_{b,i}$ be support radii and $\mathcal{M}_i$ their masses, with centre separation d . The assumptions $R_{b,i} \geq R_{s,i}$ and $d \geq R_{b,1} + R_{b,2}$, with the cross-centre inputs $\alpha_{i,\text{ext}}(d) = R_{s,i}/d$, give the monopole reduction and its bound:

$$F = \frac{G\mathcal{M}_1\mathcal{M}_2}{d^2} \leq \frac{F_{\text{max}}}{4}. \tag{7}$$

Equality belongs to saturated equal supports at contact. The universal open curvature interval and force ceiling precede this ansatz. In GR the displayed monopole expression is the leading weak-field, slow-motion result.

Let ℓ_{opt} be optical distance, and let $d\Sigma_{\text{sph}}^2$ denote the unit-sphere angular line element. The optical face of I-3 is exact in the exterior radial chart:

$$d\ell_{\text{opt}}^2 = \frac{dr_f^2}{(1 - \alpha_{\text{ext}})^2} + \frac{r_f^2 d\Sigma_{\text{sph}}^2}{1 - \alpha_{\text{ext}}}. \tag{8}$$

The indices n_{iso} and n_{cone} denote, respectively, the isotropic optical index and the causal-aperture index of P-4. For refraction at an interface, $\mathcal{N}_1, \mathcal{N}_2$ are the two optical indices and θ_1, θ_2 the corresponding ray angles. I-3 and P-4 retain exact Snell law:

$$\mathcal{N}_1 \sin \theta_1 = \mathcal{N}_2 \sin \theta_2. \tag{9}$$

Let $G_{\mu\nu}$ denote the Einstein tensor, $T_{\mu\nu}$ the stress tensor, $g_{\mu\nu}$ the metric and κ the Einstein coupling; Greek tensor indices are summation labels. The third face is the unchanged EFE encoding:

$$G_{\mu\nu} = \kappa T_{\mu\nu}, \quad \kappa = \frac{8\pi G}{c^4}, \quad F_{\max}\kappa = 2\pi. \quad (10)$$

Curvature ratios are downstream evaluations of this geometry. The exterior atlas of a source and the interior chart of its bound configuration are two charts, with no transfer map. The configuration's room radius R_{room} comes from data, and an interior datum uses its observation region and profile-weighted mean. The apparatus supplies no interior profile.

1.3 Clocks, neighbours, and phase

The clock factor $\mathbf{m}$ rescales a pattern's kept length and time together. Let $\mathcal{U}^\mu$ denote its four-velocity, normalised $g_{\mu\nu}\mathcal{U}^\mu\mathcal{U}^\nu = -c^2$, and $\mathfrak{P}^{\mu\nu}$ the spatial projector times c^2 . Clause 0.1c writes the bookkeeper's reading as

$$\begin{aligned} g_{\mu\nu} &\mapsto \mathbf{m}^2 g_{\mu\nu}, & d/t &= c, \\ \nabla_\mu \mathcal{U}^\mu &= -\mathfrak{P}^{\mu\nu} \partial_\nu \ln \mathbf{m}, & \mathfrak{P}^{\mu\nu} &= c^2 g^{\mu\nu} + \mathcal{U}^\mu \mathcal{U}^\nu. \end{aligned} \quad (11)$$

Motion at constant speed through a density gradient is gravity: the extended equivalence principle. On the pattern's own clocks and rulers nothing changes. A slow pattern reads the lapse $\sqrt{1 - \alpha_{\text{ext}}}$, while an open stroke reads equation (8); their leading weak-field readings differ by the I-3 factor of two. The conformal clock factor preserves null paths. For a perfect-form stress tensor, the medium's clock factor is its temperature at zero net conserved count, or its enthalpy per count at fixed entropy per count. This conditional statement concerns the medium's flow. A carried clock's thermal shift is the time dilation of its own thermal motion.

Let v be the infall speed and t_{own} the falling pattern's time. Clause 0.1c gives the exterior flow from rest far away:

$$\frac{dr_f}{dt_{\text{own}}} = -v, \quad v = c\sqrt{\alpha_{\text{ext}}}, \quad \frac{d^2 r_f}{dt_{\text{own}}^2} = -\frac{G\mathcal{M}}{r_f^2}. \quad (12)$$

A rotating source adds swirl; a gyroscope reads half its curl, with the leading Lense–Thirring limit. The flow operates at every size. I-3a reads curvature, tides and gradients between neighbours: two patterns or a pattern and a reference path. The trace reads density, the antisymmetric part reads vorticity, and the symmetric trace-free part reads shear. An extended pattern's quadrupole compares its skin with its centre path. Each field test below makes such a comparison.

For I-4, let ψ be a complex mode, A its amplitude, ϕ its helical phase, ϕ_0 its initial phase, ϕ_h its time-dependent phase, and ω its angular frequency. Let $\mathbf{e}_1, \mathbf{e}_2$ be orthonormal transverse Clifford vectors and $\mathbf{B}$ their oriented bivector. The cylindrical lift is

$$\psi = Ae^{i\phi_h}, \quad \phi_h = \phi_0 - \omega t, \quad i \longleftrightarrow \mathbf{B} = \mathbf{e}_1\mathbf{e}_2, \quad \mathbf{B}^2 = -1. \quad (13)$$

The real cylindrical radius is the mode amplitude, its azimuth is ϕ_h , and its longitudinal coordinate is the propagating path. The exponential $e^{\mathbf{B}\phi_h}$ is a dimensionless single-angle phase rotor, distinct from a half-angle spinor rotor. Observation fixes phase; ignorance of ϕ_0 is superposition in I-4. The universe is deterministic; there are no probability amplitudes. The mode has fixed field identity and no strand-count assignment.

1.4 Confinement and the mass ledger

Let D be the confinement operator, Ω its domain, B its boundary data, n the strand count, χ the chirality, and u_q a mode eigenfunction. The eigenfrequency ω_q multiplies the mode u_q . The dimensionless confinement-chart argument is written $\mathfrak{c}$ to keep t as time. I-5’s eigenproblem is

$$D(\Omega, B; n, \chi, \mathfrak{c})u_q = \omega_q u_q. \quad (14)$$

The operator is the owed O-9 construction. This expression assigns no mass formula, support radius or absolute chart address to an ion. Optical excitation, Raman rotation and optical pumping change configurations at fixed strand count; I-5 states that “changing class requires re-braiding the helix count — a topological transition, never a smooth shift”.

Let M be rest mass already counted, P pressure, V volume, T temperature, and a the radiation energy-density constant. The constant σ_{SB} is the Stefan–Boltzmann flux constant. I-7 writes

$$\mathcal{M} = M + \frac{E}{c^2} + \frac{PV}{c^2} + \frac{aT^4V}{c^2} + \cdots, \quad a = \frac{4\sigma_{\text{SB}}}{c}. \quad (15)$$

Each energy contribution enters once. Here the configuration energy is a change relative to the counted rest configuration, the cooled motion is a separate energy contribution, and radiation contributes through its energy density. Gravitational binding is not added as a local duplicate term. Exact conserved books close in the whole event, including outgoing open excitations.

1.5 Notation guard

The source’s analysis phase is ϑ , ensemble phase is ϖ , host count is N , and parity contrast is C . Its population share is $\mathcal{P}$, fidelity is $\mathcal{F}$, and target ensemble vector is Ψ_N . The operators $\hat{X}, \hat{Y}, \hat{Z}$ are Pauli operators; $\hat{X}_\vartheta$ is the analysis-axis operator and j indexes hosts. The configuration pairs are $\mathcal{Q}_{\text{net}}, \mathcal{Q}_{\text{mem}}, \mathcal{Q}_{\text{aux}}$. Their symbols always denote pairs of configurations. The mean phonon occupation is $\bar{n}_{\text{ph}}$. Upright S, P, D with subscripts are spectroscopic terms. The table below applies the complete source-symbol census.

Source notation	Present notation	Meaning retained
Analysis phase	ϑ	Analyser setting
Pauli symbols	$\hat{X}, \hat{Y}, \hat{Z}$	Configuration-pair operators
Circular-polarisation label	Circularly polarised	Optical preparation
Relative phase	ϖ	Ensemble parity phase
Qubit count	N	Number of hosts
Target ket	Ψ_N	Ensemble target
Product index	j	Host index
Mean occupation	$\bar{n}_{\text{ph}}$	Gate-mode occupation
Article “a”	No source quantity	a reserved for radiation
Fidelity	$\mathcal{F}$	Tomographic estimator
Term letters	Upright terms	Atomic configuration labels
Angular momentum	Ordered pair in words	Total value, projection
Population sum	$\mathcal{P}$	Two target populations
Qubit labels	$\mathcal{Q}_{\text{net}}, \mathcal{Q}_{\text{mem}}, \mathcal{Q}_{\text{aux}}$	Network, memory, auxiliary

These correspond to SC-078 (L151), SC-043 (L86), SC-051 (L105), SC-082 (L164), SC-063 (L137), SC-062 (L134), SC-081 (L160), SC-107 (L219), SC-085 (L173), SC-036 (L79), SC-029 (L71), SC-077 (L150), and SC-091 (L180).

2 The system chart

The source reports modules each containing one $^{88}\text{Sr}^+$ ion and one $^{43}\text{Ca}^+$ ion (SC-020, L49). The notation $\mathcal{B}$ denotes field magnitude and $\mathfrak{s}_{\text{net}}, \mathfrak{s}_{\text{mem}}, \mathfrak{s}_{\text{aux}}$ the signed frequency response of each configuration pair to that field. The table below separates the exterior geometry from the addressed configurations.

Region	Experimental referent	Chart and constraint
Each module	Surface-electrode Paul trap in an ultrahigh vacuum chamber (SC-027, L71; SC-028, L72)	A-1 exterior; region geometry from apparatus data
Network host	$\mathcal{Q}_{\text{net}}$: $(S_{1/2}, -1/2)$ and $(D_{5/2}, -3/2)$ (SC-036, L79)	Same braid class, distinct configurations
Memory host	$\mathcal{Q}_{\text{mem}}$: $(4, 0)$ and $(3, 0)$ (SC-037, L81; SC-038, L82)	Ground hyperfine pair
Auxiliary host	$\mathcal{Q}_{\text{aux}}$: $(4, +4)$ and $(3, +3)$ (SC-029, L71; SC-030, L72)	Ground hyperfine pair used for local gates
Optical link	Single-mode fibres, central herald station (SC-056, L112; SC-057, L114)	Open strokes; index and path geometry independently calibrated
Local gate	Driven mixed-species motional loop (SC-043, L86; SC-044, L88)	Phase-axis dynamics at fixed field identity

The source reports an approximately 0.5 mT bias (SC-033, L74) that sets the quantisation axis and lifts Zeeman degeneracies (SC-034, L75; SC-035, L76). It uses 402 nm Raman beams for calcium rotations (SC-039, L79) and a 674 nm optical drive for the network pair (SC-040, L81). Calcium’s nuclear spin 7/2 and strontium’s zero nuclear spin are external inputs (U-07). This manuscript’s reading of I-5’s “There are no intrinsic particle masses or properties” is that the calcium nucleus pattern turns and the strontium nucleus pattern does not; the calcium hyperfine structure supplies both addressed ground-manifold pairs. Their nuclear spins are data; equation (14) supplies no numerical nuclear-spin calculation.

3 Observation map

3.1 Heralding, local gates, and ensemble reconstruction

The source reports a two-photon try-until-success protocol (SC-048, L100), with approximately 320 ns optical pumping (SC-050, L104), an approximately 10 ps excitation pulse at 422 nm (SC-051, L105), and an excited-state lifetime of 7 ns (SC-053, L107). The source calls the central operation a projective Bell state measurement (SC-057, L114); particular outcomes herald success (SC-058, L117), after which a 674 nm pulse maps a Zeeman configuration into the upper optical manifold (SC-059, L121; SC-060, L122). The source’s preparation label at L103 names a memory label for the network ground configuration; the configuration itself fixes the intended network preparation (SC-049, L103). The source states that there is a 5% branching ratio for decays to the $D_{3/2}$ manifold and that these decays result in an unsuccessful entanglement attempt and so “can be neglected” (SC-158, L464–L465; SC-159, L466). Their energy remains in the event’s exact books.

I-4 names the entanglement reading “shared bivector grade” and reads observation as phase fixation. This manuscript’s reading places the network’s identity condition at the meeting of the two optical strokes in the herald station. The two strontium hosts across the modules have identical closed-pattern constraints; the two calcium hosts have their own identical constraints. Within each module the species differ. Entanglement in this reading is the joint density-gradient constraint,

settled as one mode of the whole apparatus; under 0.1a every step is a system-wide settlement. The reading never assigns the ensemble offset ϖ to an individual host's ϕ_0 .

The source's target vector and parity model (SC-062, L134; SC-081, L160) are written below. Let $\langle \cdot \rangle$ denote the ensemble expectation, $|0\rangle, |1\rangle$ the addressed configurations, and i the complex unit. The symbol $\otimes$ denotes a tensor product; $\bigotimes_j$ denotes its product over hosts. The equations preserve the source's conditional target-state premise:

$$|\Psi_N\rangle = \frac{|0\rangle^{\otimes N} + e^{i\varpi}|1\rangle^{\otimes N}}{\sqrt{2}}, \quad \hat{X}_\vartheta = \cos \vartheta \hat{X} + \sin \vartheta \hat{Y}. \quad (16)$$

Define $\mathcal{E}_N$ as the parity expectation and $\mathcal{P}$ as the sum of the all-zero and all-one populations. Source equations (2) and (3) give (SC-081, L160; SC-085, L173)

$$\mathcal{E}_N(\vartheta) = \left\langle \bigotimes_{j=1}^N \hat{X}_{\vartheta,j} \right\rangle = C \cos(N\vartheta - \varpi), \quad \mathcal{F} = \frac{\mathcal{P} + C}{2}. \quad (17)$$

The host-count multiplication of analyser phase is an identity of the target form. Its agreement corroborates no invariant. The fitted contrast is an ensemble parameter, and the estimator presumes the target family (SC-075, L145; SC-083, L168). The source's full tomography reconstructs a density matrix (SC-065, L142). Neither operation calculates the deterministic initial phases.

The source reports local geometric phase gates from a driven spin-dependent force (SC-043, L86; SC-044, L88), following the mixed-species gate work [12] (SC-160, L368). This manuscript's reading makes the common motional stroke the local identity constraint. In the conventional gate calculation, the identity map with the ions' masses read from data (O-9), the driven displacement closes its loop, leaving the enclosed-area joint phase. I-1 states that a driven observable "vanishes at zero drive and never 'recovers' the static force": the gate force vanishes with its drive and never recovers the static force of the I-1 law; at the two ions' compactness the bare law returns a small number, a correct reading. The universal I-1 force law remains equation (6), with the charge-to-geometry map recorded below.

The source uses an iSWAP followed by a strontium check for transfer to the auxiliary pair (SC-086, L153; SC-087, L157; SC-088, L163). It reports that the modules "exchange the outcomes" over the classical link (SC-089, L169) and abort on a detected error (SC-090, L173). The strontium configuration after the iSWAP is known; its check detects errors in the mixed-species gates. Core clause 0.1a states, "Every step is a system-wide settlement": "Events do not commute, and a process run backward is never the mirror of the forward event. Responses are system-wide and many-to-many (I-5b's reclosure is one), never one-to-one, particle by particle". The iSWAP therefore draws a system-wide, many-to-many response, and the gates are events, which do not commute. In this manuscript's reading their boundary data are ordered. Under 0.1a a drawn sequence run backward is a second event, never the mirror of the first. The source uses local mixed-species CNOT gates to entangle the auxiliary pairs with the network pairs (SC-113, L228–L229); in this manuscript's picture each CNOT leaves both host gradients in the joint mode, as metronomes on one surface, the crystal's mode. Under 0.1a the Raman beams' coherent map into the memory pairs (SC-121, L259–L261) and any map back are two events, neither the other's mirror.

The table below preserves Table I's units and separates the fidelities fitted from partial state tomography (PST) from those reconstructed by full state tomography (FST). Let $\mathcal{Y}_{\text{succ}}$ be success probability and $\mathfrak{r}$ the net generation rate. Parenthesised Table I errors are read as standard uncertainties by convention U-23; the source specifies that convention for figure points (SC-116, L240; SC-146, L306).

Hosts	PST (%)	FST (%)	$10^4 \mathcal{Y}_{\text{succ}}$	τ (s $^{-1}$)
Sr–Sr	96.0(7)	96.94(9)	1.236(3)	39.31(9)
Sr–Ca	95.1(8)	94.1(6)	1.03(1)	7.14(7)
Ca–Ca	92(1)	93.1(7)	1.24(1)	8.6(1)
Three hosts	94(1)	93.1(7)	1.20(1)	8.26(8)
Four hosts	91(1)	91.9(8)	1.44(2)	9.9(1)

The rows are SC-170–SC-174 (L190), SC-175–SC-179 (L191), SC-180–SC-184 (L192), SC-185–SC-189 (L193), and SC-190–SC-194 (L194). Table I’s calcium states use the auxiliary pair; the memory pair is not employed there (SC-091, L180; SC-092, L181). The raw reconstruction uses 200000 tomographic measurements (SC-066, L132); the mixed-pair reconstruction uses 10000 (SC-093, L182). These are reconstruction sample counts, not independent measurements of an FDT parameter.

For a comparison of two estimates, define standard uncertainties $\mathfrak{d}_i, \mathfrak{d}_j$ and covariance Cov_{ij} . The difference uncertainty $\mathfrak{d}_{i-j}$ is derived by expanding its variance:

$$\mathfrak{d}_{i-j} = \sqrt{\mathfrak{d}_i^2 + \mathfrak{d}_j^2 - 2 \text{Cov}_{ij}}. \quad (18)$$

The source calls the entanglement fidelity of 96.94(9)% “consistent with” the results of partial state tomography, which yielded a fidelity of 96.0(7)% (SC-067, L134; SC-068, L136–L137); by equation (18) with U-23’s illustrative zero covariance the two fidelities differ by 0.9 ± 0.7 percentage points, 1.3 combined standard uncertainties. The two error-detection gains are reported as 4.2(2)% and 8.4(2)% (SC-100, L208–L210). Their ratio is derived as 2.00 ± 0.11 under U-23’s illustrative zero covariance. The printed statement alone leaves open both the unit, relative percent or percentage points, and the fidelity estimate the gains refer to, partial or full tomography. Likewise, the success column does not state per row whether the error-detection aborts and restarts count (SC-090, L172–L173) and gives no common attempt denominator. Its rows cannot determine an elementary link probability model. Net rates include cooling and selected operations; their reciprocals are not individual attempt periods. The source’s earlier link protocol [14] and memory-node protocol [15] identify the experimental antecedents (SC-048, L100–L101; SC-162, L418; SC-111, L222–L225; SC-165, L435).

For this cluster, equations (16) and (17) at the stated target-family order are the identity map, read on I-4’s quantum face. Fitting or reconstructing the same fidelities from the same data is the identity map and corroborates no invariant. An independent parity curve outside the fitted target family tests the estimator premise; it is a falsifier of that premise at the covariance precision of equation (18).

3.2 Field responses and neighbouring configurations

P-5 states, “A magnetic field is a macroscopic helical density gradient of the omnium”. This manuscript’s reading treats a qubit frequency as the comparison of two configurations of one host inside that gradient, read against the drive’s phase reference; the two configurations are Use item 7’s neighbours, and “a response that acts on both neighbours alike” cancels in their difference. Both configurations respond, and their difference sets the pair’s frequency. A reference drift also moves the measured parity phase. A field reading therefore requires an independently characterised reference and neighbouring-pattern comparison.

Define $\mathfrak{z}$ as the Bohr-magneton-to-Planck ratio, and $\mathfrak{g}_{\text{Sr}, S_{1/2}}$ and $\mathfrak{g}_{\text{Sr}, D_{5/2}}$ as the two strontium Landé factors. The illustrative LS input is $\mathfrak{g}_{\text{Sr}, S_{1/2}} = 2.0023$ and $\mathfrak{g}_{\text{Sr}, D_{5/2}} = 1 + (\mathfrak{g}_{\text{Sr}, S_{1/2}} - 1)/5$

(U-05). The external constant is $\mathfrak{z} = 13.9962449361 \text{ MHz mT}^{-1}$ (U-04; [3]). Subtracting the two configuration slopes gives

$$\mathfrak{s}_{\text{net}} = \mathfrak{z} \left(-\frac{3}{2} \mathfrak{g}_{\text{Sr}, \text{D}_{5/2}} + \frac{1}{2} \mathfrak{g}_{\text{Sr}, \text{S}_{1/2}} \right) = -11.19 \text{ MHz mT}^{-1}. \quad (19)$$

This reproduces the source's rounded -11 MHz mT^{-1} (SC-124, L259), with the extra digits belonging to U-05's model.

For calcium define $\mathcal{A}_{\text{hfs}}$ as the hyperfine constant, $\mathfrak{g}_{\text{Ca}, \text{S}_{1/2}}$ as its electronic factor, $\mathfrak{g}_I$ as the nuclear factor in the energy Hamiltonian, and $\mathcal{J}$ as nuclear spin. Let j label the total angular-momentum projection. With a negative nuclear magnetic moment the energy factor is positive: $\mathfrak{g}_I = -(-1.315350)/[(7/2)1836.15267343]$ (U-06, U-07). The other inputs are $\mathcal{A}_{\text{hfs}} = -806.40207160 \text{ MHz}$, $\mathfrak{g}_{\text{Ca}, \text{S}_{1/2}} = 2.00225664$, and $\mathcal{J} = 7/2$ (U-06, U-07; [4, 5, 6]). Let $\mathfrak{e}_4, \mathfrak{e}_3$ be configuration energies divided by h in frequency units, and let $\mathfrak{k} = \mathfrak{z}(\mathfrak{g}_{\text{Ca}, \text{S}_{1/2}} - \mathfrak{g}_I)$. In the spin-projection basis the Hamiltonian divided by h has trace $-\mathcal{A}_{\text{hfs}}/2 + 2\mathfrak{z}\mathfrak{g}_I\mathcal{J}\mathcal{B}$, diagonal difference $\mathcal{A}_{\text{hfs}}j + \mathfrak{k}\mathcal{B}$, and twice its off-diagonal entry $\mathcal{A}_{\text{hfs}}\sqrt{16 - j^2}$. The eigenvalues are half the trace plus or minus half the square root of the squared diagonal difference plus four times the squared off-diagonal entry. Diagonalising the two-state hyperfine Hamiltonian gives the conventional Breit–Rabi expressions, derived from its trace and eigenvalue discriminant. The paired notation $\mathfrak{e}_{4,3}$ orders those two configuration energies:

$$\begin{aligned} \mathfrak{e}_{4,3}(j, \mathcal{B}) = & -\frac{\mathcal{A}_{\text{hfs}}}{4} + \mathfrak{z}\mathfrak{g}_I\mathcal{J}\mathcal{B} \\ & \mp \frac{1}{2} \sqrt{(\mathcal{A}_{\text{hfs}}j + \mathfrak{k}\mathcal{B})^2 + \mathcal{A}_{\text{hfs}}^2(16 - j^2)}. \end{aligned} \quad (20)$$

The zero-field hyperfine interval is $4|\mathcal{A}_{\text{hfs}}| = 3225.608 \text{ MHz}$ (U-08). The minus branch is the total-four configuration because the hyperfine constant is negative. At the stretched endpoints the sole physical configuration uses $\mathcal{A}_{\text{hfs}}\mathcal{J}/2 + \mathfrak{z}(\mathfrak{g}_{\text{Ca}, \text{S}_{1/2}}/2 + \mathfrak{g}_I\mathcal{J})\mathcal{B}$ for positive projection, with the Zeeman term reversed for negative projection. Define $\mathfrak{f}_{j_4, j_3}$ as the frequency difference between total-four projection j_4 and total-three projection j_3 . Write $\mathfrak{s}_{j_4, j_3}$ for its field derivative.

$$\mathfrak{f}_{j_4, j_3} = \mathfrak{e}_3(j_3, \mathcal{B}) - \mathfrak{e}_4(j_4, \mathcal{B}), \quad \mathfrak{s}_{j_4, j_3} = \partial_{\mathcal{B}} \mathfrak{f}_{j_4, j_3}. \quad (21)$$

At the chosen evaluation field $\mathcal{B} = 0.5 \text{ mT}$ (SC-025, L68), the derived memory and auxiliary responses are

$$\mathfrak{s}_{\text{mem}} = +121.71 \text{ kHz mT}^{-1}, \quad \mathfrak{s}_{\text{aux}} = -24.495 \text{ MHz mT}^{-1}. \quad (22)$$

The memory pair has zero linear Zeeman term at zero field; its quoted operating-field sensitivity is the slope of a quadratic contribution. The source's 122 kHz mT^{-1} and “roughly 2 orders” comparison are retained (SC-025, L68; SC-026, L69). The derived memory-to-network response ratio is -0.01088 . The network-to-memory slope magnitude ratio is 91.9 from the same atomic inputs. The network and memory references remain independent of their fitted storage times; high-fidelity calcium preparation is the external experimental antecedent [13] (SC-161, L402).

For common field modulation in both module coils, a strontium–strontium difference state cancels the common response, while its sum state reads the sum of the slopes. The derived combinations, in MHz mT^{-1} , are

$$\begin{aligned} 2\mathfrak{s}_{\text{net}} &= -22.38, & \mathfrak{s}_{\text{aux}} + \mathfrak{s}_{\text{net}} &= -35.69, \\ \mathfrak{s}_{\text{aux}} - \mathfrak{s}_{\text{net}} &= -13.30, & \mathfrak{s}_{\text{mem}} + \mathfrak{s}_{\text{net}} &= -11.07. \end{aligned} \quad (23)$$

The GHZ pair’s per-module response is the auxiliary-plus-network combination, 3.19 times the network-only per-module response. The common-field null is an iff statement: equal fields cancel exactly when the pair responses and phase-reference prefactors are matched. Covariance and calibration mismatch set its finite experimental uncertainty through equation (18).

Let $\mathcal{B}_{\text{match}}$ solve opposite slope matching for the calcium $(4, -2)-(3, -1)$ pair, and $\mathcal{B}_{\text{zero}}$ solve the zero-slope condition for $(4, 0)-(3, +1)$ (U-31). Differentiating equation (20) gives

$$\begin{aligned} \mathfrak{s}_{-2,-1}(\mathcal{B}_{\text{match}}) &= -\mathfrak{s}_{\text{net}}, & \mathcal{B}_{\text{match}} &\simeq 3.36 \text{ mT}, \\ \mathfrak{s}_{0,+1}(\mathcal{B}_{\text{zero}}) &= 0, & \mathcal{B}_{\text{zero}} &\simeq 14.609 \text{ mT}. \end{aligned} \tag{24}$$

The settings are rounded representations of roots, not exact roots at the printed field. At the matching root the derived second derivative is $198.8 \text{ kHz mT}^{-2}$, giving a quadratic coefficient 99.4 kHz mT^{-2} . The branches of an emitted strontium stroke then separate by the ground-term splitting $\mathfrak{g}_{\text{Sr}, S_{1/2}} \mathfrak{B}$, approximately 94 MHz, compared with 14.0 MHz at the 0.5 mT evaluation field (SC-025, L68). The lifetime-based linewidth is $1/(2\pi \cdot 7 \text{ ns})$, approximately $2 \times 10^1 \text{ MHz}$ at the lifetime’s one-figure precision (SC-053, L107). Heralding at the source’s approximate bias followed by storage at the matching root avoids that larger optical distinction. For the illustrative field excursion of $1 \mu\text{T}$ (U-20), the zero-slope pair changes by 0.121 Hz, while the memory pair’s linear response gives 121.7 Hz at the 0.5 mT evaluation field (SC-025, L68).

This cluster tests the configuration dictionary and reference calibration, with the derived precision fixed by the stated atomic inputs. Equations (19)–(24) are the conventional atomic calculation; its reproduction corroborates no invariant. An independently measured slope outside the propagated atomic and field covariance falsifies that dictionary. I-3a’s neighbouring-pattern requirement is operative in the common-field cancellation; it supplies the comparison, not an extra numerical Zeeman term.

3.3 Storage, cooling, and the offset

The source interleaves the raw link’s $500 \mu\text{s}$ attempt window with approximately $320 \mu\text{s}$ Doppler and $500 \mu\text{s}$ EIT cooling (SC-071, L140; SC-072, L141; SC-073, L142). The mixed-species sequence instead uses $200 \mu\text{s}$ attempts and $500 \mu\text{s}$ for each cooling step (SC-101, L211; SC-102, L212; SC-103, L213). Its estimated gate-mode occupations are approximately 0.15 and 0.1 before the excitation loop, and the excitation loop adds approximately 0.2, a heating the source cites to its earlier memory-node work [15] (SC-107, L219; SC-108, L220; SC-109, L221; SC-110, L222; SC-165, L435). These belong to the mixed-species runs. Measuring the raw link’s fidelity against separately measured occupation in each module tests the conventional recoil account [16] (SC-164, L418). Assigning those gate occupations to the raw link would change the source conditions. I-7 counts the energy removed by cooling once.

The source has “observed coherence times of the network qubit of approximately” 8 ms (SC-106, L217–L218), printing no curve or uncertainty. It observes significant network-storage degradation beyond 10 ms (SC-122, L255–L257) and attributes this to the relatively high sensitivity of the network qubits to magnetic field fluctuations (SC-123, L258; SC-124, L259). The source reports fidelity below 50% beyond 100 ms (SC-125, L260–L261), “indicating” amplitude damping processes “such as the decay of the” upper network configuration “due to the finite lifetime of the” metastable $D_{5/2}$ manifold (SC-126, L262; SC-127, L263; SC-128, L264). The cited metastable lifetime is approximately 390 ms (SC-129, L265; [18]). The fitted fidelity-decay constant is 44(3) ms (SC-131, L267). These are different observables. Dephasing alone leaves the relevant target populations fixed and takes a balanced Bell state’s fidelity to its population floor. A value below that floor requires population change or a changed estimator premise; it singles out no unique relaxation mechanism.

The source observes a memory fidelity of 69(4)% at 10 s (SC-135, L271), and extracts a decay constant of 14(4) s using the same exponential model (SC-136, L273; SC-137, L275). Let $t_{\text{net}}, t_{\text{mem}}$ denote the fitted constants, b a fidelity asymptote, and $\mathcal{F}_0$ the initial fidelity. Here t is the appropriate fitted constant. The offset-aware family and its solved asymptote are an in-manuscript reconstruction, not the missing fitted function:

$$\mathcal{F}(t) = b + (\mathcal{F}_0 - b)e^{-t/t}, \quad b = \frac{\mathcal{F}(t) - \mathcal{F}_0 e^{-t/t}}{1 - e^{-t/t}}. \quad (25)$$

At the memory point, $\mathcal{F}_0 \leq 1$ gives the derived bound $b \geq 0.39 \pm 0.14$. With the illustrative initial value $\mathcal{F}_0 = 0.931 \pm 0.007$ from the auxiliary-pair reconstruction (SC-182, L192; U-29), it gives $b = 0.46 \pm 0.12$. These propagated errors use U-23’s zero-covariance convention and the source’s point and fit errors. The actual initial memory fidelity and fit covariance are absent; the auxiliary value is an assumed proxy. A zero-offset exponential with unit initial fidelity returns about 0.49 ± 0.10 at the central fit constant, whereas a half-offset exponential returns about 0.74 ± 0.05 . Both values derive from the same reported constant. The network’s below-half statement at the comparison duration similarly bounds b below approximately 0.446 ± 0.009 using the raw initial reconstruction (SC-172, L190). Strictly the source’s statement applies beyond that duration; this bound evaluates its limiting comparison point under the monotone exponential model (U-30).

The source adjusts universally robust decoupling from 4 to 48 pulses (SC-134, L268; SC-117, L247; SC-133, L267; [17]). The unused species supplies sympathetic cooling (SC-118, L249). Those time-dependent controls accompany the storage fits. The fitted fidelity’s duration times the mixed-species rates spans approximately 71–99 generation intervals; the fitted memory constant times those rates spans approximately $(1.0 \pm 0.3) \times 10^2 - (1.4 \pm 0.4) \times 10^2$. The rates are SC-179 (L191) and SC-194 (L194); the durations are SC-135 (L271) and SC-137 (L275). Thus the source’s “reliably stored for more than 10 s” (SC-140, L287) and approximate order comparison (SC-141, L288) retain their own scope. A fitted constant, a fitted fidelity at 10 s and an estimated creation timescale are distinct quantities.

For this cluster, the fitted constants are the source’s, reused in sample, and I-7 accounts for cooling and radiation. The identity map corroborates no invariant. The errors just stated fix the precision of the offset reconstruction; an independently supplied fit function and covariance falsify it if their implied asymptote lies outside that propagated interval. A measured fixed-control storage curve is the required test of a noise-spectrum reading.

4 Cone-position translation and energy accounting

P-4 identifies fibre refraction and gravitational lensing as one optical phenomenon; equation (9) gives the local refraction condition. The fibre’s index and length are data, absent numerically from the source (SC-056, L112). The cone index is the causal-aperture assignment of P-4; its derivation is recorded below. No fibre index, photon success share or fidelity determines a compactness. Two emitters with different strokes herald after conversion to identical strokes at the station. Frequency conversion is the conventional route, and the source cites the strontium interface [20] (SC-166, L481). This manuscript’s identity reading places its condition at that same station; it predicts no additional conversion yield.

Define f_{opt} as the external strontium line-centre frequency, ΔE as the configuration step and $\Delta \mathcal{M}$ as its mass contribution. The external frequency is 444779044095486.3 Hz (U-09; [7]), and

$h = 6.62607015 \times 10^{-34}$ J s is exact (U-02). Equation (2) then yields

$$\begin{aligned}\Delta E &= h f_{\text{opt}} \simeq 2.9471 \times 10^{-19} \text{ J}, \\ \Delta \mathcal{M} &= \frac{\Delta E}{c^2} \simeq 3.2791 \times 10^{-36} \text{ kg}, \\ \mathcal{T}_q &= \frac{1}{f_{\text{opt}}} \simeq 2.2483 \times 10^{-15} \text{ s}, \quad \ell_q \simeq 674.0 \text{ nm}.\end{aligned}\tag{26}$$

The network pair at the source’s approximate bias lies about 6 MHz below that line centre by equation (19). The length in equation (26) is the Compton length, never the support radius. I-5 reads both the short-lived optical excitation and the metastable upper configuration as decaying by eigenmode relaxation (intra-family, at fixed strand count). Let Γ denote the latter relaxation rate: $\Gamma = 1/(390 \text{ ms}) \simeq 2.6 \text{ s}^{-1}$ (SC-129, L265). The event conserves every exact book across all final patterns.

For an illustrative exterior evaluation take $r_f = 1 \mu\text{m}$ (U-18), the strontium atomic mass 87.905612 in atomic-mass units, electron mass 0.000548579909 in those units, and unit mass $1.66053906660 \times 10^{-27} \text{ kg}$ (U-10; [8]). Using atomic mass minus one electron for the ion and $G = 6.67430 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$ (U-03), equations (3) and (4) give

$$R_s = \frac{\mathcal{M}c^2}{2F_{\text{max}}}, \quad \alpha_{\text{ext}} = \frac{\mathcal{M}c^2}{2F_{\text{max}}r_f} \simeq 2.1680 \times 10^{-46}.\tag{27}$$

This is a correct A-1 exterior reading in the general-relativistic regime. The evaluation radius is a field point, not a confinement anchor. The skin’s saturation diagnostic is schematic for the nuclei’s P-3 pinning sites.

The table below states the operative translation without assigning unearned geometry to the ensemble parameters.

Observable	FDT reading	Numerical scope
Optical frequency	Configuration energy in I-7	External line centre and applied Zeeman shift
Remote parity	Phase-axis ensemble in I-4	Target-family estimator identity
Fibre guidance	Exact Snell law, P-4	Measured optical index required
Static field comparison	Neighbouring configurations, this manuscript’s reading of I-3a	Atomic slopes plus calibrated reference
Ion exterior	A-1 geometry, I-1 and I-3	Illustrative field point, supplied mass
Cooling and radiation	Separate I-7 contributions	Each counted once

The energy and compactness values instantiate core bridges on external inputs; they corroborate no invariant. Independent spectroscopic and mass data test those input assignments at their stated precision. I-3 containment means the same curvature from the same stress tensor and data, not confirmation by an energy-bookkeeping identity.

5 Predictions

P-5 states, “Imposing a physical twist (torsion, helical geometry) on a material is establishing a magnetic field.” This manuscript’s reading identifies the field’s axis with the twist, coil or rotation axis and its reversal with the hand or sense. P-5 fixes neither an absolute sign nor a magnitude.

The first four tests are conditional by construction: they test that existence and reversal rule at a declared finite sensitivity. A uniformly twisted symmetric object has an axial field odd about its centre under this reading. That field vanishes at the centre and integrates to zero over the whole symmetric axis. The ion tests therefore place the ion beyond an end; the optical test breaks the end symmetry. Static shifts are read in free evolution within each pair's coherence, not with the source's static-refocusing decoupling sequence.

Let $\eta = \pm 1$ label the mechanical hand or sense and $\zeta = \pm 1$ the bias polarity, with both pairs of settings interleaved. Let $y_{\eta\zeta}$ be a measured frequency or phase-rate datum, $\mathbf{w}$ its contrast weights, $\mathcal{V}$ the complete covariance matrix of the fitted data, the configuration pairs' projection noise included (T-1, T-2 and T-4), $\mathcal{C}$ the conventional contrast and $\mathcal{R}$ the residual. The systematic bound is $\mathcal{Z}_{\text{sys}}$; the standard uncertainty $\mathfrak{d}_{\mathcal{R}}$ includes calibration, reference drift and control-order covariance. The chosen multiplier is $z = 3$ (U-21). The generic odd contrast and its variance follow by linear propagation. The superscript T denotes transpose:

$$\begin{aligned}\mathcal{R} &= \frac{1}{4} \sum_{\eta, \zeta} \eta \zeta y_{\eta\zeta} - \mathcal{C}, & \mathbf{w}_{\eta\zeta} &= \eta \zeta / 4, \\ \mathfrak{d}_{\mathcal{R}}^2 &= \mathbf{w}^{\mathsf{T}} \mathcal{V} \mathbf{w} + \text{Var}(\mathcal{C}) - 2 \text{Cov}(\mathbf{w}^{\mathsf{T}} y, \mathcal{C}).\end{aligned}\tag{28}$$

Signal and reference share common laser noise, so that covariance is retained. Each design estimates its own matrix from interleaved repetitions and a separate reference calibration. A fitted phase change divided by the independently varied free-evolution time returns frequency; no field value is inferred from a comparator fed back as data.

For the first four tests define the categorical observable $\mathfrak{q}$ as existence of a residual with the stated odd reversal rule: positive code for the FDT rule and negative code for its ablated conventional limit. The subscripts F and C denote FDT and conventional values. Its unit decision interval is $z\mathfrak{d}_{\mathfrak{q}} = 1$. This categorical interval is separate from the physical frequency or rotation threshold $z\mathfrak{d}_{\mathcal{R}}$. A finite null excludes specified physical magnitudes above that threshold and the systematic bound; arbitrarily small existence statements remain untested by that null.

5.1 T-1: Static torsion outside one module

DC-1 discriminates SA-42: the source's bias-axis description (SC-034, L75) determines the applied axis, while it supplies no test of a twisted insulator's additional field. Place a fused-silica rod outside Alice's chamber on that axis, with the ion beyond one end; Bob's module is unchanged. The material is illustrative-assumed (U-22). Turn the remote network pair into its difference form by a π rotation of one pair and hold equal opposite static twists. Reverse Alice's bias in interleaved settings. The neighbours are the two module hosts; common field response cancels after matched response calibration.

Let $\dot{\varpi}$ denote fitted remote phase rate and $\Delta\mathcal{B}_1$ the hand-odd axial field at Alice relative to Bob, projected on the positive reference axis. The independently measured datum is $y_{\eta\zeta} = \dot{\varpi}_{\eta\zeta} / (2\pi)$. For this test $\mathcal{R}_1$ is the residual and $\mathcal{C}_1$ the conventional contrast. Solving the pair-frequency condition gives

$$\mathcal{R}_1 = \mathfrak{s}_{\text{net}} \Delta\mathcal{B}_1, \quad \Delta\mathcal{B}_1 = \frac{\mathcal{R}_1}{\mathfrak{s}_{\text{net}}}, \quad \mathcal{C}_1 = 0.\tag{29}$$

This manuscript's P-5 reading supplies the additional source and its reversal, with single axial-field scope. The categorical prediction is

$$\mathfrak{q}_{1,\text{F}} = +1, \quad \mathfrak{q}_{1,\text{C}} = -1, \quad z\mathfrak{d}_{\mathfrak{q}_1} = 1.\tag{30}$$

A current-free, unmagnetised insulator gives the conventional zero. Its bias-induced moment reverses with the bias and is even in the projected frequency; hand-even effects cancel. A permanent moment of the rod, clamps or moving mechanism survives both contrasts and passes the field check. Map those moments away from the apparatus and propagate their geometric uncertainty into $\mathcal{Z}_{\text{sys},1}$. Residual coil mismatch, laser drift and order-dependent strain enter the same bound or the covariance, according to whether they are bounded biases or sampled fluctuations.

The sign scope is: candidate and permanent moments are odd in hand and bias projection; induced magnetisation is even in bias projection; common-field and hand-even terms cancel. The memory-to-network frequency ratio is -0.01088 by equation (22); measuring it checks a field channel, not the field's origin. Detect a departure when $|\mathcal{R}_1| > z\mathfrak{d}_{\mathcal{R}_1} + \mathcal{Z}_{\text{sys},1}$. Exclude a specified field when its predicted residual differs from the observed one by more than that rule, with the specified-field calibration covariance included. Attribute a departure to the proposed source only after all surviving permanent moments are bounded and the two-pair ratio and reversals agree. The resolvable field is $(z\mathfrak{d}_{\mathcal{R}_1} + \mathcal{Z}_{\text{sys},1})/|\mathfrak{s}_{\text{net}}|$, which has field units. This is an apparatus sensitivity, not an FDT magnitude.

5.2 T-2: An unstressed helical fibre

DC-2 discriminates SA-43: the source's memory configurations (SC-037, L81) fix a comparison pair but do not measure the field of a helical dielectric. Place equal-geometry left- and right-handed unstressed fused-silica coils outside one chamber, coaxial with its quantisation axis, with the ion beyond one end. No current flows. The material choice is U-22. This manuscript's reading makes the two hands of this fixed geometry the neighbours of I-3a; their common response cancels in the hand contrast.

Let $\Delta\mathcal{B}_2$ denote the hand-odd field and $\mathcal{R}_2$ the network-pair residual from equation (28), measured by free-evolution spectroscopy with both bias polarities; $\mathcal{C}_2$ is its conventional contrast. The solved condition is

$$\mathcal{R}_2 = \mathfrak{s}_{\text{net}}\Delta\mathcal{B}_2, \quad \Delta\mathcal{B}_2 = \mathcal{R}_2/\mathfrak{s}_{\text{net}}, \quad \mathcal{C}_2 = 0. \quad (31)$$

The additional P-5 input is the helical geometry itself. Its categorical rule is

$$\mathfrak{q}_{2,\text{F}} = +1, \quad \mathfrak{q}_{2,\text{C}} = -1, \quad z\mathfrak{d}_{\mathfrak{q}_2} = 1. \quad (32)$$

Define ξ_{vol} as volume magnetic susceptibility, an external illustrative value -1.1×10^{-5} (U-13). At the 0.5 mT evaluation field (SC-025, L68), the conventional magnetisation in field units is $\xi_{\text{vol}}\mathcal{B} = -5.5 \times 10^{-9}$ T. This is the magnetisation scale, not a stray field at the ion without geometry. The two mirror coils have equal induced response on axis; its bias projection is even. A differing permanent moment is odd in bias projection and survives both contrasts. Measure each coil and its mounts away from the apparatus to bound that contribution in $\mathcal{Z}_{\text{sys},2}$.

The sign scope is single axial field: induced magnetisation and hand-even shifts cancel; candidate and mismatched permanent moments survive. Read the memory pair against the same calibrated phase reference; its field ratio to the network pair is -0.01088 . Electric and optical shifts have independently measured two-pair responses. Estimate equation (28)'s covariance including coil replacement, drift, pair comparison and bias calibration. Detection requires $|\mathcal{R}_2| > z\mathfrak{d}_{\mathcal{R}_2} + \mathcal{Z}_{\text{sys},2}$. Exclusion applies to specified fields whose predicted contrasts differ by more than this combined threshold, using their calibration covariance. Attribution requires the field ratio, reversals and an off-apparatus permanent moment bound below the residual. The field resolution is this threshold divided by $|\mathfrak{s}_{\text{net}}|$.

5.3 T-3: Nonreciprocal rotation in an asymmetric twisted span

DC-3 discriminates SA-44: the source's single-mode fibres (SC-056, L112) transport the heralding light, while their torsional magnetic response is unmeasured. Use an illustrative fused-silica span at the source's optical wavelength (U-22; SC-054, L109), clamped at one end face and at a point along the fibre beyond which the glass continues. Equal opposite twists and the asymmetric boundary conditions avoid the whole-axis symmetry null. Launch weak light from each end in turn into a polarimeter at the other. In this manuscript's reading the path of the launch from the other end is the reference path of Use item 7. Under 0.1a that launch is a second event, never the mirror of the first.

Let $\mathcal{H}_\eta^\rightarrow, \mathcal{H}_\eta^\leftarrow$ be the measured rotations about one fixed physical axis, $\mathcal{H}_{\eta,\text{nr}}$ their nonreciprocal half-sum, $\mathcal{K}_{\text{Ver}}$ the independently calibrated Verdet constant, and $\mathcal{I}_3$ the hand-odd axial field integral through the glass. Here $\mathcal{R}_3$ is the hand contrast and $\mathcal{C}_3$ its conventional value. The observable and its solved Faraday condition are

$$\begin{aligned}\mathcal{H}_{\eta,\text{nr}} &= (\mathcal{H}_\eta^\rightarrow + \mathcal{H}_\eta^\leftarrow)/2, \\ \mathcal{R}_3 &= (\mathcal{H}_{+, \text{nr}} - \mathcal{H}_{-, \text{nr}})/2 = \mathcal{K}_{\text{Ver}}\mathcal{I}_3, \quad \mathcal{I}_3 = \mathcal{R}_3/\mathcal{K}_{\text{Ver}}, \quad \mathcal{C}_3 = 0.\end{aligned}\tag{33}$$

The integral is the path integral of axial field, not a local sensitivity multiplied by an unspecified length. The categorical P-5 rule is

$$\mathfrak{q}_{3,\text{F}} = +1, \quad \mathfrak{q}_{3,\text{C}} = -1, \quad z\mathfrak{d}_{\mathfrak{q}_3} = 1.\tag{34}$$

The external silica value $310 \pm 3 \text{ deg T}^{-1} \text{ m}^{-1}$ at 532 nm (U-12; [10]) gives an illustrative $\mathcal{K}_{\text{Ver}} \simeq 8.6 \text{ rad T}^{-1} \text{ m}^{-1}$ at 422 nm by inverse-wavelength-squared scaling. Calibration on the actual glass replaces that estimate in the experiment.

In the conventional calculation, which gives the twist's optical activity one matrix element for both directions, that activity cancels in the directional half-sum, and ambient Faraday rotation is hand-even, both only in the absence of linear birefringence. Measured linear-birefringence matrices bound both surviving hand-odd terms; repeat the contrast with ambient field reversed to separate its contribution. A permanent moment rotating with a clamp or mechanism survives these tests and requires an off-apparatus moment map. Thus the sign scope includes candidate and clamp fields, optical-activity leakage and ambient-field leakage; reversal alone does not identify their origin. Use the four rotation weights in the covariance formula, the polarimeter's readout noise included in the rotations' own matrix, augmented by ambient-field repetitions and Verdet calibration, to obtain $\mathfrak{d}_{\mathcal{R}_3}$ and $\mathcal{Z}_{\text{sys},3}$. Detect when $|\mathcal{R}_3| > z\mathfrak{d}_{\mathcal{R}_3} + \mathcal{Z}_{\text{sys},3}$; exclude a specified field integral when its predicted hand contrast differs from the observed $\mathcal{R}_3$ by more than that threshold, with its calibration covariance included. Attribution requires bounded birefringence leakage and permanent moments as well as the nonreciprocal hand reversal. The resolvable field integral is that threshold divided by $|\mathcal{K}_{\text{Ver}}|$, with units of field times length. A null includes the possible geometric cancellation of a nonzero local axial field.

5.4 T-4: Mechanical rotation beside the trap

DC-4 discriminates SA-45: the source's geometric phase gates (SC-044, L88) probe a driven motional loop, while this experiment probes a static mean field from mechanical rotation. Spin a fused-silica disc beside one module about its quantisation axis in both senses. Read both configuration pairs in free evolution and reverse the bias. This manuscript's reading takes the two rotation senses as neighbouring configurations whose sense-even response cancels. P-5 states that

“mechanical vorticity and magnetic moments are different grade projections of one density-gradient topography, with no carrier exchange (I-2)”, and I-3a reads the antisymmetric part of the neighbour comparison as “vorticity: the bivector grade, the mechanical circulation whose magnetic projection is that of P-5”.

Let f_{rot} denote disc rotation frequency, $\mathfrak{Z}_{\text{el}}$ the electron charge-to-mass ratio and ξ_{VV} the illustrative Van Vleck susceptibility. The inputs are $f_{\text{rot}} = 100 \text{ Hz}$ (U-19), $\mathfrak{Z}_{\text{el}} = 1.75882001076 \times 10^{11}$ coulomb per kilogram and $\xi_{\text{VV}} = 1.1 \times 10^{-5}$ (U-13). Define $\mathcal{B}_{\text{Barnett}}$ as the conventional electron-equivalent rotation field and $\mathcal{B}_{\text{mag}}$ as its susceptibility-weighted magnetisation in field units. The conventional calculation is

$$\mathcal{B}_{\text{Barnett}} = \frac{4\pi f_{\text{rot}}}{\mathfrak{Z}_{\text{el}}} \simeq 7.1 \times 10^{-9} \text{ T}, \quad \mathcal{B}_{\text{mag}} = \xi_{\text{VV}} \mathcal{B}_{\text{Barnett}} \simeq 7.9 \times 10^{-14} \text{ T}. \quad (35)$$

The second scale requires the measured disc geometry to become a field at the ion. The conventional contrast $\mathcal{C}_4$ also contains the Rowland field of free charge, the Röntgen field of bound charge, and a drive-current field that reverses with the sense. Bound the charge terms from measured charge and mapped electric field, and map the drive with the disc removed.

Let $\Delta\mathcal{B}_4$ be the extra axial field after these conventional contributions; $\mathcal{R}_4$ is the measured residual. The independent frequency measurement and categorical rule are

$$\mathcal{R}_4 = \mathfrak{s}_{\text{net}} \Delta\mathcal{B}_4, \quad \Delta\mathcal{B}_4 = \mathcal{R}_4 / \mathfrak{s}_{\text{net}}, \quad \mathcal{R}_{4,\text{C}} = 0. \quad (36)$$

$$\mathfrak{q}_{4,\text{F}} = +1, \quad \mathfrak{q}_{4,\text{C}} = -1, \quad z\mathfrak{d}_{\mathfrak{q}_4} = 1. \quad (37)$$

All four conventional fields are sense-odd, fixed under bias reversal and therefore odd in the projected frequency. All pass the memory-to-network field ratio. The sign scope thus demands subtraction and bounds, not a sign-only separation from those fields. Use equation (28) with covariance between rotation speed, magnetic subtraction, drive and charge calibration. Detect when $|\mathcal{R}_4| > z\mathfrak{d}_{\mathcal{R}_4} + \mathcal{Z}_{\text{sys},4}$; exclude a specified extra field when its residual differs beyond that bound with its own calibration variance. Attribute only after the four conventional fields and moving permanent moments are bounded below the residual and the field ratio and sense reversal agree. The threshold divided by $|\mathfrak{s}_{\text{net}}|$ is the resolvable extra field.

5.5 T-5: Isotope dependence of the glass response

DC-5 discriminates SA-46: the source’s optical fibres (SC-056, L112) supply no isotope comparison of their constitutive response. I-7’s discriminator states, “For purely density-coupled equilibrium observables, a heavier isotope” gives larger gravitational radius, higher curvature and larger response. This test is conditional by construction on an additional density sensitivity at fixed molar volume and optical dispersion. Draw equal straight single-mode fibres for 422 nm (U-22; SC-054, L109) of one design from natural-oxygen and enriched-oxygen silica. Measure each Verdet constant at that wavelength in turn along one calibrated solenoid, with equal lengths, independently measured linear birefringence and a bound on its residual correction. The neighbouring samples share geometry, solenoid and optical reference.

Let $\mathfrak{M}_{\text{L}}, \mathfrak{M}_{\text{H}}$ denote the light and heavy molar masses, $\mathfrak{M}_{\text{Si}}, \mathfrak{M}_{\text{O}}, \mathfrak{M}_{18}$ the constituent molar masses, and u the heavy-oxygen fraction. Inputs are 28.0855, 15.9994, and 17.99916 g mol⁻¹ respectively (U-14; [9, 8]), with $u = 0.95$ (U-17). The derived fractional and logarithmic changes are distinct:

$$\begin{aligned} \mathfrak{M}_{\text{L}} &= \mathfrak{M}_{\text{Si}} + 2\mathfrak{M}_{\text{O}}, \\ \mathfrak{M}_{\text{H}} &= \mathfrak{M}_{\text{Si}} + 2[u\mathfrak{M}_{18} + (1-u)\mathfrak{M}_{\text{O}}], \\ \frac{\mathfrak{M}_{\text{H}} - \mathfrak{M}_{\text{L}}}{\mathfrak{M}_{\text{L}}} &\simeq 0.0632, \quad \ln \frac{\mathfrak{M}_{\text{H}}}{\mathfrak{M}_{\text{L}}} \simeq 0.0613. \end{aligned} \quad (38)$$

The molar-mass ratio equals the mass ratio at fixed sample amount. These digits describe the specified composition test point; an actual sample requires its measured isotope fraction and covariance.

Define Δ_{Ver} as the logarithmic heavy-to-light Verdet ratio, $S_{\mathcal{M}}$ as its logarithmic mass sensitivity at fixed molar volume and dispersion, S_{vol} as its molar-volume sensitivity at fixed mass and dispersion, and S_{disp} as its dispersion sensitivity at fixed mass and volume. Let $\mathfrak{V}_{\text{mol}}$ be molar volume and $\mathcal{D}_{\text{opt}}$ an independently calibrated dispersion coordinate. The exact finite-path form of I-7 discipline 2 is

$$\Delta_{\text{Ver}} = \int_{\text{L}}^{\text{H}} S_{\mathcal{M}} d \ln \mathcal{M} + \int_{\text{L}}^{\text{H}} S_{\text{vol}} d \ln \mathfrak{V}_{\text{mol}} + \int_{\text{L}}^{\text{H}} S_{\text{disp}} d \ln \mathcal{D}_{\text{opt}}. \quad (39)$$

The comparator $\mathcal{C}_5$ is the consensus Becquerel response using the isotope-shifted dispersion and molar volume. The investigator-chosen bound is $|\mathcal{C}_5| \leq 0.01$ (U-15), checked by separate material measurements. I-3 chart discipline 5 states that fixed-geometry perturbations, isotope substitution with pressure, radius and packing all fixed, “move compactness only”; the fixed-geometry curvature change keeps molar volume fixed, and isotope-induced molar-volume change is explicitly its own term. At the chosen test point $S_{\mathcal{M}} = 1$ throughout the path (U-17), the comparator-subtracted condition uses $\mathcal{R}_5$ for the residual and $\mathcal{R}_{5,C}$ for its conventional limit; $\mathfrak{d}_{\mathcal{R}_5}$ is its standard uncertainty. The condition and its ablation are

$$\mathcal{R}_5 = \Delta_{\text{Ver}} - \mathcal{C}_5 = 0.0613, \quad \mathcal{R}_{5,C} = 0, \quad z\mathfrak{d}_{\mathcal{R}_5} = 0.015. \quad (40)$$

The chosen standard uncertainty is $\mathfrak{d}_{\mathcal{R}_5} = 0.005$ (U-24). Replacing the density sensitivity by its conventional zero removes the first integral; the remaining material calculation is unchanged. This is a constitutive input, not a divergence manufactured by a chart label.

For precision, differentiate the measured logarithmic ratio and comparator with respect to the two rotations, lengths, field calibration, isotope fraction, volume, dispersion and birefringence corrections. With gradient vector $\mathfrak{v}$ and their covariance $\mathcal{V}_5$, the two rotations’ readout noise and the solenoid-field and temperature drift between the two fibres’ measurements and their order included, the propagated variance is $\mathfrak{d}_{\mathcal{R}_5}^2 = \mathfrak{v}^T \mathcal{V}_5 \mathfrak{v}$. The path’s sensitivity uncertainty is included when testing the specified FDT value. The sign table in words is: mass is positive at the stipulated sensitivity; volume follows the measured volume sensitivity; dispersion follows the calibrated dispersion derivative; residual birefringence has either sign. Consequently the total observed sign remains conditional until those sensitivities and corrections are established.

Detect an extra response when $|\mathcal{R}_5| > z\mathfrak{d}_{\mathcal{R}_5} + \mathcal{Z}_{\text{sys},5}$, where the systematic bound includes U-15 and the residual birefringence bound unless those contributions have already been subtracted with their covariance. Exclude the stipulated unit-density-sensitivity input when the observed residual differs from its specified path integral beyond the same combined criterion including sensitivity uncertainty. Attribute a departure to density only after volume, dispersion and birefringence are independently bounded. At the stated precision the statistical threshold is 0.015, and the additional comparator allowance is 0.01 before any birefringence allowance. The proposed signal exceeds their sum. Both sensitivities and experimental uncertainties are test inputs; none is a source measurement.

6 Cross-domain consequences

The source states that in atomic clock networks entangled states engineered across species with complementary sensitivities “can yield improved stability and reduced systematic uncertainties”

(SC-152, L326–L327; SC-153, L328), citing combination clocks [19] (SC-169, L494). The matched-pair calculation gives a specific conventional route to suppress a common field. In the FDT reading, the carried clock’s thermal shift remains the time dilation of its own thermal motion; it never reads the temperature of the surrounding medium as its frequency. A frequency comparison between network nodes is a neighbour comparison (0.1c, I-3a, Use item 7): for the same source and data a height-separated clock pair reads general relativity’s redshift (I-3). The source also states that the generation of multipartite entangled states across remote modules “could serve as a distributed” entanglement resource for quantum error correction in networked quantum computing architectures (SC-155, L332–L337). That application modal remains distinct from a demonstrated fault-tolerant resource.

A Bell comparison external to the source supplies the benchmark. Let $\mathcal{S}_{\text{CHSH}}$ denote that comparison’s CHSH sum. The benchmark is $\mathcal{S}_{\text{CHSH}} = 2.677(6)$ (U-11; [11]), above the conventional bound 2 (U-26). This manuscript’s shared-mode reading is one mode, both analyser settings among its boundary data; under 0.1a the four terms of the chain, equation (1), adjust simultaneously: the omnium settles matter, energy and spacetime by “one global optimisation, never one term at a time”. The retained target ensemble has phase-independent single-module marginals: tracing out the other module’s hosts removes the cross terms in equation (16). The shared-mode reading retains those marginals, and each module’s outcome shares, read alone, follow no setting of the other module (the standard account’s no-signalling). The core supplies no derived correlation function or numerical CHSH sum here. Above the conventional bound, the benchmark excludes two local copies of a common phase, each read by its own analyser with a setting independent of the copy (the standard account’s theorem); the shared-mode reading is not of that kind, and the value enters as an external input, never as a result derived from I-4.

7 System-level reading (exploratory)

Scope: one in-sample survival-exponent description of the two reported storage constants, with the source’s changing control sequence left explicit. For X-1, let $\mathfrak{p}$ be an effective exponent relating storage time to field sensitivity. Its observable is the logarithmic ratio of fitted storage constants divided by the logarithmic ratio of pair sensitivities; its defining condition is a constant-prefactor power law. Its comparator is a fixed-control noise model. Using the slope ratio 91.9 of equations (19) and (22) (the source’s sensitivities are -11 MHz mT^{-1} and 122 kHz mT^{-1} , the latter at 0.5 mT , SC-124, L259; SC-025, L68) and fitted constants (SC-131, L267; SC-137, L275) defines

$$\frac{t_{\text{mem}}}{t_{\text{net}}} = \left| \frac{s_{\text{net}}}{s_{\text{mem}}} \right|^{\mathfrak{p}}, \quad \mathfrak{p} = \frac{\ln(14/0.044)}{\ln 91.9} \simeq 1.27. \quad (41)$$

The fitted-time errors give approximately 0.06 uncertainty under U-23, while the slope ratio carries no stated experimental covariance. The endpoints fix a secant, not a derivative. The conventional flicker and white-noise comparators have exponents 1 and 2 under fixed pulse count (U-27). Here pulse count changes with duration, so this exponent identifies no noise spectrum. A unit ratio, equal fitted constants, would imply a zero exponent iff the prefactor and control conditions were constant.

Guards. X-1 is an in-sample re-description. The offset family, decay mechanisms, changing decoupling sequence and cooling schedule remain separate variables. The exponent occupies no curvature, strand-count or mass slot and enters none of the prospective prediction count.

8 Convergence statement

For the same source inputs and dictionary, equations (16) and (17), Table I’s fitted (PST) and re-constructed (FST) fidelities, and the reported exponential fit constants return the consensus states, fringes, fidelities and constants. The atomic response calculations likewise reproduce the rounded source slopes, and the estimated quantities return with their tag: the entanglement generation timescale, the storage durations and their ratio to it, the network pair’s coherence time, and the gate-mode occupations with their added heating. These operations are the identity map of core Use item 2 and corroborate no invariant. I-3 contains the same curvature for the same stress tensor and data; the ensemble calculation at its stated target-family order is the identity map, read on I-4’s quantum face. FDT is a true extension of GR and QM; its predictions depart from theirs only where it supplies an additional source, a constitutive input or a changed observable dictionary, as in the prospective tests above.

The fitted storage constants do not supply an asymptote, a homogeneous noise spectrum or the memory pair’s initial fidelity. The printed success column supplies no shared attempt denominator; the rate includes cooling; the gains leave their unit and their reference estimate open. A network fidelity below one half requires population change or a changed estimator premise only where it lies below half the stored population share, the zero-contrast floor of equation (17), a share the source does not print; the one curve identifies no unique amplitude-damping channel. The network preparation configuration fixes the local label ambiguity. These are limits of the conventional reconstruction itself, carried unchanged into the convergence map.

For SA-01, the source describes entanglement between physically separated systems (SC-015, L25), and the standard account reads the remote state as one joint amplitude whose correlations are nonlocal. FDT reads the correlation as the shared bivector grade, superposition as ignorance of the helical phase ϕ_0 at observation, the universe deterministic (I-4); in this manuscript’s reading one medium’s constrained patterns settle one mode; under 0.1a every step is a system-wide settlement.

For SA-27, the source names its equation’s target an N-particle GHZ state up to a phase (SC-064, L138), and the standard account reads each ion as a distinct particle with intrinsic properties. FDT reads the ions as closed patterns of the one omnium, their masses confinement eigenvalues (I-5, 0.1b); the counted entries are hosts of configurations, and the source’s ensemble vector keeps its calculation.

For SA-28, the source says that the magnetic field sets the quantisation axis and lifts degeneracies (SC-034, L75; SC-035, L76), and the standard account reads the field as an independent entity. FDT reads it as a macroscopic helical density gradient of the omnium, the bivector grade of the density field coherently aligned along an axis (P-5), its axis the quantisation axis; in this manuscript’s reading two configurations of one host are compared inside that gradient, read against the drive’s phase reference.

For SA-29, the source uses the auxiliary pair “for mediating mixed-species quantum logic” (SC-030, L72; SC-032, L74), and the standard account describes the common motional mode as mediating the local gate. FDT reads one carrier and no mediation, interactions being curvature plus geodesic motion (I-2); the gate is a shared excitation and phase constraint of the one medium.

For SA-31, the source calls the central operation a projective Bell state measurement (SC-057, L114), and the standard account reads it as the collapse of a joint amplitude that swaps the ion–photon entanglement onto the ions. FDT reads the herald as projection and phase fixation, the correlation the shared bivector grade, never a nonlocal action (I-4); in this manuscript’s reading the joint mode is settled at the common strokes with the full boundary data; under 0.1a every step is a system-wide settlement.

For SA-32, the source uses local mixed-species iSWAP gates “to transfer the quantum states of

the remotely entangled network qubits” to the auxiliary pairs (SC-086, L153–L155; SC-087, L157) and Raman beams “to coherently map the quantum information” into the memory pairs (SC-121, L259–L261), and the standard account reads a transfer as a one-to-one, particle-wise move of a state from one qubit to another. FDT reads the ions as closed patterns of the one omnium, “There are no separate particles and no boxes: there is only omnium, and omnium patterns” (0.1b); under 0.1a, “Events do not commute, and a process run backward is never the mirror of the forward event”: each gate or map is the system-wide, many-to-many settlement of the state it starts from (Use item 6), and a map run back is a second event, never the mirror of the first.

For SA-33, the source names an ultrahigh vacuum chamber (SC-027, L71), and the standard account reads a vacuum as an empty background in which c is an abstract constant. FDT reads no empty background: no variable in the chain vanishes at the chamber’s low pressure, and c^2 is a medium property of the omnium, whose response coefficients and invariant speed remain those of equation (1) (0.1).

9 Status ledger

The table below states the outstanding constructions, prospective scope, in-sample readings and unused chart tokens. The two mass ratios remain held-out targets even where an external ratio enters an atomic input.

Item	Status and convergence value
O-1	Owed: the finite-core cutoff r_c , the regular core chart, or the outward phase-transfer law.
O-2	Owed: a geometrically constructed odds for the overlap-contrast application (A-3).
O-3	Owed: a canonical odds for the confinement application (A-4).
O-4	Owed: the local profile from the omnium constitutive law with boundary, surface and core data, reducing to the measured nuclear profile.
O-6	Owed: the maps from a charge or a colour seat to an I-1 input; derivation of the A ₂ seat table from cone geometry; the gluon octet's dynamics.
O-8	Owed: the constitutive derivation of effective speed and cone index and its reconciliation with lensing.
O-9	Owed: the confinement operator, its domains, boundary data and spectrum; every mass ratio, including the two held-out targets.
O-12	Owed: the phase-exchange rates and the decay kernel, spectrum, chirality and rates.
A-3, A-4, A-5	PROVISIONAL; unused tokens, open range only, no numerical map. A-2 has geometric warrant and is unused.
T-1	Prospective; conditional by construction, single axial-field scope. Conventional residual zero. P-5 twist-to-moment kernel unspecified.
T-2	Prospective; conditional by construction, single axial-field scope. Conventional residual zero. P-5 helix-to-field kernel unspecified.
T-3	Prospective; conditional by construction, axial field integral. Conventional residual zero after optical corrections. P-5 kernel unspecified.
T-4	Prospective; conditional by construction, extra axial field beyond four conventional fields. Conventional residual zero. P-5 kernel unspecified.
T-5	Prospective; conditional by construction on the stipulated density sensitivity. Conventional extra density response zero.
X-1	In-sample effective exponent; constant-prefactor fixed-control interpretation unestablished.
Ensemble fits and reconstructions, field calculations	In-sample estimator and atomic identities; no invariant corroboration.
Shared-mode and identity reading	Manuscript reading of core clauses; no derived Bell correlation function.
Helical axis and reversal	Manuscript reading of P-5; no numerical twist kernel.
Mass-ratio targets	HELD-OUT: proton-to-electron ratio 1836.15267343 (U-06) and squared muon-to-electron ratio 4.2753×10^4 (U-28), not outputs.

10 Conclusions

The network's measured, fitted and reconstructed ensemble quantities retain their source definitions. Configuration-pair field comparisons within the conventional atomic calculation give the memory pair a field response 91.9 times below the network pair's at the 0.5 mT evaluation field (SC-025, L68), and the source attributes the network pair's significant storage degradation beyond 10 ms to the relatively high sensitivity of the network qubits to magnetic field fluctuations (SC-122, L255–L257; SC-123, L258; SC-124, L259), while the offset and changing controls limit what the two fitted constants determine. In this manuscript's reading, hosts, motional loops and optical strokes belong to one constrained medium; under 0.1a, phase fixation is a system-wide settlement

and events do not commute. The prospective separation from GR and QM lies in an additional helical-field source and a stipulated density-coupled constitutive response. Their tests specify neighbouring patterns, symmetry nulls, conventional backgrounds and independent measurements that determine what a departure, a finite exclusion and an attribution mean.

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